Proceedings

11th Agricultural Science Congress

Transforming Agricultural Education for Reshaping India's Future

Editor
R.B. Singh

NAAS

National Academy of Agricultural Sciences
NASC, DPS Marg, New Delhi - 110 012, India

PROCEEDINGS

11th Agricultural Science Congress

Transforming Agricultural Education for Reshaping India's Future

Edited by

R.B. Singh

NAAS

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Foreword

Agriculture is the pivotal component of India's prosperity and livelihood security of its 1.25 billion people. Through the Green Revolution and subsequent development processes, the country had registered unprecedented growth in food and agricultural production, food security and poverty alleviation. Yet, the country is home to almost one-fourth of the world's hungry, undernourished and poor people. And freeing our peoples from this triple burden must be our foremost priority. Further, although agriculture today contributes only about 14 percent of the Gross Domestic Product (GDP), it accounts for more than 50 percent of the employment. Consequently, and given that the growth rate in the agricultural sector has been about $1/3^{rd}$ of that in the non-agricultural sector, the income gap between farmers and non-farmers has been wide and is further widening. And, the inequities and inequalities are proving a major deterrent to accelerated overall development.

Moreover, agriculture, encompassing crops, livestock, fisheries, agro-forestry and forestry, natural resources (land, water, biodiversity), diverse agricultural products and value chains, and their veritable interactions and interdependencies, is a highly complex sector. In recent years, fast changing political economies, global trade and liberalization, price inflation and, above all, the intensifying risks of climate change have rendered the sector doubly complex. On the other hand, the agricultural knowledge pool encompassing the various sub-sectors has been expanding fast, underpinning the increasingly competitive role of knowledge domain in development. In order to achieve and maintain a competitive edge in the globalised and liberalised world, suitably trained human resources will be needed all along the value chain. The higher agricultural education system in India would thus need to be streamlined to cope up with the fast changing agricultural world.

This Proceedings Volume arising from the XI^{th} Agricultural Science Congress of the National Academy of Agricultural Sciences (NAAS), contains detailed analyses of the current status, effectiveness, issues and challenges of higher agricultural education and suggests way forward to build a high quality human resource capital in the field of agricultural research, education and extension for development (AREE4D). The various thought-provoking papers based on rigorous situational analysis presented by leading Indian and foreign experts had revealed that all is not well with the AREE4D system and it needs serious transformation towards reshaping India's future. In particular, it highlights the importance of quality assurance, governance and investment in agricultural education, youth employability and preparedness to capture the fast-changing entrepreneurial opportunities, inclusiveness and women empowerment to meet the demands arising from the fast feminization of agriculture, urgency to harness latest technologies and ICT for benefitting from the vast and ever-expanding knowledge pool to align our agricultural education system with the most responsive agricultural research, extension and innovation system nationally and internationally. I am sure, all concerned with the creation of a dynamic AREE4D system through institutionalising and applying high quality education, especially policy makers, scientists, educationists, development experts, teachers, students, and farmers will greatly benefit from this invaluable and timely publication.

I must express my gratitude to Prof. R.B. Singh, Immediate Past President of NAAS, who had eminently pioneered and steered this herculean effort for conceptualization, organization, ensuring participation of world thought leaders and finally shaping this Proceedings Volume. I am confident, the pathways suggested will be duly internalized in our plans, strategies, policies and actions to transform our agricultural education to reshape India's agriculture-led future.

S. Ayyappan
President

Preface

Education is the most valued possession of a person and the most powerful engine of a nation's development – human, social and economic. Agricultural education, coupled with research and extension had ushered in and nurtured the Green Revolution in India. Structured on the pattern of Land Grant University (LGU) system of the USA, the Indian Agricultural Education System, the ICAR deemed universities, the State Agricultural Universities (SAUs) and other institutions had not only created the human capital but also nurtured science, technology and innovation for development. These universities had duly emphasized integration of basic and social sciences in their teaching and research programmes and brought out qualified well rounded agricultural scientists and skilled humanpower.

The national agricultural education system, especially the SAUs are no longer the same. The widespread perception is that "the journey of higher agricultural education got interrupted" and the SAUs have generally slipped back to the business as usual. Among other things, the intensity for comprehensiveness has diminished, the characteristic research-education-extension synergy has loosened and there is widespread academic inbreeding depression, and erosion of meritocracy. Consequently, educational standard, faculty number and quality, and research and extension outcomes have declined. These may be ascribed to the lack of autonomy of our universities, poor governance, lack of a credible monitoring, evaluation and accountability system, and not the least, to the unmindful splitting of the SAUs. Let us remember, a substandard education is a crime.

On the other hand, the Indian enigma of co-existence of high economic growth with entrenched high prevalence of hunger and poverty continues. And part of it could be attributed to the neglect of agriculture, especially agricultural education and research in an agriculturally important country like India. Further, the world is changing rapidly. Demand for high value quality food is escalating whereas the total factor productivity and natural resources are shrinking. The situation is exacerbated by the intensifying volatilities and the consequent vulnerabilities caused due to climate change, as also unbridled inflation and market uncertainties. These asymmetrical developments can be minimized primarily through the generation and development of new knowledge, technologies and innovations – all linked with the availability of smart humanware and performance of education and research institutions. The agricultural institutions are thus challenged to transform themselves to meet the new and complex ground realities.

The XI Agricultural Science Congress, February 2013, at Bhubaneswar, with its theme “Transforming Agricultural Education for Reshaping India’s Future”, a meet of world leaders in the field of Agricultural Education representing main stakeholders – policy makers, managers, educationists, researchers, scientists, teachers, students and farmers had critically analyzed the challenges and suggested the path ahead towards a prosperous and evergreen India. The enlightening Inaugural and Valedictory Sessions notwithstanding, the Congress had six Plenary Technical Sessions and Panel Discussions involving leading invited/selected speakers. This Proceedings Volume of the Congress contains recommendations for concrete actions for enhancing quality investment in agricultural education, research and extension; granting financial and functional autonomy to the universities; promoting meritocracy; and overhauling governance, curricula standards, and quality assurance mechanisms.

Another strong message that this publication contains is that we must bring ourselves back on track, restore the interrupted journey of SAUs and build a robust and responsive ARRE4D system. Towards shaping India to achieve the future we want, it must be realized that we cannot think of a world without a thriving, multifunctional and comprehensive agriculture. And this is closely linked with the transformation of the Indian Agricultural Education System. As freedom from hunger is still a far cry, the urgency for change can hardly be over-emphasized. Agricultural education, research and extension institutions are therefore increasingly challenged to transform to produce newer technologies, create comprehensive knowledge pool and strengthen trained, skilled and retooled human resources to meet the challenges and new opportunities unleashed by technological revolutions and the fast changing world.

Several of the papers bring forth that as we move forward to transform our agriculture through enhancing the symmetries and synergies in agricultural education, we must assure ourselves that: (i) today's agricultural leadership is ready to address the complex demands put on agriculture and our agricultural education system is prepared to produce such leaders, (ii) we have experts who would assess veritable asymmetries in agricultural education and prepare staff and students possessing real-world experience to iron out and manage the asymmetries, and (iii) The universities have the necessary resources, autonomy, governance and commitment couched in the desired political will to meet the challenges.

I must express my gratitude to the Congress participants for their sterling contributions. My heartfelt thanks are due to Dr. S. Ayyappan, Director General, ICAR and Secretary, DARE for his sustained support and guidance. Special thanks are due to Ms. A. Shashi Verma, Editor (English), ICAR for her painstaking and able editorial assistance. Grateful thanks are also due to Prof. Anwar Alam, Former Secretary, NAAS, Dr. Arvind Kumar, Deputy Director General, ICAR (Education) and Dr. C. Devakumar, Editor, NAAS for their invaluable suggestions.

R.B. Singh
Editor

Acronyms

AATF	African Agricultural Technology Foundation
AATF	African Agricultural Technology Fund
AAU	Anand Agricultural University
ACABC	Agriclinic and Agribusiness Centres
ADB	Asian Development Bank
AE	Agricultural Education
AET	Agricultural Education and Training
AgGDP	Agricultural Gross Domestic Product
AICTE	All-India Council of Technical Education
AIEE	All-India Entrance Examinations
AIEEA	All India Entrance Examinations for Admission
AILE	Adaptable Interactive Learning Environments
AIO	Assistent in Opleiding
AIP	Agricultural Innovation Partnership
AIS	Agricultural Innovation System
AKIS	Agricultural Knowledge and Information System
AMU	Aligarh Muslim University
ANGRAU	Acharya N. G. Ranga Agricultural University
APTA	São Paulo Agency for Agribusiness Technology
AR4D	Agricultural Research for Development
AREE4D	Agricultural Research, Education and Extension for Development
ARS	Agricultural Research Service
ARYA	Attracting and Retaining Youth in Agriculture
ASPIRE	Agricultural Sciences Pursuit for Inspired Research Excellence
ASRB	Agricultural Scientists' Recruitment Board
ASTI	Agricultural Science and Technology Indicators
ATIC	Agricultural Technology Information Centres

ATMA	Agricultural Technology Management Agency
ATP	Advanced Technologies Program
ATVET	Agricultural Technical and Vocational Education and Training
BARC	Bhabha Atomic Research Centre
BCKVV	Bidhan Chandra Krishi Viswavidyalaya
BHU	Banaras Hindu University
BLOSSOMS	Blended Learning Open Source Science or Mathematics Studies
BMGF	Bill and Melinda Gates Foundation
BOM	Board of Management
BSMA	Broad Subject Matter Area
CAAS	Chinese Academy of Agricultural Sciences
CAFT	Centre of Excellence for Advanced Faculty Training
CAPES	Coordination for the Improvement of Higher Education Personnel
CAS	Chinese Academy of Sciences
CAU	Central Agricultural University
CBSE	Central Board of Secondary Education
CCAFS	Climate Change, Agriculture and Food Security
CDD	Community Driven Development
CD-ROM	Compact Disc, Read-Only-Memory
CEE	Centre for Environment Education
CEPEA	Center for Advanced Studies on Applied Economics
CeRA	Consortium for e-Resources in Agriculture
CES	Central Experiment Station
CGIAR	Consultative Group on International Agricultural Research
CGPS	Cumulative Grade Point Score
CIAE	Central Institute of Agricultural Engineering
CIBio	Internal Biosafety Commission
CIDA	Canadian International Development Agency
CIFE	Central Institute of Fisheries Education
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
CIPHET	Central Institute of Post-Harvest Engineering and Technology

CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (Centre for International Cooperation for Agricultural Research for Development)
CNPq	Conselho Nacional de Desenvolvimento Científico e Tecnológico (National Council for Scientific and Technological Development)
CNRS	Centre National de la Recherche Scientifique (National Centre for Scientific Research)
CRADAs	Cooperative Research and Development Agreements
CRPs	Consortia Research Platforms
CSAUAT	Chandra Shekhar Azad University of Agriculture & Technology
CSIR	Council of Scientific and Industrial Research
CSREES	Cooperative State Research, Education, and Extension Service
CTNBio	Comissão Técnica Nacional de Biossegurança (National Biosafety Technical Commission)
DAC	Department of Agriculture and Cooperation
DARE	Department of Agriculture Research and Education
DASP	Diversified Agricultural Support Project
DBT	Department of Biotechnology
DCCBs	District Central Co-operative Banks
DE	Distance Education
DFID	Department for International Development
DGP	Departamento de Gestão de Pessoas (Department of Personnel Management)
DKMA	Directorate of Knowledge Management in Agriculture
DLO	Dienst Landbouwkundig Onderzoek (Agricultural Research Department)
DOE	Department of Energy
DPIC	District Project Implementation Committee
DRDAs	District Rural Development Agencies
DRWA	Directorate of Research on Women in Agriculture
DUs	Deemed Universities
EL	Experiential Learning Schemes
ELISA	Enzyme Linked Immuno Sorbent Assays
ELP	Experiential Learning Programme
EMATER	Empresa de Assistência Técnica e Extensão Rural (Enterprise Technical Assistance and Rural Extension)

EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Enterprise for Agricultural Research)
EPS	Experimental Plant Sciences
ERNET	Education and Research Network
ESALQ	Escola Superior de Agricultura Luiz de Queiroz (Luiz de Queiroz College of Agriculture)
FAO	Food and Agriculture Organisation of the United Nations
FDI	Foreign Direct Investment
FINO	Financial Inclusion Network & Operations Ltd
FMD	Foot-and-Mouth Disease
FTEs	Full-Time Equivalents
FYP	Five-Year Plans
GADVASU	Guru Angad Dev Veterinary and Animal Sciences University
GAPs	Good Agricultural Practices
GAU	Gujarat Agricultural University
GBPUAT	Govind Ballabh Pant University of Agriculture and Technology
GCARD	Global Conference on Agricultural Research for Development
GCHERA	Global Consortium of Higher Education and Research in Agriculture
GDP	Gross Domestic Product
GFAR	Global Forum of Agricultural Research
GFRAS	Global Forum for Rural Advisory Services
GIS	Geographical Information System
GMOs	Genetically Modified Organisms
GPS	Global Positioning System
GSDP	Gross State Domestic Product
HAU	Haryana Agricultural University
HIL	Hindustan Insecticides Limited
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
IAC	Campinas Agronomic Institute
IAMR	Institute of Applied Manpower research
IAR	Indian Agricultural Research
IARD	International Agriculture and Rural Development
IARI	Indian Agricultural Research Institute

IASRI	Indian Agricultural Statistical Research Institute
IAUs	Indian Agricultural Universities
IBC	Brazilian Institute do Café (Brazilian Coffee Institute)
ICAE	Indian Council of Agricultural Education
ICAR	Indian Council of Agricultural Research
ICDS	Integrated Child Development Services
ICMR	Indian Council of Medical Research
ICOR	Incremental Capital-Output Ratio
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology
IDD	Indian Diploma in Dairying
IFPRI	International Food Policy Research Institute
IGIDR	Indira Gandhi Institute of Development Research
IGKV	Indira Gandhi Krishi Vishwavidyalaya
IGNOU	Indira Gandhi National Open University
IHD	Institute for Human Development
IIASER	Indian Institute of Agricultural Science Education and Research
IIM	Indian Institute of Management
IISc	Indian Institute of Science
IIT	Indian Institute of Technology
IITA	International Institute of Tropical Agriculture
INFLIBNET	Information and Library Network
INRA	Institut National de la Recherche Agronomique (National Institute of Agricultural Research)
INREF	Interdisciplinary Research and Education Fund
INSERM	Institut National de la Santé Et de la Recherche Médicale (French Institute of Health and Medical Research)
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IPR &TM	Intellectual Property Rights and Trade Mark
IQAC	Internal Quality Assurance Cell
IRD	Institut de Recherche pour le Développement (Institute of research for development)
IRMA	Institute of Rural Management at Anand
ISAE	Indian Society of Agricultural Engineers

IT	Information Technology
IVLP	International Visitor Leadership Program
JAU	Junagadh Agricultural University
KAU	Kerala Agricultural University
KKV	Konkan Krishi Vidyapeeth
KLV	Royal University for Veterinary and Agricultural Sciences
KVA&FS	Karnataka Veterinary, Animal and Fisheries Sciences University
KVK	Krishi Vigyan Kendras
LGIs	Land-Grant Institutions
LMS	Learning Management System
M&E	Monitoring and Evaluation
MAFSU	Maharashtra Animal & Fishery Sciences University
MAPA	Ministério da Agricultura, Pecuária e Abastecimento (Ministry of Agriculture, Livestock, and Supply)
MC3	MIT Core Concept Catalog
MCI	Medical Council of India
MDA	Ministério do Desenvolvimento Agrário (Ministry of Agrarian Development)
MDG	Millennium Development Goal
MGCGV	Maharashtra Animal & Fishery Sciences University
MIT	Massachusetts Institute of Technology
MNCs	Multi-National Companies
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MOOCs	Massive Open Line Courses
MOST	Ministry of Science and Technology
MPKV	Mahatma Phule Krishi Vidyapeeth
MPUA&T	Maharana Pratap Univ. of Agriculture & Technology
NAARM	National Academy of Agricultural Research Management
NABARD	National Bank for Agriculture and Rural Development
NAC	National Advisory Council
NAEP	National Agricultural Education Project
NAIP	National Agricultural Innovation Project
NAPCC	National Action Plan on Climate Change
NARES	National Agricultural Research and Education System
NARP	National Agricultural Research Project

NARS	National Agricultural Research Systems
NASSCOM	National Association of Software and Services Companies
NATCOM	National Communication
NATP	National Agriculture Technology Project
NBPGR	National Bureau of Plant Genetics Resources
NBS	National Bureau of Statistics
NCAP	National Centre for Agricultural Economics & Policy Research
NCTE	National Council for Teachers Education
NDDB	National Dairy Development Board
NDRI	National Dairy Research Institute
NIC	National Informatics Centre
NICRA	National Initiative on Climate Resilient Agriculture
NIFA	National Institute of Food and Agriculture
NIH	National Institutes of Health
NIN	National Institute of Nutrition
NISAGENET	National Information System on Agricultural Education Network in India
NKN	National Knowledge Network
NMSA	National Mission on Sustainable Agriculture
NNMB	National Nutrition Monitoring Bureau
NORAD	Norwegian Agency for International Development
NPCC	Network Project on Climate Change
NRC	National Research Council
NSAI	National Seed Association of India
NSC	National Seed Corporation
NSF	National Science Foundation
NSS	National Sample Survey
NSSO	National Sample Survey Office
NTS	Non-Traditional Security
NWDPRA	National Watershed Development Program for Rainfed Areas
NWO	Nederlandse organisatie voor Wetenschappelijk Onderzoek (The Netherlands Organisation for Scientific Research)
OCW	Ministerie van Onderwijs, Cultuur en Wetenschappen (The Ministry of Education, Culture and Science)
ODL	Open Distance Learning

OECD	Organization for Economic Co-operation and Development
OPAC	Online Public Access Catalogue
OUAT	Orissa University of Agriculture and Technology
PACS	Primary Agricultural Co-operative Societies
PAU	Punjab Agricultural University
PCARDBs	Primary Co-operative and Rural Development Banks
PCAST	President's Council of Advisors on Science and Technology
PDKV	Panjabrao Deshmukh Krishi Vidyapeeth
PE&RC	Production Ecology and Resource Conservation
PES	Prefectural Experiment Stations
PPP	Public-Private Partnership
PVPA	Plant Varietal Protection Act
QANU	Quality Assurance Netherlands Universities
QRT	Quality Report Tool
RAU	Rajendra Agricultural University
RAWE	Rural Agricultural Work Experience
RBI	Reserve Bank of India
RCT	Randomized Controlled Trials
READY	Rural Entrepreneurship and Awareness Development Yojana
REE	Research, Education and Extension
RKVY	Rashtriya Krishi Vikas Yojana
RRBs	Regional Rural Banks
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
SAARC	South Asian Association for Regional Cooperation
SAC-PM	Scientific Advisory Council to the Prime Minister
SAEC	State Agriculture Education Council
SAES	State Agricultural Experiment Stations
SAFANSI	South Asia Food and Nutrition Security Initiative
SAUs	State Agricultural Universities
SBIR	Small Business Innovation Research
SCARDBs	State Co-operative Agricultural and Rural Development Bank
SCBs	State Co-operative Banks
SFCI	State Farms Corporation of India

SHIATS	Sam Higginbottom Institute of Agriculture, Technology and Science
SIDA	Swedish International Development Agency
SKAC	Smart Knowledge Agriculture Corridor
SOAU	Siksha 'O' Anusandhan University
SSEPER	Support to State Extension Programmes for Extension Reform
STCP	Sustainable Tree Crops Program
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TAMNET	Tropical Asian Maize Network
TANUVAS	Tamil Nadu Veterinary & Animal Sciences University
TBA	Theory-Based Approaches for evaluation
TCM	Technical Cooperation Mission
TERI	Tata Energy and Resources Institute
TFP	Total Factor Productivity
TIP	Technology Innovation Program
TKS	Tata Kisan Sansars
TNAU	Tamil Nadu Agricultural University
TQM	Total Quality Management
TSS	Technical Supplementary School
TVET	Technical and Vocational Education and Training
UBA	União Brasileira de Avicultura (Brazilian Poultry Union)
UENF	Universidade Estadual do Norte Fluminense (State University of North Fluminense)
UFAL	Universidade Federal de Alagoas (Federal University of Alagoas)
UFG	Universidade Federal de Goiás (Federal University of Goiás)
UFLA	Universidade Federal de Lavras (Federal University of Lavras)
UFMT	Universidade Federal de Mato Grosso (Federal University of Mato Grosso)
UFPI	Universidade Federal do Piauí (Federal University of Piauí)
UFPR	Universidade Federal do Paraná (Federal University of Paraná)
UFRJ	Universidade Federal do Rio de Janeiro (Federal University of Rio de Janeiro)

UFRPE	Universidade Federal Rural de Pernambuco (Federal Rural University of Pernambuco)
UFS	Universidade Federal de Sergipe (Federal University of Sergipe)
UFSCAR	Universidade Federal de São Carlos (Federal University of São Carlos)
UFSM	Universidade Federal de Santa Maria (Federal University of Santa Maria)
UFV	Universidade Federal de Viçosa (Federal University of Vicosa)
UGC	University Grants Commission
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USDA	U.S. Department of Agriculture
USDA-ERS	US Department of Agriculture, Economic Research Service
USDA-ISE	US Department of Agriculture, International Science and Education
USP	Universidade de São Paulo (University of São Paulo)
VCI	Veterinary Council of India
VHFR	Very High Frequency Radio
VNMKV	Vasantrao Naik Marathwada Krishi Vidyapeeth
VSAT	Very Small Aperture Terminals
VSR	Value and Social Responsibilities
WASS	Wageningen School of Social Sciences
WBUAFS	West Bengal University of Animal & Fishery Sciences
WGAE	Working Group on Agricultural Extension
WIAS	Wageningen Institute of Animal Sciences
WIMEK	Wageningen Institute for Environment and Climate Research
WTO	World Trade Organization
WUR	Wageningen University and Research Centre
WWAP	World Water Assessment Program

The Bhubaneswar Declaration on Transforming Agricultural Education for Reshaping India's Future

We, the academicians, innovators and development partners who participated in the XI Agricultural Science Congress on the theme **Transforming Agricultural Education for Reshaping India's Future**, organized by the National Academy of Agricultural Sciences during 79 February 2013 at the Orissa University of Agriculture and Technology, Bhubaneswar, reiterate that to have a productive, efficient, sustainable, science-led agriculture in an agriculturally important country-like India, a sound agricultural education system has to be the main driver and decisive factor for achieving harmonious, economically-independent, socially, nutritionally and environmentally secure nation.

We all acknowledge the impressive contributions made by the institutions under the Indian Council of Agricultural Research (ICAR) and by the State Agricultural Universities (SAUs) in ushering in the Green, White, Blue and Yellow Revolutions, which transformed India from a ship-to-mouth food dependence to the contemporary Food Bill. India recorded an all-time high production of foodgrains in 2011-12, and has emerged as the world's leading milk producer, despite increase in vulnerability to intensifying volatilities of the climate change. The country has also succeeded in achieving an annual agricultural growth rate of about 3.5% during the past five years, which is higher than that observed since the past decades.

We have achieved impressive economical and agricultural growth, but still incidences of hunger, malnutrition and poverty are unacceptably high. Even inequality in income has increased, and country is far off the target of achieving the *Millennium Development Goal* 1 of eradicating extreme poverty and hunger. By 2050, India will become the most populous country in the world, and the already stressed land, water and biodiversity resources will be under greater pressure. We are also aware that global environment is radically changing, and this calls for a competitive, climate-resilient, multifunctional agriculture.

We all as well recognize fully that agricultural education, the foundation of the agricultural development, is internally facing challenging issues of poor governance, inadequate investment, disconnect among research, extension and education, lack of reforms and slow or no implementation of the adopted reforms, absence of meritocracy, and increased quality-deficit. And despite fast feminization of agriculture, the woman remains invisible in the approach to agricultural development.

We acknowledge that the ICAR has initiated many programmes to address these issues, but there is lack of co-ordination among them, and their implementation, efficacy and impact are yet to be felt.

As emphasized by the Hon'ble Prime Minister at the Centenary Science Congress on 3 January 2013, we firmly believe that agricultural transformation must be the top-most national priority for addressing veritable challenges of comprehensive livelihood security and for envisioning transformative changes in the agricultural education, research and extension to attract the best of the science and of the global and local knowledge in a partnership mode for managing sustainably local, regional and national needs.

We are determined to create new paradigms through the envisaged agenda for change for accelerated, inclusive, gender-sensitive and sustainable agriculture-led growth and development as that will shape India's future in the fast-changing world, unleashing uncommon challenges and opportunities, and we call upon the policy-makers, education leaders, Agricultural Research, Education and Extension for Development (AREE4D) managers and development partners to:

I. Embrace agricultural education and AREE4D as an integral component of the national agricultural policy to ensure adequate, consistent and predictable investments in agriculture, especially education, research and extension in creating a world-class agricultural university system attuned to face challenges and opportunities over short, medium and long term,

II. Ensure and institutionalize transparent governance, autonomy, meritocracy, dynamic assessment of human resource requirement, judicious allocation of resources, effective implementation, monitoring, evaluation, accountability and responsibility based system, and to minimize splitting and inbreeding,

III. Pay focused attention to the standards, norms, and accreditation in quality agricultural education, create centres of excellence and institutes for agricultural education, science, knowledge, research, technology and innovation in an interdisciplinary and multifaculty mode,

IV. Identify national- and state- level public and private sector leaders with differentiated but reiterative responsibilities to work on the design and implementation of reforms and to develop a strong inter-ministerial and inter-departmental cooperation mechanism,

V. Revamp teaching/learning processes and methodologies to attract best of talents and blooming young minds for nurturing them leading to a nation-wide programme on "Youth for Leadership in Farming", and

VI. Support India's proposed development of an active and continuous long-term relationship-based international cooperation, rejuvenate and dynamically strengthen initial very successful collaboration between Indian SAUs and US Land Grant Universities, and launch need-based South-South and South-North collaborations such as the Brazilian LABEX programme of scientific exchange.

Inaugural Session

Inaugural Session

XI Agricultural Science Congress on Transforming Agricultural Education for Reshaping India's Future

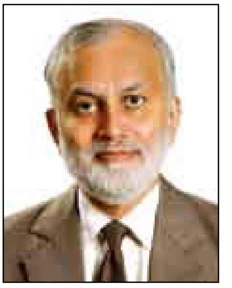
XI Agricultural Science Congress (XI ASC) under the aegis of National Academy of Agricultural Sciences, in collaboration with Indian Council of Agricultural Research (ICAR), was organized at Orissa University of Agriculture and Technology, Bhubaneswar from 7-9 February 2013. The theme of the Congress was **Transforming Agricultural Education for Reshaping India's Future**. Over 750 Eminent Scientists, policy planners, academicians, young researchers and students from all across the country including a good number of foreign delegates from Brazil, China, France, Japan, Netherlands and USA participated in the Congress and shared their expertise and country experiences.

H.E. Sj. M.C. Bhandare, Governor of Odisha, lighting the lamp at the Inaugural Session

The Congress was inaugurated on 7th February 2013 by His Excellency Sj M.C. Bhandare, Governor of Odisha and Sj Debi Prasad Mishra, Hon'ble Minister Agriculture, Fisheries and Animal Resources Development, Government of Odisha was the Guest of Honour at the Inaugural Function. Dr. Simeon Ehui, Sector Manager, The World Bank, Dr. S. Ayyappan, Secretary, DARE and DG, ICAR and Dr. Mangala Rai, Past President, NAAS and Ex-Secretary, DARE and DG, ICAR were the Guests of Honour. Dr. D.P. Ray Convener of the Congress and former Vice Chancellor, OUAT, Dr. K. Pradhan, Co-Convener of the Congress and Chancellor of the Siksha 'O' Anusandhan University (SOAU), Bhubaneswar and Prof. S. S. Nanda, Dean, Extension Education and Acting Vice Chancellor, OUAT were also present. Prof. R.B. Singh, President, NAAS presided over the session.

His Excellency the Governor gave away NAAS awards to eminent agricultural scientists and educationists, and also released the Proceedings of the X Agricultural Science Congress.

H.E. Sj. M.C. Bhandare, Governor of Odisha honouring Dr. G.S. Khush by the B.P. Pal Memorial Award



Address by Guest of Honour

S. Ayyappan

On behalf of the ICAR and the National Agricultural Research System, I am honoured to welcome the distinguished delegates from India and abroad to this extremely important Congress. It provides an excellent opportunity to share and benefit from diverse experiences towards building vibrant agricultural education systems.

India's foodgrain production has steadily been growing especially in the recent years, attaining all time high productions year after year during the last three years, the current production being over 260 million tonnes. This trend must be maintained as our agriculture and agrarian economy employ 50 percent of the labour force and agriculture is the main pillar of the national food security. However, despite record production, India continues to have a high burden of poverty, food insecurity particularly at household and individual levels, and undernutrition. Therefore, our foremost priority should be to attain comprehensive food security and to have a healthy and happy India.

While reshaping future of India's agriculture the challenges posed by the changing economic and industrial scenarios of the country must be kept in mind. In this context, it may be reiterated that innovation and entrepreneurship in agriculture have the potential to make agriculture more profitable and attractive as the career option for the youth. For this purpose, we will need to improve the quality of higher agricultural education through an effective accreditation process and to render it more objective. In the 12th Five Year Plan, the accreditation process would be based on quantifiable parameters. Revision and modification in SAU's curricula is necessary to improve quality and acceptability of the pass-outs in the job market and as agripreneurs. In this move, we must focus on three Cs – Competence, Convergence and Communication. Our AREE4D system should prepare its R&D programmes and university curricula keeping in mind the need for synergies among the three Cs.

As we know, science and technology, suitably trained human resources and efficient technology transfer and adoption systems are a must for achieving the desired level of sustainable production. We need technological interventions for fighting escalating costs of food and other essential agricultural commodities, biotic and abiotic stresses, climate change volatilities and risks, and degeneration of natural resources. Our research, education and extension system should judiciously harness the power of technology, particularly the new and emerging technologies such as Biotechnology, including GMOs, Nanotechnology, and ICT.

Address by Guest of Honour

Simeon Ehui

Despite the Green Revolution and impressive agricultural production gains, and India having attained the overall national food security, household and individual level food insecurity is still a serious problem. Moreover, the incidences of nutritional insecurity, especially child malnutrition, are one of the highest in the world, which was referred to as a national shame by the Hon'ble Prime Minister of India a couple of years ago. Therefore, nutritional security should be the foremost priority of the country. The situation is exacerbated due to the adverse impacts of climate change and the associated vulnerability. On the other hand, there is a sort of slowdown in the generation and adoption of new technologies. Further, the slowing yield growths have widened the nutrition gaps. The high incidence of anemia in farm women is also adversely affecting the labour productivity.

The need for nutritional revolution in India can thus hardly be overemphasized. There should be strong convergence among agriculture (food), nutrition and health. Judicious technological solutions are needed for bridging the gaps. And, the science-led technological solutions can come only from suitably trained human resources to undertake the needed research and extension activities. Thus agricultural education must be geared to undertake the needed R-E-E activities and train the next generation scientists, teachers professionals and extensionists. Necessary action plans should be prepared at the national, state and university levels.

There was a need for a committed visionary leadership in agricultural education as this could help eliminate stubborn malnutrition as well as in employing huge labour force. The youth must be trained particularly in land-based activities and be exposed to various partnerships and institutional linkages. The World Bank is pleased to participate in this most topical and timely Congress organized by the National Academy of Agricultural Sciences and would be willing to work with India in transforming its agricultural education towards reshaping India's future.

Address by Guest of Honour

Mangala Rai

Indian agriculture is currently facing several challenges. Generally, there is a tendency to worry about the past and the future, and we often ignore the present. Today we are faced with the challenges of nutritional insecurity, huge post-harvest losses and wastes, poor value chain management and value addition, loss of soil fertility and poor nutrient management, and low water use efficiency. A strong integrated REE system, including extension research and education research, is needed to meet the challenges. We must ask ourselves as to what kind of technologies do we need. We have not adequately harnessed the microbial power, especially for waste management and bioremediation for environmental and economic gains (look at the rising dung price which is accelerating at a faster rate than the grain price).

The educational and human resources domain should have a system perspective to reshape institutions and to promote innovations. The system should be designed and pursued to inter actively promote effectiveness, efficiency and equity. But, the system today is suffering due to the lack of freedom, flexibility and accountability. We must strive to remove these shortcomings. The teachers should be role models as practitioners not just preachers.

We must recognise that agriculture is the biggest private sector. But, the private sector investment in agriculture has remained poor, while the public sector investment in agriculture continues to be low. The need for increasing the investments in human resources development, in research and technology development, and in intersectoral linkages can hardly be overemphasized. In this context, I am pleased to mention that Bihar is the only state in the country which provides Rs. 2,000/- p.m. scholarship to every post-graduate agriculture student in the state. Further, the state has launched Intermediate in Agriculture course. Other states may follow the Bihar model.

Keeping in mind the huge gap between the potential and the achievements, we must use our resources judiciously for attaining food, nutrition, environment and livelihood security, through synchronizing investment, innovation and institutional development in an inter-disciplinary and inter-sectoral mode. Finally, let us remember that human resource is the most important resource for human development.

Address by Guest of Honour

Hon'ble Minister Sj. Debi Prasad Mishra

I am delighted to welcome and address the galaxy of agricultural scientist educationists at this very important Congress.

Global food crisis, hunger and inflation of food prices are the major challenges in the 21st Century. The problem will be accentuated with the increasing population and the deteriorating production resources. As we sit down for dinner this evening, in India alone about 40,000 additional mouths will have to be fed. In an agriculturally important country like India, agriculture is the main driver of agrarian prosperity, profitability, food and nutritional security and overall livelihood security. This calls for sustained enhancement in its productivity which has been only average to low. Further, there is need for collaboration among concerned Ministries, particularly between Ministry of Agriculture and Ministry of Health, towards ensuring sound mind in sound body.

The impressive presence of over 60 agricultural universities, nearly 100 ICAR institutes and more than 650 Krishi Vigyan Kendras throughout the country should ensure quality research, technologies and human resources for a vibrant agricultural sector. But, the pace of adaptation and progress has been slow. We ought to develop a formidable knowledge pool and its sharing among all stakeholders, up to the farmers. Appropriate policies and actions should be formulated and implemented for the purpose.

Special attention should be paid to extension education. Location-specific technology packages, skills for managing agro-ecologically differentiated problems and solutions will be needed. Further, traditional knowledge and wisdom should be used complementarily to address local challenges. There is a need for attitude and mindset change to work in partnership mode and not in isolation and in silos.

Universities' curricula and syllabi should be dynamically revised and critical skills and innovations should be promoted. Sensitization is needed right from the school to the post-graduate level. Moreover, the universities should perform as incubators for new technologies and innovations. These efforts should culminate in developing appropriate Human Development Indicators which should help in creating reliable Human Development Indices for the country.

As I am proud of you leading scientists participating in this Congress, I am sure you will provide new leads for transforming our agricultural education to reshape India's future.

Thank you,
Jai Hind

Presidential Address

Transforming Agricultural Education for Reshaping India's Future

R.B. Singh

As President of the National Academy of Agricultural Sciences (NAAS), it is my privilege and great honour to welcome our Chief Guest, His Excellency the Governor of Odisha, who is a great educationist and an embodiment of humanity, benevolence, progress and peace. I also welcome Hon'ble Minister of Agriculture, Fisheries and Animal Resource Development, Govt. of Odisha, who has so ably been leading his Ministry for the improved livelihood security of the people of Odisha.

We are beholden to our Guests of Honour Prof. S. Ayyappan, Secretary, Department of Agricultural Research Education (DARE) and Director-General, Indian Council of Agricultural Research (ICAR), Dr. Mangala Rai, Past President, NAAS and former Secretary DARE and DG, ICAR, and Dr. Simeon Ehui, Sector Manager, World Bank – the thought leaders in agricultural transformation.

A very warm welcome is due to the galaxy of distinguished agricultural educationists, Vice Chancellors, scientists, researchers, innovators, policy makers and thinkers from India and abroad who have gathered here in Bhubaneswar to participate in the Congress, and deliberate together to write a new chapter in India's march to develop and institutionalise a dynamic, effective and efficient agricultural education and agricultural research-education-extension integrated system for accelerated, inclusive and sustainable agricultural transformation as it shapes India's future.

This XI Agricultural Science Congress, with its theme **Transforming**

Agricultural Education for Reshaping India's Future, is different from all the past Congresses.

Firstly, it has turned out to be a truly international Congress. Besides the eminent presence of leading Indian agricultural educationists and researchers, we are blessed with the distinguished participation of world leaders in this field from Brazil, China, France, Japan, the Netherlands and United States of America (USA), and from international organizations such as World Bank, Food and Agriculture Organisation (FAO) of the United Nations, Global Forum of Agricultural Research (GFAR), International Food Policy Research Institute (IFPRI) and Bioversity of the CGIAR, Global Confederation of Higher Education Associations for the Agricultural and Life Sciences (GCHERA), and from one of the greatest friends of humanity – Bill and Melinda Gates Foundation (BMGF).

Permit me to recognise the deep commitment, support and guidance of Dr. Uma Lele, Independent Scholar, Ex-World Bank and a global agricultural research, education and extension leader, and Dr. Madhur Gautam, Lead Economist, World Bank, the young brilliant protagonist of high value support to agricultural education, research and innovation in the service of humankind.

Secondly, for the first time in the 23 years of the most gratifying journey of the Academy, this Congress is comprehensively addressing the most vital issue of strengthening and transforming agricultural education and human resources development as well as the agricultural research-education-extension synergies for development (AREE4D) in a dynamic and mutually reinforcing mode. It is hoped that the Congress will come up with concrete recommendations and possible solutions towards transforming our AREE4D system.

Thirdly, the Congress has been designed to share outstanding global experiences, lessons and challenges to help India prepare the necessary roadmap for achieving the desired agricultural transformation especially the desired human capital, for putting Indian agriculture at a higher pedestal and trajectory to achieve accelerated, inclusive and sustainable development. More than half of the world, not only in terms of population, but also in terms of diversity, excellence and success is represented here which provides unique opportunity for synergistic alliances.

Fourthly, and finally, the experiences shared should enable us to identify major issues which could help India articulate a new partnership for our mutual development as well as to provide a platform to integrate our efforts to evolve innovative national and global development agenda. The effort will not only help ourselves but would also provide support to selected needy countries.

We are meeting here in Bhubaneswar, the Golden Triangle of temples and the heritage city of art, culture, architecture, mathematics and sculpture. Odisha is famous not only for its archaeological monuments but is also the primary centre of biodiversity of rice – the foremost food crop of the world and is known for its innovative, hard-working and resilient farmers.

Our kind host, the Orissa University of Agriculture and Technology (OUAT), established in 1962, is one of the first phase pioneering Land Grant Universities of India. We are extremely grateful to the Vice-Chancellor and Dr. D.P. Ray, Convenor of the Congress and former Vice-Chancellor of this University for their formidable support and guidance. Greater Bhubaneswar is host also to some of the pioneering ICAR institutes, especially the world famous Central Rice Research Institute, Cuttack, Central Institute of Freshwater Aquaculture, Directorate of Water Management and Directorate of Research on Women in Agriculture, and some other leading educational and research institutes.

State of Indian Agriculture : Where are We Today

Science- and technology-led Green, White and Blue Revolutions have greatly transformed Indian agricultural production and agrarian economy. Between 1951 and 2011, foodgrain production increased 5-fold, from 51 to 257 million tonnes; milk production swelled 8 fold, from 17 to 127 million tonnes (rendering India the top milk producer in the world), and fish production jumped 11fold from 0.75 to 8.40 million tonnes, primarily due to accelerated growth in aquaculture production.

These unprecedented production gains, coupled with efficacious policies and actions, had resulted in more than halving the percentages of hungry, under-nourished and ultra-poor. An orchestra of the technological breakthroughs, political will, services, suitable input support, appropriate pricing policies and, above all, farmers' enthusiasm had resulted in the Revolutions and transformed India from a ship-to-mouth situation in the 1960s to the Food Bill i.e. Right to Food (based on home-grown food).

The Green Revolution has, however, almost waned. During the last decade or so, while the overall national gross domestic product (GDP) had registered a high growth rate of about 8%, the agricultural growth had gone sluggish, hovering around only 1.5 to 2% (although recovered lately) and the total factor productivity growth remained stagnant or even declined. Consequently, the income gap between farmers and non-farmers had further widened to 1:4. Despite several social protection floors, inequalities as well as inequities have multiplied and are proving serious deterrents to inclusive growth and the high overall growth rate is somewhat ineffective in lowering the poverty incidence.

Unethical as it is, the country is still home to almost one-fourth of the world's hungry and poor. Over 40 percent of world's hungry children are our own children. It is estimated that the entrenched high undernutrition in the country annually costs about 3 percent of the national GDP.

In terms of poverty reduction, in India, the share of people living on less than $1.25 a day dropped from 59.8 per cent in 1981 to 51.3 per cent in 1990 and to 37.4 per cent in 2008. During the same period in China, poverty percentage which was as high as 84% in 1981 fell sharply to 13% in 2008. As regards percentage undernutrition, in India it had climbed down from about 26% in 1990-92 to 18% in 2010-2012. In China during the same period, the prevalence of undernutrition fell down from 21% to 12%. As regards Global Hunger Index (GHI), in India it stubbornly stands at around 24% - a critical level, against about 5% both in Brazil and China, an acceptable level. India is thus off-track in achieving the Millennium Development Goal (MDG)-1 – halving percentages of hunger and poverty.

As regards R&D investments, IFPRI studies have shown that in 2008 China spent $1457 million against $707 million by India. The expected investment in 2025 in China was $ 6102 million and in India $ 2367 million. At the productivity growth rate of 1% during 2008-2025 in India compared to 1.38% in China, the increased investment in India is projected to shed off 100 million from the list of 569 million poor in 2008. The analogous reduction in China is expected to be 42 million from 208 million in 2008. The rate of return on investment in R&D, as compared to that in other sectors, was the highest both in India (13.8) and China (6.8). The R&D investments have thus substantially reduced rural poverty, which when complemented with investments in rural infrastructures especially road, education and health have high payoffs. Policy implications of these findings are to prioritise spending in agricultural R&D coupled with those in rural infrastructure and education.

The Indian enigma of the coexistence of high economic growth and the entrenched high prevalence of hunger and poverty and veritable asymmetries can be attributed substantially to the neglect of agriculture in an agriculturally important country. Promoting manufacturing and services sectors at the cost of agriculture sector has not paid the dividends to the majority rural people. In this context, Nobel Laureate Amartya Sen had recently observed "I do not think there's enough clarity on economics here. I do not judge the performance of the Indian economy by growth alone….. And the fact is that human capability expansion is also very critical for economic growth".

The Future We Want

The theme of this Congress, **Transforming Agricultural Education for Reshaping India's Future**, reflects the dream and determination of every generation of Indians, particularly Indian agricultural educationists and scientists to have a prosperous, ever-progressing and happy India. An India free from hunger, acute poverty, deprivation and undernutrition. It wishes to have a comprehensive and congruent economic, social and environmental security.

The Rio+20 UN Conference on Sustainable Development, June 2012 declared a broad framework of "The Future We Want". The declaration envisions:

i. Building a Green Economy to achieve sustainable development and to lift people out of poverty,
ii. Providing support for developing countries to enable them to find a green path for development, and
iii. Improving international coordination for sustainable development by building an institutional framework.

The heads of State of the 192 governments, in attendance at the summit, reiterated commitment to sustainable development and to ensuring the promotion of an economically, socially and environmentally sustainable future for our planet and for present and future generations. It agreed to explore alternatives to GDP as a measure of wealth that take environmental and social factors into account in an effort to access and pay for 'environmental services' provided by nature, such as carbon sequestration and habitat protection and called on countries to develop and implement science based management plans. While India fully adopts this Declaration, it must ensure that there will be little trade-off between the Green Economy approach and the food, energy and livelihood security approach, instead their synergies should be optimised.

The future we want is an agriculture that is parallel, along with the services and industrial sectors, in contributing to India's economic development and growth. There are a few states in India that have shown growth rates in agricultural GDP of over 10 per cent for a decade or more showing the potential that agriculture has in economic development. And with agricultural development, rural areas prosper more and this leads to significant reduction in extreme poverty and greater equity in prosperity unlike that from development of industry and the service sector.

Why the urgency to transform?

Towards shaping India to achieve the future we want, it must be realized that we cannot think of a world without a thriving, multifunctional and comprehensive agriculture. ***If agriculture fails, nothing else will succeed***. Then why the neglect. I am sure, all, including farmers, students of agriculture, scientists, researchers, the academia, policy makers and politicians agree with this fact and shall not only save but also enrich agriculture to render this world still more beautiful. The hungry child cannot wait. His brain and bones are being formed today. We cannot name him Tomorrow. His/her name is Today.

The Planet Earth is already under stress. Of the nine interconnected planetary boundaries with defined tipping points in the Earth system, three of them, namely, climate change, biodiversity loss and nitrogen cycle have been crossed. Climate change is already the most destabilising factor. The challenge is to produce more and more from less and less and under more difficult and complex environmental, carbon and GHG imbalances and worsening socio-economic inequities and inequalities. As agriculture impacts climate change and gets impacted by it, the enterprise is increasingly obliged to mitigate its own GHG emissions.

The world is changing fast. The high population and income growths are continuously pushing up the demand for food particularly high value quality foods. As we sit down for dinner tonight we would have additional 40,000 guests at the Indian dinner table, out of the 200,000 fresh arrivals in the world as a whole. The demand for energy is likewise multiplying and renewable sources of energy will be increasingly utilised and put under increasing pressure. On the other hand, the total factor productivity is declining and natural and other production resources are further shrinking.

Excellency and Fellow Scientists!

The urgency for change thus can hardly be over-emphasized. Agricultural education, research and extension institutions are therefore increasingly challenged to transform to produce newer technologies, create comprehensive knowledge pool and strengthen trained, skilled and retooled human resources to meet the challenges and new opportunities unleashed by technological revolutions and the fast changing world.

India is falling behind in the international competitiveness. None of India's Universities, IITs and IIMs figure in the top 200 universities in the world. In the global research contributions, India's share is only 4% against 18% of China. These two revelations are not unrelated. High ranking universities are generally research intensive and comprehensive – including humanities, social sciences, natural sciences, engineering, medicine and management. India has generally failed to develop comprehensive teaching-research or research-teaching universities. We are already facing the challenges of making our economic development more rapid, competitive, sustainable, resilient, inclusive and gender sensitive and more knowledge based. And it is for this that India needs a New Agriculture backed by good science and Best of Practices.

We must ask ourselves the following questions as we move forward to transform our agriculture towards reshaping India:

- ❖ Is today's agricultural leadership ready to address the complex demands put on agriculture?
- ❖ Is our agricultural education system prepared to produce such leaders?
- ❖ Do we have navigators who would navigate us through the changing water?
- ❖ Do the staff and students have real-world experience as part of learning?
- ❖ How relevant are the existing teaching programmes and institutions?
- ❖ Do we have the necessary resources, commitment and political will to meet the challenges?

The State of Agricultural Education and Its Integration with Research and Extension

SAUs were truly research and innovation universities to begin with, as being currently advocated, and were a critical element of the Indian REE system with a mandate to perform not only the role of providing higher education, but also important roles in research, particularly adaptive research, and extension and the Green Revolution process. But for these universities there would have not been any Green Revolution or "Human Capacity Revolution".

India inherited a few agricultural and veterinary colleges scattered across the country in 1947. Great statesman such as (Bharat Ratna President) Sarvepalli Radhakrishnan headed the Indian University Education Commission and his report, submitted in 1949, had envisioned rural universities that would usher the generation and use of new knowledge, skills and technology needed to develop India, a largely rural country then. With support from the United States of America, and based on the blueprint of an agricultural university prepared by Dean H.W. Hannah of the University of Illinois, India in the 1960s developed several State Agricultural Universities modeled on the U.S. Land Grants Universities and focused only on agriculture. The first in the series was the agricultural university Pantnagar established in 1960, today famous as the Govind Ballabh Pant University of Agriculture and Technology (GBPUAT).

Presently, there are 56 State Agricultural Universities, five Deemed Universities (four of them are constituent institutes of ICAR), four Central Universities with strong Agriculture Faculty and, one Central Agricultural University for the States of North-eastern region. Agricultural universities set up in India initially were multi faculty mono-campus universities. With time, most of them have become multi-campus. Eighteen universities have become single discipline universities (Animal and Veterinary Sciences 12, Fishery Science 2 and Horticulture and Forestry. About 40,000 students are currently admitted annually with an outturn of 24,000 graduates, postgraduates and doctorates in agriculture and allied sciences.

All countries participating in the Congress have a long and notable history of success in agricultural technology as a major driver of growth in productivity with contributions from all three aspects of REE. The Land Grant Universities in USA, have transformed from the agricultural land-based research and resources to research parks growing primarily technology, innovation and business towers of innumerable companies and not only corn and cows. Think of the students, teachers and researchers sharing these parks comprising industry leaders and being mutually exposed to the real-world situations. Our SAUs, several celebrating their 50^{th} anniversary, Golden Jubilee, on the other hand have lost even on the cows and corn fronts. Instead of consolidation, there is lot of splitting.

In the Netherlands, Wageningen University, underwent a significant reorientation in the 1990s to renew its focus on "healthy food and living environment" in a rapidly changing environmental, financial and physical landscape and has now established a Third Generation University. Brazil and China have undertaken periodic reforms in the different elements of their AREE4D system to reinvent them and reorient them to become more relevant and effective in meeting the growing and changing challenges facing the countries.

As mentioned earlier, University of Illinois, USA had helped establish the first LGU in India, namely, Govind Ballabh Pant University of Agriculture and Technology (GBPUAT) in 1960. Notwithstanding the externalities, a brief description in terms of planning, execution, and outcomes of the two universities will give a comparative picture of their ability to internalize the interconnected community-state-national progress in their development agendas, thrust on quality of students and faculty, partnership between university and industry, magnitude and quality of investment and emphasis on hands-on training of students and faculty, and the impact these interventions have made in achievements of the two institutions.

University of Illinois, a Land Grant University, established in 1867 with its charter "Learning and Labor", campuses at Urbana, Chicago and Springfield has remained as incubator of progress for the past 150 years. "Innovation born on our campuses is ingrained in our daily lives. Our graduates more than 19,000 every year emerge as leader who guide our nations unending push for even better tomorrow. As we build for the future, our world-class academic and research programs also support prosperity today, pumping $13 billion into the Illinois economy every year and creating more than 150,000 jobs" (Robert A. Easter, President UI, 2012). The University measures its progress by quantifying millions pumped in the state economy and in number of jobs created. It has rich legacy of excellence in teaching, research and service in the field of agriculture, medicine and humanities, houses Nobel Laureates and its faculties have high citation indices. Its annual budget is US$ 5.1 billion for the 3 campuses.

High ranking of the university and prestigious national/state level fellowships offered by the university help attract bright students, especially in basic sciences. Its new paradigm of offering online degree and certificate programmes is a huge success, even internationally. Embracing public-private partnership, research is the main forte of the University, a leading research university becoming also a leading teaching university and developer of leading human resources. Its public-private partnership (PPP) initiative gives industry needed new products and technologies to grow. In turn, the Industry funds University to retain top faculties and support their researches and attract best students. It has established strong centres of multidisciplinary researches for sustainable development.

Promoting foresight research and education, the university has established a centre for partnership for food, nutrition, health and livelihood security. The centre is exploring impact of nutrition on brain development, learning and cognitive abilities and nutrition and neuroscience interaction supported by genomic biology. The Energy Bioscience Institute funded by industry giants is researching to produce carbon neutral fuels moving beyond corn-based ethanol to develop biofuels that protect both the environment and the world's food supply, as well as on-farm income. Still more, an Innovation Centre to serve industry, education and research, functioning for the past ten years, is proving a breeding ground for progress and young minds and unites corporate leaders with students and faculty. Together they cultivate new products and services that provide real-world solutions for businesses of today and real-world experience for students who will become the industry leaders tomorrow.

GBPUAT, established in 1960, was the first SAU based on the Land Grant University pattern, emphasizing integration of research-education-extension. Within a few years of its establishment, it emerged as the leading and a model Land Grant University in India. The land granted to it not only provided it excellent experimental farms but also huge seed farms which evolved into the famous Tarai Development Corporation – a major seed centre in the country. The University attracted bright students and faculty from throughout the country. Several of its students and faculty members occupied top national and international research, education and development positions and the HYVs developed by the University occupied millions of ha and contributed immensely to the national food security.

Yet, several of the original Plans remain unimplemented. The half-circle at GBPUAT is still empty. Worst, the original half circle which houses the foundation pillars of the University and was once the most vibrant and "green" part of the campus, is today not as bright and green as expected. Instead, the basic and social sciences and humanities components have shrunk and overall there is some erosion of the academic capital. This trend should not only be stopped and reversed, but the ever-empty half circle should be judiciously filled with medical sciences, engineering, human sciences and other new and emerging sciences and with incubators.

Today the SAUs are not the same. The widespread perception is that "the journey of higher agricultural education got interrupted". With the passage of time and fading away of the original collaboration, enthusiasm, necessary support and priority, the SAUs generally slipped back to the business as usual. Among other things, the intensity for comprehensiveness declined, the characteristic research-education-extension synergy loosened and academic inbreeding depression had set-in. Consequently, educational standard, faculty quality and research and extension outcomes have declined. Several of the grand designs and plans were abandoned and forgotten. It is hard to imagine that one of the frontline agricultural universities like GBPUAT will be without a regular Vice-Chancellor for the last almost one year.

The main reasons for decline of SAUs are : thoughtless splitting of Universities, declining investment and funding crunch, inbreeding, poor governance, non-implementation of quality and accreditation norms, lack of autonomy, lack of man power in the frontier areas of science and technology, inadequate hands-on skill/experience for the multiple disciplines within the profession, depleted faculty strength, inadequate and poor quality of private sector participation, lack of modern teaching and other facilities and infrastructures, declining quality of students and faculty, weak teaching-learning process, outdated curricula and poor coordination between central and state governments and lack of central regulatory authority.

A fundamental shortcoming of the Universities is that their grants requests are mostly for constructing buildings (bricks and mortar) and permanent structures and very little for "softer" components i.e. research, teaching and training, equipment, talent development and academic activities. About 90% of the recurring grants are exhausted in meeting salaries and hardly 10% for operational purposes. Teachers, scientists and technicians salaries have improved considerably but that is not reflected in the increased responsibility, outcome and accountability. Generally, there is initiative, commitment and attitude deficit, and "comfort with mediocrity" has become the trend.

In addition, the agricultural education system in the country will face a serious gap between the demand (2020) and the current supply of trained human resources and would have to more than double the number of graduates produced to meet the projected demand. Against 24,000 graduates produced in 2010, the projected requirement is 54,000 in 2020.

The ICAR has been making efforts during the past several years and has taken actions to address many of the above shortcomings. These include: curriculum revision: transition towards students Rural Entrepreneurship and Awareness Development Yojana (READY), attracting talents to agricultural education, faculty competence improvement, addressing-encompassing Experiential Learning Programme (ELP). Rural Agricultural Work Experience (RAWE) and in-plant/industrial attachment, faculty shortage, reducing inbreeding and promoting national integration, linkages among institutions and partnership, promoting education in basic and emerging sciences, regulation of agricultural education, centres of excellence, international agriculture, modernization of AU farms, manpower planning, enhanced financial support, strengthening education for agricultural extension and rural development, public-private partnership for innovations in agricultural education and research, vocational education, IT for networking, e-courses and distance education, and national agricultural education project.

The Council has stepped up efforts to attract talented students and young faculty, such as the Agricultural Science Pursuit for Inspired Research Excellence (ASPIRE) programme. Alongwith READY, Attracting and Retaining Youth in Agriculture (ARYA) programme, is most timely, and could mutually reinforce the Farmer First campaign of ICAR. These various initiatives should be congrued and regularly monitored for their implementation and impact assessment.

Excellency and Hon'ble Minister!

Agriculture and agricultural education research and extension are State subjects and the action lies with States. There are wide variations in State performances in terms of academic standards, investments in AREE, research and technology outcomes, overall performance of agriculture and agrarian livelihood. Generally, the SAUs are competing for fragmentation – a destructive mode while their faculty and financial resources have been shrinking. The situation is further aggravated by the mushrooming of private colleges exclusively as business propositions with little concern for quality.

Comparing the status of agricultural development in some of the fast growing developing economies and the current India's agrarian economy and the role and performance of LGUs, the prevailing unsatisfactory performance of agricultural education system in India may be ascribed to the followings:

I. Huge implementation gap and the lack of judicious monitoring, evaluation and accountability system,

II. Inadequate and inconsistent funding of and investment in agriculture, especially education, research and extension,

III. The increasing inequities and inequalities and their huge negative effect on overall growth; we have ignored these gaps for too long and have thus been ditching progress,

IV. Increasing indifference to the decline in the standard and quality of agricultural education, resulting in erosion of human capital and sub-optimal outcomes from research, technology and innovation, and

V. The lack of political will and of commitment at various levels - national, provincial, institutional and individual (teacher / scientist / student).

The Way Forward: Policies, Strategies and Actions

In Collaboration with Dr. Uma Lele and Dr. Madhur Gautam, I had prepared a brief background note comprising primarily of nearly 150 questions in the various areas of the Theme of the Congress, which was circulated to all presenters at this Congress. The themes relate to: Achieving Excellence in Agricultural Education: Experience from Across the World; Agricultural Research, Education and Extension Integration for Development (AREE4D): Status, Elements of Successes, Issues, Challenges and Prospects; Governance and Quality Assurance in Agricultural Education; View Points of SAU Teachers; View Points of Students; Investment and Institutions; AREE for Nutritional Security; Knowledge Sharing, Linkages and Partnership; View Points of Industry; Human Resources and Skill Development, Employability and Retention of Youth in Agriculture; Monitoring, Evaluation and Accountability; and Towards Indian Institutes of Agricultural Science, Education, Research, Technology and Innovations.

Excellent feedbacks have been received and the gaps could be filled during the presentations and deliberations. Based on the feedbacks, I am hoping that we should be able to come up with a Roadmap, howsoever rough, which when finalised will become the **Bhubaneswar Declaration** from the City of Gods and Culture. We need your deep indulgence in this process. For your ready reference, the document containing the questions is being made available to everyone at this Congress and beyond.

In the meantime, I have laid out a few macro approaches, but these need to be discussed at this Congress and detailed discussion should follow at provincial, institutional and individual levels to ensure effective implementation along the value chain, from the Parliament through the universities and scientists' laboratories, the industries, the farmers and ultimately the peoples.

Agriculture as Highest National Priority to be Served by Science and National Resolve

This XI Agricultural Science Congress is being held just one month after the Centenary Session of the Indian Science Congress. Theme of our Congress is **Transforming Agricultural Education for Reshaping India's Future** and of the Science Congress was "Science for Shaping the Future of India". Notwithstanding the analogy of the two themes, it stands out that education and science must co-evolve dynamically to shape India's future. It is still more important to note that the Hon'ble Prime Minister in his Presidential Address, recognising the centrality of agriculture in achieving comprehensive and sustained livelihood security, had singled out transformation of agriculture as the top priority of the country's public policies including those on science and technology.

There could have not been a greater convergence between the national theme, priority and agenda outlined by none other than the Hon'ble Prime Minister and the theme and thrust of this Congress of the Academy. As this congruence must please us, we stand charged with our responsibility to the nation as well as to the humanity at large to come up with an implementable roadmap and action plan for transforming and strengthening India's agricultural education, especially higher agricultural education, and an integrated agricultural research-education-extension system for accelerated and inclusive national development consistent with the following approaches outlined in the National Science, Technology and Innovation Policy 2013:

- A sustained growth in agriculture at the rate of four per cent per annum is essential to achieve food security and also to sustain an overall GDP growth rate of 8 to 10 percent.

- New breakthroughs are needed in water-saving technologies in cultivation, enhancement of land productivity and development of climate-resilient varieties; natural resource management and climate resilient agriculture.
- While ensuring a sustained growth in national income, harness the tools of science and technology to cater to the needs of the underprivileged and to bridge the gap between haves and the have-nots; minimize inequalities to allow faster and inclusive growth.
- Complex issues, be they genetically modified food or nuclear energy or the exploration of outer space, cannot be settled by faith, emotion and fear, but by structured debate, scientific analysis and enlightenment; let judicious science and scientific rigour guide our actions.
- Produce and nurture talent in science to stimulate research and develop young leaders in science and to adopt science-based value systems, and create an environment for greater private sector cooperation in research, innovation and education.
- International collaboration was vital for increasingly resource-intensive modern science to progress.

President Lula's most successful Zero Hunger Programme of Brazil, has a strong message not only for India but for the whole world. Encouraged by the Brazilian movement, the United Nations Secretary General, Ban Ki-Moon, during the Rio+20, June 2012, announced the Global Zero Hunger programme and, echoing the Brazilian success, said that we can achieve zero hunger during our life time. The congruent fulfilment of the five pillars, namely, 100% access to adequate food all year round, Zero stunted children less than 2 years, All food systems are sustainable, 100% increase in smallholder productivity and income and Zero loss of waste of food, seek multidisciplinary and multisectoral actions and international solidarity and commitment. FAO's declaration of 2014 as the International Year of Family Farming augurs well with the centrality of smallholder farmers in national development, especially in India where 85% of farmers are smallholder farmers.

Mind the gap

Referring to the inequalities and the hollow growth, Hon'ble President of India had recently observed "the results of our policies should be seen in our villages, farms and factories, schools and hospitals....the figures (GDP growth rates) mean nothing to those who do not benefit from them". Likewise, the Hon'ble Prime Minister in his Presidential

Address to the 100th Session of the Indian Science Congress on January 3, 2013 had emphasised "As India seeks a sustained growth in national income, we must endeavour to harness the tools of science and technology to cater to the needs of the underprivileged and to bridge the gap between haves and the have-nots." Strongly advocating the 'equality of opportunity', the scientific community must sharpen its focus on informing the policy process, policy options and actions emphasizing the essentiality of reducing the load of entrenched inequality to liberate the growth and development process to pervade all sections of our society.

Towards achieving the goals of livelihood security and narrowing the farmer-non-farmer and rural-urban divides, it is absolutely essential to improve economic viability of farming by ensuring that farmers earn a "minimum net income", and ensure that agricultural progress is measured by advances made in improving that income and livelihood security of the farming families.

Inclusiveness and mainstreaming of the human and gender dimensions should be assured in all farm policies and programmes and given explicit attention to sustainable rural livelihoods. Productivity, profitability and income of the overwhelmingly large proportion of small, marginal, sub-marginal and landless farmers should be enhanced through developing, transferring and providing appropriate technologies, inputs and services and improving input use efficiency. India should emerge as a global outsourcing hub in the production and supply of products and processes developed through biotechnology and Information and Communication Technologies. Support is needed for comprehensive retooling and retraining to cope-up with new challenges and opportunities.

Agriculture is getting feminized (73 percent women as compared to 52 percent men). Therefore, it is very essential to adopt strategies to generate rural employment for women and for their empowerment. Skill acquisition and workforce participation are integral to women's empowerment and equality. Women's ability should be improved to enable them to exercise control over the means of production and distribution.

Business unusual

As the science progresses and knowledge pool gets enriched, innovative and creative ideas must translate the knowledge into usable solutions and development. The process must be institutionalised suitably. The research university system as common in USA and being promoted in India and other countries, is a proven path. It forges tight linkage of undergraduate and graduate training along with a strong research base with incubation centres created in university campuses. Such settings become natural incubators for new ideas and stimulate and trigger young minds to innovate. Several of such innovations find practical applications and synergise the university-industry linkage and also enrich the research and academic stream. With such a set-up, a good number of students shall be working as interns with the companies, gaining invaluable able hands on experience that will jump start their careers. The incubators for start-up companies will help convert innovations into commercial businesses. Through such partnerships, many of our scientists can have joint appointments with line companies – a new culture of PPP – a business unusual for India.

For India's new agriculture, one which is more knowledge intensive, we need new capacities. And these capacities need to be built in the entire Indian population of one and a quarter billion and growing and who have a stake in food, either directly or indirectly. They all need to contribute to improving productivity and efficiency of entire food chains, from input to production, marketing and consumption to reduce and eliminate hunger, malnutrition and poverty. And this becomes the most important challenge for India's agricultural education and learning-enabling India in its entirety to improve production, productivity, profit and sustainability of its food chains to successfully tackle and eliminate hunger, malnutrition and extreme poverty while conserving and using dwindling natural resources sustainably.

Unfortunately, we have data and foresight that tells us that we face what can only be called a "capacity cliff" within a few years even in the formal agricultural education sector regarding the scientists, extension specialists and teachers which we now and in the future need. In sheer numbers, the Indian system of agricultural research and innovation has in its human capacities shrunk by 17 per cent in the past decade. India will need 54,000 new agricultural graduates by 2020. But these are not the only key issues. Quality of its trained human resources and the development of capacities needed to effectively harness new trans-disciplinary scientific areas such as biotechnology, nanotechnology, information and communications technology, materials sciences and space technologies in relation to agriculture are also important.

A Roadmap to reshape India's agricultural education needs not only to be developed but developed based on a fresh vision. A vision that is congruent not only to aspirations of its own people for economic and social growth and development and prosperity for all but also to the sustainable development goals being established after Rio + 20 Conference making India a responsible member of the global community which faces common challenges emerging from climate changes, dwindling access to natural resources, fossil fuels and energy, loss of biodiversity and spread of diseases and pests from afar and across geographic and natural boundaries. The vision should include, as reiterated recently at the Global Conference on Agricultural Research for Development in Uruguay, the needs for educating and learning the entire society and the diverse communities of the country to make agriculture more productive, sustainable in the use of natural resources, resilient to natural and man-made shocks to it, environmentally friendly and improve incomes, livelihoods and quality of life. It should recognize that women, as a proportion, are increasingly not only working in but managing agriculture in the developing world and, that, the youth, who now do not see a future in farming or in pursuing agricultural sciences as a vocation, are attracted again to it. The vision has to revitalize that the youth find agriculture, agribusiness, agriculture related service sector and the pursuit of agricultural science and technology generation as attractive vocations and careers. One way of doing so is to include the new trans-disciplinary areas and entrepreneurship as new subjects of formal study and informal learning for all.

The vision for reshaping agricultural education and learning for India's new agriculture requires that agricultural education Institutions, especially the State Agricultural Universities and National Research Institutes, re-envision themselves. They have to shift from viewing agriculture as only a production and productivity challenge that can be solved by a set of generic technology packages to one where agriculture is a key contributor to sustainable and resilient growth, development and improvement of quality of life and the environment. The Universities have to be the fountainheads and facilitators of innovation for development especially for the communities in their catchments through their academic excellence. How true was Sir Radhakrishnan when he recommended Rural Universities nearly 65 years ago.

The bringing of a more knowledge intensive agriculture and associated food chains as also safeguarding the environment through sustainable use of natural resources requires a new strategy for education and learning. One that enables in addition to formal, on-campus education, open, informal, distance, off-campus, continuing learning for all. It is here that new information and communications technologies using the now widespread connectivity being brought into this country through an amazing telecommunication revolution should be fully harnessed. Along with this strategy, new Institutional approaches including policies and structures such as those that not only hold the faculties accountable for but also reward innovation and excellence need to be developed afresh and existing ones strengthened.

May I turn to one of the collaborators of this Congress, we all know that Bill Gates has been one of the all-time greatest innovators in ICT. Today, through the BMGF in India, he is innovating in the areas of social engineering and humanity through his agricultural projects towards enhancing and stabilizing livelihood security of the majority resource-poor and vulnerable rice farmers. Being a telecommunication giant, it would be wonderful if the Foundation establishes model Innovation Centres at selected SAU campuses to link farmers, agriculture, agribusiness and digital communication in a real-world situation to trigger new exciting opportunities, particularly for the young innovators in harnessing best of the science and technology in serving farmers to save and transform farming.

Global Classrooms and Connectivity

Online teaching and learning is indeed a revolution in education culture and system. The huge bulge of India's youth can greatly benefit from the Massive Open Line Courses (MOOCs) which can be streamed anywhere in the world. Classroom teaching could thus be augmented in many ways by online teaching. Various universities and institutes can be interlinked domestically and even internationally to promote multidisciplinary teaching and research to strengthen inter-institutional collaboration. We could also tap into international networks. For instance, all the Indian Land Grant Universities could connect and renew ties with their initial collaborators and partners, such as PAU with Ohio State University and GBPUAT with University of Illinois, and OUAT with the University of Missouri, and mutually enrich their teaching and research programmes and capture innovative solutions to complex and new and emerging problems.

Mentoring role of the National Academy of Agricultural Sciences will thus expand and we would thus "clone" our Best Teachers-Researchers and consequently partly obviate the paucity of teaching faculty, especially the quality teachers.

Institutes of Agricultural Science Education and Research

At this juncture, it is gratifying to note that the Scientific Advisory Council to the Prime Minister (SAC-PM) under the Chairmanship of Prof. C.N.R. Rao, had recommended creation of five new institutions devoted to science education and research to be named "Indian Institutes of Science Education and Research" (IISER) broadly on the lines of Indian Institute of Science (IISc.) Bangalore. Five such Institutes have already been established at Kolkata, Pune, Mohali, Bhopal and Thiruvananthapuram. It is a different matter that in late 1990s, as the then Director of Indian Agricultural Research Institute (IARI), I had envisioned that IARI should be restructured on the pattern of IISc (IARI Vision 2020). Let us hope that with the IISER initiative, we could have at least one Indian Institute of Agricultural Science Education and Research (IIASER). I suggest that we may proceed a step further and also integrate social sciences and humanities in IIASER.

On December 25, 2012, Banaras Hindu University (BHU) celebrated the 150th Anniversary of Mahamana Pt. Madan Mohan Malviaya, the founder of the University. The Hon'ble President and Prime Minister, several other national and international dignitaries participated in the Celebration and pledged several innovative actions to render the University and the national educational system truly a world class educational system. Now it is for us to convert these pledges into actions and the desired outcomes. BHU's circle is full. In it, Institutes of Agriculture, Medical Sciences, Ayurveda, Technology, Science, Humanities etc. co-exist, but there is negligible interaction among them. The silos must be broken and multidisciplinary research and teaching should be the preferred path. Selected IITs, and IIMs should grant degrees also in selected agricultural sciences and in agribusiness management.

The vision of these institutes encompasses creation of research centres of the highest caliber in which teaching and education in basic and social sciences will be totally integrated with state-of-the-art research. These Institutions should be devoted to under-graduate and post-graduate teaching in sciences and humanities in an intellectually vibrant atmosphere of research and make education and career in basic as well as social sciences more attractive by providing opportunities in integrative teaching and learning. These institutes will not have only teachers and only researchers, but all will be teacher-researcher and researcher-teacher. This will create mutually synergistic quality education and research and attract, nurture and retain talented students and high quality academic faculty and integrate and mutually enrich undergraduate, graduate, Ph.D. and post-Ph.D. programmes. This calls for redefining goal, vision, mandate, strategy and functioning of institutions of learning and research. Obviously, serious changes and adjustments will be needed in policies and implementation pathways.

Investment in Agricultural REE

As enunciated in India's National Science, Technology and Innovation Policy, 2013, Education, Human Resource Development, Science, Technology and Innovation, all inter-dependent and mutually reinforcing, are the main drivers of national development globally. The role of technology as the central driver of agricultural productivity growth is well documented. Recent studies have further revealed that whereas agricultural technology is important, other factors also play a role, such as investment in infrastructure, education, market access etc. A recent study comparing productivity growth and the structural transformation experience of over 100 countries, had demonstrated that countries, including India, experiencing slow productivity growth are falling further behind other countries, experiencing a delayed economic transformation process than has historically been the case.

In view of the poor financial health of most SAUs, substantial increase in funding to the universities is essential. Being a State subject, States have to be sensitized of the urgent need to adequately support their SAUs and effective mechanisms should be in place to ensure that the Centre's funds reach the universities and are used judiciously. I am expecting that the Congress deliberations may reveal that success in innovation and technical advance depends on factors beyond the allocation of public funds for technology generation and dissemination. Brazil is perceived to be spending its funds most innovatively and has established a highly successful research system. Similarly, the experience of China shows the importance of the focus on quality not just quantity in ensuring success. But, in India there is non-judicious proliferation and fragmentation of the system. Besides consolidation, in India, major shifts are called for in the appointment of Vice-Chancellors, faculty and staff and in enrollment of students.

Finally, it is apparent that the pursuit of excellence with the size of the new catchments that will need to be addressed and the constraints of finance and human capacities that we face today. This will require significant consolidation of the formal agricultural academic establishments in the country as otherwise the investments needed for the now more than 150 establishments at between 300-500 crores rupees each in a short time span of 5 years would be exorbitant. We need a political commitment and investment in the pursuit of excellence as we had seen in the 1960s and 70s for agricultural education in India again so that agricultural education can reshape India again as it did then. Several good studies have revealed high rate of return to investment in R&D. In order to strongly influence policy options for reshaping agricultural education, we need to have some critical studies, although difficult, to delineate the impact of investment in agricultural education on the agrarian and overall economy.

Most governments recognize the importance of research, education and extension (REE) for agriculture, including in developed countries where large amounts of public resources have historically been devoted to developing and disseminating agricultural technology, even as private investment has increased substantially over time. In recent years the landscape of agricultural R&D spending has been shifting; developing countries (broadly defined to include low and middle income countries) clearly recognize the need for science and innovation to drive their development objectives and together now invest as much as the developed countries.

India's challenges in improving its agriculture are not unique. They are very similar to those the entire world faces. However, India has the wherewithal that few developing countries have to reshape agriculture and agricultural education and therefore we have invited the leading luminaries in agricultural development to this congress and deliberate the way forward. We humbly request their contribution to Indian agriculture, starting from the deliberations at this Congress, so that we all can contribute, using India as an example, to the shaping of the future of agriculture together throughout the world.

Every Agricultural Graduate an Entrepreneur: Youth for Leadership

Education for Agriculture in the 21st Century should have the goal that every scholar becomes an entrepreneur. Thus, Business Management should be mainstreamed in all applied courses, e.g. Seed Technology and Business. The Colleges of Human Sciences should revamp their courses and internalise business management component. Regional Institutes on Food Safety and Security should be established to ensure availability of safe and nutritious food. Like the IITs, Centres of Excellence in form of Agricultural IITs and Agricultural IIMs should be created to ensure availability of quality human resources in agriculture-led development. A new Government programme on 'Youth for Leadership in Farming' should be launched.

As knowledge domain is expanding fast, formal and non-formal courses and the learning processes should be rendered intellectually stimulating and economically rewarding. The trainers themselves would need to be trained in several of the new areas. Ministry of Agriculture, ICAR, Ministry of Human Resources and UGC should provide financial support to such institutions for retraining and retooling the staff to upgrade their overall skills to meet the new demands.

Each SAU and other concerned education and training institute should restructure its curricula for enabling every farm and home science graduate to become an entrepreneur and to make agricultural education gender sensitive. Private companies and cooperatives, manufacturing and distributing agricultural inputs and related products should, other things being equal, give preference to agricultural graduates for employment and granting licenses and dealerships.

Diploma courses in farming systems should be institutionalized by the SAUs, particularly for extension, cooperatives and Panchayati Raj personnel and other development agents involved in technology assessment and transfer with emphasis on conservation agriculture, climate change management and market-led extension. Need-based certificate courses on IPM, INM, seed production and distribution etc. should be introduced in all SAUs. Preference for enrollment for such courses should be given to rural youth, school and college drop-outs as well as to literate progressive farmers, including those chosen for organizing farmers' field schools.

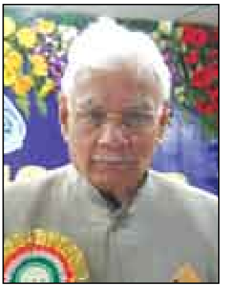
Excellency, Ladies and Gentlemen!

The first Prime Minister of India, Pt. Jawaharlal Nehru, on the midnight of August 14-15 1947, the day India became independent and entered into a tryst with destiny, had emphasised "***everything else can wait, but not agriculture***". From then and now obviously at times we have lost our way. We must bring ourselves back on track, restore the interrupted journey of SAUs. We cannot condemn one-fourth of our population who are hungry and below poverty line, around 250 million real people, to languish in the backwaters of poverty and deprivation.

High quality relevant agricultural education and human resource capital at all levels along all value-chains and knowledge pools is the solution. We must act now. The hungry child cannot wait any longer.

Good luck.

Inaugural Address by



His Excellency Shri Murlidhar Chandrakant Bhandare Governor of Odisha

Sj. Debi Prasad Mishra, Minister of Agriculture, Fisheries and Animal Resource Development, Govt. of Odisha Padma Bhushan Prof. R.B. Singh, President, National Academy of Agricultural Sciences; Prof. S. Ayyappan, Secretary, DARE & DG, ICAR; Prof. Mangala Rai, Immediate Past President, NAAS and Former Secretary, DARE & DG, ICAR; Mr. Simeon Ehui, Sector Manager, World Bank; Prof. Anwar Alam, Secretary, NAAS; Vice-Chancellor, Orissa University of Agriculture and Technology; Prof. D.P. Ray, Former Vice Chancellor, OUAT and the Convener; Distinguished Delegates from India and abroad; Students; Press and Media, Ladies and Gentlemen!

I feel extremely happy to be present amongst this gathering of eminent agricultural scientists, scholars, students and academicians to address the 11th Agricultural Science Congress being organized by the National Academy of Agricultural Sciences at the Orissa University of Agriculture & Technology. It is my pleasure to extend very hearty greetings and good wishes to one and all present on this momentous occasion.

Agriculture has attained an annual growth rate of about 3.5% during the 11th Plan (Economic Survey, 2011-12), up from the growth rate of 2.5 and 2.4% recorded during the 9th and 10th Plan, respectively. The 12th Plan targets 4 percent growth rate in agriculture and allied sectors. To achieve this goal we have to gear up the green, white, yellow and blue revolutions, thus rendering the country self-sufficient and self-reliant on food and nutritional fronts.

Indian Agriculture is now at the crossroads and is facing far greater and newer challenges of global competitiveness, increasing productivity with lesser input and natural resources, environmental sustainability and climate change. In view of the problems and challenges faced for rapid industrialization and sustainability of agriculture-based economy in our country, search for quality assurance in higher education assumes high priority. Although culturally and minerally rich, Odisha is economically a poor state and is striving hard to transform its agrarian economy. I am pleased to mention that Odisha had attained the highest agricultural growth rate during the last year, and the University had played an important role in this development. SAUs all over the country need to be strengthened and encouraged to lead agrarian transformation.

Human resource development is critical for sustaining and realizing the potentials of agriculture. The establishment of institutions for higher agricultural education throughout the country has been the cradle of successful agricultural transformation and translation. These institutions developed skilled human resource, which in turn generated new technologies through quality research vis-à-vis dissemination to the farming community. Enhancing quality of human resource is the absolute requirement for implementing and up-grading education and research programmes, developing technologies, evolving institutional arrangements to face challenges and harness opportunities. Capacity building of the faculties and researchers in the country on regular basis in cutting edge areas is required for enhancing the quality and output of human resource as well as to boost the functional capability of the researchers.

Trained human resources are needed in different sectors of agriculture with higher skills than before to ensure technology based education and research in the country. Given the high level of feminization of agriculture, enrollment of girl students in SAUs should increase from current level of 35-40% to about 60%, as attained in Odisha's Utkal University.

The Agricultural universities and ICAR institutes with Deemed to be university status are the source of developing agricultural human resources. I would like to avail this opportunity to share with you the outcome of a recent study on manpower requirements in agriculture undertaken by the National Academy of Agricultural Research Management (NAARM). It indicates that presently, the existing education system is producing about 24,000 graduates per year with crop sciences contributing 2/3rd of it. The projections indicate that by 2020 the annual out turn required would have to be about 54,000, i.e. the demand supply gap would be 30,000. This is true across the board, though the shortfall is high in case of rapidly growing horticulture, dairy and fisheries sectors and less serious in other sectors. Dairy, fisheries, veterinary and horticulture are the future engines of growth which would have a bearing on manpower requirements. Discipline-wise, the additional annual requirements of out turns are expected to be: Agriculture-9335; Horticulture-7153; Forestry-1116; Dairy 3005; Veterinary and Animal Husbandry-4989; Fishery-2181; Agricultural Engineering-1749; and Agricultural Biotechnology-305.

To achieve this goal, our State Agricultural Universities need to enhance their student intake capacity. It is pleasing to note that ICAR is already in the process of establishing a Central Agricultural University in the Bundelkhand region. I am optimistic that in the XII Plan emphasis will be on improvement of quality of higher agricultural education through making the accreditation process more objective based on quantifiable parameters; revision/modification in the course curriculum and syllabi to make agricultural education more comprehensive providing knowledge, skills and attitude thereby enhancing the quality and acceptability of the passouts.

Efforts should be on reducing inbreeding in faculty and students, and on faculty improvement to a great extent particularly in view of implementation of revised curriculum in agricultural universities. The scope of agricultural education must be widened to increase enrollment ratio. Performance assessment of universities, colleges, faculties and programmes should be linked with the magnitude central support. Also, impact assessment of the various initiatives including reforms should be an integral component of the system.

It is heartening to note that in the new SAU curricula a one year composite programme, namely, Rural Entrepreneurship and Awareness Development Yojana (READY), with three components: Experiential Learning Programme (ELP), Rural Agricultural Work Experience (RAWE), and in-plant training/industrial attachment is being contemplated. The main objectives of ELP are to promote professional skills, entrepreneurship, knowledge and marketing skills through meaningful hands on training and working in project mode; to build confidence through end to end approach in the product development, and to acquire enterprise management capabilities including skills for project development and execution, accountancy and national/international marketing. The proposed new initiative on Attracting and Retaining Youth in Agriculture (ARYA) is a welcome step by the Council.

The implementation of the transformation should be based on a rural youth centric approach with concentration on activities that lead to sensitization and motivation of farm youth. It should target the areas of agriculture research outputs that could be converted into viable economic enterprises and build the capacities for attracting rural youth to agriculture. I would urge that agricultural universities should implement the reforms to bring about the desired change in the agricultural education to make it relevant to national needs so that we are able to attract and retain youth in agriculture.

There should be autonomy to Agricultural Universities and their colleges and academic freedom to faculty and scientists. Their labs should be modernized and well equipped with requisite precision, saving their labour and time. Course and curricula should be flexible facilitating learning and innovative instincts and curiosity of young mind. ICAR Model Act should be adhered to. Internal institutional efficiency should be dynamically improved with priority setting and monitoring and evaluation in place. Capacities created should be utilized fully in public institutions to meet rising aspirations of the students for which there should be norms and standards.

It is gratifying that ICAR which is nodal in promoting higher agricultural education in the country, has done a commendable job. However, excellence has to be achieved in new and frontier areas. Agricultural scientists in collaboration with policy makers, financial institutions and farmers had succeeded in ushering in the Green, White, Blue and Yellow Revolutions making India self-sufficient in food in spite of the growing population. However, second generation problems have cropped up retarding growth rate in agriculture. Challenges ahead are far more demanding for which human resources and dynamic knowledge domains have to be created.

Freedom from hunger and poverty is the foremost human right. This formidable challenge can be met only by quality Education. Agricultural education has not received the due support in the past and cannot be ignored further. The experience of participating scientists from abroad regarding higher education system in their countries should be shared and implemented in our country for reorienting agricultural education for fostering academic excellence, new skills for capturing uncommon opportunities, inculcating entrepreneurship in the graduates, addressing key concern for quality assurance, promoting gender sensitivity and ultimately in achieving freedom from hunger and extreme poverty.

Lastly, I believe that during these three day's deliberations, the outcome of the presentations, discussions and emerging recommendations will be discussed and finally the Roadmap for Agricultural Education and Agricultural Research, Education and Extension towards Shaping India's Future will be presented, discussed and adopted.

I wish you all success.

Jai Hind

Special Session

Agricultural Research, Education and Extension for Nutritional Security

The Hon'ble Chief Minister of Odisha, Sj. Naveen Patnaik, chaired and addressed a Special Session on Agricultural Research, Education and Extension for Nutritional Security. Sj. Debi Prasad Mishra, Hon'ble Agriculture Minister, Odisha, Prof. R.B. Singh, President NAAS, Prof. Abhijit Sen, Member Planning Commission, Dr. Kul Gautam, Advisor, South Asia Food and Nutrition Security Initiative, World Bank, and Dr. Mahtab Bamji, Honorary Scientist, INSA also addressed the Session.

Why Nutrition Should Top the Agenda for AREE4D

Mahtab S. Bamji

Nutrition security is defined as : “Physical, economic and social access to an age-appropriate balanced diet, safe drinking water, environmental hygiene, and primary health care for all”. Thus nutrition security goes beyond food security. For nutrition security, there has to be awareness and access at affordable cost to Food security, environment and drinking water security (to ensure absorption of nutrients) and Primary Healthcare outreach. The responsibility of the agriculture professionals is to ensure food security and of the politicians and administrators is to ensure all of these through convergence between activities of different departments. Food security does not end with having adequate stocks of cereals-rice and wheat at the national level. It implies physical, economic and social access to an age-appropriate balanced diet at the household and at the individual level.

Problem of Hidden Hunger

Country-wide diet surveys done by the National Nutrition Monitoring Bureau (NNMB) show that cereal-pulse based Indian diets are qualitatively more deficient in micronutrients (vitamins and minerals) than in proteins. Meeting the calorie gap may to a great extent meet protein requirement (though quality has to improve), but large deficits in minerals like iron, zinc and calcium and vitamins like A, B_2, folic acid and even B_{12} and vitamin D persist due to low intake of protective foods, vegetables, fruits and animal products. Pulses and millets are also good sources of micro-nutrients. Unfortunately the Green Revolution which has kept the wolf of hunger away from India has by-passed pulses and millets. Though India is among the top two countries for the production of vegetables and fruits and milk, what is produced is insufficient for the large population, and beyond the reach of the poor due to high price. Even farmers who produce them prefer to sell them for money rather than give them to their children. This requires agricultural engineering to keep the cost of production low and social engineering to convince families about the importance of these foods for health, particularly of women, children and adolescents. Within a family, diet of pre-school children is most deprived since these youngsters cannot express and articulate. The younger children (under 2 years of age), who are most vulnerable escape benefits of feeding programmes like supplementary feeding programme of the ICDS, because the take-home food that is given for them is often shared by the family. Food supplied through supplementary feeding programmes like ICDS and school mid-day meal are deficient in vegetables though eggs are given in some states like Andhra Pradesh.

Decentralized Production-Homestead Production

The purpose of agriculture is often perceived as ensuring income, export, and at best meeting calorie requirement of people through cereals. While income and calories are important; a balanced diet should ensure adequate intake of macro and micro nutrients - vitamins, minerals and even health giving phytochemicals. For that, greater attention is needed to production of pulses, millets, vegetables and fruits and animal products at the affordable cost. Millets are the grains of future since they need lesser water, are hardy, and rich in minerals and vitamins. Since over 70% of India resides in villages, agriculture planning should be decentralized to ensure adequacy of all food groups-cereals, millets, pulses, vegetables and fruits and animal products at the village level. Homestead production with strong dose of advocacy and nutrition education is a strategy worth exploring.

In select villages of Medak district of Andhra Pradesh where there is no lift irrigation and farm holdings are very small, **Nutritionally and Environmentally Promotive Agriculture** was experimented with. In these villages most households have own or leased land. There are very few large landlords. Most farmers work on their own fields and of others for wages. Diversification from water guzzling crops like paddy and sugar cane to nutrient-rich varieties of vegetables and fruits, pulses, and millets was encouraged with technical support and hand holding. Nutrition education was a strong component of this strategy. Organic methods of farming like vermi-composting, and use of botanical pesticides (neem kernel decoction, chilli-garlic decoction) was encouraged. Judicious use of fertilizers after soil testing using rapid testing kit developed by ANGRAU was encouraged. Fodder cultivation was also promoted. Introduction of backyard poultry using high egg-yielding strains was quite successful, even though farmers had to pay for the birds, with one cock given free. Night shelters were insisted upon.

Despite advocacy and education, 25-50% vegetables were sold. Household production helped to protect against steep increase in market price of vegetables. Some increase in frequency and quantity of green leafy vegetables consumed by the households was recorded. Backyard poultry showed marked improvement in frequency and quantity of eggs consumed. Record of poultry meat was not kept. Thus farming strategy can have two dimensions - production of economically viable crops for income along with homestead production of protective foods for home consumption and nutrition security.

In urban areas also homestead production of vegetables was found to help family nutrition in some countries. India needs to do more in this direction. **Nutrition education has to be a strong component.** While some KVKs do attempt this strategy, their numbers are small and outreach limited. Country needs to increase the number of KVKs and encourage them to be involved in local planning for crop cultivation, and livestock production for nutrition security.

The bottom line is:

- ❖ Leadership at all levels and governance to ensure **convergence between the efforts of different departments/programmes**.
- ❖ Make nutrition an important input and output parameter for all government programmes that can directly or indirectly impact nutrition.
- ❖ Targeting and monitoring.
- ❖ Health, Nutrition, Education, Environment and Gender equity should be the indicators of National development, and not trickle-down beneficiary of economic growth-GDP.

Not by the Food Alone, Ensuring Nutritional Security through Agricultural Research, Education and Extension

Kul Chandra Gautam

We at the South Asia Food and Nutrition Security Initiative (SAFANSI) believe that the challenge of hunger and malnutrition in South Asia, as elsewhere, requires a multi-pronged approach, including: greater availability of food; enhanced livelihoods; education; clean water and sanitation; women's empowerment; social protection; and a special focus on infant and child care.

But above all else, genuine food and nutrition security requires a political commitment that recognizes hunger and malnutrition as violation of people's human rights as well as a serious impediment to national development.

The importance of political commitment was graphically highlighted by the Nobel Laureate Amartya Sen who argued that the Great Bengal Famine of 1943 was not caused by shortage of food, as the granaries of Kolkata were apparently quite full, but the British Raj of the time felt no political obligation to protect starving masses from famine.

Amartya Sen has also propounded a thesis that there is no large-scale famine in a functioning democracy.

Well, democracy may indeed help avert visible famines, but as we have seen here in India, in South Asia and other parts of the world, democracy is not an adequate anti-dote to combat malnutrition, which is often invisible to naked eye, and therefore cannot be sensationalized in election campaigns.

Conventional wisdom would have it that hunger results from lack of food and malnutrition due to unbalanced diet. But we know that hunger has many dimensions; there are at least following four types of hunger.

- The first hunger is the most obvious one, caused by lack of food. When we speak about millions of people going to bed hungry, or when we see the heart-wrenching pictures of emaciated children dying in famines, that is the common kind of hunger we refer to.
- The second hunger, which we have not talked about much, is the "hidden hunger" for micronutrients — the minerals and vitamins such as iodine, iron, and vitamin A. This type does not manifest itself in the form of a bloated belly or emaciated body. But it strikes at the core of people's health and vitality. It seriously damages human brain, learning ability, human health, and productivity.
- The third type is the need of children and women for adequate care, nurturing, and protection from infections, without which food alone cannot protect them from malnutrition.
- The fourth hunger is for safe water, clean air, and sanitary environment - so essential for promoting health, growth and nutrition, as well as liberating women from drudgery of time-consuming chores.

  To these, we might add the growing occurrence of obesity, largely caused by junk foods and unhealthy life-style, which is becoming an alarming phenomenon alongside under-nutrition, even in very poor countries and communities.

Indeed, it has been noted that both under-nutrition and obesity are a reflection of the life-cycle consequences of inadequate foetal and infant growth, and life-style related consequences of urbanization where the poorer people, including children, often eat cheap, processed foods, which fill the belly and satisfy taste buds, but harm their health.

Interestingly, some of the solutions to under-nutrition and over-nutrition are common. Optimum breastfeeding to infants, for example, prevents both under-nutrition as well as provides protection from some obesity-related diseases.

Overcoming these different types of hungers, requires a holistic, life-cycle approach to ensure that all children get a healthy start in life; that all families have essential household food security; that primary health-care and basic education are universally available in all communities; and that we promote good nutrition and healthy lifestyles among adolescents and adults.

Learned nutritionists have debated about the intricacies of various nutrients and enzymes, and failed to persuade politicians and policy-makers with simple and persuasive messages as to why investing in nutrition is one of the best bargains to promote national development.

We all say that nutrition requires a multi-sectoral approach. When something is multi-sectoral, it becomes nobody's priority. Most sectoral ministries of governments understandably champion their own sectors. And multi-sectoral programmes become secondary and discretionary for which one can always pass the buck to another ministry.

Nutrition has become a subject that is over-studied and under-acted upon. Lately, there has been a significant change in the last decade and also a growing consensus nationally and internationally on what needs to be done to improve nutrition.

About a decade ago, the World Bank issued a seminal report on "*Repositioning Nutrition as Central to Development*", drawing on evidence from many countries' studies that demonstrated very high cost-effectiveness of many nutrition interventions.

In 2008, the British medical journal, *The Lancet*, published a series of articles, again drawing on lessons learned from many projects around the world, and made the case that there is a golden 1000 days' "window of opportunity" from pregnancy to two years of age, during which a set of specific nutritional interventions result in the greatest impact in dramatically reducing malnutrition, morbidity and mortality in children, and greatly enhancing their learning and earning ability as they grow up to adolescence and adulthood.

Around the same time, a group of leading economists, including several Nobel Laureates, came up with what is known as the "Copenhagen Consensus" that showed that investment in nutrition, such as on micronutrients and some community-based nutrition interventions have had far higher rate of economic returns and social impact than investments in any other sector.

All of this culminated into a bold proposal for "Scaling Up Nutrition" – The SUN Initiative - around which there is now an emerging global consensus among governments, UN agencies, multilateral and bilateral organizations, academics and NGOs, key players in promoting nutrition.

The SUN Initiative recommends two complimentary approaches to reducing under-nutrition – a set of about a dozen specific and evidence-based direct interventions to prevent and treat under-nutrition, and a broader multi-sectoral approach to deal with the underlying causes of malnutrition (www.scalingupnutrition.org).

The South Asia Food and Nutrition Security Initiative (SAFANSI) was partly inspired by the SUN Initiative. By the way, SAFANSI is a World Bank-managed Trust Fund, supported by UKAid (DFID) and AusAid, which seeks to build alliances across borders among the SAARC countries, and across various sectors to connect analysis, advocacy and action among implementers, policy-makers and civil society players to promote food and nutrition security.

The SAFANSI was also partly inspired by what came to be known as the "*Asian Enigma*", a term coined in the mid-1990s that referred to the puzzle of why despite the "Green Revolution" and rapid economic growth, South Asian countries had double the rate of malnutrition than sub-Saharan Africa.

As a South Asian who happened to be the Director of Programmes at the UNICEF HQ in the nineties, I wanted to better understand this enigma. So we got UNICEF to commission three leading experts on health and nutrition with deep experience in Asia and Africa, the late Dr Vulmiri Ramalingaswamy, Urban Jonsson, and Jon Rohde to elucidate causes and consequences of this reality. What they reported then in 1995 was intriguing and fascinating, and is still valid today.

First, they examined, and ruled out, the 'usual suspects' for potential causes of malnutrition in South Asia – concluding that it was not really due to high level of poverty, or vegetarian diet, or poor agricultural performance that was the main culprit; because in those respects most African countries are worse off than Asians.

Instead they concluded that the lower status and greater neglect of girls and women, and the poorer hygiene and sanitation in South Asia which had higher level of urbanization than Africa, were more critical factors. These led to inter-generational transmission of malnutrition through low-birth weight, inadequate breastfeeding, poorer health and nutrition of adolescent girls and pregnant women; all of which made Asian children more vulnerable to infection and malnutrition.

Even at present, there are several "Puzzle States" in India, such as Gujarat, Kerala and Punjab where, despite high agricultural growth and high literacy rates, very high rate of malnutrition persists. At the household level, adequate income does not seem to guarantee adequate nutrition; as even among the richest quintile in India, 64% of preschool children are iron-deficient and 26% are underweight.

Similar stories can be cited from other South Asian countries. This knowledge is now leading to action.

My home country, Nepal, has recognized this reality, and recently has come up with an ambitious multi-sectoral food and nutrition security plan. I know that there are similar initiatives afoot in other countries of the region, and several states of India, including Odisha

Odisha from being one of the laggard states in India in terms of nutrition, has been transformed into one of the better performing states where most indicators of malnutrition have improved quite significantly in the last decade.

Odisha's malnutrition rates are now closer to India's national average.

So, based on this diagnosis of the problems, and lessons learned, what we do next, and in particular how can those of us involved in agricultural research, education and extension be helpful?

I believe that several decades of experience, trial and errors, and lessons learned from the best practices in India, South Asia and other countries in the world that have made better progress than we have point to the need for us to follow a two-pronged approach.

First, let us scale up certain proven interventions such as: breastfeeding, complementary feeding, improved hygiene practices, including hand-washing. Let us ensure provision of micronutrients for young children and their mothers, including vitamin A and zinc supplements, deworming, iron-folic acid supplements, ensuring therapeutic feeding and treatment of malnourished children with special foods, and a massive effort for salt iodization and iron fortification of staple foods.

I believe that the M.S. Swaminathan Research Foundation's "Malnutrition-Free Odisha Program" emphasizing bio-fortification as a "horticultural remedy for nutritional malady" offers a good example to emulate.

Ensuring food and nutrition security is clearly one of the central challenges of human development in India and all-over South Asia. Our countries will fail to achieve or sustain most of the Millennium Development Goals if we cannot ensure a minimum of food and nutrition security. I would, therefore, hope that the eminent agriculture and extension experts can make a major contribution through applied research and especially human resource development in this area.

Secondly, recognizing the multi-sectoral nature of nutrition, let us work on such underlying social determinants of nutrition, and malnutrition, including girls' education and women's empowerment, improved gender equality and social protection; and universal access to clean water and safe sanitation.

In this context, some of India's great efforts through improved coverage of ICDS centres and anganwadis, the Total Sanitation Campaign, the National Rural Health Mission, and the more successful State-level Nutrition Missions are highly promising, and need to be further strengthened and expanded.

Nutrition must be made everybody's business. Thus India's judicial activism and civil society's campaign for the right to food and nutrition are welcome initiatives. The Citizens' Alliance against Malnutrition that brings together parliamentarians and journalists, movie actors and musicians, celebrities whose voices can create a HUNGaMA, are needed to accelerate progress.

Strong political commitment and leadership are needed to ensure greater inter-ministerial coordination.

The world produces enough food to feed every man, woman and child on earth. Hunger and malnutrition are therefore not due to lack of food alone, but are mainly a consequence of poverty, inequality and misplaced priorities.

Let us use our collective energy and innovative genius to overcome this shameful blemish on our region, South Asia, as the epicenter of the world's worst malnutrition. Let us make this ancient land of great civilizations, rich culture and natural beauty, a land free of hunger and malnutrition as it emerges as the new economic power-house of the 21st century.

Agricultural Research, Education and Extension for Nutritional Security

R.B. Singh

Hon'ble Chief Minister of Odisha Sj. Naveen Patnaik ji,

Hon'ble Member (Agriculture), Planning Commission, Prof. Abhijit Sen,

Dr. Mahtab Bamji, Indian National Science Academy Honorary Scientist,

Mr. Kul Gautam, Advisor, South Asia Food and Nutrition Security Initiative (SAFANSI), The World Bank,

Distinguished delegates, ladies and gentlemen!

It is indeed a great honour to have with us Hon'ble Chief Minister of Odisha as our Chief Guest at this brief but extremely important function. Sir, the entire scientific community sees you as one of the most dynamic and progressive leaders in the contemporary years and looks forward to your benevolent guidance in liberating humanity from perpetual deprivation through mustering the best of science and human capital.

The focus of this function is to seek pathways to achieve comprehensive nutritional security through transforming Agricultural Education and its integration and synergies with Agricultural Research and Extension. At this XI Agricultural Science Congress, organized by the National Academy of Agricultural Sciences with its theme on **Transforming Agricultural Education for Reshaping India's Future** in collaboration with this famous Orissa Agricultural University and Technology, we have eminent presence of leading agricultural educationists and researchers from India and abroad, including thought leaders from Brazil, France, Japan, The Netherlands and

USA and from international organizations such as World Bank, FAO, GFAR and CGIAR.

I am pleased to mention that science- and technology-led Green, White and Blue Revolutions have greatly transformed Indian agricultural production and agrarian economy, achieving record productions of foodgrains, fruits, vegetables, milk and fish. During the past 40 years, these unprecedented gains, coupled with efficacious policies and actions, had resulted in more than halving the percentages of hungry, under-nourished and ultra-poor, and had transformed India from a ship-to-mouth situation to the Food Bill i.e. Right to Food status.

The Green Revolution has, however, almost waned. During the last decade or so, while the overall national gross domestic product (GDP) had registered a high growth rate of about 8%, the agricultural growth had gone sluggish, hovering around only 1.5 to 2% (although has picked up in recent years), rendering the high overall growth rather hollow as the income gap between farmers and non-farmers had further widened to 1:6, thus multiplying inequities.

Unethical as it is, the country is still home to almost one-fourth of the world's hungry and poor. India has the dubious distinction of having the highest burden of malnutrition in the world – higher than Sub-Saharan Africa. Nearly 50 per cent of our children are underweight and stunted and 70 per cent suffer from serious nutritional deficiencies. The very high incidence of child undernutrition in India is both an ethical and economic imperative. Hon'ble Prime Minister, Dr Manmohan Singh, while releasing the HUNGaMA (Hunger and Malnutrition) Report on January 10, 2012, had observed that the problem of malnutrition in the country is a matter of national shame.

Evidences show that avoidable undernutrition among young children reduces the effectiveness of investments in education and economic development. It is estimated that the entrenched high undernutrition in the country annually costs about 3.8 percent of the national GDP. Studies have shown that the benefit-cost ratio for nutrition interventions ranges from 5 to 200, much more than for other interventions. Overcoming early childhood undernutrition requires investing in targeted nutrition interventions for immediate impacts, as well as investing in packages of interventions that address the immediate and underlying determinants of undernutrition.

Recent evidence shows that the window of opportunity for improving nutrition is much narrower, spanning the period from -9 to +24 months (that is, the 1,000 days between conception and a child's second birthday). This is the period when children are in greatest need of adequate amounts of nutritious food for healthy development. Further, most importantly, interventions during this period are most likely to prevent undernutrition from setting in. Studies show that after the age of two, the effects of undernutrition are largely irreversible. Children, who are undernourished during the thousand-day window, face lifelong risk, including poor physical and cognitive development, poor health, and even early death.

Notwithstanding the moral responsibility of liberating our children from the entrenched deprivation, the nation is constitutionally obliged to "regard the raising of the nutrition and the standard of living of its people and the improvement of public health as its primary duties" (Art. 147). Towards this objective, several initiatives such as the National Nutrition Policy, National Nutrition Plan of Action, National Nutrition Mission and Coalition for Sustainable Nutrition Security have been mooted with varying successes. But, the fact remains that over 40 per cent of world's malnourished children are our own children. There is lack of a comprehensive national programme or approach specifically aimed at improving nutrition, resulting in lack of convergence and synergy among existing programmes. Moreover, there is lack of a focus with nutrition as an outcome in the government programmes which have the potential to impact nutrition.

Appreciating the seriousness of the problem, the National Academy of Agricultural Sciences, in collaboration with the Nutrition Society of India and the National Institute of Nutrition (NIN) organized a Brainstorming Session on 'Fighting Child Malnutrition' on 13th November 2011 at NIN, Hyderabad to suggest policy options and actions to meet the challenges. Among other things, we had suggested a Life Cycle Approach should be adopted for fighting malnutrition so as to target resources towards the critical nutritional periods of the human life cycle which includes the following: vulnerable women during pregnancy, the first two years of life of the child and during adolescence.

To achieve sustainable improvements in child nutrition, decision-makers must tackle the underlying causes of undernutrition: food insecurity, insufficient care for women and children, and limited access to healthcare and a healthy environment. Nutrition-sensitive policies; protective and productive social safety-net programs; and pro-poor, pro-women, pro-nutrition agricultural policies and programs that specifically integrate nutrition goals and actions and track nutrition impacts can play a critical role in improving the overall environment in which young children grow and develop.

Links between agriculture and nutrition are extremely strong and work on local, national and global scale as per the physical, social, legal, economic and governance settings. Anything that affects agriculture is bound to impact nutrition particularly in countries like India where agriculture is also the mainstay of a very large number of people, and the converse is equally true. In order to mainstream nutrition in agriculture-led and other human-oriented development plans, economic, social, equity, governance and science and technology components have to be synergistically congrued. Biotechnology and GM Crops, such as Golden Rice, hold great promise in fighting not only malnutrition but also in achieving high performing climate resilient agriculture. Appropriate policies must be in place to harness these uncommon opportunities.

Excellency!

Knowing your commitment to fight the human suffering, I have the honour to present one copy of the Academy's Policy Paper entitled 'Fighting Child Malnutrition', 2012 to your goodself. It is hoped that the various stakeholders, including the policy makers, will seriously consider the policy options and ensure effective implementation of the recommendations. Odisha with its agroecological treasures and liabilities, high concentration of tribal population and high vulnerability to climate change, faces formidable challenges to achieve accelerated and inclusive growth. We are sure, under your dynamic leadership, and commitment, science, technology and innovation will be put to best use to alleviate the insecurities.

I am pleased that Prof. Abhijit Sen, Member (Agriculture), Planning Commission, is fortunately with us at this moment. Under his leadership, the Planning Commission has decided to give high priority to the alleviation of undernutrition, and nutrition has been identified as a development priority in the XII Plan.

Policy makers and scientists must greatly appreciate that there are strong linkages among education, agriculture, health, sanitation & hygiene, drinking water and nutrition and their synergies should be shaped accordingly. The Hon'ble Prime Minister had observed that "these sectors can no longer work in isolation of each other and should: start a multi-sectoral programme for 200 high-burden districts; initiate a nationwide communication campaign against malnutrition; and bring nutrition focus to key programmes of agricultural development, research and development in agriculture, the Public Distribution System, the mid-day meals programme, drinking water, sanitation, health and the latest on the horizon is the Food Security Bill etc.”

With the determined efforts of our able scientists under the outstanding leadership of political leaders like the Hon’ble Chief Minister and the distinguished policy and planning guides like Prof. Abhijit Sen, in partnership with global development partners such as World Bank, I am sure, we will soon succeed in freeing ourselves from the unethical and economic burden of undernutrition.

This is our chance to name the hungry child “Today”. “Tomorrow” is too late. His/her bones and brain are being formed today. Time is not on our side. We must act now.

Thank you.

Science-led Agricultural Transformation for Nutritional Security in Odisha

Hon'ble Chief Minister of Odisha
Sj. Naveen Patnaik

I must express my gratitude to the National Academy of Agricultural Sciences and the organizers for inviting me to this important Agricultural Science Congress and to this very topical session addressing the nutritional security concern. I extend you all a warm welcome.

Agriculture, food and nutritional security, and farmers' welfare are priority concerns of my Government. We recognize that Agriculture, although now contributing only 16% of the overall GDP of the state, accounts for 65% of the employment and is the main anchor of our food and nutritional security, especially for the small and marginal farmers who constitute 83% of the farming community. Therefore, we have been giving high priority to agricultural growth and development, including through the promotion of research, technology, extension, education and appropriate policies. This effort has resulted in achieving highly satisfactory growth rates in agriculture in recent years, sometimes reaching 5-10%. We have also progressed in insulating our agriculture from climate change related risks. I am pleased to mention that during 2012-2013 we are expecting an all-time high production of 9.4 million tonnes of rice. These developments have significantly contributed to the overall GDP growth rate of the state, touching 8-10%. It is gratifying that we could achieve the high development outcomes despite Odisha being highly vulnerable to climate change volatilities and the vast coastal agriculture suffers frequently from storms and cyclones.

Our agricultural strategy and policy stipulates a shift from the present level of subsistence agriculture to a profitable commercial agriculture through enhancing productivity of important crops by increasing seed replacement, availability of quality planting materials, integrated nutrient management, integrated pest management, water management, farm mechanization and technology transfer. We wish to encourage crop substitution particularly in uplands and medium lands, focus on horticultural crops including dry-land horticulture, promote poultry, dairy and fisheries to augment the income and nutrition of the farmers, and to encourage modern farming system approach. We envisage that the enhanced production must be sustainable and eco-friendly. Thus, we continue to strive to enhance water conservation and use efficiency, soil conservation and biodiversity conservation through peoples' participation. Further, integrated watershed development programmes will be strengthened.

The Government is keen to increase quality investment in the agriculture sector and is facilitating increased long term investment in the sector (on farm as well as off farm) both by private sector, public sector and private & public partnership (PPP), particularly for post harvest management, marketing, agro processing and value addition, etc. Market information and farmer-market linkages will further be strengthened. Institutional efforts are being augmented to increase access to credit for small and marginal farmers. Moreover, additional appropriate institutions / facilities are underway to undertake regulatory, enforcement and quality assurance activities matching to the emergent needs. We shall be vigorously promoting innovations and shall redefine the roles and responsibilities of the agricultural extension machinery by suitably restructuring the field extension set up and the entire research-technology-education-extension-farmer-market chain.

The above efforts are duly reflected in significant reductions in poverty in different regions and social groups, thus promoting an inclusive growth. The Government's integrated approach involving irrigation, access to finance with low interest, providing quality inputs and creating marketing facilities has paid dividend through enhanced production of food grains and horticultural and agro-processed products. Notwithstanding the problems of physical, economic and social access to nutritional security, the successful operation of the PDS, the thrust on *Bijli*, *Sarak* and *Pani*, the special focus on *Mamata Yojana* for pregnant mothers and mid-day meal programme for school children in the State have yielded excellent results. The scientific community is urged to concentrate on the development of crop and fruit varieties rich in vitamins and minerals, with special emphasis on quality rice, quality protein maize, pulses and oilseeds and to ensure nutrition from both plant and animal products, especially for small and marginal farmers through adopting integrated farming system. Alongwith, secondary agriculture to strengthen the prevention of post-harvest losses, value-addition, and nutritional enrichment of food deserves greater attention.

Once again a hearty welcome to each one of you, and I wish the Congress a great success.

Jai Hind

Participants at the Congress

Technical Session 1

Towards Excellence in Agricultural Education: Selected Global Experiences

Technical Session 1, Chair Prof. K.V. Raman

Excellence in Agricultural Education: Indian Experience

Arvind Kumar, Kusumakar Sharma and Meenakshi Arya

In India, extensive spread of agricultural universities and colleges has opened opportunities for higher agricultural education throughout the country and has paid rich dividends because of integration of education, research and extension education. Although routine agricultural subjects dominate total admissions, agricultural education is being revamped in favour of sustainable natural resource management, biotechnology, information technology, bioinformatics, food processing, value-addition, agri-business management etc. Inadequate availability of competent faculty and infrastructure facilities are, however, major constraints to promote a culture of innovations and of resolving problems. Falling faculty strength affects adversely composition of cadre distribution. The ICAR has taken a major initiative to develop and strengthen agricultural education across rural-urban conglomerates and sexes through series of endeavours to meet growing requirement of people, who can bring best of science.

Present Scenario of Agricultural Education

Emerging expectations

Agricultural education needs to be harmonized with existing and emerging issues related to the WTO and free market economies. Worldwide, agriculture is becoming competitive price-wise and its produce quality-wise. Price and brand equity have become more prominent than before. The entire system will have to gear up to take full advantage of new cutting-edge technologies (*biotechnology, nanotechnology, precision agriculture and information and communication technology*), legal aspects, good practices of trade, ethics of IPR and GMO, market intelligence and modern information and communication techniques and global efforts for climate resilience agriculture to promote efficiency, awareness, equity, competitiveness and sustainability in agriculture. The gains in income will also have to be accrued from post-harvest management, value-addition and marketing. Therefore, the future approach to education will need to focus on generating new human resource, who will be equipped with modern developments in science and technology and will be responsive to stakeholder demands and needs, clients' perspective, peer concerns and market vibes. Though the opportunities are vast and so are the challenges. Given the investment required, it is expected that the needed transformation will be ensured for overall growth of agriculture and allied sectors by firming up linkages and partnerships among SAUs and other public and private sector institutions.

Alarming demand–supply gap

According to a recent study of human capital requirements conducted by the National Academy of Agricultural Research Management, Hyderabad, there are substantial gaps between the demand (2020) and supply (2010) of manpower in agriculture and allied sciences to the tune of 50%. The shortfall will be high in the case of rapidly growing sectors such as horticulture, dairy, veterinary and fisheries. During the last decade, outturn of graduates and above grew at the rate of 5% and in the coming decade it is projected to grow at twice the growth observed in the last decade to meet the demand.

The NAARM study also indicates that demand for agricultural human resources has shifted from public to private sector (Rama Rao *et al.*, 2011). The share of various segments by employment during 2010 is: 33% in government, 44% in private, 10% in financial, 4% in research and academic and 9 % in others (Figure 1). The major shifts are due to freezing employment in government and expansion of opportunities in the private sector, and emergence of commercialization and diversification. Agriculture education has to meet societal needs at various levels. It has to serve the requirements of the industries as well as of farmers to ensure food security. Appropriate policy interventions for developing skills needed as per market indicators should be given a serious thought along with a revamp in educational expansion and its structure. The existing educational facilities at their current levels of output will not be able to cope with the demand pressure likely to emerge in the next decade, and substantial step-up is required to reduce current and future demand-supply gap. Although there has been some acceleration in the outturn of high-level agricultural manpower in

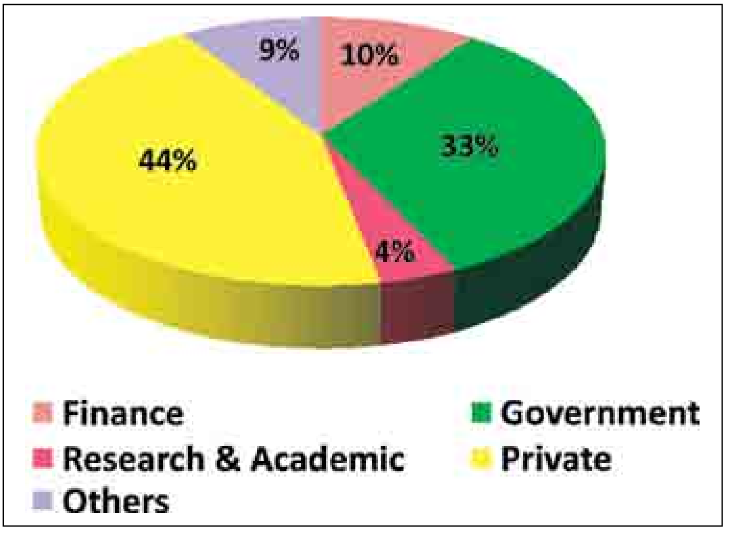


Figure 1. Pattern of Agriculture Human Resources Deployment

Source: NAARM & IAMR, 2011 Study

recent years, stronger policy initiatives are imperative to attain desired growth to make a dent on the seriousness of the problem.

Challenges and issues

Some of the challenges include declining quality of students admitted to agricultural universities, rising unemployment and employability among graduates, a general lack of manpower in frontier areas of science and technology, slow expansion, urban bias and brain drain, inadequate hands-on skills/experience for the multiple disciplines within the profession, lack of research exposure, diminishing core of universities, depleted faculty strength, funding crunch, limited private sector participation, extensive inbreeding in faculty, lack of modern infrastructure for education and research and rising competitiveness under the globalization. Additionally, regional inequalities in development coupled with rise in natural resource degradation, climate change, increasing population, and opening of global economy have brought affront new daunting challenges. Therefore, it is imperative to restructure agricultural education in a manner to meet the expectations of all stakeholders along with concerns of sustainability and profitability in agriculture. Various initiatives taken in the recent past have led to substantial improvement in the quality of agricultural education.

Policy initiatives for delivery, human resource development, sustainability and excellence

The basic objective in redefining agricultural education in the changing scenario is to promote development and delivery of educational programmes that would enhance employment potential and build-up an easy, accessible and cost-effective knowledge intensive information system. Some of the strategic approaches and strategies initiated by the ICAR aim at modernization of existing educational facilities, promotion of excellence across SAUs in cutting-edge areas of agricultural sciences, HRD for capacity-building in deficient areas of contemporary relevance and anticipated future for enhancing relevance of Agricultural Education, as briefly described below.

Curriculum revision: transition towards Students READY: Agriculture Colleges in the country followed the British educational pattern after independence. But the course content, duration of programme and conventional teaching and evaluation of the students were quite variable between states. In 1952, establishment of the Indian Council of Agricultural Education (ICAE) under the ICAR helped the development of uniform pattern of agricultural education. Establishment of Agricultural Universities since 1960, necessitated revision and remodeling of curriculum into trimester or semester pattern, though some colleges continued with the traditional annual based system of education. The reorganization of ICAR in 1966 enlarged its role to include agricultural education as of the UGC in case of general universities. A full-fledged Division of Agricultural Education under the Deputy Director General (Education) was established in ICAR to provide necessary support and leadership to promote the pace of development. The ICAR constituted first second, third and fourth Deans' Committees sofar in 1966, 1981, 1995 and 2009, respectively, to bring uniformity with respect to academic regulations, duration of degree programme, course credit system of teaching, and updating of course contents from time to time in SAUs. It also recommended guidelines for post-graduate academic programmes and norms of work load for teachers in SAUs. The revised course curricula and syllabi as recommended by IV Deans' Committee constituted by the ICAR have been adopted by all the AUs. The ICAR proposes to further improve curricula to provide students an excellent opportunity to develop analytical and entrepreneurial skills and knowledge and confidence in their ability to design and execute project-work through meaningful hands on experience by recommending a one year composite programme, Rural Entrepreneurship and Awareness Development Yojana (READY). READY will have three components: Experiential Learning (EL), Rural Agricultural Work Experience (RAWE) and In-plant Training/ industrial attachment.

Attracting talents to agricultural education: Highly talented young people from low-income families and also from remote and/or rural areas are not sufficiently motivated for agriculture. To attract young talented students to agriculture and allied streams, ICAR proposes following initiatives.

- A new fellowship scheme ***"Agricultural Sciences Pursuit for Inspired Research Excellence (ASPIRE)"***
- Sandwich/Exchange programmes with Foreign Universities for Masters/Doctoral Programmes and Post Doctoral Fellowships for assured careers
- Broadening scope of NTS also to PG students to promote merit
- RAWE/Inplant Trainings including Internship for Hands on Training
- Better Student Amenities including Counseling, Personality Development and Placement and Examination reforms

Faculty competence improvement: The faculties must understand and be oriented towards research to have a better intellectual framework for problem solving and to challenge unsubstantiated dogma that sometimes creeps into educational process. There is also a need to train faculty in problem based and interactive teaching-learning methodologies to improve instructional delivery. The ICAR has initiated re-orientation of educational programmes through training and faculty development in frontier areas of science and technology along with a provision of visiting Faculty and Adjunct Faculty to fill critical gaps in cutting-edge areas, and excellence-promotion. The ICAR provides strategic support to promote capacity-building of the NARS by:

- Provision of visiting/adjunct faculty
- Development of relevant instructional resources/ E-learning tools
- International fellowships
- Periodic updating of skills and knowledge (CAFT/Summer - Winter Schools)
- Support for participating in professional events

There is a move not only to further strengthen the ongoing programmes but also to initiate innovative steps for infusing excellence in agricultural education, research, and technology output and application. These include:

- ❖ Establishment of National Faculty Development Centre as National Faculty Training Facility at the NAARM for teachers
- ❖ Initiation of Centres of Faculty Development in AUs for institutionalizing processes for mentoring young faculty and prioritizing, planning and identifying institutions for faculty development
- ❖ Initiation of programme for overseas faculty training in cutting edge areas.
- ❖ Faculty exposure to International Conferences/ Symposia
- ❖ Best Teacher Award at AU level
- ❖ Support for participating in professional international events

Addressing faculty shortage: There is an acute shortage of human resource in Colleges of Agriculture and allied sciences all over India. The present strength of teaching faculty put together in all the colleges accounts for only 67% of Professors, 47% of Associate Professors and 52% of Assistant Professors. The present faculty occupancy ratio of 0.40-0.60 is low calling for a better organization of teaching system. It has been observed that at post graduate level the intake per course in veterinary stream is very low as compared to other fields of technical and professional education. Compartmentalisation of research and teaching functions also adds to problem and needs to be addressed. Some of the ICAR initiatives to address this problem include:

- ❖ Initiation of ICAR Emeritus Professor Scheme to utilize talent and services of outstanding superannuated scientists/teachers from the NARS in teaching UG/ PG courses
- ❖ Developing instructional material/ Text Books including e-learning resources for use in the national agricultural education programme and distance education.
- ❖ Strengthening of ICAR Emeritus Scientist Scheme to utilize talent and services of outstanding superannuated scientists for research.
- ❖ Provision of Teaching Associates/Teaching Assistants to attract bright young researchers to teaching and provide a pipeline for recruitment in educational institutes in near future.

- Establishment of Centres of Distance Education to reach the un-reached and technological empowerment of weaker sections for accelerating pace of livestock development.
- Separate Budgetary Provision for Visiting/Adjunct Faculty

Reducing inbreeding and promoting national integration: Regional barriers in admissions and faculty recruitment are perceived as threats to advancement of agricultural education. The structural rigidity of the SAUs also rules out the possibility for inter-segmental mobility with difficulty in moving to other organizations. The following initiatives taken by ICAR have rectified regional barriers to some extent.

- Each year All India Entrance Examination is conducted to fill 15% UG and 25% PG seats in all SAUs/SVUs. Through this examination each year about 1900 students at UG level and about 2400 students at PG level are admitted to different Universities. This has changed cultural life on campuses, brought healthy competition, promoted national integration, leading to improvement in instruction.
- National Talent Scholarships at the UG level awarded to all students who opted to move out of their state of domicile. The scope of NTS may be extended for PG students also to attract talent and promote national integration.
- Award of 475 ICAR-Junior Research Fellowships each year to students on merit for Master's degree course only if they join programme in the University other than from which they obtained UG degree. This has been a major step in reducing inbreeding to a large extent. The number of JRF may be further increased.
- Award of 202 ICAR-Senior Research Fellowships for pursuing Ph.D. degree in Agricultural Universities other than the one that awarded the Master's degree,
- Recruitment at Assistant Professor Level in all SAUs based on NET conducted centrally by Agricultural Scientists Recruitment Board. Proposal to select faculty at the national level to the extent of at least 25% may also go a long way in reducing inbreeding and enhancing faculty competence.
- Provision for visiting faculty/adjunct faculty, and exchange of faculty and students.

The Agricultural Universities in the country need to assume the responsibility of holistic development in their geographical areas by developing teaching and training programmes in all relevant disciplines of agriculture and allied sciences to meet aspirations of the people of the region.

***Promoting education in basic and emerging sciences*:** Education in the less attended areas like basic sciences, bio-diversity, environment, fisheries, post harvest technology, forestry, veterinary sciences etc, and the new areas like nanotechnology, biotechnology, and information technology requiring cutting edge science is being strengthened to meet growing demand of trained human resource. The ICAR has launched a programme to promote Niche Area of Excellence to further enhance capabilities of Deemed Universities and AUs in areas like Hi-tech horticulture, molecular diagnostics of diseases, resource conservation technology, soil and water management, bio-fuels, buffalo genomics, metagenomic analysis of rumen microbes, arsenic management in soils, fin-fish farming, immunodiagnostics, tropical home gardens, nutraceuticals etc.

Regulation of agricultural education: The constitution of India provides statuary authority to regulate higher agricultural education to respective states. Despite the legal handicap, ICAR and SAUs have developed a strong academic link and professional relationship to infuse important reforms in agricultural education. The ICAR has recommended uniform schedule of education in agriculture and allied sciences across the country. The ICAR in partnership of AUs has started process of accreditation of faculties/programmes, constituent colleges and SAUs since 1996 to introduce norms and standards of quality agricultural education and regulate their compliance. SAUs have been offered continued support to this activity; 43 agricultural universities have been accredited.

Centres of excellence: The ICAR Scheme for developing centres of excellence by identifying outstanding scientists as National Professors and National Fellows has been successful for advanced scientific research and in motivating agricultural scientists.

***International agriculture*:** There is an urgent need to reorient academic programmes to meet the emerging global market forces. New courses have been started to address various issues related to world trade, IPR etc. to help improve agriculture based industry and compete in the world market. The ICAR is also building global competence in Indian students and attracting foreign students by providing Overseas Fellowships/Scholarships and International Hostels.

***Modernization of AU farms*:** This new mega programme with a budget outlay of Rs 421.95 crore for three years was started in 2008-09 to provide a one-time grant to all the State Agricultural Universities and Central Universities with Agriculture Faculty. This has led enhancement in quality of education/training/research, promote excellence, and augmented supply of research products (such as seed and bio-agents) with concomitant resource generation.

Manpower planning: Human resource development efforts are being systematically planned and implemented. A greater emphasis is given for training in the frontier areas of agricultural sciences.

Enhanced financial support: Agricultural education was given greater financial support in 11th plan than ever before. The ICAR provides supplementary grant for achieving improvement in

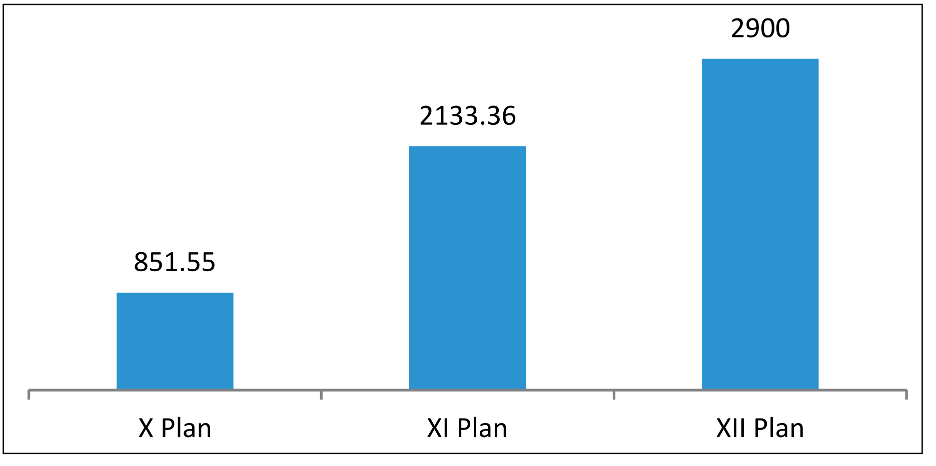


Figure 2. Investment in Agricultural Education in 10th, 11th and 12th Plans

Source: Education Division, ICAR, New Delhi 2014

educational standards in SAUs, besides strengthening libraries, gender mainstreaming including girls' hostel, amenities and facilities for sports and games including gymnasiums. Financial support has been prioritized for modernization of AU Farms.

Education for Agricultural Extension

Great emphasis on congruence among productivity, sustainability, profitability and equity for sustainable agricultural development, which requires a system based approach, is laid for increasing productivity. In spite of this, there has been serious gap in technology transfer even in the case of rice and wheat, as observed by the difference in realized and achievable yield, what to speak of the yield of other crops, in view of mounting demand. The yield gap between demonstrated yield and actual yield achieved on farms ranged 5 % to 100 % in many crops. This shows ineffectiveness of the agricultural extension/transfer of technology programmes. Efforts are on way to improve extension system through improving the knowledge of extension workers through various trainings and repeated demonstrations for sustainable technology improvement on farms and making the inputs available for increasing farm productivity.

Public-Private Partnerships for Innovations in Agricultural Education and Research

Agriculture research and education are key for developing agricultural industries to take advantage of open market. A number of private colleges are coming forward to impart agricultural education. There is a need for more serious dialogue on entry of private sector to maintain quality in agri-education. While initiatives by private sector are welcome as public sector alone cannot meet the increasing demand of the agri education sector, the public system should support these institutions to ensure quality in education.

Vocational Education

Small and marginal farmers, landless labourers, farm women and school drop outs in villages constitute bulk of the 40 million unemployed or semi employed work force of the country. The absence of well structured vocational programmes have created gap in not only effective transfer of technology from lab to land but also a hindrance in becoming partner in agriculture transformation. Rural youth unable to pursue higher education, school and college drop outs, women in agriculture who have no facilities of higher education can easily be trained and oriented towards agriculture vocation. This will lead to total transformation in rural areas. At lower level the requirements are at operational level i.e. persons with specific skills who can be termed as ***bare foot technicians***. In general, self-employment generating areas are applications of advances in technology like genetically improved seeds, modern agricultural practices including micro-irrigation, plasticulture, nursery, organic and inorganic fertilizer production, post harvest technology, testing of agricultural produce, soil, water, fertilizer, waste and waste water analysis, biofertilizers, pesticide, veterinary services, livestock production, fishery production, agro ecotourism, environmental impact methods and analysis, renewable and non-renewable energy, bio-technology, marketing, etc. Knowledge in weather forecast, water management, satellite imagery, commercial information, market information, Govt schemes, policy on agriculture and agri-business can be made available through agri-clinics, agri-business centres, bio-technology parks, food processing parks, veterinary pharmaceuticals, computer aided rural knowledge centres, testing labs, etc. The skills can be developed through a variety of approaches like providing diploma level courses, vocational education and training and finishing school training. Skill development can also be had under ***Skill Development Initiative Scheme*** based on Modular Employable Skills initiated by government of India. Initiatives for the future demand-driven growth in agricultural education at the diploma and undergraduate levels should be left to the private sector or should be taken in a PPP mode, subject to quality assurance systems being in place.

ICT for Net Working, e-Courses and Distance Education

Wireless digital transfer of information has made access to necessary information independent of time and place. The IT revolution can provide many technological tools like CD-ROM's on multimedia PCs, distance education through e-courses, automation of libraries, net working of institutes and sharing of resources and information for education delivery. The ICAR has initiated through mission-mode consortia approach-based project on e-course development under the NAIP in different streams of agriculture in the NARS.

E-courses have been developed for UG programmes in agriculture, agriculture engineering, horticulture, veterinary sciences, fisheries, dairy sciences and home science. The delivery of knowledge in this manner will have a competitive advantage and will allow agriculture and allied colleges to share information, including class material, more efficiently and address some of the constraints in achieving excellence in agriculture education like faculty shortage, content creation, poor teaching quality, and lack of systematic feedback and evaluation. This will enable each college to market specific educational information for students at other colleges or continuing education modules to graduates in agriculture around the world. However, on-line certificate programmes in specific topics need to be developed. By digitizing library, classroom, and laboratory visual images, students can access these materials at any time or place, freeing them from library and classroom schedules. Information technologies provide both horizontal and vertical integration of the professional curriculum, allowing students to explore information to the depth at which they are comfortable and allow students to see future applications of current learning material.

National Agricultural Education Project

The ICAR is proposing to launch a National Agricultural Education Project with the objective to improve and sustain quality of higher agricultural education for addressing emerging challenges for livelihood security and sustainable development with the support of World Bank. The project is likely to introduce desired reforms in Governance of AUs and system's internal efficiency. Besides, it will strengthen institutional development by restructuring and modernization of undergraduate and postgraduate programmes in various specializations, promote academic excellence in critical/ emerging areas at postgraduate and doctoral levels, increase scope and effectiveness of networking with educational institutions and research organizations within India and abroad, and enhance reach and effectiveness of agricultural education to agribusiness, farmers and rural women. Efforts would also be made to increase public-private partnership in agricultural education through the increased role of the private sector in curriculum design, faculty and students development, research and development, institution's governance, and providing a window for direct project support for other specific initiatives.

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The Role of Universities in the Development of Brazilian Agriculture

Erly Cardoso Teixeira, Felippe Clemente, and Marcelo José Braga

Considering the period 1975 to 2011, Gasques and Bastos (2012) found total factor productivity (TFP) average growth rate of Brazil at 3.56% a year. Such growth in agribusiness was strongly linked to research, extension services, and agricultural policy, and to the Brazilian farmer entrepreneurship.

In his work *"Transforming traditional agriculture"*, Schultz (1964) developed a framework to explain hypothesis that farmers are "poor but efficient". He argued that the key to promote growth is to supply farmers with new profitable knowledge-based inputs at fair prices. Schultz (1971) pointed the role of education of rural workers to deal with disequilibrium situation caused by new technologies. Schultz (1964) emphasized two elements to promote agricultural development - human capital and technological development. These ideas were very influential in Brazilian scholars and policy-makers.

Agricultural research was initially carried out in agricultural colleges created in late nineteenth century. According to Sediyama *et al.* (2012), establishment of agricultural schools created a privileged site for construction of scientific and technical knowledge, which was accumulated and applied in agricultural production. Later, that effort was expanded with the creation of research institutes and state and federal research centres.

Universities' Contribution to Human Resource Development

An important contribution from the universities to the development of Brazilian agribusiness has been supplying professionals. In the nineteenth century, according to Sediyama *et al.* (2012), the first Brazilian agricultural schools to confer the title of agronomist were: The Taquariense School of Agronomy, in Rio Grande do Sul, and the Rio de Janeiro Polytechnic School by 1896; the Polytechnic School of São Paulo by 1898; and the Porto Alegre School of Engineering by 1897. The Brazilian agricultural universities were built on solid foundation in the early twentieth century, reflecting experience of the Land-Grant Colleges and the European tradition. The institutions Luiz de Queiroz College School (ESALQ-USP), established in 1901; the Lavras College of Agriculture, today Federal University of Lavras (UFLA), in 1908; and the School of Agriculture and Veterinary Medicine, today Federal University of Vicosa (UFV) founded in 1922 always maintained a high-quality faculty supported by technical research, experiment, teaching and rural extension. The training of the universities faculties in the degrees of Master of Science (M.S.) and Philosopher Doctor (Ph.D.) became faster after the creation of the Coordination for the Improvement of Higher Education Personnel (CAPES) and the National Council for Scientific and Technological Development (CNPq) in 1951. These two institutions granted scholarships for training in Brazil and abroad to strengthen the already existing undergraduate courses and graduate programmes that were created by 1961. CAPES and CNPq were also instrumental in negotiation and financing of various programmes between American and Brazilian universities. Under the programmes came trained teachers, who helped creation of the first Master's programme in economics and also in crop science in Brazil by 1961. The professors, mostly Americans, also collaborated by lecturing, researching and publishing; assisting in assemblage of laboratories and in selection of students to be sent to the best American universities. The presence of American professors strongly affected Brazilian university teaching system.

The main agreement between American and Brazilian universities involved between Purdue University and UFV. It was signed in 1959, and was supported by CAPES, CNPq, Kellogg Foundation and the Ford Foundation (Fernandez, 1991). Under the agreement 200 researchers, technicians and professors from Purdue University came to the UFV from 1959 to 1970. This cooperation strengthened training of Brazilian students abroad. Ninety UFV professors obtained master's and doctoral degrees at Purdue University between 1973 and 1976. Currently, the country has more than 5,000 master (M.Sc.) and Ph.D. (D.Sc.) and professional master (M.Sc.P) programs. In the area of Agricultural Sciences, there are 588 graduate programs. The Agricultural Science graduate programs produced 7,824 theses in the period 2007-2009 (CAPES). Those researches give an idea of the contribution of faculty and graduate students for the development of agriculture in Brazil.

The UFV graduate programmes contributed greatly to train researchers for the national research system, extensionists for the rural extension programmes and professionals for agribusiness chains. These programmes were fundamental for conducting important research work on animal and plant breeding, soils and fertility, and on mechanization. They also promoted creation of products that allowed development of Brazilian agribusiness. University research continues seeking answers to problems such as climate change, control of new pests and diseases, and environmental conservation. Modern techniques such as genetic engineering, molecular markers, genome identification and development of genetically modified organisms and cultures have been explored in laboratories.

Universities' Contribution to Research and Product Development

Soil fertility

Another important research carried out by universities is related to the expansion of agriculture in the cerrado area. The researches that determined the dosages of lime and phosphate for the cerrado soil turned millions of hectares known until the late 1960s as desert areas or savanna into an oasis or the Brazilian breadbasket of 79.0 million hectares in the 1970s (Novais *et al.*, 2007). The Cerrado is the second largest biome in Brazil, which covers 207.0 million hectares and accounts for 24% of the national territory. From this total, 139 million hectares are arable land, but only 79.0 million hectares are currently cultivated. The cultivated savannah area is occupied with 54.0 million hectares of pastures, 21.6 million hectares of crops, and 3.4 million hectares of reforested areas (EMBRAPA). A field experiment, involving fertilization in the cerrado region soils, was conducted in early 1900. This research confirmed that the cerrado soil is very productive when properly fertilized (Novais *et al.*, 2007).

In 1970, the Department of Soil Science at North Carolina State University, U.S.A., started the Tropical Soils Research Project in Latin America. The Project objectives were to analyze and interpret the published literature and other sources of information related to soil factors that affected crop production in tropical Latin America. Researchers at the newly established Centre for Agricultural Research in the Cerrado (CPAC) in close collaboration with researchers from Cornell University and North Carolina State University, U.S.A. developed research on various aspects of fertility in cerrado soils in 1970 (Novais *et al.*, 2007). Table 1 shows the contribution of the cerrado area for domestic production in 2007.

Table 1. The cerrado area participation in domestic production - 2007

Crop	**%**
Cotton	89.0
Coffee	48.0
Sugarcane	10.0
Beef	55.0
Beans	30.0
Corn	26.0
Soybean	63.5
Sorghum	81.0

Source: Faleiro and Sousa (2007).

Hybrid corn

An important outcome of the research carried out in universities already emerged in the 1930s. It was the development of the first strains of hybrid corn by Brazilian researchers Carlos Arnaldo Krugg at the Campinas Agronomic Institute (IAC) in 1932, and Antonio Secundino de São José Araújo, Diogo Alves de Mello and Gladstone de Almeida Drummond, at UFV in 1935 (Coelho, 1992). Hybrid maize soon became the most cultivated corn seed in the country. At some extent, the adoption process was due to the extension service, but most of it resulted from the Agroceres[1] company, created by Secundino Araújo and collaborators in 1945, which marketed the hybrid corn throughout the country[2]. Brazil was the second

[1]Agroceres became the largest enterprise producing hybrid corn and vegetables seeds in the country. This company was acquired by Monsanto in 1999.

[2]Corn production reached 72.8 million tons in 2012.

country to develop hybrid maize and adopt it in commercial crops. Universities have recently developed corn hybrids, including UFVM 100, UFVM 200, UFLA JM100, UENF 01 and 14. Nowadays, these cultivars developed at universities represent only 2% of the corn planted in the country. Reduced participation of universities in the market is mainly explained by the fact that multinational companies are developing their own new cultivars (Sediyama *et al.*, 2012).

Coffee

The high rates of return on investments in research and rural extension in the coffee plantation in Minas Gerais in the period 1970 to 1990 are presented in Ferreira (1993). Research on coffee was conducted by the Federal University of Lavras, Federal University of Vicosa, Brazilian Coffee Institute (IBC) and Minas Gerais Agricultural Research Corporation (Epamig). The extension service was conducted by IBC and by Minas Gerais Technical Assistance and Rural Extension Company (MG-Emater). The internal rate of return obtained was 82% or 108% depending on whether the benefits began in 1973 or 1975. The technology developed by these researches and spread out by the extension service allowed the expansion of Brazilian coffee production from 20 million bags (sixty kilogram bag) in 1960 to the current 50 million bags. Coffee yield rose from 10 bags (sixty kilograms bag) per hectare to more than 20 bags per hectare in Minas Gerais (Coffee, 2007). Research and extension also turned the state of Minas Gerais into the largest coffee producer in the country, with over 50% of the national production.

Soybean

Research universities also contributed to the development of soybean varieties. The first experience with soybeans in Brazil occured in 1882 in the state of Bahia. In São Paulo, the first soybean varieties were introduced by IAC in 1889 under the coordination of Franz W. Dafert (Sediyama *et al.*, 2012). The UFV soybean breeding program started in 1963, through a partnership with Purdue University (USA) and the American researchers Marvin L. Sweatingin and Kirk L. Athow, aiming to develop varieties adapted to the cerrado areas, located in the central areas of Brazil. At that time several varieties of soybeans from the southern region of the United States were brought to UFV. However, the soybean photoperiod sensitivity produced very short plants that could not be harvested mechanically. After a series of experiments two lineages stood out: Mineira and Viçoja released in 1969 by Professor Tuneo Sediyama. Those varieties were indicated for soils naturally fertile or corrected. After that, more than 2,000 hybridizations were performed, always searching for features like productivity, adaptation to mechanical harvesting, good seed quality, uniform ripening, high oil and protein content, and resistance to pests and diseases. In the 1980s, the UFV included in its research agenda the development of a soybean variety appropriate for human consumption. Tests were conducted to increase protein and oil content and eliminate anti-nutritional factors. In 2000, two other soybean research programs were created; one for the production of biodiesel and the other, for feed. In 2011, the UFV held 58 soybean cultivars bred in the institution, and 33 of these were registered and protected by the National Plant Variety Protection Service (SNPC) (Sediyama *et al.*, 2012). The cultivars developed at UFV have contributed to increased productivity and quality of soybeans in Brazil, Bolivia, Paraguay and several countries in Central America. Currently, the national average soybean yield is 3,106 kg / ha. Research on soybean generated varieties that are cultivated from the temperate regions in Southern Brazil, at -33rd degrees of latitude, up to the Northern Brazil, where the equator line passes (Sediyama *et al.*, 2012).

Eucalyptus

Eucalyptus was introduced in Brazil in 1868. The researcher Edmundo Navarro de Andrade, considered a pioneer in reforestation in the country, started his research with eucalyptus in Paulista Company of Railroads by 1903. In the 1950s, eucalyptus trees were planted to provide raw material for the supply of pulp and paper mills. By late 1970s and early 1980s, leading universities and research institutes developed eucalyptus cloning technique that reached commercial scale. Thus, since 1990, Brazil has become a global benchmark in eucalyptus plantations. According to Abraf (2007), eucalyptus plantations occupy more than 3 million hectares and account for 3.5% of Brazil's GDP. The export of products derived from planted forests totalled US$ 6.1 billion, 70% of which was from eucalyptus. Due to the importance of the sector, research institutes aimed to develop new varieties adapted to different soils and climatic conditions, adding traits of economic and social interest, such as increased productivity and greater regional adaptability, resistance to some diseases and pests and tolerance to stress conditions. Those genetically improved varieties possess productivity tenfold higher than in countries such as Finland, Portugal and the United States (Abraf, 2007). Some forestry companies produced an average of 20 m^3/ha/year in the 1970s. Today, they can produce up to 50 m^3/ha/year using improved genetic material and available technologies. Eucalyptus trees provide hardwood pulp exported to the whole international market for the production of printing and writing paper. Eucalyptus pulp is the alternative to softwood pulp from European pine trees, which reach the cutoff point in 30 years, a period four times longer than that of the Brazilian eucalyptus. Figure 1 shows eucalyptus productivity in different producing countries.

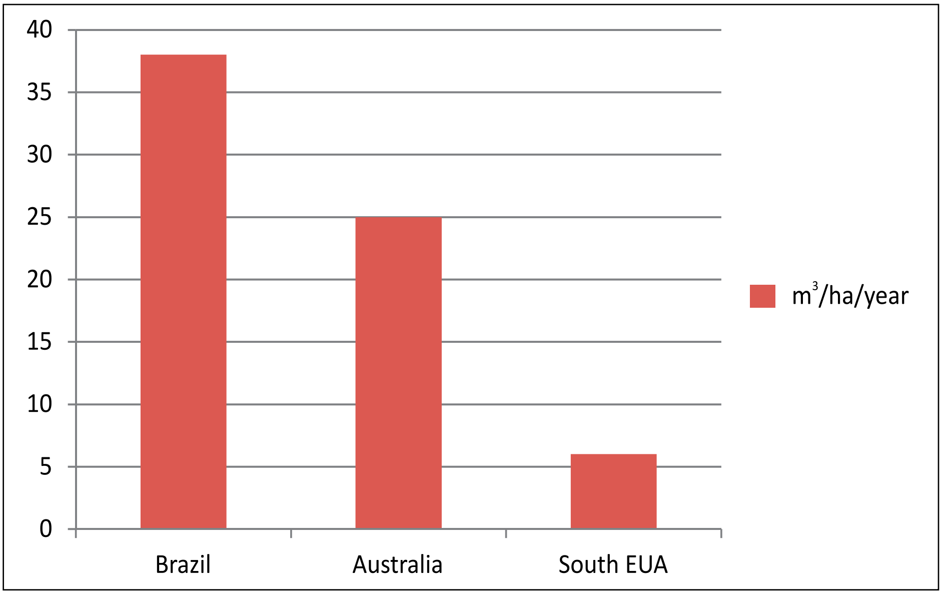

Figure 1. Eucalyptus yield in Brazil, Australia and in the U.S

Source: Abraf (2006).

Current university research works on eucalyptus encompass genomic sequencing to biological pests and diseases control by the use of molecular markers; and from genetic breeding for production of desirable traits to the production of genetically modified organisms.

Sugarcane

Research on sugarcane has been developed by the University Network for the Development of the Sector - Ridesa, which involves 10 Federal Universities. The network was created in 1990 and is formed by the Federal University of Alagoas (UFAL), Pernambuco (UFRPE), São Carlos

(UFSCAR), Rio de Janeiro (UFRJ) and Vicosa (UFV). In 1992, the Federal University of Paraná (UFPR) and Federal University of Sergipe (UFS) joined the network. In 2003, the University of Goiás (UFG) entered the network and in 2008, the University of Mato Grosso (UFMT) and Piauí (UFPI) were also included. Ridesa involves several public-private partnerships for the development of cultivars. Since its inception, the network has developed 59 sugarcane varieties that account for 59% of the cultivated area in Brazil. In the last five years, 286 agronomists were trained through the program to work in the industry. Since 2007, Ridesa has graduated 35 M.S., 24 Ph.D. and 7 postdocs who developed research with genetically modified sugarcane (Sediyama *et al.*, 2012).

Broiler

Research on genetics and breeding of broiler in Brazil started in the 1950s. The Ministry of Agriculture recommended ESALQ to begin research on genetic breeding of laying hens and broilers (Costa, 1997). In 1975, the UFV started to develop research on this area. These two institutions had agreements with private companies for the development of basic research to obtain chicken lineages for the production of meat and eggs. In 1979, the Institute of Zoology of New Odessa - SP developed a plan to obtain commercial lineages of laying hens by genetic improvement of commercial strains. In the 1980s, the Federal University of Santa Maria (UFSM) in Rio Grande do Sul started to develop strains of laying hens that could produce red eggs. Also, the researchers were looking for a strain of dual ability, that is, a chicken that could produce eggs and meat (Costa, 1997). Those researches resulted in the increase in the most important technological indicators in poultry production. Table 2 reports on the progress of feed conversion and slaughter age.

Another important result of research for the poultry industry refers to the number of broiler housed per m^2. In the 1970s it was possible to house up to 10 broilers per m^2 while since the 1990s, the intensive production process accommodates up to 20 broilers per m^2.

Beef cattle[3]

In the early twentieth century, the Brazilian scientific community began

[3]All the information on beef cattle that is not referenced in the text was kindly offered by Professor Mário Fonseca Paulino, Animal Science Department, Federal University of Vicosa.

Table 2. Evolution of poultry production in Brazil

Year	Live Weight (kg)	Feed Conversion	Slaughter Age
1930	1.500	3.50	15 weeks
1940	1.550	3.00	14 weeks
1950	1.580	2.50	10 weeks
1960	1.600	2.25	8 weeks
1970	1.700	2.15	7 weeks
1980	1.800	2.05	8 weeks
1984	1.860	2.00	47 day
1988	1.940	2.00	47 day
1994	2.050	1.98	45 day
1998	2.150	1.95	45 day
2000	2.250	1.88	43 day
2004	2.390	1.83	43 day
2009	2.440	1.76	41 day
2011*	2.730	1.74	41 day

Source: Brazilian Board of Aviculture Annual Report (UBA, 2009)
**Based on data from the Brazilian tables for poultry and swine 2011.*

its efforts to provide the country with the necessary means to improve bovine genetics. The government was responsible for the structuring of experimental stations intended for selection activity. In the 1940s, after the initial work of assessment and biological characterization, research work started to be performed for the development of a national race. This race should ally the greatest production potential observed in the European cattle and the rusticity and adaptability of zebu breeds imported from India. Researchers decided to use the zebu cattle because it produces a soft beef whose fat content can be defined by costumers, since fat is outside the beef and can be removed. In early 1950, at the Experimental Station of São José do Rio Preto, research started using Nellore breed, an Indian race. At that time, an experimental station was created in Ribeirão Preto for the selection of a breed called Gir, another zebu breed imported from India. At the end of that decade, another experimental station called Experiment and Creation Cattle Farm was established in Uberaba, MG. These stations were pioneers in the genetic improvement of zebu cattle in Brazil (Euclides Filho, 2009).

Brazilian beef cattle industry is based on three pillars: zebu cattle, Brachiaria grass and multiple supplements; all three elements were the subject of great research effort by universities. Zebu cattle was subjected to intense genetic breeding process, which has allowed animals fed grass and multiple supplements to be slaughtered in commercial properties, weighing 480 kilograms at 20 months of age. In the 1970s, it took between 36 and 48 months for an animal to achieve the same weight, that is, twice as long, to go to slaughter. Nowadays, 41.2 million cattle are slaughtered every year in Brazil. Only 7% of these slaughtered cattle come from feedlots (Anualpec 2012). The development of breeding bulls merit indicators for desired traits and the technique of fixed time artificial insemination were very important for the genetic breeding of livestock under field condition.

The introduction of Brachiaria grasses of African origin in Brazil, in the late 1970s, was very important to reduce seasonality in cattle production. Brachiaria grasses also allowed the incorporation of the Cerrado area as grassland. Currently, there are 54.0 million hectares of high quality savanna grasslands (EMBRAPA).

In the area of animal nutrition, the research effort of the Agricultural Research Corporation of Minas Gerais (Epamig) and universities were essential for the development of multiple Supplements in the 1980s. This supplement provides the nutrients missing in pastures and allows herds to gain weight continuously basis throughout the year. Besides, it allowed slaughter rate to increase from 16.0% in 1970 to 22.2% presently (Anualpec, 2012). Preventive veterinary medicine against FMD and brucellosis contributes greatly to the quality of the beef produced.

Conclusion

The universities most important contribution for the development of Brazilian agriculture was the training of high quality professionals in order to meet the demand from the research and extension institutions, from the agricultural schools, and from the agribusiness chains. Universities could fulfill this role supported by the solid foundations established by the competence and idealism of their faculties, by the funding agencies CAPES and CNPq, and by the agreements signed with foreign universities.

The contribution of universities to agricultural research has been of great relevance in the areas of plant and animal breeding, pest and disease control, soil fertility, genomic sequencing, precision agriculture, development of genetically modified organisms and crops, and product development. Some of the activities benefited by research carried out by universities involve the production of corn, soybeans, coffee, sugarcane, eucalyptus, broiler and beef cattle.

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Agricultural Education in China[1]

Ren Wang and Entao Wang

Introduction

China is a leading agricultural nation with promising agricultural education. Since the founding of the People's Republic of China, various agricultural institutions have trained more than 1.6 million graduates above college level for the modern agricultural development and new rural construction.

Agricultural education is an important part of China's education system, and plays an indispensable role in economic and social development. The Country's agricultural education has developed rapidly since the reform and opening-up, and has made steady progress especially in the past 10 years.

Features of China's Agricultural Education

- Multi-levels (Ph.D, Master, Bachelor, Junior College Student, Secondary Vocational School Student)
- Multi-types (full-time programs, part-time programs for Veterinary Medicine Master and Master of Agriculture Extension)
- Multi-channels (Universities, colleges and research institutes)

The executive bodies of China's agricultural education include:

- Universities and junior colleges
- Scientific research institutes
- Joint programs offered by universities and research institutes for graduates

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[1]Full text of the presentation was not available. The rich and important information contained in the power point presentation is contained in an abridged version in this chapter.

- ❖ Linkages among agricultural education, research and extension are strong and productive, as summarised below:
- ❖ Agricultural education, research and extension are promoting each other mutually.
- ❖ Agricultural education is serving agricultural research and extension institutions.
- ❖ Agricultural research and extension institutions are advancing the agricultural education development.
- ❖ The graduate and post-graduate students actively participate in extension activities.

Higher education institutions in China are getting increasingly involved in training agricultural professionals. As seen from Figure 1, increasing number of higher agricultural education institutions are awarding Ph.D. and Master degrees. Interestingly, rapidly increasing number of higher education institutions are offering Bachelor degrees.

In 2011, over 90,000 graduate students were registered. Of these, 20,000 were Ph.D. candidates and 70,000 Masters candidates. Whereas 580,000 were registered as undergraduates and junior college students (Figure 2).

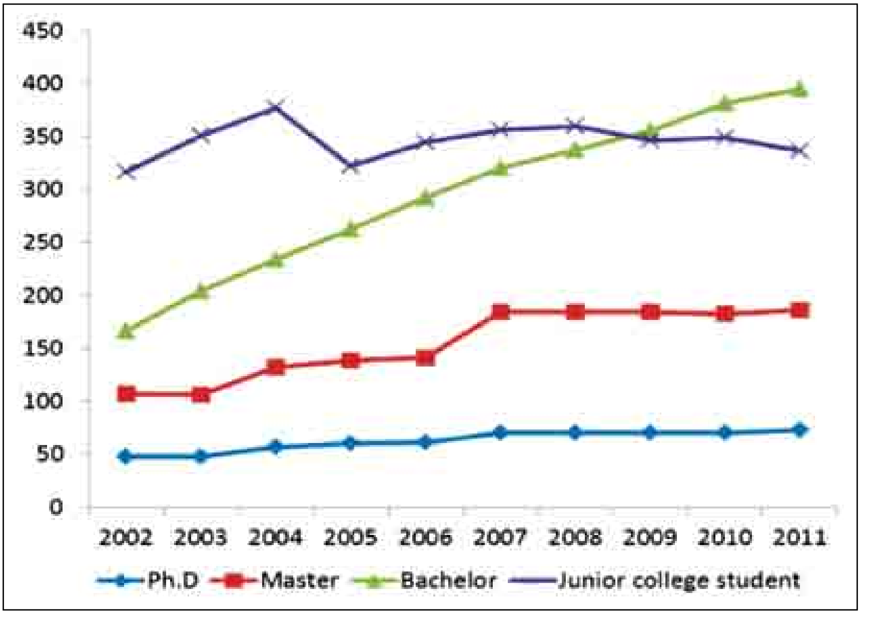

Figure 1. Number of higher agricultural education institutions, 2002-2011

Source: Ministry of Education

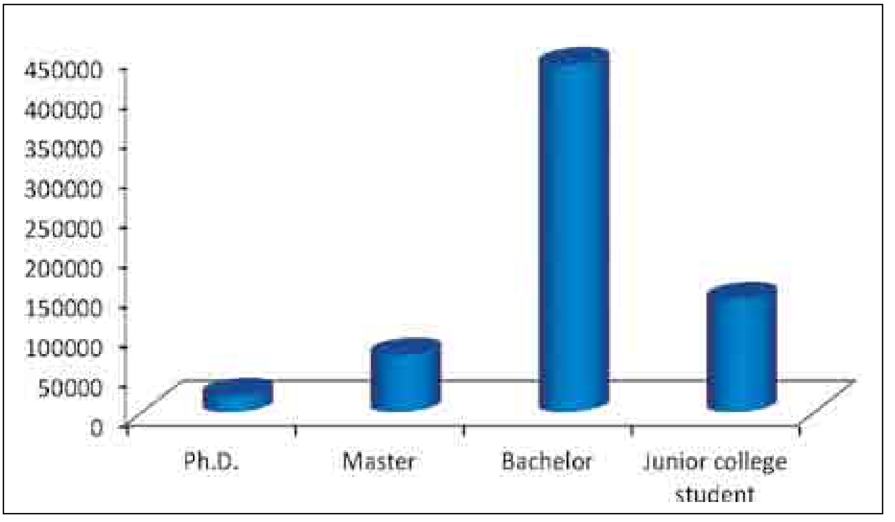

Figure 2. Number of registered students at higher agricultural institutions, 2011

The annual enrollment of graduate students has been stable – 5,000 Ph.D. candidates and more than 20,000 Master candidates. However, there has been continued increase in enrolment at Bachelor level (Figure 3).

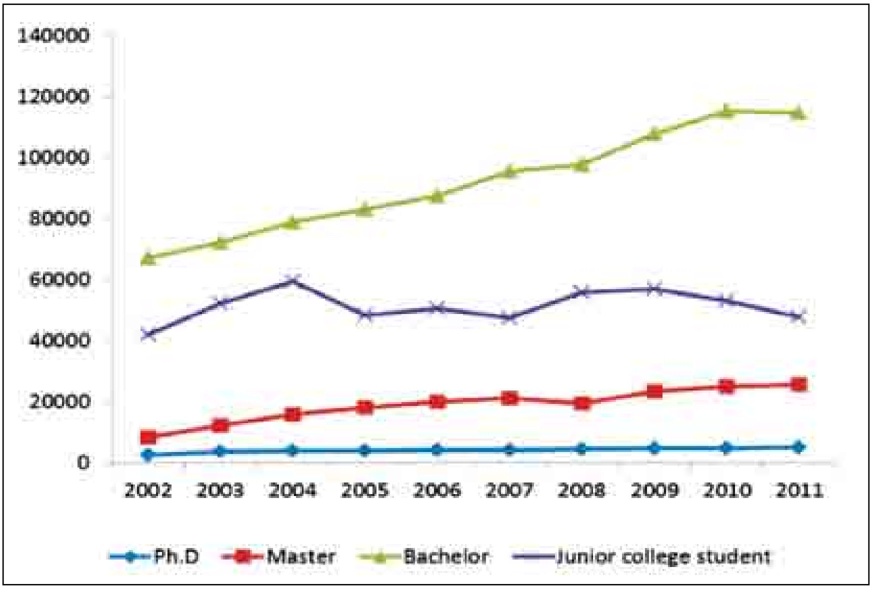

Figure 3. Enrollment in higher agricultural institutions, 2002-2011

Universities are playing a pivotal role in training agricultural graduates, and only small percentage is being trained in research institutes. Nearly 92 % of the enrolled Ph.D. candidates in 2011 came from universities, and 8% from research institutes. Likewise, 90.8% of the enrolled Master candidates in 2011 came from universities, 3.6% from research institutes, and 5.6% from junior colleges (Figure 4).

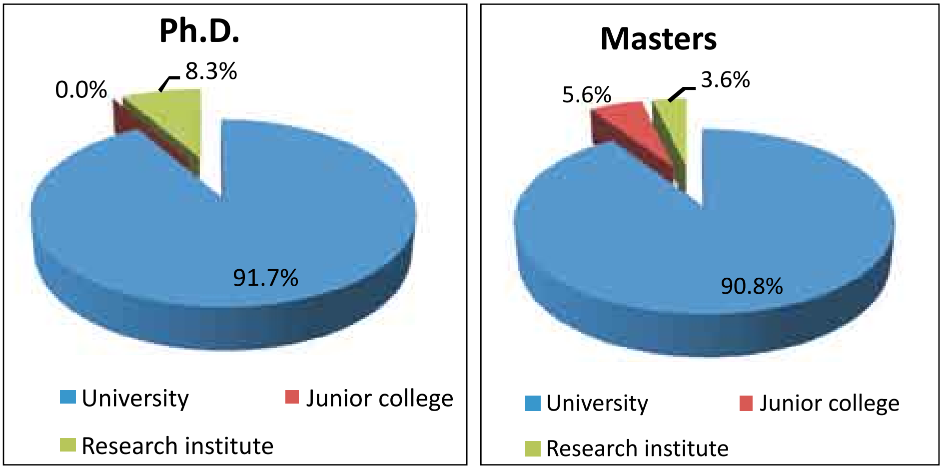

Figure 4. Distribution Ph.D. and Master degree training in universities and research institutes, 2011

Undergraduate training is mainly in universities, while junior colleges are playing a major role in training agricultural junior college students.

68.1% of the enrolled undergraduates in 2011 came from universities, and 31.9% from junior colleges (Figure 5a).

95.7% of the enrolled junior college students in 2011 came from junior colleges, and 4.3% from universities (Figure 5b).

Role of the central and local governments in building the human resource capital were complementarily differentiated.

Ph.D. training was mainly in institutions affiliated to central government ministries; while M.Sc. training was mainly in institutions affiliated to local governments.

62.2% of the enrolled agricultural Ph.D. candidates in 2011 came from institutions affiliated to the Ministries, and 37.8% from institutions affiliated to local governments (Figure 6a).

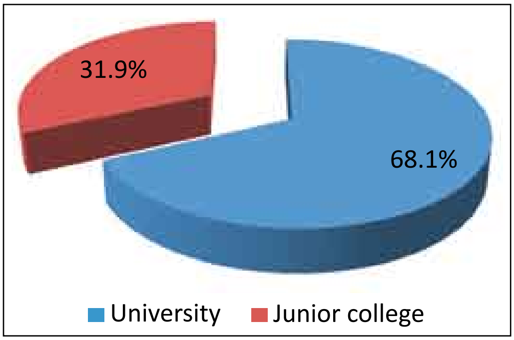

Figure 5a. Distribution of undergraduate training, 2011

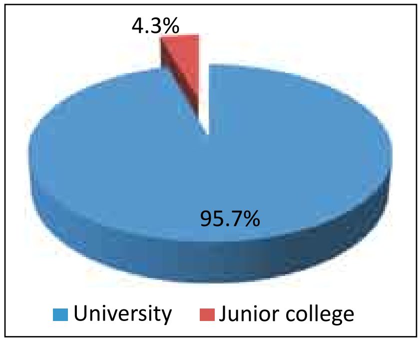

Figure 5b. Distribution of Junior college students training, 2011

Figure 5. Role of universities and Junior colleges in training undergraduate, 2011

62.7% of the enrolled agricultural M.Sc. candidates in 2011 came from institutions affiliated to local governments, and 37.3% from institutions affiliated to the Ministries (Figure 6b).

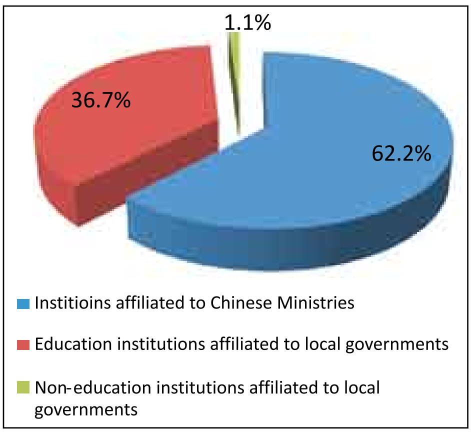

Figure 6a. The affiliated institutions of agricultural Ph.D candidates in 2011

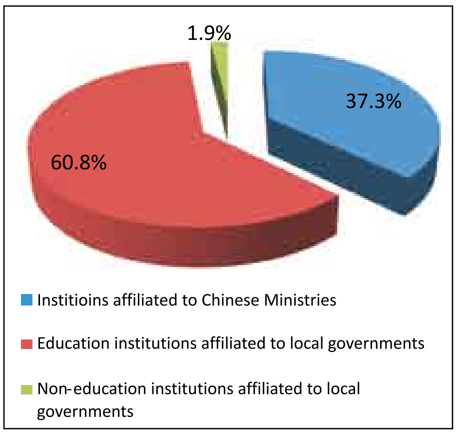

Figure 6b. The affiliated institutions of agricultural Masters candidates in 2011

Figure 6. Role of the Central and Local Governments in post-graduate trainings, 2011

Undergraduate training was mainly in institutions affiliated to local governments, with small percentage in institutions affiliated to the Central government ministries.

84.4% of the enrolled agricultural undergraduates in 2011 came from institutions affiliated to local governments, and 13.6% from institutions affiliated to the Ministries (Figure 7a).

All agricultural junior college students were trained by the institutions affiliated to local governments (Figure 7b).

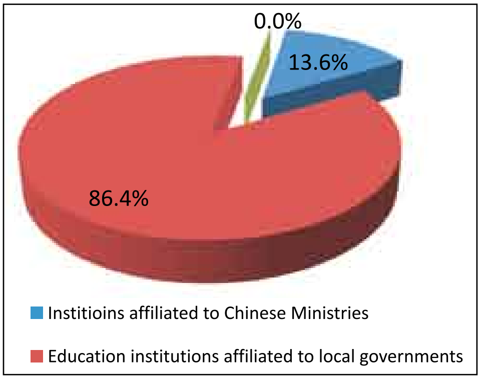

Figure 7a. Affiliations of agricultural undergraduate training, 2011

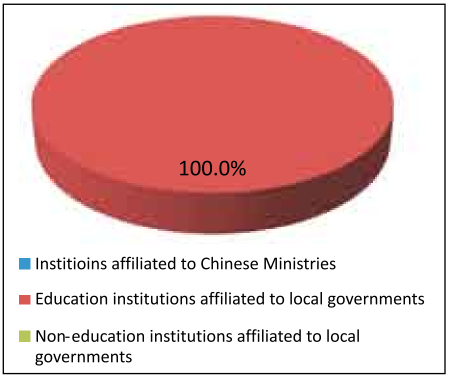

Figure 7b. The affiliations of agricultural junior college student training, 2011

Figure 7. Roles of institutions affiliated to Chinese Ministries and local government in training undergraduates, 2011

Employability of the Chinese graduates and postgraduates is rather high. 54.7% of the Ph.D. graduates were employed in education and 17.4% were employed in research institutes (Figure 8a). Employment distribution of M.Sc. graduates has diversified; 30.4% were employed in enterprises, 15.9% in education and 15.4% went for further study (Figure 8b).

B.Scs and junior college degree holders comprised the backbone of the agriculture-based enterprises in China (Figures 9). 40.2% of agricultural undergraduates (B.Scs) were employed in enterprises and 26.2% went for further study (Figure 9a). 71.8% of agricultural junior college students were employed in enterprises (Figure 9b).

Level of the employers and scope of employment for post-graduate degree holders was effectively differentiated (Figure 10). Ph.D. graduates were mainly employed at provincial, municipal and national level institutions with 61.9% in provincial institutions (Figure 10a). M.Sc. graduates were mainly employed at provincial and

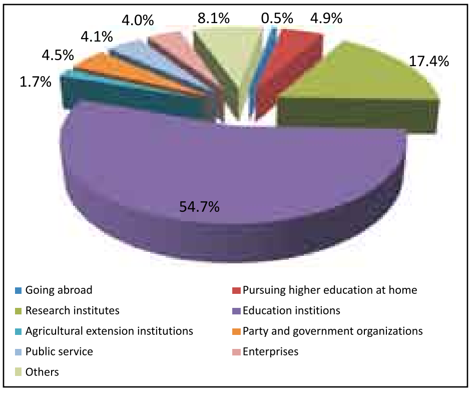

Figure 8a. Employment distribution of Ph.D. graduates, 2011

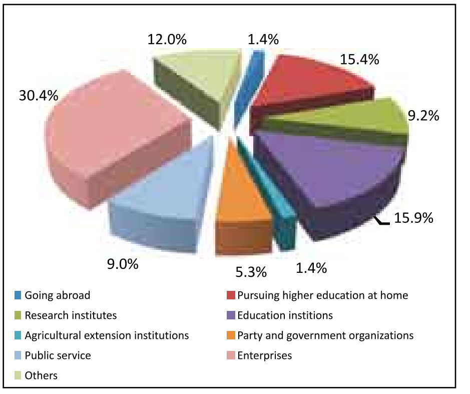

Figure 8b. Employment distribution of M.Sc. graduates, 2011

Figure 8. Employment pattern of the Ph.Ds and M.Scs, 2011

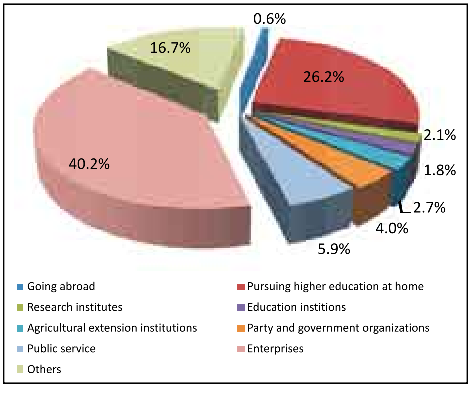

Figure 9a. Employment distribution of B.Sc. Degree holders in 2011

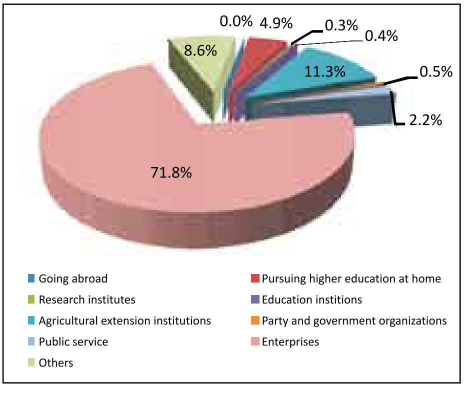

Figure 9b. Employment distribution of junior college graduates in 2011

Figure 9. Employment pattern of the B.Scs and Junior college degree holders, 2011

municipal level institutions, with 51.7% in municipal institutions (Figure 10b).

As regards B.Sc. and junior college degree holders, 55.1% of B.Sc. agricultural undergraduates were employed in municipal institutions; and others in national, provincial and county level institutions (Figure 11a). Majority of the agricultural junior college passouts were employed in county level institutions or enterprises (Figure 11b).

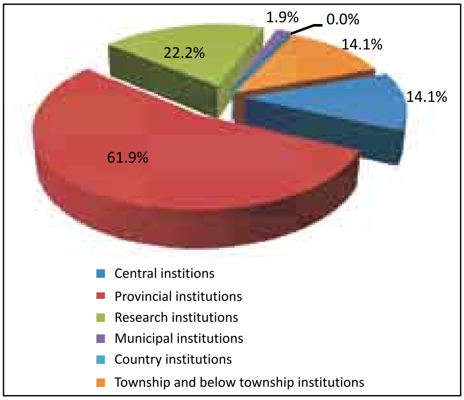

Figure 10a. Employment of Ph.D. graduates in 2011

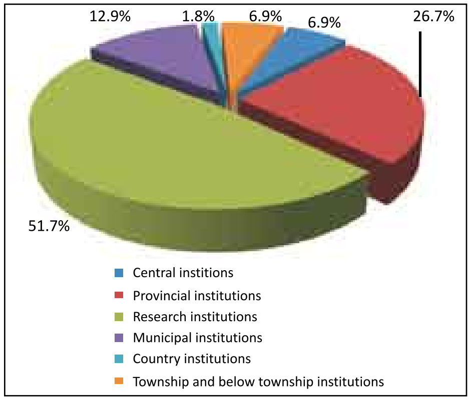

Figure 10b. Employment of M.Sc. graduates in 2011

Figure 10. The employment pattern of the Ph.Ds and M.Scs, 2011

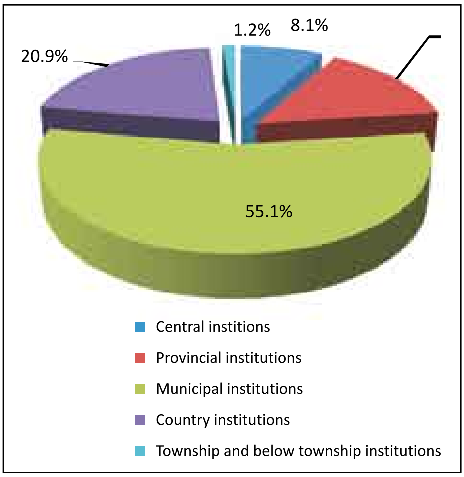

Figure 11a. Level of employment of Undergraduates in 2011

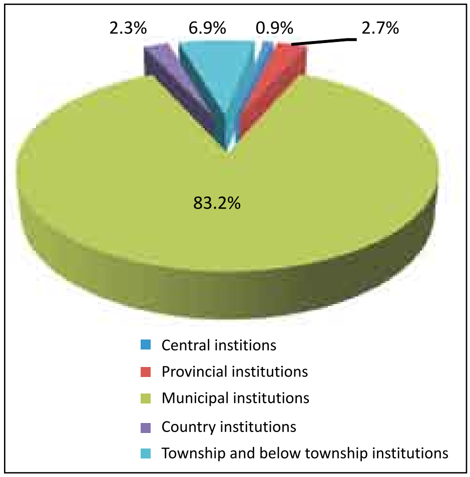

Figure 11b. Level of employment of agricultural junior college students in 2011

Figure 11. Level of employment of undergraduate degree holders

In order to support the vast and fast expanding agricultural enterprises, China has developed comprehensive secondary vocational agricultural education. Although the number of secondary vocational agricultural institutions declined from 2012 in 2003 to 1719 in 2008, it increased to 2065 in 2009 and to 2886 in 2010, an increase of 43% between 2003 and 2010 (Figure 12).

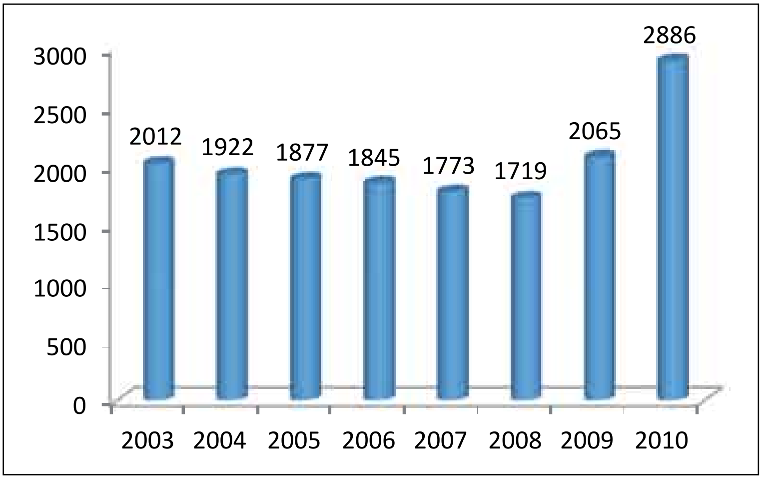

Figure 12. Number of secondary vocational agricultural institutions (2003-2010)

With the enrollment expansion, number of registered students in vocational courses approached 2 million in 2010 (Figure 13), the burst taking place in 2009-2010. The number of graduates of secondary vocational agricultural education had also increased rapidly.

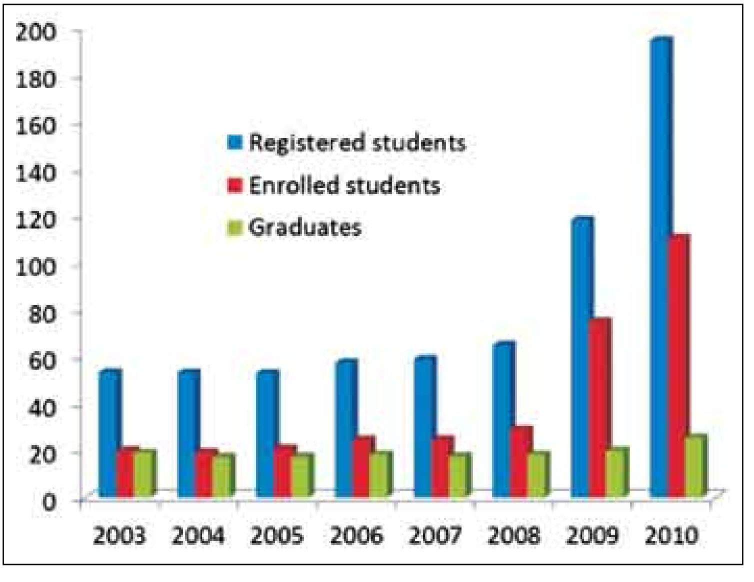

Figure 13. Number of registered students, enrolled students and graduates of secondary vocational agricultural institutions, 2003-2010

Conclusions

Agricultural education in China has made considerable progress in the past 10 years.

The number of higher agricultural institutions for graduates has increased, so is the number of the graduates.

The number of higher agricultural education institutions for undergraduates and junior college students has increased steadily, so is the student number.

Universities are playing a major role in training agricultural graduates and undergraduates, while junior colleges are playing a major role in training agricultural junior college students.

The employment distribution of higher agricultural graduates is getting diversified, and a large part of agricultural graduates get employed in enterprises.

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Higher Education in Agriculture - The French System

Philippe Choquet

The French Higher Education system was inherited from history with a dual system--universities mainly focusing on liberal arts, laws, science for academic purposes, and medical curricula and gather a total of about 60 % of the students, and *"Grandes Ecoles"*, part of a high-level system set up by Napoleon and based on a very strong selection in the recruitment process; gathering around 30 % of the student population and benefit from very strong tights with industries and corporate sector.

The *Grandes Ecoles* are small to medium size institutions (average size of 600-800 students), thus enabling a high quality and personalized education for the students. These institutions generally benefit from a solid financial and administrative backing. They reflect an education based on two imperatives: careful selection of applicants through a highly competitive entrance examination and training of those students to reach an individual level of excellence corresponding to demands of the business sector. These institutions are education-driven, but do not stop them to have many academic and applied research activities. This pedagogy is very focused during the first three years on basic sciences, and then is more oriented towards applied science and technology at the Master's level. This broad theoretical knowledge combined with practical training make *Grandes Ecoles* students particularly adaptable beyond their field of specialization. Students are continuously supervised and assessed to maintain low failure and low dropout rates.

The *Grandes Ecoles* deliver post-graduate level degrees and are accredited by the French Ministry of Education and the French Ministry of Agriculture.

Secondly, France has a dual system in research, split between universities – *Grandes Ecoles* and research institutes (for example:

CNRS INRA INSERM…etc.) The first group of institutions is more focused on academic research, whereas research institutes are generally concentrating their efforts on fundamental research. With regard to agronomy, all research is concentrated in the agrarian *Grandes Ecoles* and the INRA institute.

In France Higher Education in Agriculture is delivered through 19 *Grandes Ecoles*, with an average size of 800 students (Figure 1). Technical agriculture is taught through 850 technical colleges of agriculture, specialized on professional training.

Example of agriculture: a split organization

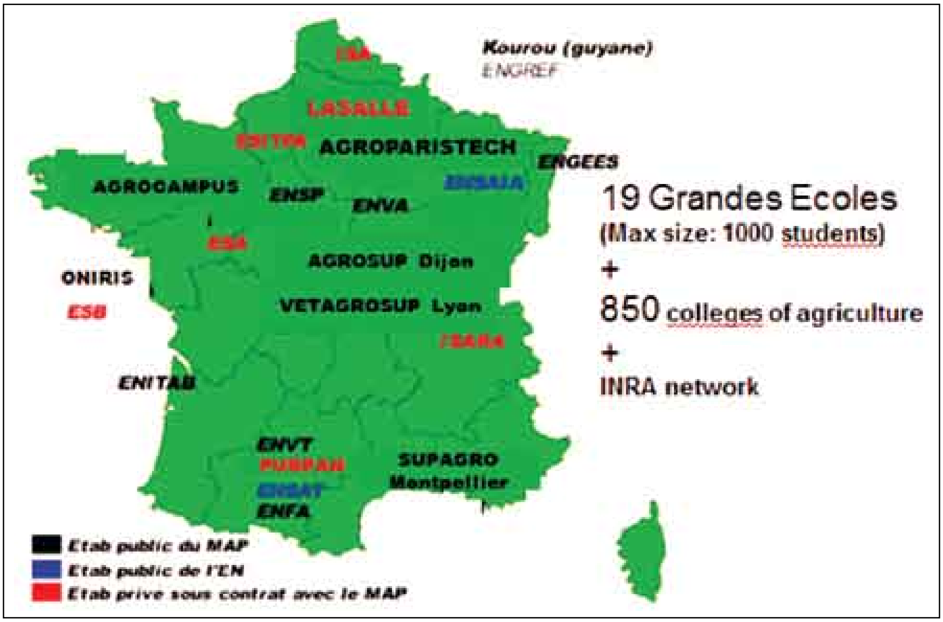

Figure 1. Higher education in France

Source: LaSalle Beauvais

The agricultural *Grandes Ecoles* are themselves divided in

- Fully public institutions (10 schools, among them AGROPARISTECH)
- Semi-public institutions based which are granted official recognition of their mission through public grants (7 schools among them Institut Polytechnique LASALLE Beauvais).

In the recent years, this educational system has been facing an increasing competition of stronger higher education institutions at the European level and they thus had to reorganize themselves to adapt to this new environment.

Consequently, if we consider the weaknesses of the French system, they could be listed as:

- split research capacities in terms of infrastructures and human resources
- the risks implied by a silos approach
- the evident lack of international visibility, linked to the small size of the Grandes Ecoles
- a high level of structural cost.

To balance these weaknesses, these institutions have remarkable following strengths that bring competitive advantage to their students, and which are valuable enough to highlight.

- A high academic level based on the strong selection of students and leading to constitution of homogeneous groups at the M.Sc. level
- An integrative and generalist approach in their scientific training at the graduate level after which the students can specialize. This T shape in educational programmes enables to break silos approach.
- Very strong connections with the corporate sector, and especially with the industries. This connection enables institutions to constantly update their programmes to meet needs of stakeholders and also ensure best placement of the graduates.
- This of course implies also some flexibility and reactivity of the G*randes Ecoles*, placing innovation at the core of their strategy in a changing context.

Employment surveys regularly demonstrate that the graduates from *Grandes Ecoles* get the easiest access to qualified jobs with best salaries: typically, about 70% of them get a job contract in the same time as they graduate. Most of the managing directors and the chief executives of the 100 biggest French Companies are graduates of *Grandes Ecoles*.

French Higher Education in Agriculture System

French *Grandes Ecoles* are currently entering a phase of reorganization to keep above described strengths, and to limit their weaknesses.

Thus they are generally endorsing a growth strategy raising the number of students or through mergers. Ten years ago, for example, there were 26 *Grandes Ecoles* in agriculture; at present, only 19 remain.

Building strategic alliances also reinforces competitive advantage and leads to greater economies of scales. Those alliances can be in education or in research (e.g. with Research institutes), can be thematic or multidisciplinary, can be local (with other H.E. institution) or global in thematic networks (Consortia).

LaSalle Beauvais, a French *Grande Ecole*

This was founded in 1854, and is located at about 70 kilometers from Paris. This graduate school is accredited by the Commission of Engineers Degrees[1]. LaSalle Beauvais offers a very strong background in science to its students for the first 3 years as well as training experiences of 10 months before they reach at the M.Sc. level. At this level, LaSalle Beauvais has an academic offer in 18 specializations, to which one can add possibilities offered by double diplomas agreements and international partnerships.

From the year 2000 to 2013, LaSalle Beauvais has raised its number of students from 600 to 1700. This significant raise was achieved through internal growth (diversifying the programmes towards Food & Health, Environment) and merging with a school of geology in 2005. LaSalle Beauvais, being an agricultural school enlarged its academic offer becoming an Earth and Life Science centre of excellence.

Curricula development: LaSalle Beauvais has organized its curricula placing real emphasis on the links with the corporate sector: internships must be done by students every year, with a greater level of responsibility to undertake from year to year. This progressive approach aims at professionalizing them and at helping them to gain maturity. There are following advantages.

- ❖ For the students, as they bring them a wide range of experience, which enrich their curriculum, enlarge their knowledge of business, help them in the choice of their orientation, as well as increase considerably their immediate employability (at the last graduation ceremony in LASALLE, last January, 11th, 70% of the students were soon employed by companies)

[1]CTI : Commission des Titres d'Ingénieur – www.cti-commission.fr

❖ For the university, because through the students making their internships, the institution has thousands of links with companies, their strategic concerns and orientation: a valuable observatory to fit with the demand and adapt curriculum.

The Figures 2 and 3 show that students have a 5 months internship schedule abroad between the 2nd and third year of studies. They can also study or travel abroad between their third, fourth and fifth year of studies.

Another key element of the curricula in lasalle Beauvais is its strong commitment to international exchange: in most programmes, international experience is required through abroad working experience or academic exchange in foreign countries/ or in study abroad programmes. More than any other sector, agriculture is and will be exposed to international exchanges, global challenges: to be international minded is thus and more than ever a key competence that our students must have. In addition, this international exposure strongly develops their adaptability, as well as agility.

Student life at the core of LaSallian pedagogy to develop leadership: To anticipate the coming and changing world, to be

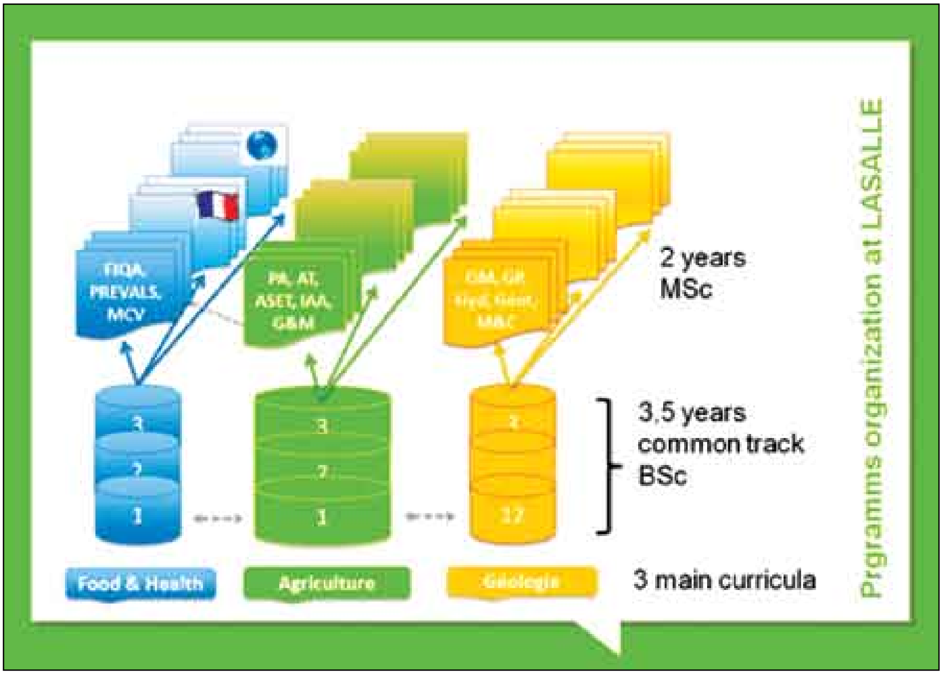

Figure 2. Programmes organization at LASALLE

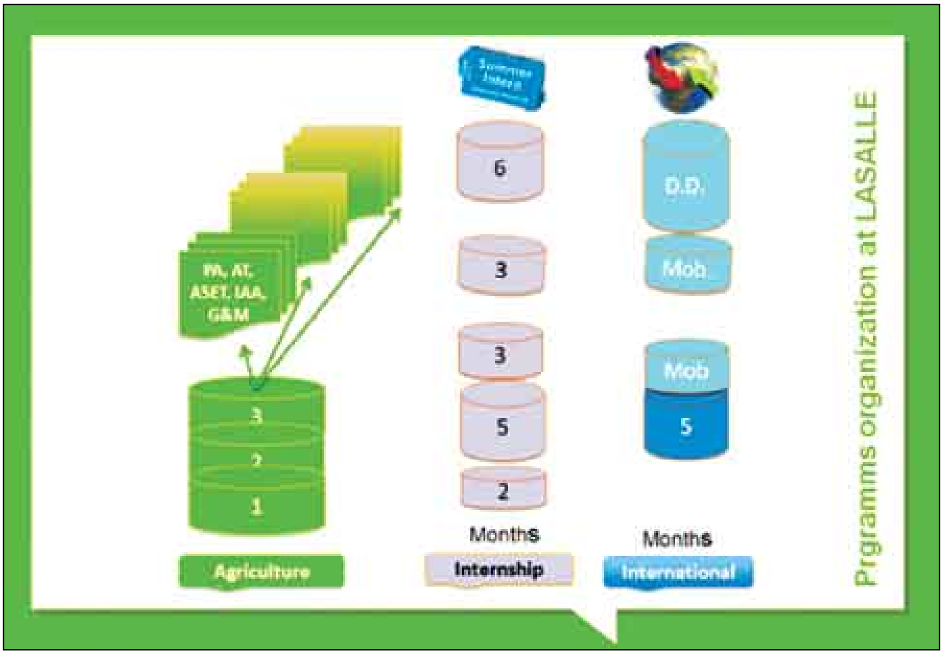

Figure 3. Programmes organization at LASALLE

Source : LaSalle Beauvais

adaptable, to be able to lead changes will require more than scientific capacities, but also strong human skills. The French *Grandes Ecoles*, and especially the agricultural ones, have long been aware of this necessity.

Those human skills are developed through academic programmes, through case studies pedagogy but most of all through very rich associative life which enables students to experiment management, take responsibilities, assume risks, develop their leadership.

LaSalle Beauvais offers a unique possibility for its students to develop such skills by inviting them to live on a single campus. The campus is a space where everyday life becomes an opportunity to discover others and become enriched by them. Living all together, students are called to adapt themselves but are also in a good environment to create, take initiatives and their subsequent responsibilities.

LaSalle Beauvais campus counts for example more than 70 students associations covering a wide range of activities (sports, music, arts in general, charities, social and relief work, technology…etc.)

Strong links with industries: At the academic level, LaSalle Beauvais strives to strengthen links with the corporate sector through following initiatives.

- Lectures delivered by professionals
- Internships
- Research contracts with enterprises
- Inclusion of companies in the governance of the school (Scientific board, Council for curricula improvement, Board of trustees, etc).

Another interesting model illustrating the symbiosis that may be set up between Universities/*Grandes Ecoles* and Industries are the French poles of competitiveness, clusters set up by Sarkozy government to foster economic development through innovation.

The region of Picardie Pole of competitiveness Industry and Agroressources (www.**iarpole**.com*),* to which LaSalle Beauvais is very committed, is a good illustration of this process: they have decided to concentrate all scientific strengths of local stakeholders such as *Grandes écoles*/Universities/Companies dealing with Biorenewables resources in one territory, and doing so by associating researchers of the public and private sector, students, companies... etc. The results have been quite remarkable with research investments and innovative projects totalizing over 1 billion Euros in five years. Thus this pole became the first French cluster in Bio renewable resources and Green chemistry.

Finally, LaSalle Beauvais has set up strategic alliances with local universities and is active member of a wide range of international networks and global consortia such as ICA, IALUand GCHERA, the Global Confederation of Higher Education Associations for the Agricultural and Life Sciences.

LaSalle Beauvais experience calls for an integration of worldwide agricultural universities into a global consortia, namely GCHERA.

Global Consortium of Higher Education and Research in Agriculture (GCHERA)

Higher Education in Agriculture will face big global challenges, which will require capacity of adaptation, agility to reform and change rapidly to adapt to new demands and scientific challenges. In that perspective, more than ever networking and benchmark is required for the benefit of universities as well as of students.

The Global Consortium of Higher Education and Research in Agriculture was set up in 1999, being the first global association of agricultural universities. Its first realization was to organize Global biannual Conferences to provide rectors and deans of Universities with the possibility to share experiences and set-up a network of exchange.

Seven conferences were organized all over the world; the last was organized in France by LASALLE Beauvais in June 2011. To have a wider penetration of GCHERA, contacts were initiated in between with regional or national associations of Universities of Agriculture. At the same time, having a better visibility towards global organizations, the relationship with FAO, GFAR, GFRAS, and the World Bank was developed, GCHERA being the universities' voice in global fora dealing with agriculture.

To reinforce the representativeness of Universities, the GCHERA decided during its General Assembly, held last October 2012, to transform itself into a Global Consortium of Regional Associations of Universities of Agriculture.

GCHERA now gathers some 15 regional associations, of which the Indian Association of Universities of Agriculture, the American APLU, the European ICA, etc., representing some 600 universities in the 5 continents (Figure 4).

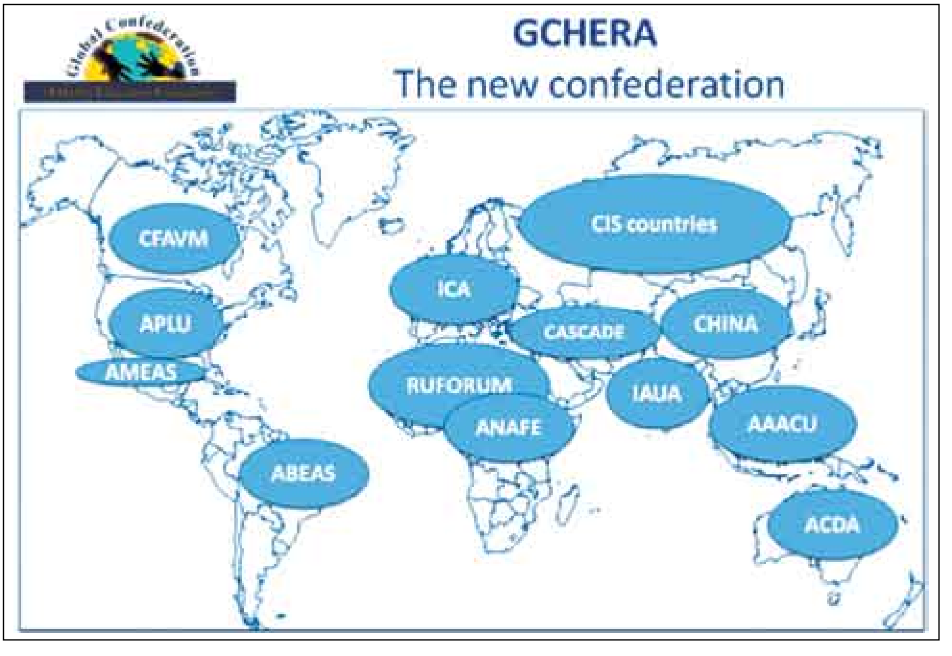

Figure 4. Constituents of GCHERA

Mission

- Encourage mutual understanding and global co-operation among higher education associations and their constituent member institutions in supporting innovation, and to provide within the global context leadership in education, research and outreach in agricultural and life sciences.
- Ensure that the higher education sector contributes to the development of initiatives and action at the global level, addressing global challenges facing agriculture, food and natural resource management systems through its involvement and contribution in global fora.

The difference GCHERA will make

GCHERA will through collaborative ventures between the member higher education associations enhance the success of higher education institutions in delivering graduates which have the skills, entrepreneurship and creativity to succeed in the global, regional and national contexts, enable each higher education association to play an enhanced role at the regional or national level through a shared understanding of the global contexts and innovative approaches in addressing the challenges facing agriculture, food and natural resource management systems (Figure 5).

Figure 5. The potential of GCHERA to play a role in addressing the global agendas

GCHERA agenda 2013

GCHERA will hold its next regional conference in Moscow, Russia from 27 to 28 June 2013 on the theme: "Bringing solution to food security in the face of climate uncertainty".

The first Award Ceremony of the GCHERA World Agricultural Prize to recognize the best Professor in agriculture will be hosted by Nanjing Agricultural University (China) on 20 October 2013.

To tackle the global challenges in agriculture, environment, that our planet will face, more than ever global cooperation is required: let us think global to better act local, to the benefits of our students and to foster agriculture and rural development.

The Role of Agricultural Education in Development: the Japanese Experience and India

Shigemochi Hirashima and Keiji Ehara

The purpose of this paper is to discuss the role of agricultural education in India by reviewing the Japanese experience during pre-war period. The pre-war experience would give more insight into this question, since the position of Japanese agriculture in economic development is comparable to that of contemporary India. In fact, the share of agriculture in terms of GDP and labour force in 1930 was 18.5% and 49.7% respectively, which are quite comparable to the present day in India. (Nakamura, 1993; GOI, 2011)

During the pre-war Japan, the most important concern in agricultural development shared by the government as well as farmers was to enhance land productivity and to reduce productivity gap among farmers and regions. With the meager resource base, labour productivity could be increased only through increased land productivity for majority of the farmers in pre-war Japan; 92.7% of farm households operated on less than 2 hectares in 1931-32 (Hirashima, 1982).

Japanese Agriculture and Technical Education

Reducing inter-farm and inter-regional productivity gap

In Japan there was still a substantial inter-regional productivity gap in mid-1880s. In fact, the productivity gap between the lowest productivity regions (average yield of 5 Prefectures) and the highest ones was around 90% in 1883-86. However, the gap was reduced gradually towards the end of the pre-war period; to 40% in 1935-40 and further to less than 30% in 1952-56 (Imamura, 1977).

As far as inter-farm productivity gap is concerned, the gap started narrowing along with the reduction of inter-regional productivity gap. In fact, towards the end of 1930s, there was little conspicuous difference between owner farmers and tenant farmers of similar operational holdings in terms of land productivity as well as labour input per unit of land (Table 1). Although the data of two different surveys in Table 1 may not be comparable in a strict sense, as smaller farmers had to labour more and got lesser output per unit of land, the difference in either case seems to be marginal to be deterministic about positive or negative relationship between size of operation and productivity. In other words, it can be hypothesized that there was not a conspicuous technology gap between different operational holdings and between different land tenure statuses in Japanese agriculture towards the end of the pre-war period.

Table 1. Labour Input per Hactare and Yield per Hectare by Type of Tenure, Japan, 1933/1942

	Owner farmers				Tenant farmers			
	Sample size (1)	Rice planted area (ha) (2)	Labour input per ha (days/ ha) (3)	Rice yield (ton/ ha) (4)	Sample size (5)	Rice planted area (ha) (6)	Labour input per ha (days/ ha) (7)	Rice yield (ton/ ha) (8)
(1) Production Cost Survey								
1933/37	934	1.55	205	3.68	915	1.45	204	3.61
1938/42	883	1.57	189	3.84	895	1.51	187	3.75
(2) Farm Household Economy Survey								
1933/37	92	0.87	2246*	3.51	90	0.93	2067*	3.57
1938/42**	88	0.95	2002*	3.7	86	0.91	2084*	3.67

*Notes: *:Hours per ha. **:Four-year average.*
Source: ASAE (1974), op. cit. Vol. 4, pp. 98-101; ASAE (1975), op. cit. Vol. 6, pp. 72-85 and RFES (1953), op, cit. pp. 60-78.

Land productivity enhancement and the reduction of inter-regional as well as inter-farm productivity gap in Japanese agriculture can be explained principally by two factors. One is the public investment in irrigation and drainage with the objective of equalizing land productivity across regions and farms. The other is the introduction of diffusion model of agricultural technologies.

Unlike Indian agriculture and village communities, the pre-war Japanese agriculture was rice-based monoculture without depending on hired labour and animal and mechanical power. Introduction of primo-geniture system, in which only the eldest son was entitled to inherit headship and farm land and other assets, enabled to avoid further sub-division and fragmentation of farm land. Moreover, unlike India, under the field-to field irrigation practice, there was no room for each farmer to be independent in terms of cropping pattern. In other words, the technology for rice cultivation tended to become homogeneous at the village level.

Although roughly 60 % of the basic irrigational infrastructure was already completed before the Meiji period, the inter-regional disparity in terms of its availability was still substantial. However, the situation in terms of the proportion of land improved by irrigation and drainage started increasing rapidly in the 1920s onwards initiated by the government with subsidy (Kikuchi and Hayami, 1978). This is evidenced by the sharp increase in the incremental capital-output ratio (ICOR) in agriculture from 1.36 in 1900-20 to 5.00 in 1920-40 (Nakamura, 1980).

Meiji government tried to introduce a variety of agricultural technologies from the West in the 1870s. However, most of the transferred technologies failed to adapt themselves to the Japanese rice farming. In response to this failure, the newly established Ministry of Agriculture and Commerce (1881) drafted two important policy papers; the Strategy for Economic Development in 1884 and the Strategy for Agricultural Development in 1891. In these, formulation of effective mechanism in terms of technology transfer was suggested on the basis of the lessons learnt from the location-specific technologies developed almost independently by the 280 Han or clan territories during the Tokugawa period. Seed Exchange and Information Exchange Meetings were held at local as well as central government level for this purpose. With these information and experiences, the Central Experiment Station Act (1887), Prefectural Experimentation Act (1899) and Farmers' Association Act (1899) and the various Ordinances for the development of Agricultural Technical Schools were passed.

The Central Experiment Station (CES) was assigned to focus on the basic research in which the technologies to be disseminated nationwide were to be identified, while the Prefectural Experiment Stations (PES) on the applied research; in which location-specific technologies were identified and developed. Farmers' Association (FA, later developed to Agricultural Cooperatives during the post-war period) was assigned to channel new ideas and technologies developed by CES, PES and academic institutions to farmers in the regions. FA was also assigned a role as a recipient agent for agricultural policies of the government. FA published journals and provided various facilities to support activities of the PES and Agricultural Schools (AS). It is also important to notice that the graduates of AS of various levels formulated a strong network in the Extension Framework such as FA, CES, PES and even Ministry of Agriculture (Hirashima, 1982).

Development of education in pre-war period

The Meiji Restoration in 1868 was the starting point of Japan as a modern state. In addition to the radical reforms necessary for the modern state, such as freedom of factor mobility, freedom of occupational choice and establishment of private ownership of land, the Meiji government was active to introduce modern technologies and institutions from the advanced Western countries. Therefore, the Meiji government had spent a substantial portion of budget for inviting professionals from the advanced Western countries and for sending capable students abroad.

Ministry of Education was established in 1871, four years after the Meiji Restoration. The new government introduced the Educational System (Gakusei) in 1872 following the systems of the USA and France. School Zones System consisting of primary school, middle school and university was formulated following the French model, but the structure of teaching, including curriculum and textbook, followed the American model. Under the school zone system, the entire country was divided into 8 university zones, and each university zone was sub-divided into 32 middle school zones. Each middle school zone was further sub-divided into 210 zones in which one primary school was to be established. With this zone system, 8 universities, 256 middle schools and 53,670 primary schools were to be established (Jica, 2003).

At the same time, the Meiji government firmly believed the important role to be played by the teacher's training school. In fact, even one year before the Educational System was introduced, Tokyo School of Education was established, and it was further decided by the Educational System that at least one teacher's training school should be established in 8 university zones.

The Educational System initially introduced, however, could not produce the expected outcome. By 1880 only one university instead of 8 initially planned, and 28,410 primary schools instead of 53,760 were established (Jica, 2003). Even though the overall performance was not up to the expectation, it can be appreciated that as many as 28 thousand primary schools and over 70 teachers' training schools were opened within 10 years (Table 2). Yet, the fact remains that the enrollment rate was as low as 50 % and the gender gap was still substantial (Figure 1). The society was not yet ready to foresee the importance of education, in particular the importance of female education and technical education.

Table 2. Development of School System in Pre-war Japan: 1875-1945

	Primary Level			Middle Level				Higher Level			
	Primary	TSS	Middle(M)	Middle(F)	Technical	JTT	High	STS	STT	University	Handicapped
1880	28,410	0	187	0	15	74	0	74	2	1	3
1885	28,283	0	106	9	26	56	1	75	1	2	3
1890	26,017	0	55	31	23	47	7	36	2	1	4
1895	26,631	55	96	15	55	47	7	52	2	1	4
1900	26,857	151	218	52	139	52	7	52	2	2	11
1905	27,407	2,746	271	100	272	66	8	63	3	2	26
1910	25,910	6,111	311	193	481	80	8	79	4	3	49
1915	25,578	8,908	321	366	541	92	8	88	4	4	71
1920	25,639	14,232	368	514	676	94	15	101	4	16	78
1925	25,459	15,316	502	805	797	99	29	135	4	34	113
1930	25,673	15,248	557	975	976	105	32	162	4	46	125
1935	25,799	16,705	557	974	1,253	102	32	177	4	45	140
1940	25,860	20,492	600	1,066	1,479	103	32	193	4	47	141
1945	26,332	15,144	776	1,272	1,743	56	33	309	7	48	136
2004	23,420	0	11,102	*	0	0	**5,429	63	0	709	999
(Private)	187	0	709	*	0	0	1,321	3	0	542	15

Source: Compiled from MOE (1962):Statistical Appendix.
TSS=Technical Supplementary School at primary level
JTT=Junior Teacher's Training School
STS=Senior Technical School
STT=Senior Teacher's Training School
Handicapped=Schools for handicapped children of various typs.

Note for 2004: *included in Middle School, **1,952 Technical Schools at the high school level is included in this fighre.
In addition, to these schools in Japan, there are 508 Two-year Colleges and 3,444 specializing single technical subjects.

It has to be mentioned here that the expenditure on basic education was borne mainly by the local governments (villages, towns and cities) and local people, including villagers. The central government could not play the key role in terms of budget allocation in the initial period because of the heavy burden of foreign experts and Japanese students overseas. Therefore, a sort of demarcation in terms of expenditure sharing was found in the pre-war period; higher education by the central government, middle level education by the Prefecture governments and basic education by the local governments (cities, towns and villages). As a result, the financial burden of the local governments was as high as 79%, while that of the central government was less than 10% in the early period. It was only towards the end of the pre-war period when the burden sharing had become almost equal among three governments (Figure 2).

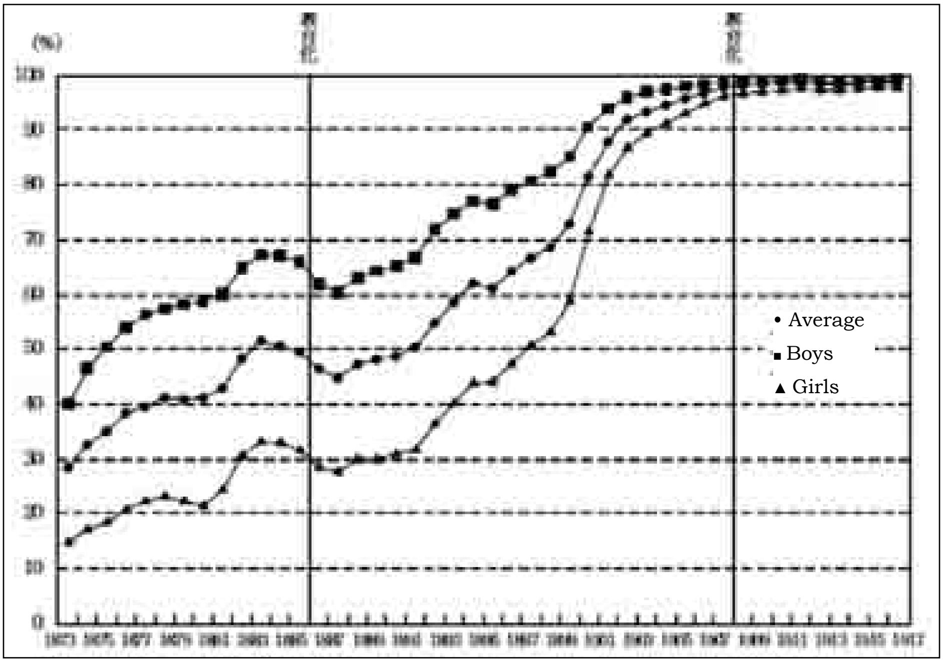

Figure 1. Trend of Enrollment Ratio in Primary School: Japan (1873-1917)

Source: Jica(2003)

The breakthrough of the educational development came when Arinori Mori became the first Minister of Education in 1885. He not only stressed the importance of education as a precondition for economic development, but also of female education, technical education and teacher's training (JICA, 2003). However, the most important contribution made by Mori was the introduction of 4-year compulsory education for the first time in the country in 1886. He should also be noted for the introduction of teachers' training schools whose expenditures were fully covered by the government. It has a significant impact because this provides the opportunities to make a career, together with military, to the children of the poor families.

The development process of educational system in pre-war Japan was a process of trial and error in response to the changing needs of the economy and society. As regards the assessment to the performance of primary education, Japan did achieve almost 100% of enrollment with gender equality by 1910, almost a quarter of century after the introduction of compulsory education system in 1886 (see Figure 1).

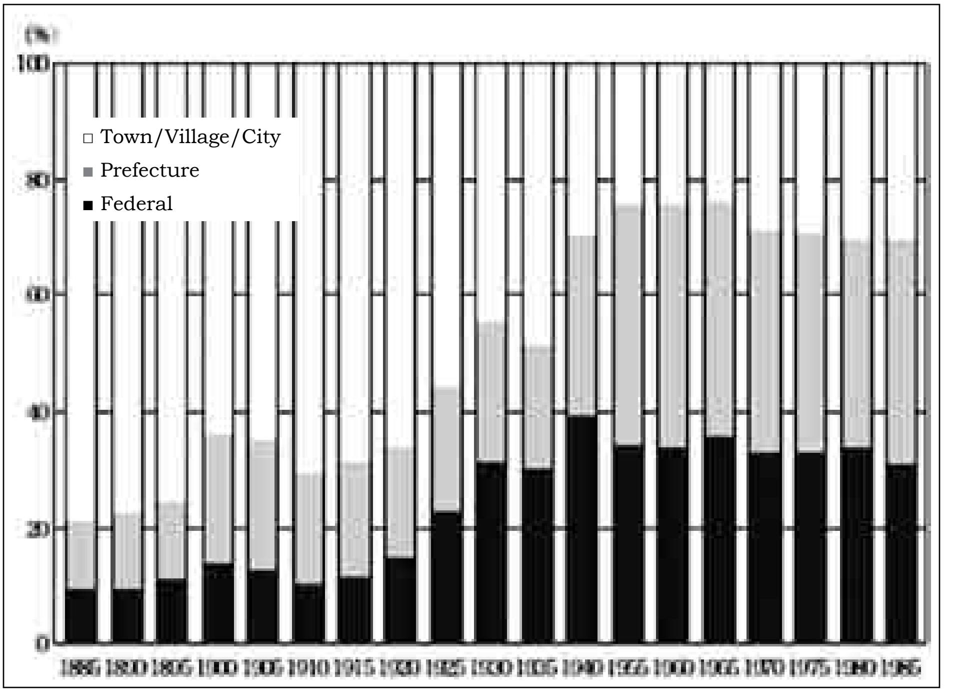

Figure 2. Burden Sharing of Compulsory Education Expenditure: Japan (1885-1985)

Source: Jica(2003)

Development of technical education

The technical education in Japan was to start only after completion of the compulsory education period; from the 5th grade up to 1907 and from the 7th grade up to 1947. It now starts from the 10th grade.

Regarding the present state of Japanese technical education at the high school level in 2011, as Table 3, seen from the proportion of the technical school in terms of number of students was as high as 30 % of the total high schools of 7,000. And even though the proportion of technical schools as well as students specializing in industry and commerce was dominant, there were 322 high schools specializing in agriculture; at least two schools in each Prefecture in Japan.

As mentioned earlier, the necessity of technical education was pointed out in the Educational System as early as in 1872. But, the demand

Table 3. Classification of High Schools in Post-war Japan: 2011

Classification	Schools*	Students	%
Total Schools and Students	6,947	3,340,831	100.0
Normal Schools	3,883	2,416,674	72.3
Technical Schools	2,471	821,039	24.6
(1)Agriculture	322	86,660	2.6
(2)Industry	557	263,856	7.9
(3)Commerce	684	217,172	6.5
(4)Fishery	45	9,556	0.3
(5)Home Economics	291	43,417	1.3
(6)Nursing	98	13,854	0.4
(7)Information	25	2,889	0.1
(8)Welfare Service	105	9,841	0.3
(9)Technical School integrated more than on subjects/courses	344	173,794	5.2
Specialized Technical Schools	593	103,118	3.1

Source:http://www.mext.go.jp/a_menu/shotou/shinkou/genjyo/021201.htm (Accessed in October 10, 2012)

*(1)-(8) teach technical subjects as well as general subjects.

for technical education was not yet strong; the primary concern of the government was still on the establishment of the normal educational system. However, the government had to pay attention to the technical education in response to the growing need of the economy towards the end of the 1890s and it was in the 1899 when the Technical Education Ordinance finalized the official position of the technical education. In this Ordinance, agriculture, industry, commerce, and commercial vessel were recognized as fields of specialization. Fishery was added in 1901.

Tables 4 and 5 show the occupational distribution of students graduated from agricultural middle schools and high schools. The Type A at the middle school level was located at the city where the Prefectural government was located, while the Type B school was located closer to rural area in the same Prefecture. The majority of graduates from the agricultural middle schools of both types remained in farming, but slightly more graduates of Type A took the non-farming jobs (Table 4). On the other hand, about half of the graduates of agricultural schools took the government job and only 8.3 % of them returned to their villages (Table 5).

Table 4. Number of Technical Supplementary Schools in Japan: 1898-

	Total	Agriculture	Industry	Commerce	Fishery	Others
1898	113	62	24	27	0	0
1899	108	62	21	25	0	0
1900	151	73	29	33	15	1
1901	222	123	32	45	20	2
1902	630	480	44	82	23	1
1903	1349	1121	82	109	36	1
1904	1684	1436	82	124	41	1
1905	2746	2450	95	133	67	1
1906	4211	3785	155	167	103	1
1907	4919	4407	227	190	94	1
1908	4751	4185	252	215	97	2
1909	5192	4541	294	230	125	2
1910	6111	4592	161	201	111	1046
1911	6740	5061	167	213	121	1178
1912	7386	5530	199	197	128	1332
1913	8014	6032	174	203	127	1478
1914	8343	6100	170	213	129	1731
1915	8908	6528	168	221	142	1849
1916	9698	7064	161	219	142	2112
1917	10781	7908	133	239	141	2360

Table 5. Pattern of Employment of Agricultural Middle School Graduates for 1935, Japan*

	Type A School				Type B School			
	Male	%	Female	%	Male	%	Female	%
Govt. Offices:								
Agriculture	37,165	18.0	89	0.7	5,289	4.5	123	0.6
Non-agriculture	18,122	8.8	355	3.0	6,258	5.4	379	1.8
Teaching Institutions:								
Agriculture	10,323	5.0	49	0.4	1,540	1.3	23	0.1
Non-agriculture	11,689	5.7	387	3.3	1,627	1.4	237	1.1
Higher education:								
Agriculture	3,404	1.6	90	0.8	1,111	1.0	42	0.2
Non-agriculture	2,729	1.3	137	1.2	269	0.2	114	0.6
Military service	10,225	4.9	0	—	4,816	4.1	0	—
Overseas	8,132	3.9	131	1.1	2,163	1.9	238	1.1
Engaged in:								
Farming	86,353	41.9	8,010	67.4	79,312	68.0	15,024	72.8
Non-farming	13,954	6.8	1,622	13.6	12,131	10.4	3,090	15.0
Others	4,381	2.1	1,021	8.6	2,049	1.8	1,371	6.6
Sub-total	206,677	100.0	11,891	100.0	116,565	100.0	20,641	100.0
Unidentified	4,847	—	242	—	1,797	—	383	—
Dead	18,710	—	385	—	8,147	—	1,137	—
Grand Total	230,234	—	12,518	—	126,509	—	22,161	—
Proportion of those engaged in agr.-related activities		66.5		69.3		74.8		73.7

Source: Calculated from *History of Japanese Agricultural Education*, op. cit.

**Middle school during the pre-war Japan was 5 years duration started from the 7th year of education.*

Development of technical supplementary school (TSS)

The Technical Education Ordinance of 1899 finalized the official position of technical education in the educational system in Japan, where it should start only after the primary school education. However, agricultural education in Japan had already initiated before 1899 at the primary level under the name of Technical Supplementary School (TSS).

The birth of TSS is credited to the strong initiative of the two persons; Arata Hamano, the Rector of the University of Tokyo and Tsuyoshi Inoue, the Minister of Education. Hamano strongly advocated the necessity of establishing TSS following after the German model. In response to his suggestion, Inoue, the Minister of Education passed the TSS Regulation in 1893.

The purpose of the TSS Regulation was to establish such schools in the category of primary school to provide opportunity for the drop-outs and non-school attendants to teach general subjects that could not be completed, thereby fulfilling the credits necessary for the graduation. At the same time, the TSS was a place to teach technical subjects that were helpful in improving the technical level of the jobs they were engaged in at home or elsewhere. Important features of this system can be summarized as follows.

First, throughout the period, agricultural schools had dominated in TSS system, numbering 62 of total of 113 in 1898 and 7908 of 10781 in 1917 (Table 6).

Second, it was flexible to the location/ region specific conditions; agricultural schools opened only during the off-seasons, commercial schools opened at night, and industrial schools opened only in the afternoon.

Third, it was a part-time school in considering the fact that most of the students were from the poor households and were the needy labour force at their homes.

Fourth, it was regarded as a part of the primary education system, since one of the important targets was to achieve 100% enrollment rate of primary education as quickly as possible.

In 1894, the government also introduced the Apprentice School (APS) in response to the growing need of the intermediate technical hands by the modern factories and of rescuing working children from the exploitative traditional apprentice system. Although the APS was

Table 6. Pattern of Employment of Agricultural High School Graduates for 1935, Japan*

	No. of Graduates	%
Government Offices	6,751	50.3
Teaching Institutions:		
Agriculture	1,707	12.7
Non-agriculture	765	5.7
Higher education & military service	310	2.3
Private companies:		
Agriculture	623	4.6
Non-agriculture	1,058	7.9
Engaged in:		
Agriculture	1,160	8.6
Non-agriculture	249	1.9
Overseas:		
Agriculture	162	1.2
Non-agriculture	85	0.6
Unemployed:		
Once employed	201	1.5
Other	237	1.8
Others	111	0.8
Sub-total	13,419	100.0
Unidentified	51	—
Dead	1,705	—
Grand Total	15,175	—

Note: There were fourteen agricultural high schools in 1935, but these statistics relate only to those who graduated from eleven public agricultural high schools.
Source: *Zenkoku Nogyo Gakkocho Kyokai* (Association for Principals of Agricultural Schools in Japan) ed. *Nihon Nogyo Kyoikushi* (*History of Agricultural Education in Japan*), (Tokyo: Nogyo Tosho Kanko, 1941).

**High school in the pre-war Japan was three years of duration from the 11th years of schooling.*

designed to supplement the education at the primary level as in the case of the TSS, it could not attract the needy students as expected because it was not a part-time school and heavily biased toward improving manufacturing technologies.

When the universal education at the primary level was almost achieved towards 1900, the role assigned to the TSS and APS to posit as a part of the primary education system was considered to be over. In response to this situation and the growing needs of the business communities, technical education was shifted up to the middle school level and above by the Technical School Ordinance of 1899 and Senior Technical School Ordinance of 1903. In fact, out of 8,612 business firms in 1902, as many as 84% were set up after 1894 (Sato, 1982).

However, it is interesting to notice that in spite of this policy shift, the TSS and APS continued to survive and did not fade away as envisaged. The TSS survived as parallel with the regular technical school at the middle school level up to the 1930s, and APS survived up to 1920 as a part of the Type B school specializing industry at the middle school level (Sato, 1984).

The brief description made so far on the growth of technical education in pre-war Japan may not be strong enough to argue that it was the technical education at the level lower than the university alone to explain the enhancement of productive capacity at the grass-root level. Yet, it is difficult to deny the important role played by these schools in the framework of technology transfer at the grass root level.

Indian Agriculture in Context of Japanese Experience

Indian agriculture is far more diversified in cropping patterns as compared with Japanese agriculture and more importantly, it is strong against risk and uncertainty due to the unique farm management system known as 'mixed farming,' where the crop sector and the livestock sector are integrated. Yet, despite these advantages, Indian agriculture has to challenge a variety of issues within the policy framework of the Inclusive Growth Strategy in the rapidly growing economic globalization (Hirashima *et al.*, 2011).

The share of the agricultural sector in overall GDP in India has fallen from 30% in 1990-91 to less than 15 % in 2011-12 (GOI, 2011). This in itself has not been considered as a serious issue of development. Rather, it has been regarded as an indicator of industrial as well as economic progress. Yet, it has continuously been the issue of concern for the government because of the so-called surplus labour problem and the persistent poverty and vulnerability in rural India, where the majority of population resides.

The Ministry of Agriculture, in its recent publication, strongly asserts that achieving an 8-9 % rate of growth in overall GDP may not deliver much in terms of poverty reduction unless agriculture grows at least by 4 % per annum (GOI, 2011). This view reflects the fact that the 1 % growth in the agricultural sector is much more effective in reducing poverty than the same percentage growth in the non-agricultural sector on one hand, and the minimum condition for the economy to avoid additional unemployment on the other. In other words, it is the expression of serious concern of the government on the declining trend of employment elasticity in both sectors over time; less than normative rate at 0.5 in most states of India in 1999-2000 (Hirashima, 2008). However, the growth at the rate of 4% with the employment elasticity at 0.5 is the minimum condition to maintain the present level of surplus labour, poverty and vulnerability, not enough to improve the situation. The agricultural sector has to grow more than 4% with employment elasticity at more than 0.5, if the conventional theory of economic progress is valid.

In this context, Indian agriculture recorded the growth rate higher than 4% in the past. However, during the post-reform period (1991-2011), there are 10 years out of 20 in which the growth rate was less than 4% (GOI, 2011-12). Moreover, in these 10 years, 6 years recorded a negative growth rate. It implies that Indian agriculture should grow more than 4% in more stable manner.

In addition to the question of stable growth rate, one has to be concerned with two more issues. One is the growth-poverty linkage and the other is the income-asset disparity.

According to our recent study based on the NSS data, out of 15 states covering 85 % of population in India, we have found out that the poverty ratio has been reduced much faster in the states where the GSDP (GDP at each State) was higher and growing faster. However, it was discovered at the same time that the inter-farm as well as intra-regional disparity in terms of consumption, income and assets increased in the 1990s as compared with the 1980s in those states (Hirashima, 2009). Although we cannot be deterministic as yet, disparity tends to increase when the non-agricultural sector is rapidly growing, while the agricultural sector is decelerating or stagnated. In fact, 11 out of 15 states fell in this pattern during the period between 1980/81-1992/93 and 1993/94-1999/00 (Hirashima, op. cit. Table 2). Even though this finding should not lead to the argument that the growth of the non-agricultural sector should be discouraged; it is clearly suggesting that the stagnant agriculture is counterproductive for inclusive growth strategy.

With respect to the income-asset disparity, the same study confirmed the fact that the disparity in terms of asset was much more conspicuous than income and consumption between the occupational groups (cultivators and non-cultivators), as well as between the social groups (higher castes and lower castes such as

SC, ST and OBC). It clearly suggests that the study on poverty and vulnerability based on the level of consumption and income alone is not sufficient, unless one should look into the question of asset disparity in rural India.

Another question we have to ask is the factors accountable for the lower productivity in India compared to the global average. Let us look into this issue by taking two staple crops, namely, wheat and rice. According to the data in 2008, wheat productivity per hectare was 2802 kg, which was 91% of the global average and 59% of the Chinese average. In the case of rice (paddy), Indian average was 3370 kg which was 78% of the global average and 51% of Chinese average (GOP, 2009-10). Certainly, it is a crude way of comparison and we should be more precise to discuss about low productivity question. We will examine this issue in two other ways.

First is the comparison between the yield at the experiment stations and that of the farmer's field. According to Table 7, the latter was 46% in the case of wheat and 38% in rice. Although the data are outdated already, no similar exercise was attempted afterward. Nevertheless, it could be interpreted that the advanced technologies to double the yield are already available at home.

Second, we know that there is a substantial productivity gap between the states in India. For instance, in the case of 15 major wheat producing states in 2009-10, the yield of Karnataka was 918 kg (the lowest yield state), which was just 21% of the highest yield state, Punjab (4462 kg). Likewise, in case of rice, yield in the lowest yield state (Madhya Pradesh) was 872 kg, which was 22% of the highest yield state (Punjab, 4010 kg) in rice. (GOI, 2011) What would be the major factors accountable for this difference? We try to explain this among others by the difference of irrigation ratio and the proportion

Table 7. Yield Gap of Major Crops of Indian Agriculture, 1985

(Quintal/ha)

	Average yield of farmers (1)	Average yield at agricultural experiment station (2)	Maximum yield at agricultural experiment station (3)	(1)/(2) (%)	(1)/(3) (%)
Wheat	18.36	40.10	63.00	45.80	29.10
Rice	12.30	32.06	75.12	38.40	16.40
Maize	11.02	31.58	63.50	34.90	17.40
Pearl Millet	4.72	26.08	45.00	18.10	10.50
Sorghum	6.63	36.14	62.50	18.30	10.60

Source: Indian Council of Agricultural Research, Project Review, 1985 of small & marginal famers in total farm households. This is to test whether the inverse correlation between the productivity and the scale of farming is observable or not in Indian agriculture. Admitting that the size of observations at the state average level is too small to be deterministic, yet we could argue that the development of irrigation in the lower productivity states is still necessary, particularly for rice cultivation. As for the inverse correlation issue, we could not obtain statistically significant results (Table 8). However, judging from the negative signs we obtained, it is still possible to argue that the productivity is less where the proportion of smaller & marginal farmers is higher. In other words, we could still argue that lower productivity could be overcome in an effort to reduce a gap between the larger farmers and the smaller farmers in terms of the absorptive capacity of new ideas and technology, and the availability of input and other services.

Table 8. Productivity Difference, Land Tenure and Irrigation Ratio in India (2005-06): Rice and Wheat of Major States

	Intercept	Proportion of Small Farmers	Irrigation Ratio	R Squre
< Rice >		−0.45	0.01	0.62
t Value		−0.98	3.97	
< Wheat >		−0.72	0.01	0.38
t Value		−1.11	1.37	

Data: GOI, Indian Agriculture at a Glance, 2011
Number of observation: Rice = 15 States, Wheat = 13 States.

Perspectives for the future

After reviewing the Japanese experience on the role of technical education in agricultural development during the pre-war period, we feel that Indian agriculture has much more room to develop and has much more comparative advantages over Japan.

There are four issues to be taken care of by the government and farming communities. First, irrigation ratio in India is still small and instable, which explains the inter-state variation of productivity. Extra effort has to be paid towards narrowing inter-state productivity gap. Second, in addition to the development of advanced technologies at the graduate level, attention has to be paid to the significance of agricultural technical education at the level lower than college and university. Third, the role of the progressive farmers in the village communities or the role of farmers' organizations (eg kisan sabha) in terms of technology transfer may be encouraged like in pre-war experience in Japan. Fourth, looking from Japanese agriculture, the most important advantage, among others, is the unique system of farm management known as a 'Mixed Farming.' Under this system, the crop sector provides land, water and fodder, the basic inputs for the livestock sector, while the livestock sector provides animal power and farmyard manure to the crop sector. On the other hand, the crop sector provides staples and other food stuff, while the livestock sector provides necessary animal protein in the form of milk, ghee, cheese and butter, in addition to fuel and construction materials for livelihood. Furthermore, the livestock sector provides hedge against risk and uncertainty at the time of crop failure due to drought or flood, for example, by selling dairy products or animal itself. Further, it provides opportunity for female labour force to participate in the production process. The mixed farming system is the most effective system in ensuring food and nutritional securities, as well as a basic social safety net, particularly for the smaller farmers. Since the majority of farm households have maintained the mixed farming system, it can be called a basic institutional as well as productive foundation of rural India. It would be counterproductive, therefore, if the efforts to enhance productivity and to reduce disparity of various kinds be made by the policy direction leading to the disintegration of the foundation and functioning of this system. Productivity and efficiency could be increased by the separation and specialization of the crop and the livestock sectors. However, it may weaken the foundation of the rural society, in which production and livelihood are one and the other side of a coin.

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Change in Knowledge Infrastructure: Experiences of Wageningen University, The Netherlands - a Third Generation University, its Mission and Strategy

Rudy Rabbinge

During the last 150 years, one dominating aspect of Dutch agriculture has been its dynamism and ability to innovate. Both the government and the private sector were convinced that science and technology have a lot to offer in improving agricultural sector's competitive ability. Investments in research, education and valorization of knowledge were promoted, even in periods of crisis. In the nineties, when the diversification of goals for agriculture and a negative public attitude towards it caused enormous challenge for the sector, the government pursued a similar policy. Wageningen UR was founded as one response to those challenges, signalling a renewed major investment in the knowledge infrastructure. The ambition to pursue its new course is strongly present in Wageningen, where the emphasis in the renewed university structure lies in extended public-private cooperation to promote and fund the desired dynamism and innovation.

The reformulated mission, the role that the university plays in education, research and, last but not least, utilization of that knowledge, was made possible by merging the university, research institutes and experimental stations. The character of this new, third generation university is different from its predecessors. It is a university where the hierarchical structure, present in the medieval and Humboldt University, has been replaced by a network structure where excellence and authority prevail. Direct government influence is limited, the orientation on science for impact determines attitude of all scientists and there is a willingness to accept that graduate schools have the right to exclude non-performing professors. The strength of a third generation university is determined by three widely accepted characteristics - the first is the internal coherence which comes as a result of the generally accepted vision and mission of the university; the second is the flexibility, but nonetheless stability of the institution's finances and; finally the willingness and ability to work with partners from very varied backgrounds.

Wageningen University can be seen as one of the first university that has made the change and reflects these characteristics. Wageningen University and Research Centre adopted this strategy about 10 years ago, and the results are visible in scientific output, growing graduate students (M.Sc. and Ph.D.) numbers, its sound financial structure and close ties with partners within the Netherlands and a growing network outside the Netherlands.

Agricultural Policies in Times of Crisis

When steamships made possible bulk transport of agricultural produce, cheap imports from New World (U.S.A.) to Europe in the second half of the nineteenth century caused collapse of grain prices. The reaction of each European country was very different. In the UK, a *laissez faire* policy was adopted and consistently followed causing many farmers to go bankrupt, and forced them to find alternative employment. In France and Germany the governments, still influenced by feudal system in the rural areas, decided to protect agricultural sector through import levies and other regulations and measures. In Germany, the emerging industries needed protection against free-trade competition. These protective measures resulted in the consolidation of not very dynamic production structures. In the Netherlands, both the protecting and the liberalization attitude were impossible. The Netherlands had been a trade nation since the 16th century and could not close its borders. At the same time, more than 50% of the population was still dependent and working in agriculture, and other employment opportunities didn't exist, so the government had to look for another survival technique. Advised by a national committee, they found a third option; neither liberalization nor protection, but strengthening competitive ability was seen to be the best way to deal with the situation. Measures to achieve this end included: new structural land improvement through efficient infrastructure; improved layout of agricultural lands in the landscape and increased farm sizes; strengthening position on the market by, for example, stimulating cooperatives; and finally, knowledge intensification through research, education and extension. All these measures proved successful.

The creation of Wageningen University and Research Centre is a natural continuation of that policy. Its creation in the nineties was a government response to a crisis caused by decreasing student number, degraded funding for agricultural research and implosion of the powerful and influential negotiation structures of the agricultural sector of the past. To address all these problems, a third generation university was created with very different structures than were characteristic of the first and second generation universities.

Development Towards the Third Generation University

The first generation university, or medieval university, was founded in Bologna in 1158; this was followed by the establishment of the University of Paris in 1200. By1300, there were some 20 European universities. They were loosely organized around individual teachers and had a rector, chancellor and General Assembly as governing bodies. Research, as we know now, was absent and the university's objectives were characterized as enlightenment of the world and stimulation of student obedience. Mobility and intellectual exchange were integral part of academic 'training'.

In the nineteenth century, first in Germany and then in other European countries was the rise of second generation university or Humboldt university. This type of intellectually elite university explicitly stimulated research. Education was called 'Bildung': not power but rationality and authority based on knowledge, experience, insight and expertise was the leitmotif. Excellence was embedded in the institution in the form of centres of excellence for the elite and, as a result, mobility was no longer a factor of importance.

This type of university had two major characteristics: firstly, the objective of science was to search for the truth in an environment free of all social pressure, and outside the influence of religion and politics. Research was organized into disciplines and all disciplines were seen as branches of the tree of reason, although closely connected to ethics and art. Scientific research could only be judged by reason, hence by science itself. However, 'Bildung' was not restricted to scientific training aimed at producing clever students, but also encompassed moral and ethical education to promote development of wisdom in the broadest sense. Education was seen as an integral part of research, and 'Bildung' was seen as a lifelong learning process.

Secondly, embedded in this university concept, was the idea that increased knowledge and the process of uncovering the truth, would increase people's insights and confidence and promote a true intellectual freedom based on reason. In this view, scientists were seen as an elite who would further society's development towards freedom by increasing intellectual insights. Societal development was, in fact, seen as the same as intellectual development. Applied research or seeking applications for knowledge were seen as mundane skills and were certainly not regarded as the domain of science at the second generation universities.

In the change from first generation universities, Latin disappeared as *lingua franca* and because second generation universities were nationally oriented, inter-university mobility, widely promoted in the medieval university, decreased. Governance of the second generation university was by a senate, fulltime professors with a chair and an executive board comprising chancellor and vice-chancellor or rector.

This type of university prevailed until the end of the twentieth century although some important developments had been putting this type of university under pressure for some time. For instance a number of philosophers and social science theories denied the existence of a single truth which can be found and known. Another force was the strong societal desire for science to provide answers to problems instead of merely increasing knowledge. Research topics were less curiosity-driven and were more dependent on potential clients or end-users for scientific findings. Science was no longer functioning as superior to or independent of society (in its ivory tower) but was becoming an integral part of it. Scientific disciplines were differentiated, creating new branches, some of which limited themselves to studying empirical reality, and avoided involving ethics and art. Mono-disciplinary research aiming to deepen insights was gradually being complemented by multidisciplinary and interdisciplinary research seen as more suited to solving complex societal problems. Within universities themselves, research and education were drifting apart. Transfer of knowledge became increasingly more important than the art of 'Bildung' – creating scientists to be part of elite with high moral standards and superior insights, able to guide society towards true freedom, based on reason. Graduate students were increasingly required to use knowledge and scientific methods (know-how) to contribute to society. This was reflected in the variety of professions that graduate students occupied after their studies. They became 'experts' instead of 'academics', but they were still 'free' from societal influence as they were trained to be objective, able to observe or measure facts in the empirical world. Ph.D. students were also trained to develop knowledge and to become career academics, aiming to replace their professors in due time, in the tradition of 'Bildung'. Yet, as there were only a limited number of vacancies for professors at universities many of these students ended up outside academia - and this required them to learn additional skills.

Wissema (2005) pointed to a number of additional developments which forced the Humboldt University to change. Research tasks were no longer the exclusive domain of universities but a number of public non-university research centres emerged. University studies were not only open for elite but university training was democratized (in the Netherlands especially from the 1960s onwards) becoming available for masses of students. The increase in number led to the need for professional managers from non-university backgrounds. The large number of new scientific fields (many of which are applied sciences) and the increase in collaborations with societal partners promoted a drift away from the clear linear faculty structure of the Humboldt University, and a mix of working structures was replacing it. Governmental steering became increasingly problematic and at least a partial shift to a more demand-driven orientation became an attractive option. Internationalisation, globalisation, computers and internet, and demand for English fluency, led to increased contacts and competition between universities, complicating steering issue and putting the concept of 'a centre of excellence, developing itself in isolation' under threat.

All of these processes and developments indicated clearly that a new type of university is needed. The know-how carousel concept was becoming more dominant. The entire knowledge chain was becoming more and more integrated and typical distinction between fundamental, curiosity-driven research, strategic research, applied research and application of research outcomes was becoming obsolete. In the know-how carousel, research at the university and outside of it, in techno-parks, by techno-starters, by private companies but also in close contact with civil society partners in land designation, planning and conservation projects, became integrated and included both academic and professional education. This know-how carousel forms the core of a third generation university. The third generation university is a network university with many partners and many research locations. Education, research and utilization/valorization of knowledge are all objectives in this model. This integration of know-how exploitation and education and research also requires an academic response in the form of a clear analysis and description to guarantee academic freedom and integrity.

Direct government influence has been reduced and funding comes in the form of grants, contracts and facilitative structures. To raise funds, the third generation university needs to be more client-oriented, aiming to provide answers or advice to end-users of research. In funding research and education, international and national science foundations' play a major role. The third generation university needs to be competitive in terms of scientific excellence to become eligible for these funds. The international character of the university is growing, and this combined with its collaboration in various partnerships has increased mobility of its staff and programmes.

Transition within the Knowledge Infrastructure to Support Dynamism and Change

The need to change was felt in all the different European countries as well as in the Netherlands and this resulted in a variety of responses to the same challenge. In Denmark, they took another road than the Netherlands. The Royal University for Veterinary and Agricultural Sciences (KLV) was not merged with research institutions to form a new entity, it was itself split up. One part formed a university with a research organization in Arhus and another part became a more academic teaching and research institute, the University of Copenhagen. Agricultural research was placed under the umbrella of more general universities. The aim was to optimize influx of students from other disciplines like biology, mathematics, etc and for that reason it was considered a better option to be associated with universities with studies in these science domains rather than creating a separate agricultural centre.

In Germany, there was considerable resistance to fundamental change in all the different States, and that only allowed for smaller incremental changes in existing institutions. Merging research institutes was not considered an option and that meant that the dispersed character of expertise throughout the Federal Republic of Germany need to be maintained. In France, the INRA (Institut Scientifique de Recherche Agronomique) extended its area of responsibility and made major structural changes, yet the far-reaching agreements to collaborate with *Haute Ecoles* or regional universities did not materialize. From 1998 onwards, thematic collaborations in joint research units (Unités Mixtes de Recherche) were formed instead as a way to promote more structural inter-institutional collaborations. The staff members of INRA, CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement), IRD (Institut de Recherche pour le Développement) and a diversity of universities and institutions for higher agricultural and veterinary education participated in these entities. In 2005, more than 50% of all INRA research units and about 40% of the CIRAD research units were *unitésmixtes*. Merging institutions themselves was not foreseen. Other types of collaborations (*recherchecontrats*) tended to include powerful regionally-based industries and remain regional initiatives, without penetrating to national level.

It remains to be seen whether the Wageningen model, described in details, is better than the Danish, French or German models. The preliminary results in the Netherlands indicate that Wageningen University and Research Centre (WUR) is functioning rather well.

The Creation of Wageningen University and Research Centre (WUR) - a Third Generation University

To understand why WUR was established in 1997, we need to look at the driving forces behind it from the perspective of agricultural research organizations and the Ministry of Agriculture. During the fifties and sixties, a large proliferation of agricultural research institutes and stations occurred. Because of their large number and diverse locations, there was a lot of overlapping in mandates and activities. This was followed by a period of centralizing activities around two of the major agricultural research centres, Wageningen and Lelystad, during the eighties, when funding became tighter. The responsibility for coordinating agricultural research in the research stations was assumed by the National Agricultural Research Council, whereas the Directorate of Agricultural Research assumed responsibility for all ministerial research organizations. The parallel structures led to duplication in policy formulation and coordination. Driven by the desire to increase the research accountability to its clients, the Dutch government decided in 1986 to privatize public agricultural research, leading to a new client-provider relationship between the Ministry and the agricultural research department (DLO) and output funding in 1991 (Van den Berg, 2001). Over time, the ministry became accountable for research to increase productivity by agricultural producers but also for environment and landscape issues expressed by consumers and society at large. In 1995, to decrease overlap and to take account of a broadening in the policy domain, the responsibility for all research, extension and education facilities (Wageningen Agricultural University included) were brought together under one roof, the Directorate of Science and Knowledge Transfer (Roseboom and Rutten, 1998). In 1995, a study on the future of the Dutch agricultural knowledge system revealed that there was also substantial overlap and competition between activities within the research components (Peper, 1996) and a merger between Wageningen Agricultural University (WAU) and DLO was recommended. The urgent need to broaden the scope and mission of Wageningen University in terms of environment, non-food activities, and nutrition were incorporated in the new mission of the university and its strategy. The Ministry of Agriculture, which commissioned the study, adopted these recommendations and started integration by merging boards of the two entities and appointing one new chairman in 1997. The new organization was called Wageningen University and Research Centre (WUR). The new status provided DLO with more flexibility to attract foreign clients and investors. In the meantime the applied research stations were also changing in status. They used to collaborate with experimental farms and gardens and were governed by representatives of agricultural and commodity board. The ministry stopped subsidizing experimental farms and gardens in 1996 to force farmers and their representatives to take more responsibility for the research by co-funding it themselves (Van den Berg, 2001).The many applied research organizations responded by merging into a fewer, larger units. Applied Plant Research and Applied Livestock Research became part of WUR in 2001, in line with the focus of WUR on a more participatory model of knowledge creation, replacing the traditional linear system.

The creation of Wageningen University and Research Centre (WUR) under the Dutch Ministry of Agriculture may be seen as part of the Ministry's greater struggle to maintain its independent position, but it should also be considered as a way to overcome dreadful situation that came about due to decreasing student numbers and reduced willingness to sponsor the university financially. After an in-depth analysis, the renewal of the university as a third generation university was preferred above other options. Prior to the creation of WUR, the Ministry of Agriculture had progressively lost prestige, partly because of the negative image that parts of agriculture had accrued in the earlier years and its subsequent diminished political clout as agriculture lost popularity. However, agriculture still remains one of the major economic sectors in the Netherlands, comprising eight of the ten top sectors of the Dutch economic activities (Porter, 1990; Jacobs and Lankhuizen, 2005; Rabbinge, 2012), and this explains why the Ministry of Economic Affairs supported the Ministry of Agriculture in its struggle for survival. During budget negotiations in 1994, there was a strong lobby to shift agricultural education and research, accounting for one-third of the ministry's budget and staff, to the ministry of education (OCW). This would have severely affected the legitimacy of the Ministry of Agriculture. Seen in this light, the idea to create a strong, competitive research and education centre such as WUR was a timely, justifying the Ministry's existence by giving it a prominent guiding/steering role, and thereby strengthening its political position. Also the strengthened collaboration with the private sector and the increased dialogue on many ethical and environmental issues improved the societal position of WUR outside the ministry of Education and Science.

From the university's perspective, the creation of WUR has been the result of a decision to go the route of the third generation university. Wageningen University has not been defeated by the negative image crisis, low student number and lack of political power from the constituency in the agricultural domain. It has not accepted its extinction as an independent university, allowing to be absorbed within mainstream Dutch universities, surviving merely in the form of a limited number of chair groups. Instead it has taken the initiative to invest in increasing its competitive power by combining different levels of research and education: university, research centres (DLO), experimental stations and professional education (Van Hall Larenstein), complemented by special centres for knowledge valorization, business schools, professional mid-career training and capacity building, in the traditional Wageningen domains: 'healthy food and a living environment' (Kropff and Kalwij, 2008).

To express its strength and unity, Wageningen UR has formulated a visionary mission statement which is: 'to explore the potential of nature to improve the quality of life'. The WUR model has led to the creation of a coherent package of research and education activities with sufficient critical mass to develop excellence. Its focus makes it clear to stakeholders what can be expected from Wageningen UR, and its additional statement 'Science for Impact' underlines its relevance to issues that affect the general public.

Sensustricto, the third generation aspect can be seen by looking at the curricula that show a balance between purely discipline-oriented and integrated courses; between focus on development of knowledge and skills and competencies needed to use knowledge in society. The prominence given to the concept of T-shaped skills means that disciplinary depth (adding to disciplinary knowledge development) is combined with sufficient interdisciplinary width (adding to discipline-overarching knowledge). Another major aspect is the attention given to beta-gamma interaction, on the assumption that synergy between natural and social sciences should increase societal relevance in improving articulation of relevant research questions and in developing adequate technologies. In each of the master study programmes all students have to do individual master thesis research projects and all also have to participate in a multidisciplinary research project commissioned by a societal party (academic master cluster). All students have the obligation to do a traineeship in industry or at a scientific institution, often abroad (>70%).

The financial structure at the Wageningen UR reveals its third generation university character. The funding structure is flexible and consists of different components. One is the successful acquisition of research fellowships for excellent research from Dutch *veni-vidi-vici* programmes and from international programmes sponsored by organizations like the European Union, the *Marie Curie Fund*. Playing a leading role or simply taking part in a large number of extremely large and complex interdisciplinary European Union funded integrated programmes underlines the institution's scientific and organizational competence in functioning in such complex arenas. Its comparative scientific excellence in the European research and development arena helps it secure operational funding. The university and research institute components function side by side in these programmes, complementing and reinforcing one another's distinctive attributes. They are fully integrated more and more, especially, in plant breeding, crop protection, and plant sciences, in general. The presence of basic sciences is in the same time expanded. WUR takes part in many international development oriented research programmes such as the Alliance for the Green Revolution in Africa (AGRA) and the challenge programmes of the Consultative Group on International Agricultural Research (CGIAR). It also plays a leading role or participates in large, privately funded programmes, for instance those set up by the Bill Gates or Rockefeller Foundations. Its participation in world-wide studies such as IPCC, IAASTD, Hunger Task Force and the Inter-Academy Council study on Africa show an international recognition of its academic qualities. Wageningen University also uses core funding to support development-oriented research by its Interdisciplinary Research and Education Fund (INREF) aimed at contributing to solution of important societal problems and at the same time investing in building up skills and competence of partners and partner institutions in developing countries. These programmes aim at the same time to develop the WU staff's own capacity to initiate, coordinate and implement interdisciplinary research programmes, building on T-shaped skills and beta-gamma interactions, which are typical components of a third generation university. One further aspect which underlines Wageningen's international character is the fact that 30% of M.Sc. students and 50% of Ph.D. students that graduated from Wageningen were not Dutch.

Last, but not least, the WUR's relationship with the Dutch government has become one of output funding. Joint decisions about the research agenda have led to an annual allocation of research budgets not only to 'provide recommendations to the ministry' but also to invest in knowledge development. Dutch politicians are aware of the crucial role that knowledge has to play in the society. The profits from sales of Dutch natural resources such as gas are invested in the intensification of the knowledge system. These funds supported larger and longer term government-funded research programmes (ICES-KIS). They are competitive and Wageningen UR is present in most of them not only due to excellence in its 'own' domain, but also because of its effective partnering with other disciplines, research organizations, and, in particular, private sector parties – to create added value through synergy.

A characteristic of third generation universities is their collaboration with private sector parties. During the last 10 years, the research institutions and activities of more than 20 national, international and multinational companies have been concentrated in *Food Valley,* which was set up in Wageningen at the WUR's initiative. In this 'valley' structural assistance has been created to foster techno starters by facilitating housing, providing support services etc. This vibrant business environment stimulates research at the Wageningen UR as well. Mutual benefit lies in the fact that partners easily find each other to create and exchange knowledge and to work on innovations. The international character leads to spin-offs in the European market and beyond. In his inaugural address on techno-starters Wissema (2005) explicitly mentioned WUR and its *Food Valley* initiative as evidence that this third generation university is probably the most developed in the Netherlands and an example to be followed by the Technical University (TU) Delft.

It is also important to note that a third generation university does not mean a drop in academic quality compared to a second generation university. In fact, a system of internationally peer-reviewed graduate schools guarantees the quality of Ph.D. research and Ph.D. teaching, and also of university staff performance. The graduate schools have developed procedures so that students are offered tailor-made courses in scientific depth and personal development, aimed at delivering well-balanced academics. At the same time research and training proposals are critically evaluated by the international peer review to ensure quality standards. In addition, the relative independence of the students in deciding their research themes, selecting their supervisors and developing their own research proposals, choosing methodologies, research locations and the degree of involvement of potential - users, provides all the ingredients for students to develop into critical, independent, reflexive researchers to make a contribution to science and society. Wageningen Business School also caters for 'lifelong learning' by providing short, in-depth courses whereby many alumni come back to the university, business school or Wageningen International to provide input in research and education from their professional life. In this way society interacts with the university enriching it with practical experience from the field.

Although the innovations in the knowledge infrastructure at Wageningen are full of promise, all is not rosy. Many paradoxes, dilemmas and debates still take place. The steering management model adopted by the WUR, for instance, remains a highly debatable issue within the organization. Management by control and procedures focussed on economic indicators appears difficult to reconcile with the characteristics of an organization of professionals where scientific quality and peer-reviewed outputs have always dominated. Similarly the debate between contracted, commissioned, market-driven research as opposed to curiosity-driven research and scientific independency is still on-going. However, these debates are only to be expected in an organization undergoing radical transformation and, as such, should be seen as a challenge rather than a problem.

The preliminary results are impressive. The university's funding has improved, collaboration with private firms has increased, its international character has become prominent, its graduate schools have a leading position in the world and the name 'Wageningen' carries more prestige than ever before. This has big advantage for Dutch agribusiness and the agricultural sector as a whole, which can be demonstrated by the increase in added value in agricultural exports. In eighties, the Netherlands ranked 27^{th}, and in 2005, it ranked 6th of all countries adding value to agriculture per capita. The added value in agriculture (expressed in constant 2000 US$) increased from 337,366 US$ per capita in 1980 to 579,336 US$ per capita in 2005 (www.nationmaster.com). The Netherlands is the second largest exporter of agribusiness products with an export value of 101 billion Euro, next to the United States with 157 million Euro, but ahead of big countries such as Brazil, Australia, France or Germany. That is only due to the very knowledge intensive and high valued products, such as seeds, seed potatoes and bulbs. The development of this third generation university confirms the historical tradition whereby, in times of crisis, the Dutch opt neither for protection nor liberalization but choose to strengthen their competitive capability by investment in knowledge infrastructure.

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Evolution of Land-Grant Universities in the USA

G.S. Khush

Land-grants to educational institutions, a practice inherited from Europe, are traceable all the way back to the societies of classical antiquity. The earlier examples, however, offered a different mission than the practical education offered by the land-grant institutions established by the act of U.S. Congress, sponsored by Justin S. Morrill. Actually, the practice of land grants to establish educational institution in the US predated Morrill Act of 1862. Thus, University of Georgia was established with a grant of land in 1784. Similarly the Agricultural College of State of Michigan was chartered under Michigan State law as a land-grant institution on12 February1855. It received an appropriation of 14,000 acres of state-owned land. Farmer's High School of Pennsylvania that became Pennsylvania State University later was also established with a land grant on 22 February 1855. The Michigan State University and Pennsylvania State University were subsequently designated as the federal land-grant colleges for their States in 1863. The oldest school to hold land-grant status was Rutgers University, founded in 1766, and was designated the land-grant college of New Jersey in 1864.

A Congress member named Justin Smith Morrill from Vermont was the first to introduce land-grant bill in U.S. Congress (legislature). The bill was passed by the Congress in 1857, but was vetoed by President James Buchanan. Morrill resubmitted the bill in 1861, and it was enacted in 1862. Under the provisions of the act, each state was granted 30,000 acres (12,140 hectares) of federal land for each member of congress representing that state. The lands were sold and resulting funds were used to finance establishment of one or more schools to teach "agriculture and mechanic arts", though the act specifically stated that other scientific and classical studies need not be excluded. Its intent was clearly to meet a rapidly industrializing nation's need for scientifically trained technicians and agriculturists. Military training was required to be included in the curriculum of all land-grant institutions, and this provision led to the establishment of the Reserve Officer Training Corps, an educational programme for future army, navy and air force officers.

Some states established new schools with their land-grant funds; others turned the money over to existing state or private schools to be used for the establishment of schools of agriculture and mechanics. These came to be known as A&M colleges. Altogether, 69 land-grant schools were founded, offering programmes in agriculture, engineering, veterinary medicine, and other technical subjects. Cornell University in New York, (College of Agriculture), Perdue University, Massachusetts Institute of Technology, Ohio State University, the University of Illinois, and the University of Wisconsin are among the earliest land-grant universities.

Second Morrill act was passed in 1890 to make additional appropriations for supporting these institutions. These appropriations were increased through subsequent legislation. Morrill act withheld funds from states that refused to admit nonwhite students unless those states provided "separate but equal" facilities for nonwhite students. It encouraged the foundation of 17 black colleges. Florida A & M University, Tennessee State University (Nashville), Alcorn State University in Mississippi, Tuskegee University in Alabama and North Carolina A&T (Greensboro) are among the best-known black land-grant institutions. Land grant status was conferred on 30 Native American tribal colleges under the "Improving America's Schools Act of 1994".

The mission of the land-grant universities was expanded by the Hatch Act of 1887 that provided federal funds to states to establish a series of agricultural experiment stations under the direction of each state's land-grant college. These were mandated to provide additional information, especially in the areas of soil minerals and plant growth. The Smith-Lever Act of 1914 added cooperative extension and expanded outreach mission, e.g. sending of extension agents into rural areas to help bring results of agricultural research to end-users. Beyond the original land grants, each land-grant college received annual Federal Appropriations for research and extension work on the condition that those funds were matched by state funds. While today's land-grant universities were initially known as land-grant colleges only; a few of the more than 69 institutions that developed from the Morrill Act retain "College" in their official names; most are universities.

The influence of land-grant colleges on American higher education has been formidable. In recent years, about one-fifth of all students seeking degrees in the United States have been enrolled in land-grant universities. Pioneering research is carried out in chemistry, physics, biological sciences, medicine, agricultural science, and other fields at land-grant institutions. Nearly two-thirds of all doctoral degrees are awarded by land-grant universities. And because their administrative policies are more open than most other institutions, land-grant schools have made it possible for women, working-class students and students from remote areas to obtain undergraduate and professional education at a low cost.

How the Land-Grant System of Colleges Evolved?

1. Land-grant system of colleges did not spring into existence as a coherent idea or a set of institutions in one decade or even one generation of leadership. The land-grant colleges evolved as an idea and then as an institution and a national system over many decades between 1850 and 1920. There was a lot of trial and much error, and it was not clear before the turn of the last century whether the idea would even be a partial success or not.
2. The land-grant idea was not conceived solely for agriculture. It is not any specific set of organizations, such as trilogy of the experiment station, extension service and on campus or resident instruction; designed specifically to address agriculture.

The land-grant idea is not just access to higher education for those with limited resources. It is not just good science. It is not just science applied to practical problems. It is not just extension education for people of the state to solve practical problems. It is all of this and more**: So, what is the land-grant idea?**

It is a set of beliefs about the social role of the university. These beliefs have defined the social role of the land-grant university.

The US history of the last century showed that the land-grant university arose out of an industrializing society's increasingly complex problems and deficiencies. There was growing need for highly trained professionals, especially in the new science-based fields necessary to address requirements of an industrial society in engineering, public-health, agriculture, forestry, nursing, etc. Many of the professional schools of the modern university were needed but did not exist. Secondly, it arose out of industrializing society's frustration with an unresponsive set of mostly private colleges providing a classical or literary education for wealthy elite of less than 1% of the population. U.S. Colleges of the day were generally church sponsored and higher education was viewed as a religious responsibility. With some exception, these institutions were unresponsive to addressing society's common but real needs. The idea of land-grant institutions arose out of middle class's concern for the "American Dream" of unlimited opportunities that were being threatened by industrialization. This was creating great wealth for some, but a large, disadvantaged working class population of poor farmers and industrial workers with no access to skills and practical education necessary for a better life.

In partial response, a new kind of college or university was created: the land-grant university or college. This was the most unique part of the 19th century public university movement. The land-grant university in its mature form is devoted to the service of society by:

1. Educating and training professional cadres of an industrial, increasingly urban society;
2. Providing broad access to higher education irrespective of wealth or social status; and
3. Working to improve welfare and social status of the most disadvantaged groups of the society such as farmers and industrial workers of the 19th century

Justin Morrill, the congressional sponsor of the act that established the land-grant university system, was primarily concerned for broader and more democratic access to higher education to strengthen democracy.

The land-grant colleges were founded on the idea that a higher and broader education should be placed within reach of those who may wish to join professions, which contribute to the production of nation's wealth. It would be a mistake to presume that it was intended for making everybody a farmer or a mechanic.

By the turn of the last century, these were well formed set of U.S. beliefs about the social role of the university. ***This is the land-grant idea.*** And it has, within the limits of society's resources, been generously supported by the society for successfully pursuing the goals.

In pursing these goals, early success of the land-grant university was in agriculture, where these beliefs translated into organization of experiment stations, the extension service plus an ever changing set of research and extension programmes. The improved welfare of the poor segment of the society of the 19th century was achieved through improved productivity and wider distribution of its benefits through more equitable access to opportunities in life. Open access and low tuition were long a general feature of the land-grant and public universities, and provided opportunity for upward mobility in the society, irrespective of the background and wealth.

Land Grant Universities at Present

Almost all of the land-grant universities in the USA have become multi-faculty universities. For example, university of California, Davis, besides college of agriculture, has a college of biological sciences, college of engineering, college of medicine, college of veterinary medicine, college of social sciences and humanities, school of business management and a law school. However, college of agriculture is pre-eminent. It has three divisions—agricultural sciences, environmental sciences and human sciences. Each division delivers its mandate through disciplinary departments as follows.

Agricultural Sciences	Environmental Sciences	Human Sciences
Animal Sciences	Environmental Sciences and Policy	Agricultural Resource Economics
Agricultural Engineering	Environmental Toxicology	Food Science and Technology
Entomology	Land Air and Water resources	Human and Community Development
Nematology	Hydrology	Community Studies and Development
Plant Pathology	Soils and Biogeochemistry	Human Development and Family Studies
Plant Sciences	Environmental Design	Nutrition
Crop and Ecosystem Sciences	Landscape Architecture	Textiles and Clothing
Horticulture	Wildlife, fish and Conservation Biology	
Viticulture		
Enology		

Impact of College of Agriculture and Environmental Sciences on the Local Economy of California

- Enhances sustainable agricultural production
- Maintains global competitiveness of California agriculture
- Protects California's resources for betterment of the future
- Provides methods for producing affordable and healthy food
- Promotes physical health and economic welfare of all Californians

Applied Research for the Future

- **Environmental impact of agriculture**
  - Pest management
  - Waste management
  - Water quality and quantity
  - Air quality
- **Technology-Robotics**
  - Imaging and sensing
  - To Increase food quality and production efficiency
  - To protect the environment
- **Genomics**
  - To improve food for health
  - To increase agricultural production efficiency
  - To better understand our biological environment
- **Environmental Policy**
  - Challenges of urbanization
  - Protection of resources
- **Human Development**

Cooperative Extension Service

Cooperative extension Service (CES) is an outreach of the land-grant university and the United States Department of agriculture and the people of each state. It is not limited to agriculture, but includes other topics to support communities such as home economics, nutrition, and youth development. Federal, state and local governments support it.

Status of Cooperative Extension Services:

- The technology for delivery of information has changed
- Only 2% of the population is directly involved in farming on much larger farms
- Farmers are well educated and well informed, and they can afford personalized advisory services concomitant with product development and sales
- The consumer is disconnected from the food systems and less willing to support public extension with taxes.

Land-grant University System in India

The land-grant university system introduced in India during 1960s served the country well. It spearheaded green revolution in the country, which contributed to national food security. A large number of scientists were trained and cooperative extension service was established for taking the results of university research to farming community. Food security contributed to national prosperity and development. It established confidence in national agricultural research system. However, there are several concerns about the health of the system, which need to be addressed. Some of these are as follows.

Fragmentation

New agricultural universities are being created due to political and other considerations. This has resulted in allocation of meager resources to several universities rather than establishing a state-of-the-art university with world-class infrastructure.

Inbreeding

Scientists are receiving all their degrees from B.Sc. to Ph.D. from the same university. This limits cross fertilization of ideas, thus producing graduates with narrow perspective on science.

Lack of robust tracking and review system

In several instances research projects are not properly tracked and reviewed, resulting in mediocre science

Lack of merit-based promotions

The seniority-based system is frequently practised. It is the worst kind of promotion system

Too much bureaucracy

Scientists waste too much time in getting approvals for purchasing supplies and equipment

Lopsided ratio of salaries and working capital

In many cases 90 % of the resources are spent on salaries and very little on working capital.

Political interference

The worst curse of the system is when a state minister or even an MLA calls the Vice Chancellor to promote or transfer his protégée to a more lucrative position.

Support by sections of leadership and public for anti-science zealots

This has prevented the results of new science reaching consumers.

Satisfaction with the status quo

Not much attention is paid to introduce new courses or programmes Land-Grant University concept has profound socio-economic dimensions. It has greatly succeeded in raising the academics research, technological, social (inclusiveness) and economic health of USA and other nations. The system has evolved and transformed over time to meet new challenges and opportunities. In India, the system should be liberated of the maladies, several mentioned above, and structured as per India's need to enhance its effectiveness.

Support for Agricultural Technology and Innovation: World Bank Experience[1, 2]

Madhur Gautam

This note briefly summarizes the lessons of experience in developing institutions for agricultural research and development (R&D), covering the disciplines of agricultural research, education and extension. These lessons are derived from decades of experience with national R&D systems around the world, including the implementation of investment and technical assistance projects and programs by the World Bank and other partners.

Dire predictions in the 1960s and early 1970s of mass "Malthusian" starvation have been proven wrong (e.g., Pardey, Alston and Chan-Kang 2012, give examples of these early predictions). On the contrary, despite starting from a bleak situation of widespread and abject poverty, rapid population growth, widespread food insecurity and low agricultural yields, laudable gains have been made with significant global investments in agricultural research and development. The world has seen a remarkable turnaround in aggregate food security with rising production per capita despite significant increases in population and falling availability of arable land per capita (Figure 1). The phenomenon of rising productivity has been so strong that even as it has resulted in falling food prices (due to rapid increases in production), which is

[1]The findings, interpretations and views expressed in this paper are entirely those of the author. They do not necessarily represent the views of the World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent.

[2]This paper has benefited from substantive inputs from Riikka Rajalahti, Sanjeeva Cooke, Eija Pehu, Jock Anderson, Deepak Ahluwalia, Animesh Shrivastava and Paul Sidhu. The responsibility for any errors or shortcomings, however, rests solely with the author.

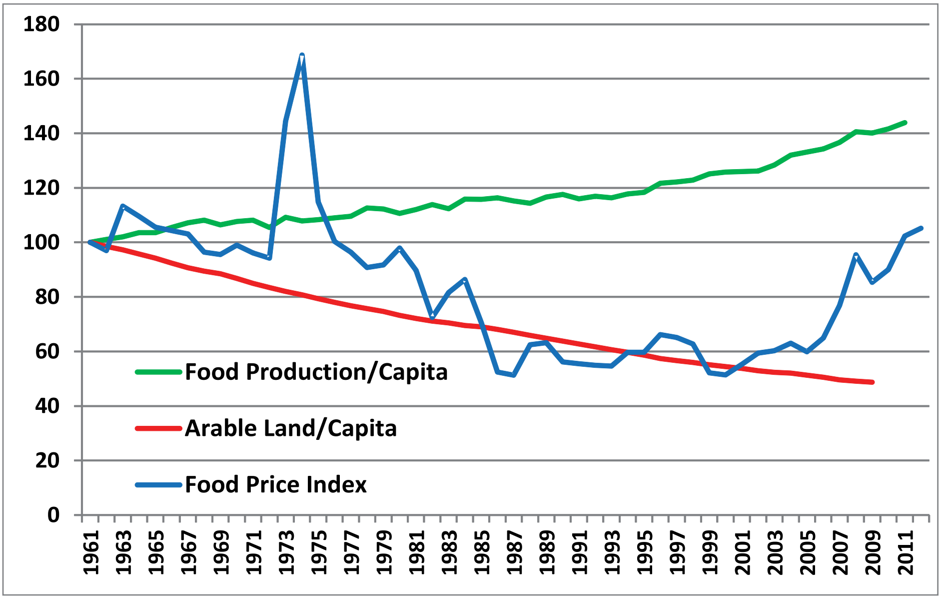

Figure 1. Global Trends: Prices, Food Production and Land

Source: World Bank data

beneficial particularly to the non-farming poor, farmer incomes have risen, contributing to substantial declines in overall poverty and the number of hungry worldwide. For example, between 1981 and 2008, the proportion of world population living below $1.25 a day (in 2005 PPP terms) fell from 52.5 percent to 22.4 percent (Chen and Ravallion, 2012) and the share of undernourished fell from 26 percent to 13 percent between 1969/71 and 2006/08 (FAO 2012).

This remarkable achievement was, of course, no accident. While many factors drive growth in agricultural productivity, such as investments in infrastructure, education, and market access, a major contributor to the historical success in raising food production has been the investment in agricultural research and extension services to raise productivity. The central role of "technology capital" in productivity growth is well documented (e.g., Alston et al. 2000, Alston et al 2010; Evenson and Fuglie, 2010; Fan, Gulati and Thorat, 1999; Fan, Hazell and Thorat, 2008, Fuglie, 2012).

Yet, the past success in avoiding major famines notwithstanding, there is very little room for complacency. Hunger and malnourishment remain at unacceptably high levels. Continuing population growth and rising incomes mean that the world now consumes more food, and this growth is expected to continue. And the growing demand for food crops for biofuels is putting additional pressures on supply. Given these trends, FAO projects that by 2050, world food production would need to increase by 50 percent (Alexandratos and Bruinsma, 2012). And this is to be achieved in the face of land and water scarcity, and the threat of climate change. Some of these pressures are already beginning to show, as evidenced in the elevated and more volatile global food prices in recent years.

Going forward, it is imperative that the shrinking land and water base becomes more productive to maintain food security and meet the projected needs for increasingly diversified foods. Agricultural productivity growth also plays a key role in poverty reduction, and much remains to be done to increase the incomes of the rural poor – both through farm and non-farm income growth.[3] In this regard, the past record on productivity (measured as Total Factor Productivity or TFP) has been good overall, but with two particularly concerning trends (Fuglie, 2012). Two regions with the largest number of poor and malnourished, South Asia and Sub-Saharan Africa (SSA), have lagged in TFP growth (Figure 2). TFP growth has been the slowest in these regions while they have the highest share of the labor force in agriculture. Technology in the form of the Green Revolution was instrumental in driving past growth in grain yields in South Asia.

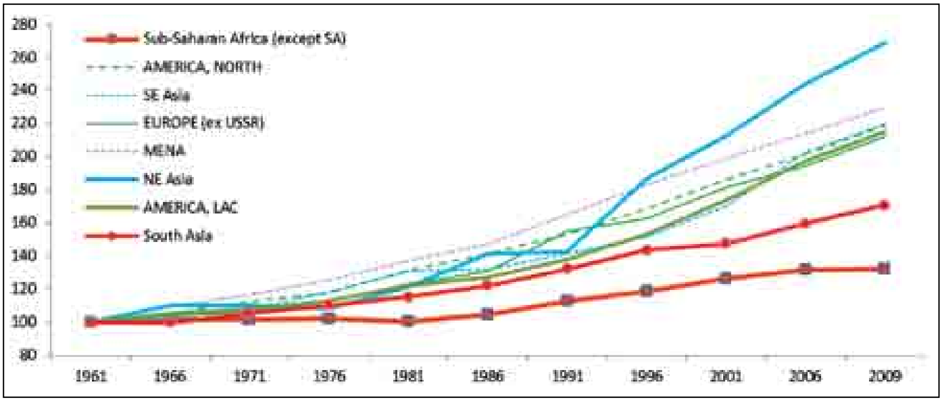

Figure 2. Trends in Regional Total Factor Productivity

Source: Reproduced using data from Fuglie (2012).

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[3]The World Bank World Development Report 2008 (World Bank 2007) noted that agricultural growth is three times more effective in reducing poverty than non-agricultural growth.

Technology has also helped in SSA, but the region has not witnessed the same burst of growth in productivity as was associated with the Green Revolution technology in South Asia.

Looking forward, perhaps more worrisome are the trends in global yields. Grain yields are slowing globally, as they also appear to be doing in South Asia (see, e.g., Chand, Kumar and Kumar 2011 for evidence on India). The frontier for global yields appears to have rather plateaued since the mid-1990s for wheat and late 1990s for rice, as seen in Figure 3, which plots the trends in the highest rice and wheat yields attained by any of the world's top 40 producers of rice and wheat, respectively, in each year since 1960. The most serious implication of these trends is the prospect of the current technology reaching its genetic limits.

The food security implications of slow global growth in cereal yields have raised concern for some time (World Bank 2007, Cassman, 2011; Ray et al., 2013). For most low-income countries, as well as large growing economies such as India, food security will remain a high priority, especially given the projected volatility in global markets. In the particular case of India, if past trends continue, recent demand-supply projection models suggest, for example, that

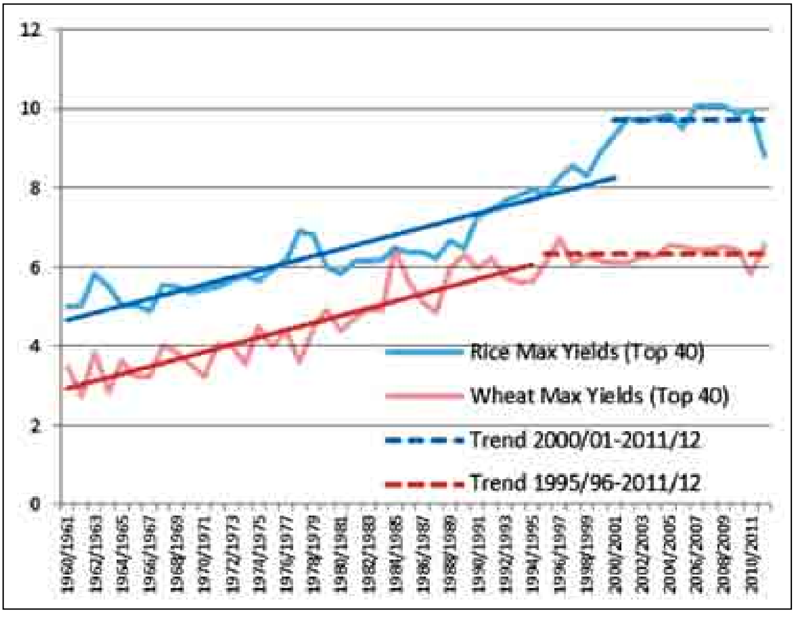


Figure 3. Global rice and wheat yields have possibly plateaued

Source: FAOSTAT data

India's food security situation probably will not be dire (GOI 2012; Ganesh-Kumar et al., 2012). However, with sluggish productivity, India might have to rely on imports to meet food demands (Parikh et al., 2011). As may be expected, given the sheer size of India, any shock on the supply or demand sides will have a significant impact on global markets.

While there is substantial room to grow in terms of current yield gaps (Fischer, Byerlee and Edmeades, 2014), long-term productivity growth will continue to require a focus on technology and innovation to drive productivity. Historically about 60% of productivity growth has been through increased inputs. The performance has varied across regions, however. In the post-1990 period, South Asia has been more reliant on inputs than the rest of the world (about 50% output growth in India is accounted by inputs vs 25% in the rest of the world, respectively, the remainder being the contribution of TFP).

There is a clear need to invest in more and better technologies, in more effective and efficient delivery models for agricultural research and extension, and in the all too often forgotten "back-end" higher agricultural education system to develop the human capacity to delivery these results. To raise production efficiency, it will also be critical to put in place enabling policies and institutional approaches to improve the resource-use efficiency in agriculture, as well as promote diversification for faster growth.

Changing Trends in Global R&D Spending

Recognizing its importance, the current high-income countries have invested heavily and for long in agricultural R&D. Pardey, Alston and Chang-Kang (2012) estimate that in 1960, total public spending on agricultural R&D was about US$ 5.5 billion (in 2005 PPP terms), with the US and other high income countries accounting for about 58%. By 2009, the total spending increased to about US $33.5 billion (in 2005 PPP terms), with the high-income countries accounting for about 48% of the total. Estimates for 2008 by IFPRI (using the ASTI database)[4] suggest global public spending on agricultural R&D to be about US$31.7 billion (in 2005 PPP terms), of which 49% is accounted for by low and middle-income countries (Beintema et al., 2012). Among these countries, China, Brazil, and India are the

[4]Agricultural Science and Technology Indicators (ASTI) available at http://www.asti.cgiar.org/

major powerhouses, together contributing about a one-quarter of the global R&D investment (Beintema et al., 2012).

The evolution of investments by developing countries reflects a response to many emerging trends. Foremost is the recognition of the need for science and innovation to drive development. In the case of Brazil, China and India, this recognition has been there for some time – to drive growth (in the case of the former) and for Green Revolution (in the latter two). Over time, slowing productivity growth—an outcome of faltering R&D investments and complacency after the success of the Green Revolution in most countries—as well as shifting R&D priorities in the developed countries, where most technological advances once originated, are among the main influencing factors. In recent years, investment has also increased to help cope with greater volatility in global food markets, the prospective impact of climate change on agriculture and food production, and the imperative to ensure future food and nutrition security in the face of growing natural resource (land and water) constraints.

But success depends on more than the allocation of public funds, as the comparative performance of Brazil, China, and India demonstrates (Lele et al., 2013). Brazil spends significantly less than the others but is still widely recognized as the most innovative and successful research system among developing countries (Beintema et al., 2012). China's experience shows the importance of focusing on the quality and not just the quantity of innovation effort (Jin et al., 2010). Successful agricultural innovation systems are built upon strong, interdependent efforts in research, education, and extension. All three countries have a long and notable history of achievements in all three components of the innovation system.

The continuous challenge facing research, education, and extension is to remain relevant, effective, and efficient. Brazil and China have undertaken periodic reforms to reorient and redesign their agricultural innovation systems to meet growing and emerging national challenges (e.g., Huang, Hu and Rozelle, 2004; Contini et al., 2010). By comparison, the performance of agricultural research, education, and extension have lagged in India in recent years (Lele et al., 2013). The impressive institutions established at the time of the Green Revolution have become less effective and relevant than in the past to stimulate the needed transformative change in Indian agriculture. Going forward, these institutions must internalize the complexities of the new and emerging food and agricultural systems, respond to local demands from smallholders as well as the broad imperatives of food and nutritional security, feed into the rapidly changing and increasingly knowledge-intensive agriculture practiced today, and provide the high-quality human resources essential for any technology.

Building effective and efficient institutions, and ensuring they remain relevant, is a complex and time-consuming task. It is in this context that this paper attempts to capture the global experience accumulated by the World Bank over the decades that it has supported agricultural R&D – both at the global level (e.g., through the CGIAR) and in numerous countries around the World.

World Bank Support for Technology

The World Bank has supported investment in agricultural R&D as a major part of its strategy for agricultural productivity since the early 1970s. It remains an area of emphasis in the current Agriculture Action Plan 2013-15 for the World Bank Group (World Bank 2013). In line with the national development strategies of borrowing countries that have emphasized investments in science and technology, total World Bank commitments for investment lending and technical assistance since 1970 have been over US$ 8 billion in nominal prices or about US$ 11 billion in real (2012) prices (Figure 4).

Figure 4. World Bank Lending for R&D 1970-2012, US$ billion

Source: World Bank data.

The current investment portfolio includes 92 projects in 54 countries with a combined commitment of US$1.65 billion. In the South Asia Region, the portfolio includes 17 projects across 5 countries with a total commitment of US$465 million. In addition, the World Bank has been a funder of the CGIAR system since its inception in 1971, with an annual contribution of $50 million. Analysis of the lending trends since 1985 for the three legs of the technology system is presented in Figure 5. The main areas of investment have been agricultural research and extension, and to a much lesser extent agricultural education. The patterns reflect demand from member governments, and the low demonstrated commitment to agricultural tertiary education remains a source of concern as it implies that the capacity for R&D will be difficult to sustain.

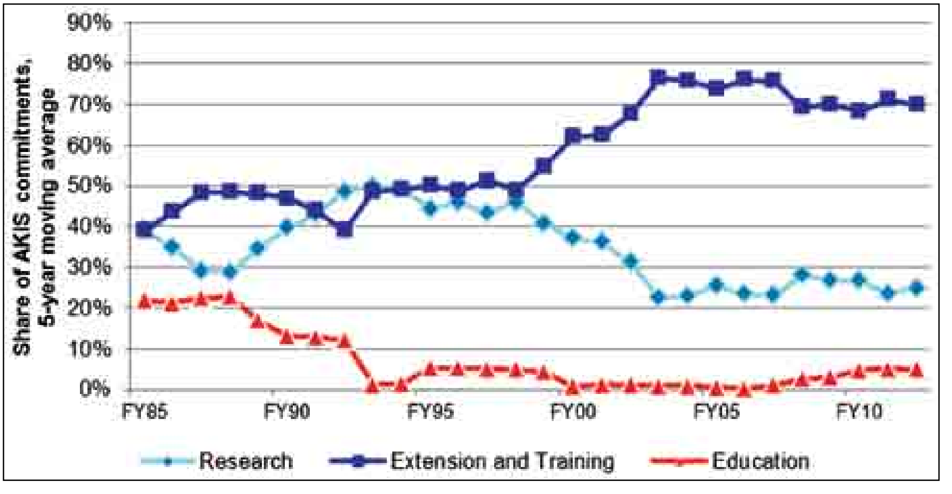
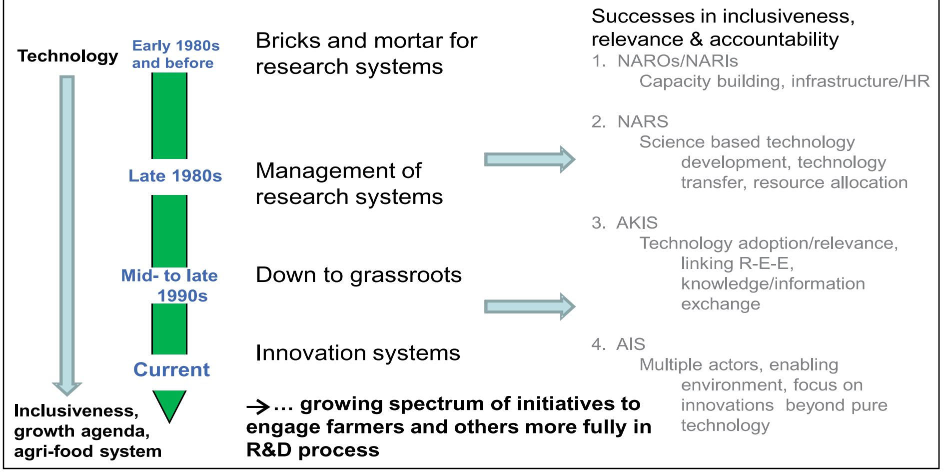


Figure 5. Composition of World Bank Lending for Agricultural R&D

Source: World Bank data.

Over the years, the approaches to support agricultural R&D and innovation have evolved in significant ways, reflecting the evolution of ideas on R&D capacity and to make institutions which deliver technology services more effective and sustainable (World Bank 2006a). The changing ideas were informed over the years by the accumulated operational experience and collective learning about how innovation and change happens in an agricultural setting. Box 1 broadly traces the corresponding evolution in thinking about the design of lending operations for R&D – from a traditional support to research and extension to a wider approach centered on promoting innovation.

Box 1: Changing Focus of Investments in Support of Agricultural Technology Services



Source: Adapted from World Bank (2006b)

In the early formative years for most developing-country R&D systems, the priority was to build basic physical infrastructure and human capacity to help support the establishment of the nascent or emerging national institutions. The focus was very much on "bricks and mortar" investments and training to undertake basic R&D functions. This was consolidated in the 1980s into the development of the National Agricultural Research Systems (NARS), and parallel national extension systems, with centralized organizations and institutions almost entirely in the public sector. Greater attention was given to improving systems management through better planning, personnel management, financial management, etc. The focus was very much on the supply side, with the research impact conceptualized primarily through generating technology and a "linear" transmission of research results to farmer levels using specific extension delivery channels. This model served its purpose early on when the level of adoption of modern technologies and practices was just beginning to accelerate and there were sufficient new and proven technologies "on the shelf" ready to disseminate.

By the 1990s, with emerging problems in many public organizations, emphasis shifted towards more holistic and pluralistic approach and the concept of Agricultural Knowledge and Information Systems (AKIS) developed, explicitly recognizing the importance of the links between research, education and extension (FAO and World Bank 2000).

The next steps were to deepen the reach of research to grassroots levels, by more explicitly incorporating farmers' demand articulation to improve the relevance of technologies generated and enhance accountability in research systems, as well as improving the linkages between research and extension services. Significant institutional changes also occurred, making agricultural R&D services more relevant, efficient and effective (e.g., Anderson and Roseboom, 2013). Involvement of stakeholders in institutional governance (as members of governing boards or advisory panels) helped provide them with real influence over research priorities. Decentralization has brought services closer to clients and improved attention to local problems and opportunities. Competitive funding has promoted demand-driven research and participation of universities, private sector and non-state actors in research.[5]

These trends have led, more recently, to the development of the Agricultural Innovation Systems (AIS) concept, which responds to the growing need for a more collaborative approach. It is rooted in the recognition of the central role innovation has to play in tackling the challenges and take advantage of the emerging opportunities by rapidly transforming markets, urbanization, globalization and the environment (Box 2). An important aspect of AIS is to go beyond the science suppliers to explicitly recognize different actors, disciplines and sectors and, in particular, the private sector in creating the environment to enable innovation for development.

Lessons of Experience

A very important aspect of World Bank operations, in addition to delivery of results and outcomes, is their learning function. Systematic reviews help identify elements of success in operations as well as problems encountered and feed into operations and programs through improved design and implementation arrangements (e.g., Purcell and Anderson 1997). The continuous evaluation of the experience with investments for R&D have generated a wealth of knowledge over the past 40 years, which has helped shape the evolution in the approaches noted above. While a large number of these lessons are

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[5]Based on the accumulated lessons and a felt need to help guide investments in R&D, in 2000 The World Bank and FAO produced an Agricultural Knowledge and Information Systems for Rural Development (AKIS/RD) "Strategic Vision and Guiding Principles." This document is available at http://siteresources.worldbank.org/INTARD/825826-1111044795683/20424542/vision.pdf.

Box 2: Innovation, Innovation Systems and Agriculture

Agricultural development demands and depends on innovation and innovation systems. Innovation is widely recognized as a major source of improved productivity, competitiveness and economic growth. It also plays an important role in creating jobs, generating income, alleviating poverty and driving social development

Innovation is the process by which individuals or organizations master and implement the design and production of goods and services that are new to them, irrespective of whether they are new to their competitors, their country or the world. An ***innovation system*** is a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance.

Agricultural innovation typically arises through dynamic interaction among the multitude of actors involved in growing, processing, packaging, distributing, and consuming or otherwise using agricultural products., These actors represent quite disparate perspectives and skills, such as metrology, safety standards, molecular genetics, intellectual property, food chemistry, resource economics, logistics, land rights – and so on. For innovation to occur, interactions among these diverse stakeholders need to be open and to draw upon the most appropriate available knowledge. Aside from a strong capacity in R&D, the ability to innovate is often related to collective action, coordination, the exchange of knowledge, the incentives and resources available to forge partnerships and develop businesses, and conditions that make it possible for farmers or entrepreneurs to use the innovations.

Source: Adapted from World Bank (2006b, 2012).

context specific, some important common themes have emerged that provide the basic principles to help guide the design of effective operations.

On the experience of what works, the broad (perhaps too generic but nevertheless important enough to continuously emphasize) lessons learned repeatedly are that an approach with an explicit institutional development focus have worked much better and have been more sustainable. Programs targeting specific technologies and those not aligned with country priorities do not yield the expected long-term results. In the current circumstances, the focus of agricultural development is very much on the technologies to deal with climate change and green growth, in addition to improving productivity and market-driven production. Given the inherent uncertainty of future outcomes, and the location specificity of technological solutions to most problems, the best-bet approach is to build high-caliber institutional capacity for R&D to diagnose and tackle the problems as they arise.

An enduring lesson, one that is also widely recognized but often hard to put into practice, is that efforts centered on improving the relevance, efficacy, responsiveness and accountability of organizations and agencies, as well as individuals, charged with service delivery are much more successful in delivering results and impact than otherwise. Closely related to this is the issue of incentives – institutional as well as individual – as they play a central role in service delivery but remain a major challenge in most bureaucratic public systems. To tackle these challenges, it is important to build in features that facilitate improved service delivery such as better responsiveness to client demand, working with farmer groups, improved communication skills of service providers, improved quality of service provision, and more effective collaboration with the private sector. These features have yielded significantly better results than operational and institutional designs without them.

In somewhat more concrete terms, these lessons are reflected in the good practices that have emerged from the past experiences:

- ❖ Farmer, private sector, and other stakeholder participation on research governing boards and advisory panels for better priority setting and relevance.
- ❖ Decentralizing research, to bring scientists closer to clients and better focus on local problems and opportunities.
- ❖ Competitive funding for demand-driven, quality and efficiency by involving key stakeholders, promoting pluralism, exploiting human capacity beyond that in public agricultural research institutions (e.g., universities, private sector, NGOs)
- ❖ Decentralized extension services accountable to farmers and local user groups, cost-sharing, use of matching grants (to allow farmers and user groups to test and disseminate new technologies)
- ❖ Use of producer organizations to take advantage of economies of scale in services and marketing

- Mixing public and private (and NGO) systems to find the 'best-fit' in service delivery, including public-private partnerships whereby extension and research services can be contracted out following the basic principle of "public funding – private delivery."

At the same time, it is important also to be fully cognizant of the important problems that have consistently emerged from implementation reviews of World Bank operations R&D operations. These problems result from strong path-dependency in institutional development but also reflect the slow pace of institutional and policy change in many instances. An analysis of the experience with public agricultural research organizations (World Bank 2006a) is reflective of the commonly encountered challenges in R&D institutional development:

- Lack of consensus on a strategic vision for public sector organizations and the evolution of the AREE4D system.
- Ineffective leadership, which is particularly critical for many research organizations, resulting in internal management problems, lack of political support and funding for research.
- Continued emphasis on building centralized organizations, such as national agricultural research organizations/institutes (NAROs/NARIs) at the expense of more pluralistic systems fostering a public-private system, including universities and global networks.
- Difficulties in establishing an appropriate legal and governance framework for AREE4D organizations to provide the efficiency and flexibility needed in managing financial, physical, and human resources.
- Problems in retaining highly qualified scientific, technical and managerial staff, and difficulties in recruiting the best and the brightest into the system.
- Weak links between NAROs and other research providers, clients, technology transfer agencies, and development organizations.
- Weak accountability to clients and funders and lack of focus on outcomes for performance

Agricultural Innovation System (AIS)

Past investments in science and technology have often been very successful, as discussed earlier in this paper. But the context has changed over time, necessitating a change in the thinking around the nature, generation and dissemination of knowledge. The context has perhaps never changed as dramatically as it has in the new millennium, with some radical and rapid changes that have transformed the role of knowledge, the manner in which it is created and used. These changes also necessitate renewed thinking on what innovation means and how best to foster it to maximize development impact (see World Bank 2006b for a more detailed discussion on this topic). Among the major changes that prompt the need to examine how innovation occurs in agriculture are:

- Markets increasingly drive agricultural development
- The economic environment (production, trade and consumption) for agriculture has become more dynamic and evolving in unpredictable ways
- Rate of change has increased with agriculture development taking place in a more globalized setting, requiring rapid responses – competition, trade rules, technological paradigms, climate, pests and diseases
- The role of the private sector in generating, using and disseminating knowledge has grown
- Exponential growth in information and communications technology (ICT) has radically changed the accessibility of knowledge and information, increasing the ability to take advantage of innovations in other places and for other purposes
- The knowledge structure of agriculture is changing – challenging the primacy of public agricultural R&D organizations.

Together with the major emerging challenges, such as the eroding natural resource base that threatens the hard-won food security and sustainability, climate change with potentially far reaching economic and social consequences, the need for more competitive and efficient value chains and food safety, a pertinent question is: how to invest in a manner that is conducive to innovation and growth?

Doing justice to the rich knowledge base that has evolved on the topic of AIS is challenging for a brief paper like this. A detailed discussion with best practice examples from around the world, and practical "how to" guidance is given in World Bank (2012).[6]

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[6]The full document entitle "Agricultural Innovation Systems: An Investment Sourcebook" (World Bank 2012) is available online at: http://siteresources.worldbank.org/INTARD/Resources/335807-1330620492317/8478371-1330712129614/9780821386842-corrected.pdf

Very briefly, the AIS concept builds on the core conviction that investments in science and technology are still critical as basic building blocks. But a fundamental shift is that while traditional investments in R&D remain important, they are not sufficient, highlighting the need to bring in complementary investments that are often not appreciated or consistently addressed. There is thus a need to integrate the traditional interventions (research, extension, education and creation of links among research, extension, farmers) with other interventions such as professional skills, incentives, resources to develop partnerships and businesses, improving knowledge flows, and ensuring that the conditions that enable actors to innovate are in place. The concept of AIS is visually summarized in Figure 6.

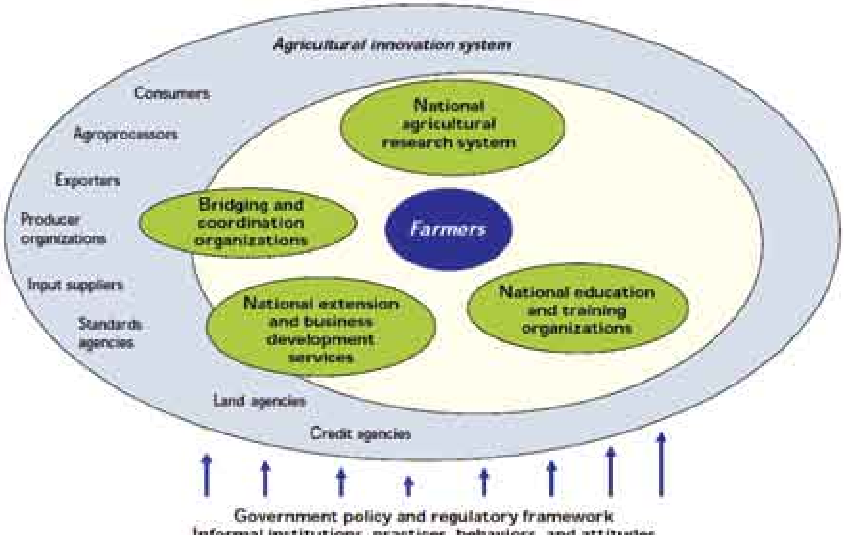

Figure 6. What is an Agricultural Innovation System (AIS)?

Source: World Bank (2012).

The operative words that best summarize the gist of the AIS concept are: interactive, dynamic and flexible. To operationalize the concept, the core elements of an effective AIS can be summarized as (see World Bank 2012 for much more detailed discussion and description of the AIS and its core elements):

1) Policy coordination and collective action for innovation:

a. Investments must be context specific and in response to a shared vision with the involvement of key stakeholders and leveraging resources from different players

b. Prioritization is central for effectiveness – everything cannot be done at once
c. Pro-active action needed to broker institutional development – for collective action and sector governance.

2) Research systems development:

a. R&D requires more than the basic capacity (infrastructure and human resources): governance, relevance and institutional mechanisms to enhance accountability
b. Innovations go beyond the traditional S&T paradigm with efforts to enable better demand articulation, partnerships and leveraging non-traditional resources
c. Enhancing cross-border technology and international cooperation and coordination will be key to faster, more effective and higher impact solutions.

3) Extension & advisory services as an integral part of the innovation continuum

a. As with research, the public sector will remain an important player in providing extension and advisory services, but it is no longer the only player in the field. Building a pluralistic and demand-driven system are core principles of successful advisory systems
b. There is much greater need for integrated services and the brokering function of extension staff in the context of the AIS to help build the partnerships among and diverse actors.
c. Exploiting new ICT tools will be a key pillar of successful advisory services of the future.

4) Private sector as an innovator

a. The rapidly changing economic landscape around the world is in part due to the rapidly increasing role of the private sector as the knowledge base for high-value and market-oriented production systems
b. The private sector offers an expanding range of skills and resources for implementation that can be exploited through appropriate public policies, well-designed incentives and capacity building to deliver not only private goods, but in some instances public goods
c. Partnerships with the private sector are important to strengthen the links between knowledge and business development, a good indicator of the vitality of an AIS.

5) Policy and enabling environment

a. Policy and regulatory frameworks play a crucial role in establishing the incentives and framework for institutional (including market) development and innovations

b. Appropriate policies will be needed to promote synergistic finance, along with core investments in markets and infrastructure.

6) Technical (including policy) & professional skills

a. This is an area that has traditionally received much less attention than needed – by developing countries as well as development agencies, including the World Bank.

b. Yet, agricultural education and training, both formal & informal, play an important roles in meeting the human capacity needs for modern agriculture and business

c. Going forward, agriculture is becoming much more knowledge intensive and will continue to be so, making investments in high-quality agricultural education and training imperative.

A good example of the transition from a traditional approach to R&D towards the more sophisticated and inclusive AIS approach is provided by the agricultural research system in India. The World Bank has been engaged in agricultural R&D in India since the late 1970s and has supported India's approach to R&D through its paradigm shifts over time – see Table 1. The designs of successive operations have adopted and supported new thinking with accumulated experience and the maturing of the Indian R&D system over the past three decades.

Table 1. Evolution of World Bank Support for Agricultural R&D in India

Paradigm	Projects	Funding	Period
Research infrastructure	National Agricultural Research Projects, I & II	USD 142 m	1978-1996
Human resource development	Agriculture Human Resource Development Project	USD 65 m	1995-2001
Technology generation and dissemination	National Agricultural Technology Project	USD 188 m	1998-2005
Innovation Systems	National Agricultural Innovation Project	USD 250 m	2006-2014

Source: World Bank data.

The key features of the current program, NAIP, are well aligned to the AIS concept. The project seeks to broaden the partnership for harnessing technology to include other research, extension and development agencies across the public and private sector spectrum, civil society and farmers. It is specifically designed to push on 5 frontiers:

- System reforms, including information technology (IT) initiatives
- Research on value chains to integrate small-scale farmers with markets
- Promote sustainable livelihoods
- Basic and strategic research
- Commercialization of technology

Future Directions

Agricultural development is facing some unprecedented challenges – some of which evolve rapidly (such as the food price crises of 2007/08) while others are more gradual (such as climate change, depletion of freshwater and soil degradation). There are also rapidly evolving opportunities. Changing tastes, maturing markets and globalization will continue to drive the search for new technological solutions. The increasing role of the private sector in agricultural R&D, the potential of bio-technology, revolutionary changes in ICT and a much wider, hitherto relatively untapped, knowledge sources provide significant optimism for greater innovation. As agriculture becomes more knowledge intensive to respond to the challenges of sustainability and "green" growth, adopting a more flexible approach that enables multiple actors to participate and collaborate in knowledge generation, use and innovation suitable to diverse contexts will be critical. Central to achieving this would be flexible and responsive institutions, human and physical capacity, incentive structures, efficient organizations and partnerships.

Given the diversity of institutional, policy and socio-economic settings, it is important to recognize that there is no generic solution or a detailed blueprint to address the specific requirements of individual countries. A number of the principles embedded in the AIS concept are now being piloted through innovative designs in different countries to address their needs for R&D. These include several World Bank investment lending operations which showcase specific features in R&D support programs. The specific cases are analyzed and discussed in greater detail in the Agricultural Innovation Systems Sourcebook (World Bank 2012).

The spectrum of approaches adopted in different circumstances and under different programs is impressive. These range from the livelihoods-focused community development programs (CDDs) that focus more on local innovation but is not science and technology centric, to partnerships with producer groups which aim to improve productivity and links to value chains through public-private partnership modalities, to agribusiness and competitiveness support programs to promote the business enabling environment and coordination of stakeholders, to advisory and research services that are more demand oriented and accountable to farmers, to projects that explicitly focus on strong innovation systems as discussed above. These initiatives are spread across many countries around the world.

The efforts in Korea, Chile and Thailand are expanding the focus from science suppliers to a broader array of participants in innovation, application and economic growth. The National Agricultural Innovation Project (NAIP) in India demonstrates the "expansion of the tent" as universities, private sector, NGOs, and producer organizations are increasingly collaborating with the public sector in undertaking innovative research. The Bolivian National Agricultural Innovation Project has a specific innovation systems focus and seeks to define more clearly and support appropriate public and private roles in agricultural R&D, while the Peruvian National Agriculture Innovation Project is improving coordination among key stakeholders, providing competitive grants for research and innovation, strengthening pluralistic extension and advisory services and institutional reforms to build a stronger AIS. Chile has adopted a sound and transparent Science and Technology Policy, which is a pre-requisite for scientific organizations to function properly through clear intellectual property rights, biosafety regulations, genetic resources policy, and seed and input market regulations.

Initiatives aimed at improving the institutional environment for R&D include the delinking of funding and execution – with a specific focus on efficiency and effectiveness, and attempting to maximize impact in minimal time in Peru. Putting in place the appropriate incentive and accountability structures are the bedrock for outcomes and performance of the Brazilian and US R&D systems. And in China, the Agricultural Technology Project is promoting partnerships through pro-active integration efforts rather than passive exhortation.

In short, with changing circumstances, significant changes are also taking place in the nature and approach to investing in R&D. They maintain the centrality of science and technology for development, but increasingly recognize the critical importance of competitiveness to drive real productivity growth, job creation and poverty reduction. In the significantly more complex world of today, innovation depends crucially on collaboration, prioritization, and tailoring investments to specific contexts. There is a rich body of global experience for the international development agencies and national implementing agencies to learn and adapt from to ensure that changes can be affected in the best directions.

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Technical Session 2

State of Agricultural Education in India

Technical Session 2, Chair Dr. K.M. Bujarbaruah

Human Resource Development in Agricultural Education, Research and Extension in India – Role of the Indian Agricultural Research Institute

H.S. Gaur and H.S. Gupta

Scriptures and reminiscences of the renowned schools of learning, Nalanda and Taxila, amply illustrate that India since ancient times has been a centre of academic, applied and spiritual education addressing different aspects of life and nature. There was a longer eclipse before the academic prowess again emerged, and the present education system, largely based on the European and North American models, started. India is the second most populous nation of the world with a population of over 1.24 billion; more than 17% of the 7 billion population of the world. It is steadily growing at 1.312%. It is astounding that India could bear this much population pressure and 11% livestock of the world with just about 4% of fresh-water and 2.3% of land area, which are further declining due to diversions for non-agricultural uses. Green Revolution achieved during the late 1960s proved role of science in agriculture, farmers' efforts and political will, which together belied Malthusian predictions of imminent fall of India owing to population pressure and starvation. The subsequent white, yellow and blue revolutions have made big strides in the agrarian economy of India. The past two decades have witnessed rice revolution, especially Basmati rice varieties produced by the IARI, which enabled increase in rice exports by India from US$ 56 million in 1991 to US$ 2.6 billion in 2011. Indian fish capture harvest doubled between 1990 and 2010, and aquaculture harvest tripled. Egg and meat production have also increased many-fold. In achieving this success, along with various factors, agricultural research, education and extension have played a pivotal role. But the challenge to meet food requirement of the predicted population of 1.7 billion in 2050, 18.1% of the global population of 9.4 billion, is huge.

During the previous decade, India exhibited accelerated economic growth, and had emerged as a global player with the world's fourth largest economy in purchasing power parity. This has brought in economic and social benefits to the country. Phenomenal increase since 1950s in productivity and production of crops and animal products despite more or less static, rather decreasing arable land, tells the story of a great success through the Green Revolution and thereafter. This was possible because of the improved technologies of genetic improvement, natural resource management, pest and disease control being appropriately used through synergy of agricultural scientists, farmers and policy-makers in the 20th and 21st century. The credit for this also goes to well-trained human resource in agricultural sciences on account of the higher education programmes started at Coimbatore (1878) and Pune (1890), followed by other famous agricultural colleges and research programmes started at the then Imperial (now Indian) Agricultural Research Institute (IARI) at Pusa, Bihar, in 1905 in India. It was this strong base that gradually has grown to one of the world's largest National Agricultural Research Systems (NARS).

However, the present and the emerging socio-economic and climatic challenges warrant introspection and much re-orientation as well as strengthening of our agricultural education system. Farmers fail to get commensurate profits from farming; and youth are showing lack of interest in agriculture. There is rapid and massive migration of rural youth to urban areas in search of alternative or supplementary vocations. Disparities in income and human development are increasing. Over the period, apparent degradation has occurred in the quality and relevance of curricula, teaching and learning skills. On the other hand, in the years ahead, we need to build a productive, competitive, and diversified agriculture sector that facilitates rural, non-farm entrepreneurship and employment. Sustainable and remunerative agriculture will need greater technological inputs, policy support, finance, extension effort as well as improved civic, agriculture, transport, storage, processing and marketing related infrastructure. Achievement of the long-term objective of sustainability and security is possible only through better education, research and extension. Investment in the generation, acquisition, dissemination and utilization of knowledge will facilitate increase in supply of various agricultural products for domestic and external markets. World Bank (2008) had emphasized that 'national knowledge economies' underpin competitive ability of a country in this globalised world.

Changing roles of public and private sectors, emergence of influential non-governmental organizations, and participatory methodologies in development programmes along with amazing advances in technology have strongly impacted capacity-development needs. Greater commercialization of agricultural system and liberalization in trade dictate necessity for greater capacity of the agricultural workforce in the 21st century, which are shaped by the following interactive programmes:

- Formal education in science, technology and agriculture programmes, provided by mainstream education institutions, that caters to in-service professionals' needs and also of those who return to schools for upgrading or career advancement,
- Non-formal agricultural and extension education programmes for farmers and rural audiences through knowledge-transfer services,
- In-service training and development programmes of private organizations and public agencies for their employees, and
- Mass-media/distance-learning programmes that provide an independent and continuous supply of information, and increasingly operate in support of the other three arenas of the agricultural education systems as mentioned above (Rivera, 1998).

HRD in Agricultural Sciences

India has one of the best organized and elaborate higher agricultural education programmes in agricultural sciences with over 65 SAUs, 5 DUs, one CAU, and a number of ICAR Institutes and central traditional universities. Three new institutes, Institute of Abiotic Stress Management; Institute of Biotic Stress Management and Institute of Biotechnology as well as a few other institutes are under consideration to be Deemed Universities. Although agriculture and agricultural education continue to be the state subjects, the Central Government supports these in a big measure through the ICAR and the DARE. As of 2010, the total intake capacity for students is 39,329; of which 27,588 (Table 1) successfully completed their degree programmes (Rama Rao *et. al.*, 2011).

Table 1. Number of Colleges and Students Intake and Outturn in 2010

Discipline	Number of colleges				Students strength	
	SAUs	Affiliated to SAUs	Gen. university	All	Intake	Outturn
Agriculture	83	112	33	228	21303	15949
Horticulture	35	8	3	46	2283	1465
Forestry	26	-	11	37	1160	716
Veterinary & AH	51	7	1	59	3521	2683
Fishery	24	-	1	25	792	424
Dairy	21	-	1	22	751	310
Agri-Engineering	33	6	1	40	2487	1507
Agri-Biotechnology	28	6	-	34	822	734
Sub-total	301	139	51	491	33,119	23,788
Food Sci. & Tech.	19	11	22	52	1,650	1,000*
Agri-business Management	22	13	30	65	3,500	2,100*
Home Science	18	-	NA	18	1,060	700
Grand Total	360	163	103	626	39,329	27,588

**Estimate based on outturn of about 60% in SAUs*
Source: Rama Rao et. al. (2011)

Rama Rao *et. al.* (2011) estimated total trained manpower with diploma up to doctorate at 105,600 for 2009-10, and predicted, a requirement of 119,680, comprising 31,280 diploma holders, 63,648 undergraduates, 14,960 postgraduates and 9,792 doctorates (Table 2). Further extrapolation on the same trend would mean increase to 160,512 by 2050. Obviously this would mean massive effort and investment along with continuous tuning of the curricula and training as well as R&D facilities.

HRD in Agricultural Education

A cadre of scientists from various disciplines including social scientists with a clear insight in agriculture-related disciplines — agricultural economics, agri-business, marketing management, rural sociology, agricultural ethics and politics has to be developed for planning for globalized agriculture. Agricultural education programmes have to be organized with emphasis on basic and applied science education, including social sciences re-enforced with

Table 2. Agricultural Human Resources Stock Requirement Projections for State Governments and Central Promotional Organizations (after Rama Rao *et al.* (2011)

Year	Diploma	UG	PG	PhD	Total
2009-10	27,600	56,160	13,200	8,640	105,600
2010-11	27,968	56,909	13,376	8,755	107008 (+1.33%)
2011-12	28,336	57,658	13,552	8,870	108,416
2012-13	28,704	58,406	13,728	8,986	109,824
2013-14	29,072	59,155	13,904	9,101	111,232
2014-15	29,440	59,904	14,080	9,216	112,640
2015-16	29,808	60,653	14,256	9,331	114,048
2016-17	30,176	61,402	14,432	9,446	115,456
2017-18	30,544	62,150	14,608	9,562	116,864
2018-19	30,912	62,899	14,784	9,677	118,272
2019-20	31,280	63,648	14,960	9,792	119,680
2029-2030*	34,592	70,389	16,544	10,827	132,352
2039-2040	38,272	77,879	18,304	11,977	146,432
2049-2050	41,952	85,369	20064	13,137	160,512 (0.96%)

**Italicized rows are extrapolation from Rama Rao et al. (2011)*

effective agricultural education and policy research. Simultaneously, agricultural education has to be made practical and rural-realities oriented, and agricultural extension should be tuned to serve the needs of the rural community through dynamic interactions with rural societies. Feedbacks from such extension activities would enrich academic institutions and universities. The need to provide curricula reorientation for academic institutions is felt increasingly to create an environment-sensitive faculty to help bring in attitudinal changes of rural community.

The National Academy of Agricultural Sciences (NAAS, 2005) has also recommended adequate infrastructure, financial support, complete autonomy coupled with accountability to ensure academic excellence in the agricultural universities. It is suggested that more Central Agricultural Universities may be established on the IIT pattern, and rural students need to be encouraged to study in them. Re-orientation of agricultural education system is a need of the hour to equip new graduates with subject competency, self motivation, positive attitude, agri-business skills, computer knowledge and information technology, and communication skills in English and regional language. Curricula should be regularly updated to incorporate changes in agricultural scenario; specific curricula could be developed for technological and skill development of women in market-driven technological enterprise and sustainable management of natural resources. The education system should emphasize on alternate farming, biofertilizers, pressurized irrigation, integrated water management, integrated nutrient management, integrated pest, disease and weed management, resource optimization, post-harvest technology and value-addition and marketing.

IARI: Leader in Shaping Agricultural Research and Education

The Indian Agricultural Research Institute (IARI), the flagship institute of the Indian Council of Agricultural Research, has served the country by developing appropriate technologies through basic, strategic and applied research leading to self-sufficiency in food grains and diversification and export of agricultural commodities. The institute also serves as the centre for academic excellence in the area of postgraduate education and human resource development in agricultural sciences. It has the distinction of serving as a model for the higher agricultural education system in India, and as a forerunner of agricultural university system. The institute, deemed to be a University since 1958, under the Sec. 3 of the UGC Act, 1956, has been consistently updating its curricula in tune with the latest developments in the relevant disciplines, and has made best efforts to maintain high standards. In addition to the 903 graduates under the 'Associateship of IARI' programme during 1923-1958, the Institute has produced 3,357 M.Sc.s and 4,232 Ph.D.s, including 318 international students from 38 countries. The contribution of IARI towards HRD for national and international agricultural research and education has no parallel. The alumni of the IARI have served as leaders in agricultural sciences, and are playing important role in India and abroad, bringing laurels to IARI and India.

The forward looking academic environment at the IARI attracts talent. The institute is committed to develop a new breed of trained manpower to face toughest challenges, including those related to research management in the changing national and international scenario (IARI, 2011). The institute is concentrating on developing personnel for crop improvement, protection, production, resource management and social sciences, and its future scientists would be facing any challenge and would be familiar with IPR, PBR, SPS and PVP regimes. Lately, IARI has established a Centre for Innovative Teaching and Learning. The multidisciplinary training, experience with state-of-the-art equipment and techniques, guidance by highly accomplished faculty and exposure to national and international problems and developments and thought process of world leaders in agricultural and allied sciences are all aimed at building leadership in agricultural research, education and extension.

Keeping the national priorities and foreseeable scenario in view, the IARI (2011) has focused its programmes and strategies on the following.

- Improving productivity and quality of cereals, pulses, oilseeds, vegetable and horticultural crops for ensuring food, nutritional and livelihood securities.
- Strengthening basic research and strategies, including molecular biology, biotechnology, microbiology and nanotechnology for advancement in crop productivity, protection from biotic and abiotic stresses value addition and national resources management.
- Enhancing crop production through conservation, efficient management and sustainable use of natural resources.
- Enhancing resilience of Indian agriculture to climate change through development of appropriate technologies and policies.
- Enhancing efficiency and efficacy of post-harvest management to minimize losses and value addition to crop commodities for better profitability.
- Ensuring biosecurity as well as sound and environment friendly plant health management to enhance quality and quantity of agricultural yields.
- Development of globally competitive human resource in basic and advanced areas of agricultural sciences through regular upgradation of faculty competence for efficient utilization of resources for furthering cause of agriculture., and
- Enhancing institutional reach to accelerate dissemination of technologies through functional linkages with R&D organizations, Government departments and other stakeholders.

New Strategies and Institutional Reforms

The agricultural education in India, over the period has got somewhat alienated from the fundamental science and technology stream, from which it had gained greatly in the first phase. It must be realized that foundation of any applied science, including agricultural science, lies in the fundamental science. There has been tendency to limit student admissions and faculty recruitments to agricultural graduates mainly or even only. In fact, agricultural science at present requires six following kinds of human resources.

i. Those who can do research and teaching to select, adopt, modify and evaluate agricultural materials and technologies (Masters/ Doctorate with knowledge and orientation of or agriculture)
ii. Those who can do research and teaching to develop novel technologies or can add novel components, which can be applied to existing technologies (Masters/Doctorate with knowledge of science and orientation in agriculture),
iii. Those who develop infrastructure and run/manage/administer operations and processes (Bachelors in agriculture or relevant technologies),
iv. Those who can manage marketing and agri-business (B.Sc./B. Tech. + MBA),
v. Those who can create mass awareness and inspire proper adoption technologies. (Bachelors/Masters in Agricultural science/technology/ journalism/mass communication), and
vi. Those who practice and supervise and advise farmers and primary entrepreneurs at the village level (Diploma in agriculture or relevant technologies)

Students from both agriculture and fundamental sciences and even commerce and communication will have relevance in higher agricultural education. It is necessary that agricultural education be made more attractive in terms of better employability and service conditions, so that talents are enamored by it. It will be good if students with knowledge of rural situation join, but restricting or preferring to rural students can be negatively viewed by students/ guardians and may be counter-productive. Talented students may also feel that the education they get may limit their future prospects or that agricultural education is meant for the rustic. In a country like India, most people are from rural areas and they with their children have moved to urban areas for work or studies. In fact sites where agricultural universities and colleges were established gradually grew into townships and lost in due course their rural character. The need is to suitably modify and impart relevant curricula and make rural areas more attractive/lucrative for employment.

Relevance of Agricultural Education

Science is a dynamic, proliferating and fast-growing. Application of the latest technologies and their gradual upgradation are essential to maintain standards and to be globally competitive (Gaur *et al.*, 2010). It is not possible to create a system *de novo* or to provide unlimited infrastructure and human resources. To optimally use existing resources and orient system to the current and emerging needs, the following are suggestions are made:

- The quality of teachers and institutions be critically regulated, and the accreditation system should be made stringent to enforce accountability.
- Inter-institutional sharing and collaboration in teaching and research should be encouraged to ensure completeness and quality, in view of shortages of faculty and facilities in certain areas.
- Specific trainings in degree programmes and specialized diploma programmes should be organized for development of para-professionals in agriculture and allied areas.
- Select scientists in each discipline should be trained in advanced science and in the state-of-the-art technologies.
- Course curricula and training programmes should be designed to suit requirement-target working-environment for better employability and productivity.
- Agricultural universities should produce professionals with sound academic as well as experiential learning relevant to the target work-environment.
- The existing Universities should have near full faculty strength and sufficient facilities and budgetary support, rather than creating new Universities without sufficient funds, facilities and faculty.
- Universities should be multifaculty with adequate inter-faculty and inter-disciplinary academic, research and extension programmes.
- The faculty and students in the university should be a mix from local and other states.

- Greater emphasis is needed to have more international students in each university, which can generate resources, help other countries and may provide broader horizons to other students.
- Teachers and scientists may be retained as long as they are efficient in teaching and research, or their superannuation age be increased to 65 years in all ICAR institutes and SAUs, as done in all central universities and institutes and several SAUs.
- Agricultural science and education must be treated at a par with competing disciplines like medicine, engineering, technology, management, science etc. At present agricultural sciences have no institutes accorded parity in status and facilities and service conditions with top institutes in these other areas, such as with AIIMS, IITs, IIMs, NISERs, IISc etc. or even with the central universities, whose numbers are increasing. The result is that neither the talented student nor the faculty gets attracted. Research is also necessary in agricultural education itself, including the pedagogies, relevance, impact, and improvement.

Integrated Agricultural Research Education and Extension System

The small-holder agricultural system essentially requires diversification and integrated multi-component farming systems. It will not be possible to deploy advisers for each component in a village. Multidisciplinary knowledge is essential at the village and at para-professional levels. The technology development also often requires multidisciplinary research, although primary experimentation may be better done in specialized labs. The multi-faculty universities with interfaculty collaborations would be a better model, than the present trend of separate universities for agriculture, horticulture, veterinary, fisheries etc.

HRD for Agricultural Research

India is a vast country comprising varied agro-climatic regions/ zones and geographical differences suitable for varied phyto-genetic diversity. To meet demand of large population in India and to increase the income as well as employment in rural areas, location-based research is emphasized. The location-specific research, under the aegis of ICAR, is conducted at various Research Institutes, National Research Centres, All-India Co-coordinated Research Projects, Project Directorates and National Bureaus. Research is also carried out at all the 65 agricultural universities (SAUs, CAU, DUs) and some of the central and traditional universities.

To fulfill the need for effective research, India's greatest challenge will be in educating, recruiting, and supporting its next generation of scientists. India has the capability as well as educational and faculty support system to achieve scientific excellence. But, the knowledge, generated by research, often gets obsolete by the time it is disseminated through extension education / teaching to farmers and practitioners due to a big lapse of time. The universities should consider this problem seriously and should reform their academic activities to strengthen links between research, teaching and extension to farmers.

The ICAR, over the years, has developed strong academic linkages with various institutions and professionals to induce vital reforms in agricultural education for improving its quality, relevance and uniformity across the country. Under this process, the Council has revised course curricula and syllabi of UG programmes through IV Deans' Committee and the PG academic programme, through a National Core Group with 18 Broad Subject Matter Area (BSMA) Committees.

Thorough, well intended, reconstitution of course curricula have been done, but many universities and colleges lack teachers and latest facilities for scientific venture. The result is poorly educated graduates. It is necessary that the faculty positions are filled up. Teachers available in other universities can be utilized through distance learning systems, employing the strength of information technology. Possibilities of retaining retiring teachers for a few more years on contract or through increasing their superannuation age as per UGC norms should be examined.

The ICAR also organizes trainings for faculty under the Summer/ Winter Schools/Short Courses at different universities and in Centres of Advance Faculty Training (CAFTs). But the provisions for training the faculty in advanced laboratories of the other countries are limited. The scientists are often compelled to seek funding from other Departments of the Govt. of India and other sources, although such trainings would directly benefit the NARS.

HRD for Extension

Agricultural Extension activities encompass imparting production and marketing knowledge, demonstrate technology/products, assessment of transferred technology and refinement through a network of SAUs, ICAR research institutes and Krishi Vigyan Kendras (KVK). There are over 50 Agricultural Technology Information Centres (ATIC) established under the ICAR institutes and State Agricultural Universities. In spite of this there have been serious gaps in technology transfer. The yield gap between demonstrated yield and actual yield achieved on farms ranges between 5 % and 100 % in many crops. The reason is lack of HRD engaged in extension work. Most of the times, even extension personnel are not aware of many technologies/packages. Even the demonstrated technologies are not followed up by the farmers in subsequent years for various reasons. Efforts now are made to improve extension system by improving knowledge of extension workers through trainings. However, tight budgets, recruitment bans and inadequate financial support are the reality for today's Extension Systems, although recently increasing attention is being paid to this. The nearly 650 KVKs with sets of trained personnel and linkages with SAUs and ICAR institutes are playing big role. One of the basic principles taught to managers is that an organization functions most efficiently when there's an optimal use of available physical, financial, and human resources. More and more organizations are realizing that their most important resources is skilled human resources. This is especially true in an organization such as Extension, whose major thrust is education (Clark, 1987). An extension education and learning is a dynamic system for developing and implementing programmes. The system consists of numerous complementary and interactive components, each contributing to the success of the total system.

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Transforming Veterinary and Animal Science Education for Reshaping India's Economy

M.P. Yadav and J.S. Bhatia

Introduction

The present day organized veterinary education in India dates back to the 18th century making the beginning of modern era. During the early phase of this period, with a view to cater to the requirements of Indian Army, stud farms and other vital establishments including Army, Veterinary Schools were created. The first civilian educational institution was established in the form of Punjab Veterinary School at Lahore (now in Pakistan) in 1882. Later on veterinary colleges were established in Bombay (Mumbai) in 1886; Calcutta (Kolkata) in 1893, Madras (Tamil Nadu) in 1903 and Patna in 1930. Madras Veterinary College, in 1936, became the first college to impart Bachelor of Veterinary Science (B.V.Sc) degree by adopting university system of education. The system of education followed was more or less of the British pattern having more emphasis on horse than on cattle. Under the influence of British faculty and experts, the indigenous system of treatment (Ayurveda) had a setback as allopathic system of medicine found favor in the existing environment.

Subsequent to India becoming independent in 1947, ten more Government Veterinary Colleges were established in different States of India in a period of about a decade. The first major transformation in veterinary and animal husbandry education took place in early 1960s when veterinary educational institutions became integral component of Agricultural system under the patronage of the Indian Council of Agricultural Research (ICAR). The ICAR acting as a central apex body for the newly created State Agricultural Universities (SAU's) on the Land Grant pattern of U.S. became the regulatory as well as governing body for managing the affairs of agricultural and veterinary education. The national institutes, namely IVRI and NDRI which were imparting veterinary and animal science education became part of ICAR in 1966. Thus, all faculties falling under the umbrella of agricultural system were made to move on a common path of governance, academic management, human resource and basic infrastructure needs as per the laid down procedures on the US land grant system.

State of Veterinary and Animal Science Education in India

The education system and veterinary institutional layout by and large follow the State Agricultural Universities (SAUs) pattern. Presently, there are nearly 60 SAUs. These include 12 Veterinary and Animal Sciences and Fisheries Sciences Universities. The chronological order of creation of Veterinary, Animal Science and Fishery Universities (SVUs) in various States is as follows: Tamil Nadu (1989), West Bengal (1995), Maharashtra (2000), Uttar Pradesh (2001), Karnataka (2005), Andhra Pradesh (2005), Punjab (2006), Rajasthan (2010), Madhya Pradesh (2010), Haryana (2010), Kerala (2011) and Chhattisgarh (2012). Further, two exclusive universities for fisheries have been created in Kerala and Tamil Nadu in the year 2011. These universities have been carved out of the existing SAU(s) of the respective States and are being governed on the same principles applicable to SAUs having funding support from the State governments and ICAR.

Presently there are over 58 veterinary colleges in India (Table 1). Among these, 30 are part of veterinary (inclusive of Animal and Fishery Science) universities. Fourteen of SAUs are having 15 constituent colleges. While the veterinary college at Aizwal in Mizoram is a constituent college of Central Agricultural University (CAU), in Imphal, the veterinary college at Pondicherry is affiliated to general University of Pondicherry. A number of states have more than one veterinary college. Amongst these Rajasthan, Maharashtra, Andhra Pradesh, Karnataka, Gujarat, Tamil Nadu, Madhya Pradesh and Uttar Pradesh have 9,6,5,4,4,4, 3, and 3 veterinary colleges, respectively. Rest of the States have one or two colleges, generally corresponding to the number of SAUs.

Table 1. Distribution of Veterinary Colleges in India

Constituent Colleges: 47		
(i)	State Veterinary Universities (SVU)	: 30
(ii)	State Agriculture Universities (SAU)	: 16
(iii)	Central Agricultural University (CAU)	: 01
Affiliated Colleges: 11		
(i)	Government Veterinary College	: 01
(ii)	Private Veterinary Colleges	: 10
Total		**: 58**

Further, out of the 3 Deemed Universities (DUs) under ICAR, dealing with veterinary, animal science and/ or fishery science education, IVRI, Izatnagar offers master's and doctoral programs in almost all branches of veterinary and animal sciences. Similarly NDRI, Karnal offers higher educational programs in dairy science, dairy technology and dairy husbandry, both at undergraduate and postgraduate levels, including doctoral level. CIFE, Mumbai is offering educational programs in fishery sciences.

Manpower Status

Presently there are around 34,500 veterinarians as against the requirement of 70-75,000 on the modest scale. Further, besides veterinarians serving in health coverage programs, there are about 2,500 serving in other organizations to manage animal & poultry farms, defense services, banking, insurance, pharmaceutical, and immune-biological units, feed industries etc. At present around 3050 professionals are engaged in teaching institutes, research organizations and extension centers. Literally, there is a shortfall of around 50% in service as well as at teaching institutions (as per VCI norms). It calls for immediate contingent measures to cover up this void. Under the fast changing world order and profession expanding in multi dimensions, the demand for competent human capital is on the rise. From a very rough estimate, India will require from 1-1.2 lakh professionals (Bhatia, 2013a) in veterinary, animal science and dairying in next 20 years (Table 2). It is feared that if the present situation is allowed to continue, the gap will reach to critically low level i.e. from 50% at this stage to 30-35% by 2035.

Table 2. Available manpower in livestock sector

Field Veterinarians	34,500
Teaching & Research	3,050
ICAR and Scientific organizations	850
Private Sector	500*
Pharmaceuticals	250*
Feed Industries	200*
Zoo and Wild animals	50*
LS farms &Poultry Industries	500*
Banking and Insurance	100*
Defense & allied sector	400*

**Tentative estimates*

Annual HRD output

Around 35-40 colleges are regularly producing veterinary graduates. Some of the young colleges are yet to reach to the stage of production of graduates. Presently, no admissions are being made in 10-15 colleges. Taking on an average 60 intake capacities in most of the colleges, while some colleges are admitting between 30-50 students, the annual output would come closer to 2000 mark (Sasidhar and Reddy, 2013).

Graduates	2,000
Post Graduates	750
Doctorates	150

In addition, there is large scale production of Diploma holders and Para-Professionals, especially from Maharashtra and Rajasthan.

Looking to the changing trends, challenges and anticipated developments in diversified spectrum of veterinary, animal and allied sciences, projection of manpower needed by 2035 (Table 3) has been projected (Bhatia, 2013 a, b, c & d). These figures on the estimates of requirement of veterinary professional corroborate well with the document presented by working group 2011 for 12th plan (2012-17) of the Department of Animal Husbandry, Dairying and Fisheries, GOI to the Planning Commission, and by the Institute of Applied Manpower Research (IAMR) and NAARM in the year 2010.

Table 3. Total requirement of Veterinarians by 2035

State Animal Husbandry Departments		1, 00,000
SAUs/SVUs		8,000
ICAR/Scientific organizations		2,000
Private Sector & self-employment		5,000
Pharmaceuticals & Immuno-biologicals		1,000
Animal Feed Industries		1,000
Banks & financial institutions		1,000
Defense sector-marginal adjustments to the present Status of		400
LS Farms and Poultry Industries		1,000
Total	**Say1,20,000**	**1,19,400**

Challenges Faced by Veterinary & Animal Science Education

Inherent limitations of veterinary education

Veterinary education is still on the cross roads being guided by road maps not primarily designed to suit this branch of science. Before understanding the problems being faced, it should be realized that Veterinary education is a State subject and thus creation of veterinary teaching colleges/universities/ institutions, their management and providing primary support are the prerogative of the State Governments. In addition, ICAR provides grant-in-aid which is very crucial in operating routine academic activities in these colleges. Institutions are created by the States independent to the advice of the VCI or ICAR. In order to foster these institutes they are made constituent or affiliated units of the SAUs/SVUs/CAUs or General University. Thereafter these colleges are made to become committed liabilities to garner support from funding agencies. Though the VCI came into being in 1984 to lay down minimum standards of veterinary education and regulate veterinary practice in the country, there are multiple control panels to oversee education with little structural relationship between these. As such the veterinary and animal husbandry education is trapped in such a mess that, even after 66 years of Independence, it is finding it difficult to find a way out to address the multiple problems being faced. Considering these limitations, pertinent issues relating to veterinary education are discussed below.

Regulatory and governance issues

Public Private Partnership (PPP) in veterinary & AH education

This concept of PPP in veterinary and animal husbandry education demands a clear understanding for its desirability, inherent shortcomings, and possible solutions. Due to inadequate funding and policy support by the concerned state governments to the veterinary colleges in the public sector, involvement of the private sector in education is the need of the hour. The inherent philosophy of Public Private Partnership (PPP) model calls for developing efficient mechanisms to engage the private sector for good social cause. To accomplish this, suitable model(s) need to be developed depending on the circumstances. Working with private sector will have the benefit of harnessing the wisdom and experiences of private entrepreneurs which would help to complement the efforts of the government in promoting the growth and development of need based quality educational programs, and in creating viable models. The government may facilitate to provide suitable land and other fixed infrastructure for the bona-fide private sector to build necessary infrastructure and viable models. However, there must be regular monitoring of standards and quality assurance of education through competent national accreditation bodies. There should be level playing principles for academic management, governance and operational freedom for any institution irrespective of its being in public or private sector. It should be made clear that 'Privatization' and 'Public-private partnership' are not synonyms. Partnership stands for a cohesive relationship and sound bondages, based on mutual trust and faith. Further, entering into PPP in no way should dilute or infringe on the existing regulatory mechanisms or create any form of unhealthy competition.

Standard operative system needed in veterinary & AH education

With the changing scenario of veterinary education, there is a need to have Standard Operative System (SOS) for establishment and operationalization of Veterinary colleges. However, the participation of the private sector in veterinary and AH education has become a subject for debate as it has created dis-harmony and imbalances in the veterinary education system. Through it becomes the paramount responsibility of the Government to streamline and facilitate a PPP system to be operational under its authority, even after the existence of private veterinary colleges in the country for more than 10 years now; no foolproof system appears to have been evolved for establishment of a college. A suitable mechanism to regulate and monitor the education in private colleges also needs to be in place. The existing mechanism of monitoring of the colleges/ institutions gives more emphasis toward physical facilities rather than evaluating standards the education in commensuration with the quality assurance. Further, the pattern adopted in institutional evaluations leave ample scope for litigation. In the interest of the bona-fide students admitted to a college and put in a year or more to study the course, ensuring smooth educational pursuits becomes the responsibility of the system, including the college, affiliating university, and the government. The students have moral rights to continue their education and should not become the victim of the system, and should not be panelized for no fault of them.

Enough damages have occurred both for the students undergoing education as well as to the institution and the creditability of the system due to application of rules that were not clearly defined. Further, there is an urgent need to cement the gaps, and tighten the loose ends, besides putting in place Standard Operational Procedures for evaluating private colleges. There is general feeling that the existing system dealing with private veterinary & AH education needs immediate revamping to restore faith in it. Thus it would be desirable to clearly delineate and define the Centre-State coordinating mechanisms for smooth functioning. Moreover, a cohesive approach and delineation of authority and responsibilities between professional bodies, technocrats and bureaucrats need serious consideration for efficiency and vibrancy in decision making process. In conclusion, concrete steps are required to be initiated by the regulatory authorities to ensure effective participation of the private sector in providing constructive support to the public sector for filling the wide gap between demand and supply pertaining to HRD developmental programs and to meet other primary needs of the profession.

Academic issues

Veterinary & AH education need revamping

An overview of the historical developments of veterinary and AH education suggests that veterinary profession made its beginning with a mono-professional approach. However, over the years, it has now attained the stage of multi-dimensional profession encompassing the diverse components of animal health, production and reproduction, societal growth, public health and zoonosis awareness, food and nutritional security, bio-safety & bio-security, bio-terrorism poverty alleviation programs, inclusive growth, livelihood of small holder and landless farmers, gender empowerment, business and market trades under global order, besides, management of livestock, wild & zoo animals and birds. The livestock has been and shall continue to be the center of focus for rural developmental programs and contribute substantially to provide sustainability to the agro dependent livelihood.

For enhancing livestock production and profitability, we need to tread the path of AREED (Agricultural Research, Education and Extension for Development). To ensure quality in house research, skill and technology development and dissemination, there is an imminent need to energize and re-vitalize veterinary and animal husbandry education for national prosperity and brighter tomorrow of our vast farming community who are dependent on livestock for their livelihood. The achievements made in the past in animal health and production have been laudable in terms of milk, egg, and meat production; control and management of livestock diseases, and capacity building for research, developing diagnostics and vaccines, and human resource development. Success stories on various fronts on daunting tasks assigned have infused confidence to take up any challenging tasks for effectively participating in national/ global developmental programs.

Veterinary graduates used to be mainly under public sector for quite long time even after independence. These graduates were primarily employed by government line departments, including the Departments of Animal Husbandry & Dairying, Veterinary Services, and Animal Resources, mainly as veterinary officers and extension specialists. Presently there are about 40,000 veterinary professionals in the country. Of these, around 75-80 per cent is in government field jobs and about 10 per cent are serving in academic and scientific research organizations. Besides, a small segment of veterinary professionals are in Indian army, co-operatives, NDDB, milk unions, agro industries, insurance, banks, pharmaceuticals and biological units, food processing industries, etc). Only a few hundred are self-employed as private practitioners, farm managers, and owners of private enterprises. Traditionally, there has been a general perception that veterinarians are only meant for health care of animals. However, the concept has now changed and now the veterinarians have to shoulder wider responsibilities in diversified fields, ranging from animal health care, animal welfare, trans-boundary diseases; biotechnological applications in animal health, production and reproduction; quarantine and defense against bioterrorism, food safety and quality assurance, export of livestock and food products, value addition to livestock produce, public health, meat inspection, wild life conservation and environmental protection.

Veterinary educational institutions are passing through a serious crisis of human resources. With the result, in most of the veterinary colleges 40 to 50% of the faculty positions are lying vacant in want of requisite man-power, thus greatly hampering the quality of education, research output and transfer of technological innovations to the livestock keepers and other stake holders. In spite of all the efforts, the veterinary graduates still continue to undergo stereotype education. Though the course curricula are periodically reviewed and updated to match the developments taking nationally and globally, the graduates are being produced with almost identical knowledge and skills due to the system fatigue and weakness. In addition to the core basic knowledge and skills, there is a need to have room for flexibility to the graduating students to undergo specialized training in their areas of interest. The VCI through its new regulations (2008) has attempted to introduce skill-based compulsory non-credit tracking programs, study circles and entrepreneur courses covering wide spectrum. Such courses would be fruitful if these are faithfully implemented.

Diversification of educational programs

The educational programs need to be technologically driven and tailor made to meet the requirement of divergent sectors, namely livestock farms, food and pet animals, Indian army; meat, dairy, feed, food, biological, biotechnology and other industries, research institutions, trade and IPR issues, specialized medicine including wild life and high altitude medicine, banking and livestock insurance, etc. As of now, the veterinary and animal science universities are not able to fulfill these requirements due to lack of trained faculty, manpower, infrastructure facilities and resource crunch. These universities need to modernize and universalize the higher education and training, encompassing on the diversified boundaries of livestock sector. Every university should develop unique character through which it must have a national and global recognition with a stamp of excellence. Universities must have collaboration with leading institutions in India and abroad to promote collaborative teaching and research. Degrees with variable professional competence and dual degree programs, specialized one year PG Diploma programs need to be given boost to meet the demand for diversified and specific talent.

Mismatch between academic standards and realistic needs

The rapid and fast changes taking place within the professional system and revolutionary advancements occurring in science and technology, and other spheres such as space, climate change, nationally and world over, calls for revamping basic veterinary education to keep it relevant to the present day time and ever changing needs in future. The VCI being the authorized body to lay and update the educational standards, need to ensure the efficacy of the regulations in the country and suggest amendments whenever and where ever needed. Some of the listed items in regulations as essential pre-requisite have gone obsolete, and thus are required to be deleted/ replaced. The present laid down standards are unachievable by majority of veterinary colleges in the given circumstances.

Implementation Mechanism: Role of Veterinary Council of India

The process of implementation of the decisions taken is very slow. It takes years to finally implement the amendments or changes even after completion of due processes and got approval. In this dynamic era if the implementation of proposed changes is delayed, it loses its relevance. There should be a time bound mechanism to ensure that amendments/ modifications/ changes that have been approved through set procedure are implemented. It is pertinent to make a mention here that recommendations made by expert committee of the VCI on manpower needs for UG colleges made in 2009, which were adopted by VCI, are pending for their implementations.

Enactment of the Indian Veterinary Council Act, 1884 (IVC, Act 1984) by the Government of India (GOI) has been a landmark decision for maintaining the quality of veterinary practice and education. This Act empowered the Veterinary Council of India (VCI) to regulate veterinary practice in all the States and Union Territories (UTs) to which this Act extends. The Act has also empowered the VCI to lay down the Regulations for Minimum Standards of Veterinary Education (MSVE). The VCI has delineated the needed parameters for educational institutions in the country for bringing greater amount of uniformity in academic regulations including eligibility criteria for UG admission, entrance examination, admission, examinations, course distributions and weightage, course contents, internship and duration of the degree throughout in the country. The VCI, however, followed the broad principles of land grant educational pattern of US with certain modifications suiting to veterinary education.

Veterinary Council of India undertakes periodical inspection of veterinary colleges imparting BVSc & AH/ BVSc Degree program. For this purpose, VCI is drafting eminent professionals as Inspectors or Visitors from the Universities, Veterinary Colleges, Scientific organizations and professionals from Government departments, besides the members of the VCI. The inspection team represents core group of professionals who remained / are working as academic managers, coordinators, planners, and having ample experience of teaching and managing the affairs of veterinary institutions in India / abroad. Those coming from the university system are well aware of the academic needs of a veterinary educational institution along with the constraints the colleges are facing in effectively executing the educational programs. The VCI is supposed to periodically organize orientation programs for the resource persons on various facets of inspection process including the IVC Act and regulations, guidelines and procedures for conducting inspections. The VCI on its executive body also have the members from amongst the Vice Chancellors, Deans, and academic managers possessing vast experience in managing and / or representing veterinary institutions in the country and entitled to be inspectors or visitors.

Meeting the Challenges Ahead in Human Resource Development

Animal Husbandry sector is playing an important role in Indian economy and socio-economic development of India. Besides providing cheap nutritional food to millions of people, it is helpful in generating gainful employment in the rural sector, particularly among the landless labourers, small and marginal farmers and women by supplementing their family incomes. Animal Husbandry Sector is an important contributor to GDP, about 24.8% of the Agriculture and allied sectors (2011-12). Further, it has to play a central role to meet the mounting challenges in the new era of globalization.

With growing emphasis on animal husbandry sector, the gap between demand and supply for qualified manpower in the country is widening further. Veterinary professionals working in the field also require updating their knowledge, which would only come with post-graduation and continuing education programs. It is, therefore, very pertinent that HRD continues to be a major component of the institute’s activities during the XII Plan period and beyond.

In the wake of new challenges faced by the livestock and animal husbandry sector in the present scenario of globalization, urbanization, climate change and global warming, squeezing agricultural lands and deterioration of natural resources, animal husbandry education comprising of veterinary and animal science streams, needs to be reoriented so as to enhance livestock produce both quantitatively as well as qualitatively in a sustainable manner. Our education should respond to the surrounding physical, economic and social environment, and concerns of food and nutritional security of our growing population. With the need to develop competent professionals for animal husbandry sector, both graduate and post graduate education needs transformation with new focus. It calls for more emphasis on hands on practical training for skill and entrepreneurship development. Among other things, experiential learning, veterinary teaching hospital, animal farm demonstration units (poultry, fishery, piggery, dairy, equine, goatry, vermin compost), ambulatory services, earn while learn schemes of broiler production, pig production, industry attachment and training will need strengthening in big way. The purpose of education should be to produce job providers rather than job seekers.

P.G. Diploma courses of one year duration may be designed for imparting specialized training in upcoming areas to fulfill the demand of industry, food processing, value edition and marketing of livestock products for human consumption, meeting international standards prescribed by Codex Alimentarius and sanitary and phyto-sanitary requirements under WTO. Knowledge of field veterinarians should be regularly updated through continuing veterinary education. The curriculum should be revised periodically to include areas of concern, such as IPR, WTO, Risk assessment and management, ethno veterinary medicine, market intelligence, ICT, climate resilient livestock production, waste management etc. Appropriate policies are required to attract and retain youth in veterinary and animal science education through provision of teaching and research associate ship, post-doctoral fellowship, and junior and senior resident ship. Veterinary and Animal Science Universities, Colleges and institutions need greater financial and functional autonomy for needed transformation to fulfill their mandate. The educational institutions need strategic planning and its faithful implementation. Opportunities for the students to work in professional settings along with exchange programs need to be encouraged. Academic institutions should include representatives of industry and other employers like banks, Indian Army, Pharma houses; feed, medicine and vaccine manufacturers on advisory boards, committees, and strategic planning.

The faculty should be exposed to educational technology, updating of knowledge through interaction and exchange programs with national and international institutions; participation in seminars, conferences and workshops; monitoring and evaluation mechanism with rewards for quality work. Inbreeding of the faculty and students need to be curbed with suitable incentives, disincentives and policy. On an average about 40 per cent of faculty positions are lying vacant due to obvious reasons. These need to be filled up on priority in transparent manner having merit as the sole criteria. For providing veterinary services at farmers' door, the available strength of veterinary specialists need to be doubled and tripled in the next 10 and 20 years, respectively. This may be accomplished by increasing the intake of the students in the existing colleges as well as by opening new colleges in public and private sectors or in PPP mode. Since, the government may not be able to spend more to meet the finances on its own, a suitable model for PPP participation for strengthening veterinary and animal science education need to be developed.

Following programs may be given due attention for transformation of veterinary and animal science education.

- ❖ Regular knowledge up-gradation and training on latest advancements in specialized areas including diagnostics, vaccinology, therapeutics, clinical medicine, micromanagement, emergency disease management etc.
- ❖ Developing and using new learning resources viz. instruction design and development, Computer and ICT based instructions, Multi-media modules for instructions to enhance quality of teaching, education and research.
- ❖ Curriculum development, reorientation of teaching methodologies and course curricula.
- ❖ Strengthening select niche areas of cutting edge technologies towards global competitiveness.
- ❖ Post-doctoral programmes.
- ❖ Faculty exchange programs.
- ❖ Workshops and brain storming for advancement of knowledge.
- ❖ Consultancy.
- ❖ Public-private sector partnership.
- ❖ Industry-academia interface workshops.
- ❖ Library information system and Database Management of bio resources.

- Interaction with industry.
- Programs to develop research project management skills.
- Motivation and time management programs for students.

Action Points

Following action points are suggested for improving the human resource requirement in veterinary and animal husbandry:

- There is need to increase the output of veterinary graduates and post graduates by increasing the intake in potential colleges and establishment of more institutes in public and private sector. It is required to be doubled immediately.
- There is urgent requirement to re-visit MSVE, Regulation, 2008. These regulations should be revised with respect to academic regulations, faculty requirement, syllabus revision and examination system. Diversification in degree program may be considered as per need assessment and employment potentials.
- Possibilities may be explored to introduce specialization in B.V. Sc. & A.H. degree program and the same may be introduced in 4th & 5th years after successful completion of core courses in first three years. Course on professional competence and area Specific needs, viz, clinical veterinary practice (companion animals / equine / wild animal, etc.), Production Sciences, Product Technologies and other industry and entrepreneurship related specific areas, etc.
- Time demands for introduction of integrated courses. Thus possibility of introducing dual degree program (B.V. Sc. & A.H. and M.V .Sc. or M.V. Sc and Ph.D.) and possibilities of having multiple entry and exit system during such degree programs should be explored. New diploma and certificate courses may also be initiated in diversified sector of veterinary & animal sciences and allied sectors.
- Continuing Veterinary Education Programs need to be considered on high priority to periodically update the knowledge, skills and competence of the professionals working in line departments, industrial houses and self employed / entrepreneurs. Refresher courses, training, workshops, summer and winter schools / short trainings for the faculty engaged in teaching, research and extension while ensuring that every scientist must get an opportunity every 5 years to enhance competence. Similarly, such programs may be also structured for field veterinarians.

- Trained manpower in the areas of primary processing of livestock products and by products at the village level is required with a view to boost rural economy. To cater the exorbitant needs, special cadre strength should be developed as middle level managers and their training programs. Directorate of extension education should be equipped for such jobs.
- Regular induction and needed replenishment of faculty is necessary for quality education to speedily fill the gaps between demand and supply. There is need for orientation courses.
- Public Private Partnership (PPP) mode should be encouraged in veterinary education and animal sciences. Specific fund allocation should be earmarked for this purpose.
- Every University should be allowed to make regular recruitments so as to maintain a proper balance in different cadres of faculty and retain proper strength. Utility of NET be re-assessed for its limitation, considering the setbacks in induction of faculty in veterinary sciences.
- Intake capacity in all veterinary/animal science colleges should be suitably raised upon the strength and evaluation of performance index of the college in order to meet the burgeoning demand of the country.
- There is an immediate need to revisit MSVE, Regulations, 2008. Various stake holders including industries should be associated in this exercise.
- Fresh meritorious B.V. Sc. & A.H. students may be inducted in the faculty as teaching associates.
- Relaxation in NET for fresh recruitments. PG students getting stipend may be made at par with the emoluments given to field veterinarians in service like medical students.
- Probation period of 2 years (where ever it exists) on fresh recruitment may be removed to retain the talent.
- New veterinary colleges should be opened in public as well as private sectors. Attempts are required to be made to develop PPP mode by sharing of recourses of land, infrastructure and expertise between public and private sectors.
- Structured arrangements should be put in place to utilize the services of retired faculty. They should be given better emoluments and honorable status. Age should not be deterrent factor provided one possesses professional competence and maintaining south health.

- There should be clear cut guidelines from the Central Government-Animal Husbandry Department / VCI on modalities of establishing and operation of private as well as Government Colleges. There is a need to develop policy framework for 'Public Private Partnership'. A suitable model for PPP needs to be prepared and circulated to all the states for translating into action.
- Guidelines for inspection of the colleges should be given to inspectors before inspecting any college. It would be in fitness if a panel of inspectors / evaluators / experts be prepared. Their qualifications and status should be kept in mind while inducting one in the panel of experts. Mechanisms may be developed to impart structured orientations / training on various facets of IVC Act, regulations, guidelines and manner of conducting inspection of a college to the inspectors / experts.
- Existing problems of education through private sector is required to be assessed and attempts be made to regulate these on realistic basis so that un-certainties are not required to linger on. All regulatory authorities and stake holders should develop joint mechanisms for proper regulation of colleges which are technically sound.
- Veterinarians should be properly trained in communication and management skills.
- The student should be trained for courses on information & communication technology.
- Practical approach in farm management & entrepreneurship needs to be focused and skills competence should be enhanced.
- The industry should assess human resource requirements for the next 10 years. They should interact with government organizations and universities. All universities should create a cell to have interface with industries, private sector organizations and self employed professionals.
- The internship program of the graduates should be clubbed with industry in order to equip graduates so that they become competent to seek their entry into private sector organizations. It would be prudent, if industries pick up graduates through on campus interview before internship. In such situations there are possibilities to structure training as per their needs.
- To have wide participation, introduction of vety-pedia-an open forum is required in veterinary field. This will greatly help in bilateral understanding and developing cordial relationship.

Policy options

- There is a need for creation of 50-60 additional Veterinary Colleges in the country both in public and private sector organizations. It is also desirable that some potential UG Colleges be upgraded to start PG programs.
- Govt. should play a pro-active role in creating Institutes/ Universities of global order through PPP mode.
- SVUs should create Institutions/ Schools/ Centers of Biotechnology, Economics and Business Management, Wild life, Forensic Sciences, Food Sciences & Animal Product Technologies and Quality Control Units to boost export potential of livestock and livestock produce/products. Possibilities should also be explored to create diversification in the existing degree courses in order to cater to the needs of different sectors such as health management, product technology, marketing etc. Universities should also venture to create relevant Bio-diversity Parks, Technology Incubators etc.
- Govt./ ICAR should create an independent National academy in Livestock Resource Management (NALSRM) on the pattern of NAARM.
- Since veterinary education is a State subject while the Central Government is entrusted to lay down to educational standards, a coordinated Center-State approach in establishing and monitoring institutions should be developed.
- Manpower need assessment and short and long term planning for HR development should be undertaken to take care of national and regional needs. Constitution of manpower planning board (constituting center and state representatives) for speedily development and implementation of HRD programs is recommended.

Monitoring of educational standards

There is also a need to revisit evaluation parameters of inspecting institutions by adding objectivity and quality assurance. Quantitative parameters are important but more than these, how far these are utilized in making qualitative output are required to be included. Final analyses of an institution should be judged on the basis of its relevance in imparting quality education on sustainable basis with the availability of existing facilities assessed along with the performance appraisal and its commitment towards future roadmaps.

Epilogue

Under the changing scenario, metamorphic approach is needed to bring transformation towards making the system more vibrant & productive, especially in producing professionals, who are competent, self-reliant and possess the capabilities to swiftly adjust to the changing environment. Change of mind set, coupled with coordinated efforts, public-private partnership & critical assessment of input to anticipated output as well as outcome analysis are the key component of the developmental processes. Government is required to accord higher priority to this sector and infuse substantial funding on sustainable basis for ensuring faster development. Both Central and State Governments, the scientific organizations, Professional Academies and Associations, the universities & colleges, industrial houses and other stake holders should work in tandem to revamp the system for faster and meaningful developments of this sector.

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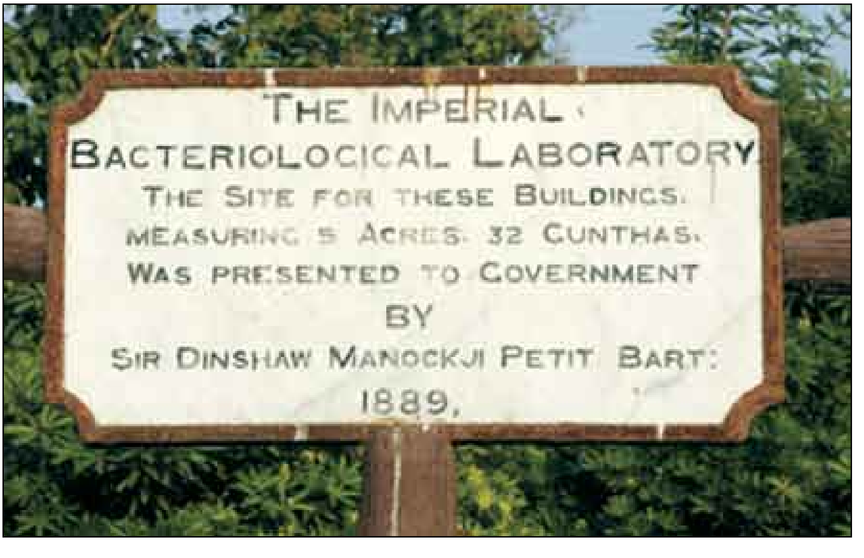
Role of Indian Veterinary Research Institute in Veterinary and Animal Sciences Higher Education

R.K. Singh and V.P. Singh

Evolutionary History of Indian Veterinary Research Institute:

Indian Veterinary Research Institute is a premier Institute in the field of Veterinary Science and Animal Husbandry in the country. The foundation stone of the Institute was laid by the Governor of Bombay, on 9th December, 1889 at Poona (Pune) on $5^{1/2}$ acres of land donated for this purpose by a Philanthropist, Sir Dinshaw Manokji Petit Bart. Thus, this is the oldest Research Institute in the country.



Foundation stone

The congested surroundings of Pune were found to be unsuitable for working with infectious diseases and for expanding the activities of the Institute. In 1893, the Institute, then known as Imperial Bacteriological Laboratory, was shifted to a picturesque locale in the Kumaon Hills at Mukteswar which is at a height of 7500 ft. above sea level. The hilly topography, lush green surroundings and salubrious climate, provided an excellent environment for conducting research and also satisfied the conditions for preservation of reagents and disease security.

Dr. Alfred Lingard, a Medical Bacteriologist, who had been trained in Germany, joined the laboratory to head as Imperial Bacteriologist. He was instrumental behind the visit of three noted Bacteriologists, Prof. Robert Koch, R. Pfeiffer, and G. Gaffky to India in 1897 to advice on the best methods for prevention and control of Rinderpest. Lt. Col. J. D. E. Holmes, who succeeded Lingard in 1907, visualized the advisability of setting up of a branch laboratory in the plains as a tributary of Mukteswar to provide such environmental facilities as were lacking in the hills. Thus, Izatnagar Campus of the Institute was established in 1913 for large scale manufacture of the sera and vaccines, and also for undertaking investigations which could not be conducted from Mukteswar. In 1936, the Imperial Serum Institute, Izatnagar became the Biological Products Section and the parent Institute which came to be known as Imperial Veterinary Research Institute.

Historic visit of Prof. Robert Koch to IVRI, Mukteswar -1897

In addition to Animal Health activities, another important development of the Institute was the establishment of Divisions of Animal Nutrition and Poultry Research by the then Viceroy and Governor General of India, Lord Linlithgow in 1939.

After independence in 1947, the name of the Institute was changed to Indian Veterinary Research Institute and in 1966 the administrative control of this Institute was transferred to the Indian Council of Agricultural Research. It was also recognized as one of the three national Institutes under the council.

Various regional stations of IVRI were established in the following manner -

i. *Regional Station Palampur (Himachal Pradesh)*: This campus provides adequate facilities for Animal Nutrition research for high altitude areas and was established in 1969.
ii. *IVRI Centre at All India Institute of Hygiene and Public Health, Calcutta (West Bengal)*: This unit was started at Calcutta in 1970 on the recommendations of the World Organization and the Government of India to impart post-graduate teaching and conduct research in Veterinary Public Health.
iii. *IVRI Campus, Bangalore (Karnataka)*: This campus was established in 1971 with Danish collaboration, for the large scale production of tissue culture FMD vaccine using fermentor technology.
iv. *IVRI Center, Srinagar (Jammu and Kashmir)*: This centre was opened in 1972 at Srinagar (J&K) to manufacture the irradiated Lungworm Vaccine for the sheep and to provide health cover to the sheep industry in Jammu and Kashmir state in particular.

The IVRI unit of Port Blair was established in 1970 for carrying out studies on Stephano-filarial dermatitis, has since been merged with the Central Agricultural Research Institute Port Blair due to administrative reasons.

The National Goat Research Center, under the administrative control of IVRI was established in 1976 at Makhdoom to provide a nucleus set up for the conservation of native and exotic germplasm as well as to coordinate the research, training and education programs for extension of goat production in the country. This centre has grown into a full fledged institute and has been de-linked from IVRI since 1976.

The Division of Poultry Research of the IVRI which was engaged in pioneering research on various facets of poultry science has been branched off as a separate full fledged institute in 1979.

Postgraduate Education and Training

Besides research, the Institute has been providing facilities for post graduate education to scholars from within the country and abroad.

In 1900, training was imparted to field veterinarians in general principles of therapeutics. In 1904, a scheme of training of official from army and civil departments in comparative pathology, bacteriology and microscopic work was initiated. These were later replaced by refresher courses and finally in 1960 reorganized into National Diploma Course. In 1943, the award of Diploma of Associateship of IVRI was initiated, as a part of post- graduate teaching programme which was equivalent to M.Sc. /M.V.Sc.

In 1955, the Joint Indo-American team on Agricultural research and education emphasized the urgency of extending facilities for post graduate education to meet the country's requirement in respect of trained teachers and technical personnel for Veterinary Colleges and Livestock Research Stations in the country. The need for establishment of such post graduate education was also felt for filling up a large number of posts created during five year plans for the development of Livestock industry.

The Government of India established the **Post Graduate College of Animal Sciences** at this Institute in 1958 as highly trained experienced and qualified staff and specially equipped laboratories were available here. This college was then affiliated to Agra University and later with the Rohilkhand University. The establishment of this college obviated the necessity of sending large number of students abroad for post graduate education.

Initially, the college imparted instruction and provided research facilities for post graduate degrees of Agra University in six Veterinary Science and Animal Husbandry subjects, namely Veterinary Bacteriology, Pathology, Parasitology, Animal Genetics and Breeding, Animal Nutrition, and Animal Physiology. In due course, post graduate programmes were started in four more subjects viz., Poultry Science, Biochemistry, Gynaecology and Pharmacology.

Master and doctoral programmes are envisaged in some more subjects such as Livestock Production Research, Livestock Products Technology, Livestock Economics and Statistics, Experimental Medicine and Surgery, Epidemiology and Extension Education. Later on, Masters degree programme was suspended in 1978-79 and got restarted with recognition of the Institute as Deemed to be University. On the recommendations of the World Health Organisation and the Government of India a Masters' degree course in Veterinary Public Health was started in collaboration with the All India Institute of Hygiene and Public Health in Calcutta in 1970.

Deemed University Status

University Grant Commission of India under Section 3 of UGC Act 1956 conferred the Deemed to be University status to IVRI in 1983 and was made effective from 15 January, 1985 by ICAR. The high powered review committee of the UGC has reviewed the progress of the university in January, 2010 and submitted their report with its appreciation on the commendable work done and service rendered by the university and recommended for its further upliftment.

The Institute as a Deemed University now offers Master's degree programme in 22 disciplines and Ph.D. programme in 19 disciplines. **Doctoral Programmes** leading to award of Ph.D. degree are offered in the disciplines of Animal Biochemistry, Animal Biotechnology, Animal Genetics and Breeding, Animal Nutrition, Livestock Production & Management, Livestock Products Technology, Poultry Science, Veterinary Bacteriology, Veterinary Extension Education, Veterinary Gynaecology & Obstetrics, Veterinary Immunology, Veterinary Medicine, Veterinary Parasitology, Veterinary Pathology, Veterinary Pharmacology, Veterinary Physiology, Veterinary Public Health, Veterinary Surgery & Radiology and Veterinary Virology. **Masters' Programmes** leading to award of M.V.Sc. degree are offered in Animal Biochemistry, Animal Biotechnology, Animal Genetics and Breeding, Animal Nutrition, Bio-Statistics, Livestock Economics, Livestock Production & Management, Livestock Products Technology, Poultry Science, Veterinary Bacteriology, Veterinary Epidemiology, Veterinary Extension Education, Veterinary Gynaecology & Obstetrics, Veterinary Immunology, Veterinary Medicine, Veterinary Parasitology, Veterinary Pathology, Veterinary Pharmacology, Veterinary Physiology, Veterinary Public Health, Veterinary Surgery & Radiology and Veterinary Virology.

National Diploma Courses

While meeting the demand of training of officers from States in various disciplines of Veterinary Science and Animal Husbandry, the earlier refresher courses were reorganised in 1960 into **National Diploma Courses** of nine month duration in four subjects viz. (i) National Diploma in Animal Husbandry (N.D.A.H.) (ii) National Diploma in Poultry Science (N.D.P.H.) (iii) National Diploma in Preventive Veterinary Medicine (N.D.P.V.M.) (iv) National Diploma in Animal Reproduction (N.D.A.R.). The two **certificate courses** i.e. (1) Advance course in artificial insemination and physiology of reproduction and (ii) Advance course in manufacture of biological products were also subsequently converted into a regular nine month National diploma courses in 1976. Presently, National Diploma Courses of ten months duration each are imparted in 10 disciplines viz. Animal Husbandry, Animal Reproduction, Animal Welfare, Equine Husbandry, Fodder and Feed Technology, Meat and Meat Products Technology, Medicine & Surgery, Poultry Husbandry, Veterinary Biological Products, Veterinary Preventive Medicine and Zoo and Wild Animal Health Care & Management.

Short-Term Specialized Training Courses

Short term training courses to the professionals, sponsored by AUs, VUs, DBT, ICAR, DST, State Governments, Industrial houses etc. and vocational training to farmers is a regular feature besides the summer/winter schools sponsored by the ICAR, DBT etc. International training courses on advanced areas are conducted exclusively for the foreign participants at IVRI regularly.

His Excellency, the President of India, Hon'ble Shri R. Venkataraman delivering the convocation address at special convocation held during centenary celebrations on 9th December 1990.

The first convocation of IVRI, Deemed University was held on 22nd October 1990 and a special convocation was held on 9th December 1990 on the concluding day of the centennial year of the Institute. Hon'ble President of India, Shri R. Venkataraman graced the occasion.

With the passage of time, the Institute made rapid strides and achieved all-round progress leading to award of the prestigious Sardar Patel Outstanding ICAR Best Institution Award. A High Security Animal Disease Laboratory (HSADL) with high-tech bio-containment facility was established at Bhopal in the year 1985 to undertake research on emerging and exotic diseases. The Centres of Advanced Studies, now named as Centre for Advanced Faculty Training on Animal Nutrition and Animal Physiology were established in the year 1995. Subsequently, a Centre of Excellence in Human Resource Development in Veterinary Biotechnology was sanctioned under National Agricultural Technology Project in 1999. The ICAR has accredited the IVRI Deemed University in 2004. The institute spread over an area of 440.54 Acres, has a well established National Library of Veterinary Sciences, Animal and fodder farms, boy's and girl's hostels, bank and post office facilities at its Izatnagar campus. The Institute has been attracting a large number of foreign students specially from developing countries.

Recently, the Memorandum of Understanding has been signed with several reputed Universities for Post Graduate student's research work and numbers of technologies developed by the scientists and students of IVRI have been transferred to young budding entrepreneurs for their commercialization. Apart from that, the scientists from various Animal Science Institutes of ICAR were included in the faculty of IVRI to guide the scholars and utilize the infrastructure and facilities of different animal research institutes. For faculty up gradation, scientists have received advanced training from UK, USA, Australia, European countries etc. under FAO/UNDP, TOMBIT-UK and World Bank assisted projects on AHRD, DBT, NAIP etc.

Mission, Vision and Mandate of the Deemed University

Mission

Undertaking pioneering research in Veterinary and Animal Sciences with holistic approach, promoting high quality education and training, developing systems and technologies for better animal health care and production and their transfer to end users, functioning as an effective instrument for nutritional security, poverty alleviation and rural construction.

Vision

Striving for excellence in innovative research, human resource development, technology generation and transfer for improved animal health, productivity responding to the needs of animal owners and lovers with acknowledged leadership among the World nations. The vision statement identifies the key strategic issues viz., to be a world class institution of academic excellence for promoting high quality education and training, developing systems and technologies for better animal health care and production and their transfer to end-users, functioning as an effective instrument of nutritional security, poverty alleviation and rural reconstruction.

Mandate

The mandate of this University is –

1. To conduct research, postgraduate education and transfer of technology in the areas of animal health and production.
2. To act as national referral centre for veterinary type cultures, disease diagnosis, biologicals and immunodiagnostics.

Library Facilities

The National Library of Veterinary Sciences at IVRI has a collection of more than 2,50,000 highly specialized reading material in the form of books, journals, monographs, theses, reference works published data, bulletins, reviews, advances, reports, reprints, micro-documents etc. The library is subscribing about 125 foreign journals and about 103 Indian journals each year. Facilities for information, access and retrieval from CD-ROM databases in the multi-user environment is provided using CD-Mirror Hybrid Server on nominal charges. Library has been using KOHA V.3.8 software for automation of library activities. All the PhD theses available in the library have been digitized in PDF form and are available for use in library premises. Library provides E-mail & Internet facilities to its users at 24 terminals during all working hours and days. Three reading sections of the library are air-conditioned. Digital Video Recording based Close Circuit TV system with 22 cameras is being used in the various sections of the library for electronic surveillance. Photocopy facility is also made available in the library at nominal charges.

Agricultural Technology Information Centres (ATICs)

The Agricultural Technology Information Centre's major purpose is to provide greater coordination and intensive interaction between the researchers and technology users beyond individual units of research institutions in contributing towards the dissemination of information. The ATIC's are to act a single window delivery system with an objective to help Farmers and other stake holders such as Farmer-Entrepreneurs, Extension workers, Development agencies, Non-Government Agencies(NGOs) and private sector organizations to provide solutions to their location - specific problems in agriculture and make available all the technological information along with technology inputs and products for testing and use by them. IVRI-ATIC though it was established in 2000, became fully functional through its new building only after 2005.

Future Growth Plan of the Deemed University

With the rapid change in technology environment, there is demand for developing graduates to harness science and technology. This calls for new courses as per changing market demand and new mode of delivery with effective use of electronic media. Efforts are being made to develop and modernize need based course curricula and methods of delivery i.e., moving from teaching to learning. This would bring about substantial improvement in the tools and techniques of imparting education to make teaching more interactive and for up scaling the skills in real life situations. Human Resources and Institutional Capacity-Building Programmes in Cross cutting areas are envisaged to develop on the areas and emerging technologies in the Deemed University.

The followings are some of the future goals of the university:

- Developing and using new learning resources viz. instruction design and development, Computer and ICT based instructions, Multi-media modules for instructions to enhance quality of teaching, education and research.
- Curriculum development, reorientation of teaching methodologies and course curricula.
- Strengthening select niche areas of cutting edge technologies towards global competitiveness.
- Post-doctoral programmes.
- Faculty exchange.
- Workshops and brain storming for advancement of knowledge.
- Consultancy.
- Public-private sector partnership, industry-academia interface workshops.
- Library information system and Database Management of bioresources.
- Interaction with industry.
- Programmes to develop research project management skills.
- Motivation and time management programmes for students.

Linkage and Coordination

For effective implementation of the identified programmes, linkages with national and international R&D organizations on one hand, and with the beneficiaries/farmers/industries through collaborative research, consultancy, contract research and contract service, training, extension activities etc. on the other are essential and have been incorporated in the perspective plan.

Challenges Ahead in Human Resource Development

Animal Husbandry sector is playing an important role in Indian economy and socio-economic development of India. Besides providing cheap nutritional food to millions of people, it is helpful in generating gainful employment in the rural sector, particularly among the landless labourers, small and marginal farmers and women by supplementing their family incomes. Animal Husbandry Sector is an important contributor to GDP, about 24.8% of the Agriculture and allied sectors (2011-12). Further, it has to play a central role to meet the mounting challenges in the new era of globalization.

With growing emphasis on animal husbandry sector, the gap between demand and supply for qualified manpower in the country is widening further. Veterinary professionals working in the field also require regular knowledge up-gradation and training on latest advancements in specialized areas including diagnostics, vaccinology, therapeutics, clinical medicine, micromanagement, emergency disease management etc. which would only come with post-graduation and continuing education programmes. It is, therefore, very pertinent that HRD continues to be a major component of the institute's activities during the XII Plan period and beyond.

Strengthening and development of Veterinary and Animal Science education needs to be undertaken to make it more relevant to the needs of the country. This may be achieved through, establishing Centers of Advance Faculty Training, Professional Chairs, Infrastructure up-gradation, faculty competence building, Training of Field Veterinarians and Subject Matter Experts, accreditation and scholarships to students and their practical training in laboratory and field situations. For improvement of training, the areas to be strengthened are Interdisciplinary teaching, collaborative Post-Graduate research, Training of the trainers and enlarging the scope of inter-institutional collaboration for the Post-Graduate programmes with premier teaching and research organizations in the country and abroad.

Dairy Science Education in India: Current Status and Way Forward

Smita Sirohi, Latha Sabikhi, Meena Malik, A.K. Singh, G.R. Patil and A.K. Srivastava

Dairying has been an integral part of rural livelihoods in India from times immemorial. Evidences of cow rearing as an important aspect in life of the society are found in the archaeological facts dating back to 3000 B.C. from Indus Valley sites of Mohenjo-Daro and Harappa. Mention of cattle centric communities and kingdoms depending on animal and milk economy is also found in Mahabharata. The Indian scriptures like Atharva Veda, ayurvedic texts and teachings like Charak Samhita, etc. are full of references on importance and value of milk for human life. Besides, its importance from the nutritional perspective, in agrarian countries like India, dairying makes a substantial contribution to livelihood security by providing income, fuel, manure, draft power and serving as current assets for a vast majority of rural households.

In past few decades, particularly after the Indian economy was swept by the wave of globalization, privatization and liberalization in the early 90s, there is a gradual shift in the way dairy is being managed as an economic activity. There is a subtle trend towards commercialization of dairy farming, enhanced value addition, growing consumer demand and quality consciousness. These trends would reinforce in the times to come and would have far reaching implications for the development of the human capital stock required for the holistic growth of the dairy sector. Human capital, that is, the stock of competencies, knowledge, social and personality attributes of the work force is being increasingly recognized as an important factor of production. In labour-abundant economies like India, human resource can be transformed into human capital with effective inputs of education, health and moral values. The transformation of raw human resource into highly productive human resource with these inputs is the process of human capital formation.

In this backdrop, this Chapter presents an overview of the dairy education system in India; gives an estimate of the future demand and supply of human resources in the sector in light of the drivers affecting the development of the sector and delineates the key initiatives required for skill upgradation of various personnel engaged in the sector.

Indian Dairy Education System

***Pre-Independence Period*:** The development of a formal dairy research and education system in India can be traced back to the birth of the Imperial Institute of Animal Husbandry and Dairying at Bangalore in 1923. The establishment of this Institute was the stepping stone for the advancement of dairy education and research in India in the pre-independence period. One of the mission statements of this Institute included "Provide training and educational programmes at all levels for meeting the manpower needs of the emerging dairy industry of the country." Since its inception at Bangalore, the Institute was the main centre for supplying trained manpower that spearheaded the dairy development programmes in different cities of India. Imperial Institute for Animal Husbandry & Dairying started a two-year training course for the award of Indian Diploma in Dairying (IDD) on the lines of National Diploma in Dairying given by the Royal Agricultural Society of England. Later in 1924, two other courses, viz., (i) a 15 month Post-graduate course (subsequently designated as Associateship course) for imparting higher knowledge in dairying and research techniques and (ii) a 3 month short course on practical training in dairy farming for the benefit of the personnel in the Industry, were initiated. Subsequently, special training courses for imparting instruction to Cooperative Inspectors and Vocational Training Course for soldiers and ex-service personnel were also started. A galaxy of pioneers, who passed out from this Institute, steered several projects in dairy development in different states of the country. During the early stage of its progress from 1923 to 1932, the activities of the Institute were mainly confined to the training of students apart from providing technical advice and guidance to the industry and the State Governments. The most historical landmark of this era was the two week training imparted to Mahatma Gandhi and Pandit Madan Mohan Malviya on modern methods of cattle management in 1927. Training facilities of Imperial Institute were further intensified with the addition of research section. The Associateship course was, however, discontinued in 1947. Training and Teaching in fundamental and applied research areas of Dairy Science was initiated in 1945 with the setting up of an Honorary Research Workers Course of two-year duration at this institute which was renamed as Indian Dairy Research Institute.

Post-Independence Period: Later in 1955, the Institute was shifted to Karnal and again renamed as National Dairy Research Institute (NDRI). Within two years of its inception in new form, NDRI started offering the country's first degree course of B.Sc (Dairying), which was of three-and-a-half year's duration with 6-month practical training in industry. In 1961, reorganization of teaching programmes of the Institute led to two B.Sc. degrees in two different streams i.e., Dairy Husbandry and Dairy Technology. In addition to under-graduate programmes, Masters Degree in Dairying initially, in four disciplines i.e. in Dairy Husbandry, Dairy Technology, Dairy Chemistry and Dairy Bacteriology and later, during the seventies, in 14 different dairy-related disciplines including Quality Control was started. Subsequently, M.Sc in Animal Biotechnology was also incorporated into the educational programme of NDRI, Karnal. A post-graduate diploma in Dairy Engineering was offered at the Institute during the late seventies. The Doctoral programme was introduced in various disciplines of Dairying in 1967 and later from 1978 course work was also introduced for the Ph.D. studies. In 1989, the Dairy Science College at NDRI was granted the status of Deemed University.

Other than NDRI, the other institutions of higher education in dairying were at Anand, Udaipur and Kolkata where post graduate courses were offered in selected fields of dairy science. Another important development in education system was the establishment of National Dairy Development Board (NDDB) in 1965. In 1979, NDDB had set up the Institute of Rural Management at Anand (IRMA), which is also catering the requirement of manpower of rapidly growing dairy industry.

Current Status: In India, the rapid increase in contribution of dairy sector to the food and nutritional security has been aided by advances in dairy research and development. India is emerging as a mega dairy market of the 21st century. In the current context, several factors such as global competition in commerce and trade, climate change, population pressure, etc. have led to a paradigm shift in the way the issues confronting the dairy sector need to be addressed. Hence, to deal with the emerging issues influencing dairying, quantitative and qualitative requirement of human capital is far more rigorous in the current scenario. To meet the human capital requirements for the dairy sector, India has now a vast network of institutions for imparting higher education in dairying and allied disciplines.

The rate of growth of dairy education institutions has been commensurate with the development of Indian dairy industry. National Dairy Research Institute continues to play a lead role in dairy education in the country and offer courses at undergraduate, postgraduate and doctoral levels. Over the years many state agricultural universities have started offering, a 4-year degree course in Dairy Technology. At present Dairy education is offered in 19 colleges/ institutes. Total intake of Dairy science students in the country is about 750 per year (487 in UG, 174 in PG and 90 in PhD). Besides degree programmes, in this discipline short-term diploma courses ranging from one year to two years are also offered by various universities (Table 1). The eligibility requirement for admission in B.Tech (DT) is 10+2 with physics, chemistry and mathematics. Many universities and colleges/ institutions (Table 2) have added PG programmes in disciplines of Dairy Technology, Dairy Microbiology, Dairy Chemistry and Dairy Engineering. In most of the colleges the admission is made on the basis of entrance tests. In addition, Education Division of Indian Council of Agricultural Research (ICAR) conducts All India Entrance Examination for admissions to Under-graduate course B.Tech. (Dairy Technology) and Post-graduate programmes for filling 15% of the total seats in state agricultural universities and 100% seats at National Dairy Research Institute, Karnal and Bangalore. The Indian Institute of Technology (Khadagpur) has started Ph.D programme in Dairy Engineering.

In addition, there are over half a dozen major research institutes under the Indian Council of Agricultural Research (ICAR) in the field of Animal Sciences, which among others work on animal health, dairy production, processing, buffalo, sheep and goats, and animal genetic evaluation/conservation. These institutions provide facilities for certificate/diploma/degree, Masters and Doctoral level education in animal and dairy science, with specialization in animal health, production and processing technology.

Besides imparting education to train professions at higher levels, in recent years, skill development at other levels has also received attention. Many general Universities offer Dairy Science as a vocational course at the B.Sc. level. Some SAUs, research

Table 1. Dairy Science Colleges in India

No.	Name of the College	University
1	SMC College of Dairy Science, Anand, Gujarat	AAU, Anand
2	College of Dairy Science, Dantiwada	GAU, Dantiwada, Gujarat
3	Dairy Science College, Amreli	Kamdhenu Veterinary University, Guajrat
4	Mansinhbhai Institute of Dairy and Food Technology, Mehsana	Kamdhenu Veterinary University, Guajrat
5	College of Dairy Technology, Kama Reddy, Nizamabad,	ANGRAU, Hyderabad
6	Dairy Technology Programme, Tirupati	SVV University, Tirupati,
7	Faculty of Dairy Technology, Mohanpura, W. Bengal	WBUAFS, Kolkata
8	College of Dairy Science, Udaipur	MPUA&T, Udaipur
9	Dairy Science College, NDRI, Karnal.	NDRI Karnal
10	Sanjay Gandhi Institute of Dairy Technology, Patna	RAU, Pusa, Bihar
11	College of Dairy Science & Technology, Raipur	IGKV, Raipur
12	College of Dairy Technology, Udgir	MAFSU, Nagpur
13	College of Dairy Technology, Warud (Pusad)	MAFSU, Nagpur
14	College of Dairy Science & Technology, Mannuthi, Thrissur	KAU, Mannuthi, Thrissur
15	Dairy Science College, Hebbal, Banagalore	KVA & FS, Bidar
16	Dairy Science College, Gulbarga	KVA & FS, Bidar
17	Dairy Science College, Chennai	TANUVAS, Chennai
18	Dairy Science College, Ludhiana	GADVASU, Ludhiana
19	Warner School of Food and Dairy Technol, Allahabad	SHIATS, Allahabad

institutes, vocational education institutions, Open Universities and Schools offer short duration diploma programmes and certificate courses covering various aspects of agriculture including dairying and animal husbandry, such as, value added products from milk,

Table 2. Post-graduate Courses in Dairy Science and Technology Offered by Different Universities and Colleges in India

Ph.D. (Dairy Science)	Madras Veterinary College, TANUVAS, Chennai Dairy Science College, Karnataka Veterinary, Animal & Fisheries Science. University, Bangalore College of Veterinary & Animal Science, KAU, Thrissur, Kerala Dairy Science College, MPUAT, Udaipur SMC College of Dairy Science, AAU, Anand
Ph.D (Dairy Technology)	National Dairy Research Institute Deemed University, Karnal
Ph.D (Dairy & Food Engineering)	Indian Institute of Technology, Kharagpur
M.V.Sc (Dairy Production/ Dairy Technology)	College of Veterinary Science, Sri Venkateswara Veterinary University, Hyderabad
M.V.Sc (Dairy Technology/ Dairy Science)	College of Veterinary Science, Tirupati
M.V.Sc (Dairy Science)	College of Veterinary & Animal Sciences, MPKV, Parbhani Madras Veterinary College, TANUVAS, Chennai
M.V.Sc (Livestock Products Technology)	College of Agriculture, GBPUAT, Pantnagar Indian Veterinary Research Institute Deemed University, Izatnagar
M.Sc. (Dairying)	National Dairy Research Institute, Karnal SMC College of Dairy Science, AAU, Anand
M.Sc./M.Tech. (Dairy Technology)	National Dairy Research Institute Deemed University, Karnal
M.Tech. (Dairy Engineering)	National Dairy Research Institute Deemed University, Karnal
M.Tech. (Dairy & Food Engineering)	Indian Institute of Technology, Kharagpur
M.Sc. (Dairy Science)	Dairy Science College, Karnataka Vet, Animal & Fisheries Science University, Bangalore College of Veterinary & Animal Science KAU, Thrissur, Kerala Dairy Science College, MUPUAT, Udaipur
M.Sc. (Dairy Husbandry)	Dairy Science College, MUPUAT, Udaipur

Contd...

Table 2 contd...

M.Sc. (Ag.) in Animal Husbandry & Dairy Science	Faculty of Agriculture, KKV, Dapoli Faculty of Agriculture, PKV, Akola Faculty of Agriculture, VNMKV, Parbhani CS Azad University of Agriculture & Technology, Kanpur Institute of Agriculture, BHU, Varanasi Kanpur University, Kanpur RBS College, Agra Udai Pratap College, Varanasi
M.Sc. (Ag.) in Dairy Science	Faculty of Agriculture, MPKV, Rahuri
M.Sc. (Ag.) in Dairy Technology	Allahabad Agricultural Institute, Allahabad
M.Sc. (Dairy Bacteriology/ Dairy Chemistry)	Dairy Science College, WBUAFS, Mohanpur

fruits and vegetables, etc. Short term Diplomas in the form of two-year "Indian Dairy Diploma" (IDD) and one year "Diploma in Dairy Technology" are offered by Allahabad Agricultural Institute, Naini, Allahabad and Indira Gandhi National Open University (IGNOU) New Delhi, respectively. In view of the increasing demand of middle level floor shop management personnel in the Dairy industry, a three years Diploma in Dairy Technology has again been introduced at Southern Regional Station of NDRI at Bangalore in 2013-14.

NDRI as the Lead Institution in Dairying

NDRI Deemed University provides high quality education in the field of Dairying, which has no parallel in Asia. Presently, the University offers Masters and Doctoral courses in thirteen different disciplines (Box 1). Research and teaching facilities available at Southern Regional Station, Bangalore are also used for running Masters programme in Dairy Chemistry and Dairy Technology, Dairy Engineering and Doctoral dissertation work in Animal Breeding, Dairy Chemistry, Dairy Technology, Dairy Engineering, Agricultural Extension/Veterinary Extension and Agricultural Economics/ Livestock Economics. Likewise, Masters Students in the discipline of Animal Biotechnology, Livestock Production and Management, Animal Nutrition and Agricultural Economics/Livestock Economics are deputed to Eastern Regional Station, Kalyani.

Box 1. Disciplines in which Masters and Doctoral degrees are awarded by NDRI

1. Dairy Microbiology
2. Dairy Chemistry
3. Dairy Technology
4. Dairy Engineering
5. Animal Biochemistry
6. Animal Genetics & Breeding
7. Livestock Production & Management
8. Animal Nutrition/Forage Production
9. Animal Physiology
10. Agricultural Economics/Livestock Economics
11. Agricultural Extension/ Veterinary Extension
12. Animal Biotechnology
13. Agronomy (Forage Production)

The admission of candidates is made on the basis of merit through All India Entrance Examination conducted by the Education Division, Indian Council of Agricultural Research and National Dairy Research Institute for the Master and Doctoral degree programmes, respectively.

The Institute also offers the prestigious undergraduate degree course leading to award of B. Tech. (Dairy Technology), a four year degree (8 semesters) programme that offers intensive training in processing, quality control of milk and dairy products, and engineering. Along with classroom teaching, one year "In-Plant Training" simulating the industrial environment is the outstanding feature of the B. Tech (Dairy Technology) programme. The in-plant training provides an opportunity to the NDRI students to manage dairy processing jobs in commercial environment. NDRI, being a Research Institute, is able to impart latest scientific knowledge to students, through the process of knowledge generation. For experiential learning of students and providing them better training, the facilities at Experimental Dairy Plant of NDRI have been expanded.

Over the years, NDRI has produced 2154 Diploma holders, 1216 Dairy Graduates, 2065 post-graduates and 946 Doctorate in different areas of Dairying. NDRI being a front ranking human resource development Institute in the field of Dairying, very high quality standards of education and teaching are maintained. Revamping of the curricula of Degree programmes of B.Tech /M. Sc./M.Tech. /M.V.Sc. and doctoral academic programmes has been done to bring the same at par with any International Institute. The additional academic programs being introduced are not only need based, but also essential to give the extra edge to the dairyman to obtain state-of-art knowledge in dairy production, processing and management. NDRI is the first institution to implement new course–curricula for B. Tech in Dairy Technology as per the guidelines laid out in Fourth Dean's Committee Report. Likewise, new PG syllabus has also been introduced from the academic session 2009-10. The programmes of NDRI Deemed University are constantly reviewed and updated to ensure the requisite knowledge levels to pass-out students and to make them academically proficient in meeting the emerging global challenges. NDRI has also got the recognition as Niche Area in Animal Biotechnology for its educational programmes.

The teaching programmes of National Dairy Research Institute have helped in generating highly trained and motivated manpower, which has been serving the country in various organizations for the improvement of animal productivity. The B.Tech programme in particular has made significant impact on the Indian dairy industry with majority of top and middle management positions in the organized sector being occupied by the dairy professionals coming out of the Institute. The postgraduate training has proved equally beneficial for the R&D, quality assurance as well as management programmes of the industry.

Educational and Training opportunities are provided to visiting scholars from various countries. Students and trainees from Nepal, Bangladesh, Afghanistan, Iran, Iraq, Myanmar, Mauritius, Sri Lanka, Vietnam, Ethiopia, Rwanda, Ghana, Holland, Egypt, Sudan, Camaroon, etc. have been benefited. In-plant training facilities are also imparted to the students from sister Institutions and SAUs. Advanced faculty training imparted to the faculty members from SAUs and other Institutes has immensely helped in improving the quality of research and teaching in the National Agricultural Research System (NARS).

Factors Driving Expansion of National Dairy Education System

In the span of past nearly 60 years, the dairy sector has come a long way registering more than 7-fold increase in milk production, from 17 million tonnes in 1950-51 to about 132 million tons at present (GoI, 2013) and is anticipated to be about 225 million tons in next 20 years. India now accounts for 15% of world milk production and its share may rise to 21% by 2050 (Alexandratos and Bruinsma, 2012). In its journey to the top position in the world in terms of milk production, the sector has witnessed several structural changes in production, processing and consumption that have been conditioned by the changing socio-economic environment in the country.

The dairy sector that accounts for about 3.5% of the national GDP is an important means of livelihood security in the country. In the past two decades, with the manifestation of the continuous deceleration in rate of production growth of most of the food and non-food grain crops, the role of livestock sector, particularly that of dairy has become vital in maintaining the growth in agriculture sector. The approach paper of the XII Five Year Plan reiterates that for achieving targeted growth rate of 4% in agriculture during the Plan period, while the crop production is anticipated to grow by about 2%, it would be horticulture, livestock, dairying, poultry and fisheries that would grow at 5 to 6% and be the harbinger of agricultural growth (Planning Commission, 2011).

The empirical evidence on economic viability of dairy farming indicates that although there are wide variations in profitability at the regional level on one hand, and across small-holder *vis-a-vis* commercial farms on the other, yet by and large, the entrepreneur's profits in dairy are positive in the country. In the presence of economic incentives, therefore, the sector is slated to grow further, thus, driving the need of trained manpower in the sector.

About half of the milk produced by the millions of small-holder dairy producers in the country is consumed as raw milk or converted into products like, curd, ghee, etc. for their domestic consumption. The consumption of milk and milk products has increased in both, rural and urban food baskets. In the quantity terms, in 2009-10, the per capita monthly liquid milk consumption (which includes milk converted into curd, butter, *ghee*, *paneer*, sweetmeats etc. within the household prior to consumption) is 4.1 liters in rural and 5.4 liters in the urban areas; 29% and 26% higher, respectively, from the consumption level in 1987-88 (NSSO, 2012). The consumption of liquid milk, the demand for value added dairy products, particularly; cheese has increased very sharply in the urban areas. India is one of the fastest growing markets for cheese with annual growth pegged at 20%.

At present, the level of milk processing in organized sector including public sector, cooperatives or organized private sector is low as only about 38% of the total milk processed in the country is handled by this sector. In countries like Israel and Holland, over 90% of the milk produced is processed. According to 'Vision 2015' of the Food Processing Industry, the processing content of milk increased at a rate of 7.4% per annum to 25% by 2009-10 and is slated to be 30% by 2014-15. This rate of growth will take the processing content to 43% by 2019-20. In conjunction to this, there has been a steady but slow trend in the direction of higher plant capacities in both cooperative and private sectors. Current discussions on a second `White Revolution' project that the average processing capacity of dairy plants will be about 150 thousand liters per day by 2020 as against 117 thousand liters per day in 2007. A continuation of this trend is likely to see an overall higher processing capacity per plant. Available data also indicate that at present only about 50% of the installed processing capacity in the organized sector is utilized. It is assumed that by 2020 near-full (80-90%) utilization of the capacity would be achieved gradually.

The main demand-led drivers that have conditioned enhancement of processing capacity of dairy plants and will also lead to their increased capacity utilization are increasing population, rising income, rapid urbanization and greater economic liberalization. Further, changing consumer preferences and new technological innovations are also the important driving forces that would continue to bring changes in the food industry. Increase in population, urbanization, better education, increasing life spans and improved communication compel the food industry to concentrate on consumer health, safety, attractiveness and convenience of foods as indicators of technological innovations. Increasing applications of newer technologies contribute to large-scale and continuous production and preservation methods for a variety of new food products containing novel ingredients. As opposed to two decades ago, more meals are being consumed away from home. Dairy processors are also gearing up to this change and producing more 'prepared' foods. This change is very visible in supermarkets which are re-inventing themselves offering more ready-to-cook and ready-to-eat foods. Global distribution of dairy food enables consumers to buy almost any item of high quality year round eliminating seasonal and regional restrictions in their diet habits. Processing techniques and know-how will have to be re-oriented towards this.

In view of the above, dairy products today are tailored to suit the changing social and dietary habits of the consumers. Recent research reveals that milk contains thousands of ingredients with unique functional properties which modern processes are capable of isolating and refining for a multiplicity of users in the food, health and related industries. A dairy plant can now manufacture products rich in micronutrients and selected fat fractions, devoid of cholesterol and sugar and containing ingredients that are helpful against specific ailments such as cancer, hypertension, diabetes etc. A dairy processing professional, will thus, need to gain more expertise, both theoretical as well as practical, on nutrition, biochemistry and physiology. Environmental issues are relatively new to dairy processing industry and have been addressed for the past two decades or so. The biochemical oxygen demand in effluent waters was not on the top of a food processor's mind in the early days. But now with laws that call for stringent pollution control measures in industries, combined with a tight cost-cutting regimen, keeping a strict watch on the quantity and quality of effluents released into water streams is an important job profile that a dairy processor has to fulfill. Basic knowledge in environmental engineering is now a desired qualification of a dairy technocrat.

In addition to domestic demand, the international demand from Indian dairy products has also shown some buoyancy. India was a net importer of dairy products till 1999-2000, although the magnitude of negative trade balance began to decline after the mid-1980s. Since the beginning of the previous decade the exports of dairy products picked up and exceeded its imports. The share of dairy exports in total exports of livestock products has now reached double digit (13.5%). Several Asian countries have been the regular customers of Indian dairy products. In recent years, China, Egypt, Algeria and Morocco have emerged as new markets of dairy exports from India. Together with geographical diversification, the Indian export basket has also diversified its product portfolio. Although Skim milk powder and whole milk powder continue to be the most important items for exports, followed by butter and similar high-fat milk products like, butter oil, dairy spread, in the recent years, trade has taken place in 18 new product lines mostly those of fermented dairy products, whey and whey-based products and cheese.

As the Indian dairy industry prepares itself to be able to make a notable place for itself in the world dairy markets, rapid technological changes due to immense developments in automation, biotechnology, nutrition, food safety, quality assurance and environmental concerns would call for world class managerial expertise for sustainability in a competitive world. Global challenges in IPR management, patenting, developing innovative biotechnological applications to improve the nutritive and health attributes of milk and milk products, conservation of energy and developing renewable sources of energy for processing and distribution, impact of development on environment, business and finance for sustainable growth are the key issues that face the present day dairy industry. Therefore, the industry needs qualified personnel with precise professional competence and ability to manage several and varied areas such as milk production, management and procurement, dairy processing, harmonization of milk production and industrial manufacturing practices with the international standards, management and marketing in addition to management of IPR, patenting, international trade under the newly emerging global economic scenario.

The pace of structural changes in Indian dairy sector would be much faster in future than experienced so far on account of two important factors: one, the communication revolution would shrink further the global technology and knowledge gap and two, economic globalisation would integrate the domestic and international markets. The manpower requirement to herald in these changes will increase as never before. The technical capabilities of that workforce will also need a revisit so that the scientific challenges that the future has in store will need to be met surely and squarely.

Dairy farming and processing has now become part of an entire food chain that entwines multiple operations and spreads across different professions. It encompasses farm agribusiness, processors, distributors, wholesale and retail vendors, restaurants and food service operations. These are interrelated parts of a large network and each depends on the proper functioning of the other. Farmers rely on agricultural supply companies for products and services. Processors, food manufacturers and ultimately the distributors and retailers rely on farmers for raw commodities to process and deliver to consumers. Many people depend on the food system for income, with the current job profiles ranging from farmers, processers, retailers, wholesalers, food outlets and restaurants, which the modern human resource generation programmes will have to keep in mind.

The statistics on milk production and processing reveal unambiguously, the need for increased trained manpower requirement in the area of dairying, be it in production or in processing. More breeding experts, cattle nutrition experts, field workers, veterinarians, compounders, farm managers, procurement officers, dairy extension workers, dairy economists, processing technologists, quality control officers and many more such specialists will be required to cater to the increased milk production as well as processing facilities that are envisaged.

Together with emphasizing on the quantity or number of manpower needed, it will be worthwhile to make a mention of the quality of the manpower requirement. Globalization has forced farm management and the production, processing and safeguarding the quality of milk and its products to be extremely competent activities. During the earlier years of dairy development, western expertise for technologies and dairy products was the only option for reforming the unorganized sector of the Indian dairy industry. However, during the past six decades, India has become the torchbearer for tropical dairying, having gained considerable expertise as well as infrastructure. Such valuable expertise on tropical dairying will herald in tremendous growth of dairy industry in India and could serve a unique model for other developing countries in the tropical regions of the world. In this context, it is relevant to recognize the need for new initiatives, qualified manpower and a restructured human resource development programme in the area of dairying.

Projected Demand of Human Manpower Requirement in Dairy Sector

The National Academy for Agricultural Research Management (NAARM), Hyderabad and Institute of Applied Manpower research (IAMR), New Delhi carried out a comprehensive study on the requirement of trained human resources in agriculture. The projections indicate that by 2020, there would be annual demand of over 40,000 graduates, 10500 post graduates and 2800 doctoral degree holders in agricultural and animal sciences. Across broad disciplines, maximum demand (about half) would be for crop sciences, followed by horticulture, veterinary, dairy, agricultural engineering, fisheries, forestry and biotechnology. Given the existing outturn of about 24000 graduates per year, the demand in 2020 would be more than double the existing supply. Based on the long term trends, the study also reports that compared to other streams of science and technology, the growth in agricultural education is relatively low (3%) during the period 1970-2000 (Rama Rao *et al.,* 2011).

Dairy sector includes a number of activities such as milk production, collection, processing, production of wide-ranging dairy products, packaging, storage, transport, distribution, etc. It also involves activities like quality control and safety, increasing shelf life, milk and milk production safety and hygiene, so that it could be consumed with its total nutritive value. The dairy industry can prosper only if the milk production, procurement and processing activities grow in a planned and connected manner. Enhancing milk production is possible through improving the quality of cattle through appropriate breeding practices (larger number of semen banks, increase in number of artificial insemination (AI) centres and raising their quality, availability of AI facilities at the doorstep of the farmer, better facilities for prevention and treatment of animal diseases through enhanced veterinary services, better animal feed, and extension services. This requires a substantial increase in the number of animal scientists (geneticists, breeders, animal nutritionists and veterinary personnel).

Procuring milk of appropriate quality and handling it till it reaches the processing plant also requires well-trained personnel. The use of bulk chilling equipment at the village level at the initial stage of milk procurement is an emerging phenomenon that is fast gaining ground. Quality testing at the local village level has also become essential in modern milk procurement practices. While thorough quality control is possible only through well-equipped laboratories at the factory level, availability of equipment as well as trained manpower to test the quality on certain standard parameters at the local level will ensure that milk of high quality flows to the processing plant.

Thus, the study maintains that the human capital in these areas of the sector can be projected on the following basis:

- ❖ Assessment of future milk production and manpower needed for efficient animal breeding, health, nutrition and management
- ❖ Projecting the number of dairy plants based on future milk production, processing content, average capacity of dairy plants and capacity utilization

- Projecting the total number of dairy personnel based on requirement of technical personnel per dairy plant
- Projecting the number of dairy personnel by level of education using establishment survey data
- Projecting the number of personnel for the transportation, marketing, sales and distribution network

Drawing from the Focus Group Discussion on Dairy Education held at NDRI, Karnal, and data collected from various published and unpublished sources, the study projected that by 2020 the required stock of dairy science professional to man the dairy processing sector would rise to 37,000 under the planned scenario, 33,000 under a less optimistic but realistic growth trend and 41,000 under a more optimistic scenario. As a reasonable via media, the average of the first two may (i.e., 35,000) be considered as the most likely set of projections.

A major proportion of doctorates, post-graduates and even some graduates find employment overseas every year. There is considerable demand for these professionals from African and Middle-east countries in dairy and food-processing industries. The Focus Group Discussion held at NDRI, Karnal stated that 50% of the last ten years' out-turn are abroad. It is, thus, evident that India, because of its demographic advantage, is emerging as training ground not only for India but for the world manpower market as a whole. The educational system should take note of this phenomenon while planning its outputs. While translating the stock demand projections into flow demands, a higher rate of replacement needs should be allowed.

The Tenth Plan Working Group on Animal Husbandry suggested that a minimum of 3,000 veterinarians will be required in the country annually in order to meet the growth rate of 10% by the year 2020. In addition, an input of 3,560 dairy graduates is required in order to sustain a growth rate of 10% in the sector (GoI, 2002).

The requirement for diploma holders is highest in this sector. There is potential requirement to train about 60,000 diploma holders annually so as to meet the large requirement for these persons in the area of dairy production and management in the rural sector.

As against the demand situation, at the current pace of student intake, the supply may fall short of the manpower requirement.

Meeting Quality Manpower Requirement: The Way Forward

The additional requirement of professions at PG and Ph.D. level can be met thorough increasing the number of seats in existing colleges, as has been done by the National Dairy Research Institute, the premier research and educational institution in field of Dairy Sciences. At the UG level, it would be possible to meet the demand by establishing additional colleges. However, it is worth pointing out that all the institutions are still not equally equipped to impart the required training and teaching to the dairy graduates. Some institutes are in urgent need of their up-gradation in terms of manpower and physical facilities. Upgradation of the teaching institutes in term of human resources and infrastructure facilities will have far-reaching implications for the dairy industry.

Enhanced capacity intake needs to be backed by recruitment of new faculty and skill-upgradation of existing faculty. It is well-known that a large number of faculty positions are vacant in the NARS system, and this increases the work burden on the available faculty beyond the optimal limit, thus, compromising on the quality of services delivered. The dynamic economic environment in which the agricultural production system is operating requires continuous improvement in knowledge and skill of the faculty. The resources on the internet are a vital medium for this, but regular human resource development programmes, especially drawing in the expertise of the faculty outside the NARS system are extremely essential for skill up-gradation. Together with Winter/Summer Schools and other training programmes aimed at imparting knowledge on general areas in a discipline, the system urgently requires refresher courses to improve standard of teaching in Universities. Although the syllabi at UG, PG and Doctoral level have been by and large harmonized in Universities under NARS, there are huge differences in subject delivery. The students' feedback in each course should be made mandatory in all the Universities and response of the students should be communicated to the concerned teacher for improvement.

Type of Education Needed

The educational needs of graduates continue to grow in complexity. Sources and amounts of information readily available have grown immensely. Tools for and methods of communication are changing continuously. Industry needs scientists, technicians, and business management types, but it also needs persons who can take advantage of the electronic revolution.

The global market is a reality. So is international ownership of many dairy firms. This situation expands the needs for including experiences in international dairying in their curricula. We need to integrate our educational and training activities with those in other leading dairy countries.

In present scenario challenges faced by the Dairy Science Colleges are numerous, including preparing an individual that is capable of higher order thinking. This stipulates that a person is proficient at making independent decisions and thinking critically. Producing a person that is capable of these essentials is no easy task. The curriculum should provide the students the needed and useful experience in judgment, analytical and critical thinking. The examination system should also be suitable be modified to provide means to objectively analyze critical thinking ability by examining five constructs: inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments.

Professors, researchers and students have a poorly developed entrepreneurial mindset that results in few spinouts and new businesses. The challenge for higher education is to provide learning environments that stimulate independence, creativity and an entrepreneurial approach to harnessing knowledge. Universities have to get more entrepreneurial. There is a need to introduce entrepreneurship in educational, research & extension programmes of Dairy Education Institutions by revamping Dairy Science curricula and introducing functional management disciplines in the curriculum and integrating entrepreneurship into each subject through methods of delivery that will instill the entrepreneurship paradigm

Need for Multi-Tier Education System

The Dairy industry in India is of different sizes such as the organized sector, small scale entrepreneurs and unorganized sector. Hence the level of knowledge and skill of the business operations in each sector is different. It is very essential to design and develop a mechanism to address the human resource needs of all these sectors at different levels of responsibilities.

Human Resource is required for different purposes such as for:

- Overall Management.
- Operations Management.
- Food Manufacturing Management.

- Food Safety and Quality Management.
- Food Product Development Management.
- Food Equipment Design and Maintenance.
- Food Packaging Management.
- Food Distribution and Logistics Management.
- Supervisors for managing work force in food factories
- Factory operational shop floor level.

Therefore, there is a distinct place and relevance for the level of training and practical work taught during this training period in the work needed in organized dairy production and processing. Earlier we had Indian Dairy diploma programme, which has been discontinued at several places on grounds of availability of trained graduates. It would be a folly to discontinue this training programme on the plea that higher educational programmes have rendered IDD training superfluous. The availability of trained graduates in other disciplines viz. engineering and medicine, has not however, resulted in discontinuation of their certificate and diploma programmes. These programmes are necessary because the nature of the work at different hierarchy in the organization as well as at different levels of production are different and needs different levels of skills. Moreover, in order to create the employment opportunities for large number of rural and urban youths who are not able to afford college level education, it is necessary to continue and encourage of such training programmes. The graduates of Dairy Technology do not find enough challenge and prospect in shop floor jobs. Thus the interest of work suffers. In fact a certificate level course is also required to take care of dairy plant operations.

Vocational training plays an important role in Switzerland: 65 per cent of all young people learn a trade involving practical training in a company plus study in a vocational school. In this apprenticeship programme, students attend a vocational school for dairy technologists for one or two days a week, and the apprentice is given some subject choice. After 23 modules, 900 hours at college and a final examination following a project, the trainees receive a vocational certificate.

In Germany also the training of dairy operatives and dairy laboratory workers is based on practical training within the company in combination with theoretical training at a vocational school.

Therefore, there is a need of introducing three tier dairy education systems:

1. Certificate level courses in (a) dairy plant operation, (b) dairy laboratory assistant, and (c) dairy plant maintenance.
2. Diploma level courses in (a) dairy technology, (b) dairy engineering, and (c) dairy quality assurance.
3. Degree level: B.Tech Dairy Technology.

Content of the Curricula

How much "science" do managers need? How much "management" do technicians and scientists need? At what level of study is specialization needed? How much Foods Science is needed in the Dairy Science courses? These are the questions one needs to answer while setting the content of curricula of various dairy courses. At present, we have a Dean's committee, which is formulated every five years to revise the course curricula of B.Tech Dairy Technology programme. While all the academicians in various dairy science colleges make sincere efforts to revise and update the course curricula to suit the industry's requirement, unfortunately the participation of industry in this process is negligible. Although, the representatives of the industry are invited to attend the meetings and the comments on the curriculum are sought, the response, in general, is very lukewarm. Since the objective of dairy technology programme is to prepare students for the industry, it is expected that the industry should give feedback on their expectations from this programme.

The future need of the dairy industry invites for a fresh look at the existing curricula. Interdisciplinary approach will have to be imparted to the student. Newer areas such as food processing technology, bioprocessing, and marketing competence & management skills will have to be introduced and expanded. Further, in the face of rapidly changing technological scenario, the motivation to learn not only during graduation but also during their professional career will be the key to success of dairy industry. Curricula reorientation aimed at attracting international students would also be instrumental while pursuing newer vistas in the future dairy education.

Curriculum Delivery

While a well balanced syllabus containing all latest topics is recommended by the Dean's committee, a majority of the Institutes involved in imparting education in the field of Dairy Science and

Technology have inadequate capacity to deliver it. Most of the institutions are invariably beleaguered by the following constraints:

1. **Lack of Infrastructure** such as Research Laboratories, Central Instrument Facilities and Dairy Processing Plants.
2. **Lack of Trained Faculty and Staff** to comprehensively provide high quality education and a high student: teacher ratio either due to the non availability of such personnel in specific regions or the lack of foresightedness on part of the administration.
3. **Paucity of Financial support** for vital activities such as research, teaching and extension.
4. **Inadequate Library and Reference Facilities** for teaching and research.
5. **Lack industrial /international exposure** to the faculty
6. **Lack of participation of personnel from industry** in curriculum delivery

Possibility of introducing 5 year integrated course

The dairy graduate generally serves as mangers of dairy unit. The course curriculum can be diversified to offer a dual degree in dairy technology and management in collaboration with management schools. This will endow the fresh graduates with the skills of entrepreneurship, technical, financial, marketing and human resource management besides the technological know-how. This will meet the HR requirements for dairy & plant managers in the country (Patil, 2010). The 5 year integrated course in different disciplines is proposed in Figure 1.

Quality of students and how to attract the talent

Further, it should be unambiguously borne in mind that merely increasing the number of seats does not ensure quality outcomes. Concerns have been expressed at various forums about the quality of education and its relevance to the labour market. It has also been pointed out that the students are not attracted towards the dairy science courses. Industries have expressed their concerns about the suitability and employability of the students who pass out of the most of these institutions imparting education in dairy science with special reference to their practical knowledge and application of learning.

Dairy education system should be tuned not to attract mere numbers but talent as well. The employment potential of degree in dairy and

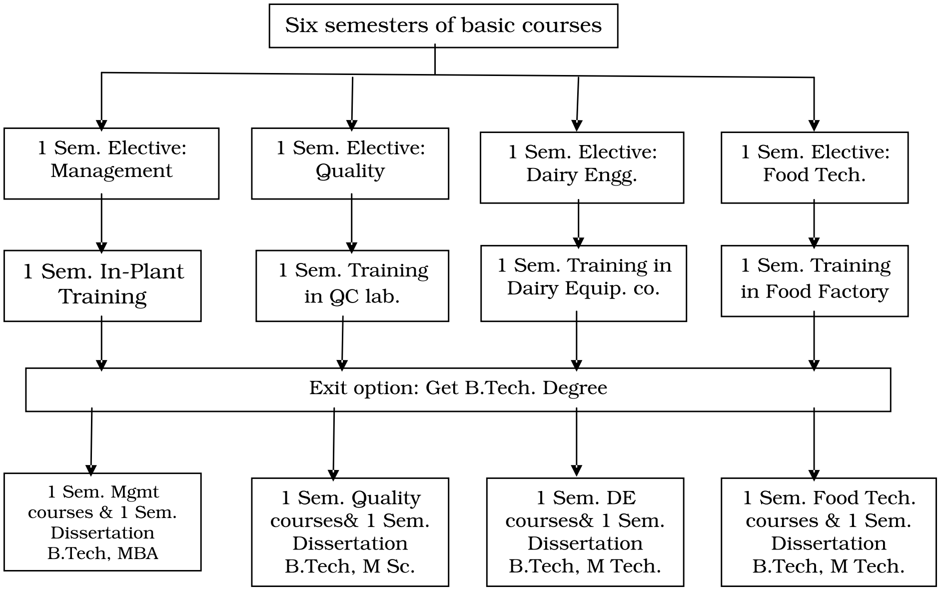


Figure 1. Proposed five year integrated course

allied sciences is in general less well-known among the masses as compared to an engineering, management or medical degree. Hence, awareness programmes to sensitize school children and their guardians should be taken up so that more and more good students enter into the system.

Why these programs are unable to attract meritorious students across the educational spectrum, i.e. undergraduate & postgraduate courses as compared to other engineering and technical streams? This is a big question. Are students not able to fetch remunerative jobs? Is profession not glamorous enough? Or, are the educational institutions not able to project the programme in proper perspective? There is a need to ponder on these issues in order to attract talent in this field. Probably, improving the admission procedure may help to some extent.

The absence in synchronization of admission procedures and dates among different dairy science colleges in the country causes confusion at the national level throwing the whole process in disarray to some extent and thus affecting the uptake of meritorious students to this professional stream. One possible remedy to this problem can be admissions at the national level on the lines of All India Engineering Entrance Examination conducted for admission to engineering courses. Alternatively, the Dairy science colleges may use AIEEE score for admitting students.

The Indian Council of Agricultural Research has been conducting All India Entrance Examination for admissions to Under-graduate programmes offered by NDRI and State Agricultural Universities. This joint entrance test can be used to prepare a national merit for ICAR seats as well as respective state merit lists to avoid duplicity, complexity and confusion at both national and state level.

Epilogue

The strength of Indian dairy sector lies in the fact that, despite limited investments, it has shown consistent and sustainable growth. With the globalization and diminishing barriers between nations, the future graduates have to acquire newer skills for facing the challenges in next millennium. They have to be job providers rather than job seekers and it requires restructuring and reorientation of our educational programmes. Investment in human resource developments is the key for success of dairy industry. Employing a trained and qualified person on the job is not enough, but training and retraining to fit into a dynamic work environment is necessary to prevent obsolescence. On the dairy research front, newer challenges in terms of value addition, health & functional foods and safety will have to be addressed in the light of advanced technological and scientific developments.

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CIFE: Marching Ahead for Excellence in Human Resource Development in Fisheries

W.S. Lakra and G. Venkateswarlu

India has vast and diverse marine and inland fisheries resources (FAO, 2012). To fulfill the need for trained and qualified manpower in this sector, the Central Institute of Fisheries Education (CIFE) was established on 6 June 1961 in Bombay (now Mumbai) as a Government of India institution with FAO/ UNDP assistance. In over 50 years of its existence, CIFE has emerged as a centre of excellence for higher education in fisheries and allied disciplines and has nurtured many illustrious scholars and leaders (Ayyappan and Biradar, 2002). CIFE became a part of the Indian Council of Agricultural Research (ICAR) in April 1979 and subsequently, the scope and mandate have been widened to include education, research and extension. Recognizing the pivotal role played by CIFE in human resource development in fisheries, the institute was accorded the status of Deemed-to-be-University in March, 1989 (Biradar and Kumar, 2007). Its educational activity commenced with two-year post-graduate Diploma in Fisheries Science to fisheries personnel, mainly from departments of fisheries of the States/Union Territories (Abidi *et al.*, 1997).

Vision and Mission of the Institute

The Vision Statement of CIFE is "To be a world-class organization providing leadership in fisheries education and research". The mission of this institute is to achieve academic and research excellence by creating state-of-the-art infrastructure and globally competitive faculty. The mission envisages CIFE as a Centre of excellence for post-graduate education and training in all aspects of fisheries science, an advanced centre of research in frontier areas of fisheries science in

National Presence of CIFE

collaboration with other organizations, a resource centre for policy formulation including different aspects of fisheries and HRD, a nodal centre for coordination of fishery education programmes including accreditation, a centre for production of study material in fisheries in print and electronic media and a centre for consultancy services in different aspects of fisheries, particularly fisheries education (Lakra and Venkateshwarlu, 2013).

Grant of Accreditation to CIFE, Mumbai

As a part of new initiatives taken by Indian Council of Agricultural Research to ensure quality in higher education by the process of accreditation of agricultural education system, CIFE has initiated institutional accreditation process in 2001. Based on the recommendations of the ICAR Peer Review Team, the Accreditation Board of ICAR, New Delhi granted the Accreditation to the CIFE, Mumbai on 25 August 2004. In view of the accreditation status granted to CIFE, Mumbai, the institute has taken a forward step to offer course work of all the MFSc and Ph.D. programmes at CIFE, Mumbai. The accreditation has helped the institute to bring all the academic programmes under its fold. In 2013, a Self-Study report encompassing institute's profile and SWOT analysis has been submitted to ICAR for further extension of accreditation.

Academic Programmes Offered by CIFE

Ever responding to the changing needs of the sector, the Institute has been incorporating new ideas and modifying its programmes and is a leader in several spheres. New courses were started at different times and emphasis is presently being laid on specializations in emerging areas of fisheries science at the post-graduate level.

Masters and Doctoral programmes offered by CIFE

1. Fisheries Resource Management
2. Aquaculture

Dr. S. Ayyappan, Director General, ICAR, addressing the XI Convocation

3. Aquatic Animal Health Management
4. Fish Nutrition & Feed Technology
5. Fish Physiology & Biochemistry
6. Post-Harvest Technology
7. Fish Genetics and Breeding
8. Fish Biotechnology
9. Fisheries Extension
10. Aquatic Environmental Management
11. Fisheries Economics

Professional Development and Training Programmes

While the full-time degree courses remain the flagship, other need-based customized programmes are offered by the institute. Professional Development Programme (PDP), Entrepreneurial Development Programme (EDP) and Skill Development Programmes are organized by CIFE and its centres. These programmes are customized programmes in fisheries and allied aspects. These courses impart intensive knowledge-based skill-oriented training,




to have updated and competent fisheries professionals as well as confident entrepreneurs. In addition to this, CIFE has the distinction of being only the Centre of Excellence for Advanced Faculty Training (CAFT) in Fisheries in the country. Many programmes have been conducted under CAFT where more than 250 faculty/scientists from State Agricultural University and ICAR institutes have been trained.

Admission Procedure for Academic Programmes

Selection for M.F.Sc.

A combined examination for the award of ICAR Junior Research Fellowship and admissions to 100% seats of Master's Degree Programme at the CIFE is conducted by the Indian Council of Agricultural Research, Krishi Anusandhan Bhavan, Pusa, New Delhi, in the 1st week of June. Candidates will be selected for the award of ICAR Junior Research Fellowship and admission to Deemed Universities on the basis of merit in the Entrance Examination and Counseling. The candidates having their Bachelor's Degree in the concerned field under 10 + 2 + 4 are eligible to apply for admission.

Selection for Ph.D.

Admissions for the degree of Doctor of Philosophy (Ph.D.) in different disciplines of fisheries will be selected for each academic year are made on the marks secured in the All India Competitive Examination conducted by CIFE and the interview. The marks obtained in written test will have a weightage of 80 percent and interview 20%. There is a provision for admitting in-service candidates from ICAR Institutes/ SAUs/CAUs/State Fisheries Department. These candidates will be required to qualify in the written entrance test. The CSIR/UGC/ DBT/ICMR fellowship holders and the candidates who cleared other national level fellowship tests will be admitted over and above to the allotted seats.

All the students who are admitted to CIFE are privileged to get institutional fellowships. The Institutional Fellowship for M.F.Sc. Programmes will be given for 2 years and for Ph.D. programmes for 3 years. Besides, the contingent grant is available to all the students for procurement of essential chemicals, equipments, books and travel allowances connected with collection of research data.

Learning Resources Available at CIFE

The laboratories have state-of-the-art facilities for providing effective learning environment. All classrooms are equipped with modern audio visual aids. A campus wide LAN facility provides round the clock internet service with high speed broadband connectivity. CIFE has a modern auditorium, conference hall, committee room equipped with the latest audio visual equipment for hosting seminars, conferences and cultural functions. CIFE and its centres are connected through video conferencing facility.

National Library for Fisheries and Allied Sciences

The institute library, designated as the 'National Library for Fisheries and Allied Sciences' has a rich collection of books, journals, online database ASFA, CeRA etc. The information on all publications in the library is available over Online Public Access Catalogue (OPAC). The library has a collection of 35,000 accession books, about 100 foreign and Indian journal subscriptions, over 8000 foreign journal back volumes, about 3500 Indian journal back volumes, 185 Ph.D theses and over 3000 M.F.Sc./M.Sc/D.F.Sc. dissertations.

The national library is equipped with state-of-the art facilities and search functions along with reference information rooms and web

Digital Section of CIFE Library

based learning corners. About 135 e-books have been added as a new facility from 2012. Digital section of the library is equipped with 28 terminals, where all the online journals and e-books can be accessed. A project 'e-GRANTH' with the assistance of NAIP has been running with an objective to digitize the in-house publications and to connect different libraries of ICAR and State Agricultural Universities (SAUs).

Research Vessels

CIFE has two fishing vessels namely M.F.V. Saraswati (OAL-36m) and M.F.V. Narmada (OAL-11m) to support its on-board research and training programmes on fishing, navigation, oceanography and other such studies. The vessel *MFV* Saraswati, acquired through a Norwegian Agency for International Development (NORAD) aid in December 1982, is equipped with Global Positioning System (GPS), Very High Frequency Radio (VHFR), Radiotelephone (RP), Echo sounder, Sonar and Trawl eye.

Farm Facilities

CIFE has four strategically located centres at Kolkata (West Bengal), Kakinada (Andhra Pradesh), Powerkheda (Madhya Pradesh) and Rohtak (Haryana). The centres are well equipped to provide experiential entrepreneurship education and training in diversified areas of aquaculture. Further, most of the outreach programmes and related activities are executed through these field centres. Kolkata centre conducts need-based training and research for eastern and north-eastern states of India and also offers consultancy and

View of MFV Saraswati Research Vessel

View of MFV Narmada Research Vessel

advisory services. Kakinada centre conducts need-based training and applied research, organizes field demonstrations and transfer of technology programmes, and offers advisory services related to both freshwater and brackish-water aquaculture. Rohtak centre conducts research on developing suitable technologies for salt-affected areas and provides demand-driven training, extension and consultancy services. Powarkheda centre conducts need-based training and applied research, organizes field demonstrations and transfer of technology programmes, and offers advisory services related to freshwater aquaculture.

Partnerships and Collaborations

CIFE has strong linkages with ICAR and CSIR institutes, various Universities and departments of Government of India, State Governments, NGOs, Fishery cooperatives, Fish Farmers Associations and Industries. CIFE cultivates active exchange and innovation processes between the University and industry to create synergies and provide direction to basic and applied research. CIFE has encouraged collaboration opportunities between major industry players, as well as with public research organizations. Through strategic collaborations with partners and active participation in global networks, CIFE offers enriching education and research and entrepreneurial programmes. Students have the opportunity to gain valuable cross-cultural experience and develop a strong appreciation of global issues alongside perspectives from India and other countries of Asia. Faculty members are well-connected with colleagues around the world, collaborating in educational and research activities. Though the entire course work and research work are carried out in CIFE, the facilities for field-oriented research and specialized research can be availed at the following ICAR institutions:

1. Central Inland Fisheries Research Institute, Barrackpore, Kolkata - 700 120
2. Central Marine Fisheries Research Institute, Tatapuram, Kochi - 682 014
3. Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar - 751002
4. Central Institute of Brackishwater Aquaculture, Raja Annamalai Puram, Chennai - 600 028
5. Central Institute of Fisheries Technology, Matsyapuri, Kochi - 682029
6. National Bureau of Fish Genetic Resources, Dilkusha, Lucknow - 226 002
7. Directorate of Coldwater Fisheries Research, Bhimtal, Nainital - 263 136

Besides, the Institute has memoranda of understanding with Chattisgarh Kamdhenu University, National Institute of Oceanography, Goa; Central Drug Research Institute, Lucknow; Industrial Toxicological Research Centre, Lucknow and Central Salt and Marine Chemicals Research Institute, Bhavnagar; Bhabha Atomic Research Centre, Mumbai; Indian Institute of Technology - Mumbai; and various central and state universities where students can utilize the required research facilities.

Recently, Academic Council of CIFE has approved to have Memoranda of Understanding with Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Central Agricultural University, Imphal and the Institute of Science, Mumbai

International collaborations

Some of the notable International collaborations in the recent past are Indo-Australian Program on developing aquaculture in degraded inland areas in India and Australia (bilateral research Project between ACIAR, Australia – ICAR, India), Indo-Norwegian

Program on Genetic improvement of *P. monodon* through selective breeding for growth and white spot disease resistance (NORAD - INPIC Norway Inter-Institutional Project), International Barcode of Life (iBoL), Project on DNA Barcoding of fish and marine life and Project on Use of Phenolic compounds as antioxidant, antimicrobial and cross linking agents in fish Surimi (International Foundation for Science, Sweden). Academic collaborations with Auburn University, USA, University of

Sterling, UK, Curtin University, Australia and Wageningen University, Netherlands are underway. Our students have been selected under various research and post doctoral fellowship programmes of international agencies and are placed all over the world.

Endowments for excellence

Dr. Hiralal Chaudhuri Fisheries Foundation: The amount of deposit is Rs.11,00,000 and the accrued interest is utilized for awarding Gold medals in different streams of M.F.Sc. and Ph.D; Annual awards for CIFE's staff and three best young scientists.

Tata Trusts Endowment: An amount of Rs.10 lakhs was instituted to impart hands on training in aquaculture/fisheries for two students (overall toppers of Masters and Doctoral programmes) every year in India or abroad.

Presentation of Gold Medal to the Masters degree first ranker

Dr. Dilip R. Jalihal Endowment: The amount of deposit is Rs.1,10,000 and every year the best thesis award will be given with this endowment.

Dr. M.A. Upare Award: The amount of endowment is Rs. 1,00,000 and Gold Medal will be awarded for Topper in Economics.

Dr. B.N. Sharma Award: The amount of deposit is Rs. 1,00,000 and Gold Medal will be awarded annually for Topper Extension discipline.

Dr C.V. Kulkarni Award: An amount of Rs. 6 lakhs was deposited for awarding Gold medals for Best Masters thesis, Best PhD thesis, Best Young Scientist, Best Girl Student Research and an annual lecture by an eminent personality in fisheries.

First Students' Research Convention on Innovations in Fisheries

The First Students' Research National Convention on Innovations in Fisheries was organized at CIFE, Mumbai coinciding with National Fish Farmers' Day on 10th July, 2013. While addressing on this occasion, Padma Bhushan Dr. R.B. Singh, President National Academy of Agricultural Sciences (NAAS) emphasized the importance of innovations and their role in evolution of a society. The convention encouraged students to share the innovations and build networks.

First Students' Research Convention on Innovations in Fisheries

Academic Accomplishments

Till date about 5100 students have completed their degrees, diplomas and certificate courses including 130 foreign students. Since 2000, a total of 185 doctoral and 809 postgraduate students have successfully completed their studies. A Personality Development and Placement Cell is functional at CIFE and the students are placed as Assistant Professors in SAUs and Colleges, Development Officers in State Governments, Banking Sector, Industry and Research Laboratories.

Several students of CIFE have secured prestigious DST-INSPIRE and Rajiv Gandhi Fellowships. Human resource created by CIFE has shown its supremacy by claiming 80-100% seats in Agricultural Research Service selections conducted by ASRB during the last five years (Table 1).

Table 1. CIFE Students' Performance in ARS Selections, 2009-2012

Discipline	ARS - Year	Total positions	Selected	%
Fisheries Resource Management	2009	21	19	90
	2010	12	10	83
	2011	6	6	100
	2012	12	11	92
Aquaculture	2011	3	3	100
	2012	27	25	93
Fish processing technology	2009	5	4	80
	2010	5	5	100
	2012	4	4	100
Fish Nutrition	2012	14	14	100
Fish Health	2012	19	19	100
Fish Genetics & breeding	2012	15	15	100

Recent Awards & Recognition to the University

CIFE was conferred with "Academic Leadership Award" by Agriculture Today through National Award Committee headed by Prof M.S. Swaminathan. Recently, CIFE has been ranked as one of the top 10 Agricultural Universities of the country by Careers360 based on research publications, citations, accreditation, learning, productivity and IP. The institute has also been identified by Rediff.com as one of the beautiful campuses of the country.

Dr W. S. Lakra, Director, receiving "Academic Leadership Award" for CIFE

Students' Amenities

The all-round development of the students remains one of the important areas in any educational institute. Providing good recreational and gymnasium facilities to channel the positive energies towards the well being of the students remains one of the commitments of CIFE to enhance the productivity of the institute in terms of academic excellence. In last five years the institute procured several high end sports equipments and developed a well equipped state-of-the-art gymnasium facility in the campus. In addition, the institute has developed outdoor sports facilities of basket ball, football, volleyball and tennis courts besides facilities for indoor games including badminton and table tennis.

Way Forward

The fisheries sector demands sustainable aquaculture systems, responsible fisheries, post-harvest management and research to augment productivity, efficiency, equity, sustainability and trade. Recognizing the urgent need to address these issues, the CIFE has identified thrust areas for the future and CIFE constantly endeavours to empower fishers and fisheries professionals towards these goals. It also aspires to be a global leader in fisheries education with the newly created state-of-the-art infrastructure and research facilities. In a globalizing world, CIFE is planning to provide education programmes that make students both nationally relevant and globally competitive. Curriculum is being revised continuously to develop human resources enabling them to address global and national demands of the stakeholders particularly the fishers, industry, academia and R & D organizations. The latest teaching and pedagogical aids are being added to improve the students' learning ability and competence.

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Govind Ballabh Pant University of Agriculture and Technology, Pantnagar: The First Land Grant University of India

J. Kumar and S.K. Kashyap

We can't blame the farmers, we can't blame the land and we can't blame anything. We, who are the leaders of the country, must not fail the farmers. We must try to bring to them the most up-to-date knowledge. That is what we have to do. If we do that, I have no doubt on the discontinuance of the import of foodgrains from abroad......I hope, the graduates of this University will set a different example and will do something substantial for the improvement of Agriculture.

Dr S. Radhakrishnan
Pantnagar; 17 November 1963
First Convocation of Pantnagar University

One of the major events leading to the success story of Indian Agriculture has been the establishment of the G.B. Pant University of Agriculture and Technology in 1960, which brought to the centre-stage age-old profession of 'agriculture' in its many dimensions. Land Grant Pattern was introduced into the country for the first time. The transformation galvanized the country known for food scarcity to a foodgrains surplus nation. It also strengthened ability of the country to compete with best of the institutions of its kind in the world. The University has set patronizing benchmarks in education, research and extension since inception. The university was termed as the harbinger of green revolution in India by Dr Norman E. Borlaug.

Beginning with only 2 faculties, the University at present has 8 full-fledged faculties with 63 departments, 13 research centres and 11 KVKs. The University offers a wide range of teaching and research programmes for many undergraduate and post-graduate degrees. Undergraduate programmes are available in 15 disciplines and post-graduate programmes are offered in 121 disciplines, which include 69 master's programmes and 52 Ph.D. programmes. University-industry linkage has also been established for supporting teaching.

The graduates trained in the university are holding key positions at the national and international levels, right from the President's Office of the United States as Chief Agricultural Negotiator to World Bank to International bodies to national organizations to corporate houses. Total of 28,000 students have passed from Pantnagar till date. As against the first batch of students enrolled in 1960 consisting of a total of 250 students (150 in B.Sc. Agriculture and 100 in B.V.Sc. & A.H. degree programmes), students strength at present of the University is more than 4,300. Thirty percent seats are reserved for females. The student profile of the University over the years has undergone considerable transformation with increasing number of girl students; presently constituting above 45% of the total student enrollment in the University.

One of characteristic features of the University has been to have regular academic sessions with 200-210 instructional days. The syllabi have been updated and course contents are regularly revised. Teaching programmes and research projects are reviewed as a matter of policy in different faculties from time-to-time.

Salient Initiatives for Educational Reform

- The University established in 1960 adopted trimester system of education. In 1985-86, changed to the semester system of education, and course curricula were accordingly modified /updated.
- The Practical Crop Production course was started by the College of Agriculture in 1962 for the first batch of students.
- Earn While You Learn programme was initiated which envisaged professional training and work experience.
- Rural Work Experience Programme of 20 credits was started in 1992 for Agriculture graduates for enhancing their competence, confidence and employability.
- Experiential learning package of 20 credits has been introduced in colleges since 2012 to improve hands-on training and develop entrepreneurial capability of students.

- ❖ Educational Technology Cell has been established for regular faculty training on instructional skills. Employability skills training for students also initiated at a regular basis.
- ❖ Initiated programmes of Biotechnology and Food Science & Technology at the Under Graduate level.
- ❖ Established University-industry and University-farmer linkages for enriching teaching, research and extension activities.
- ❖ Implementation of a perspective plan of the University ***Vision-2020***.
- ❖ The University has collaboration with more than 100 international and national institutions for collaboration in teaching, research and extension.

Adoption of ICAR/ VCI Model Curricula

Utmost care is taken to revise curricula for inclusion of new knowledge and exclusion of obsolete information. The recommendations of the central agencies like ICAR/VCI/AICTE are incorporated. Some of the faculties have introduced the concept of pedagogy/Teaching Coordination Committees, which ensure effective implementation of educational policies, meticulous monitoring of teaching programmes and reappraisal of problems related to teaching. The responsibilities of the Committees are as follows.

i. To ensure coordination of teaching programmes

ii. To prepare schedule for pre-final examinations

iii. To address difficulties and ensure smooth conduct of teaching schedule

iv. To ensure coordination among the teachers and departments involved in teaching

v. To ensure timely distribution of the answer books of the pre-final examinations to the students and removal of their difficulties

Urgent Interventions Needed for Updating Educational Strength

- ❖ Shaping up academic environment through total quality management (TQM) at all levels.
- ❖ It is imperative for Agriculture education to use extensively innovations of IT, digitalization of course content, virtual class room, e-learning and video conferencing.

- Agreements, cooperation and coordination at inter-institutional and international levels should become fully functional including faculty-exchange among SAUs and ICAR institutes as well as other national and international bodies.
- The quality of different colleges and departments need to be critically assessed to enforce accountability.
- In-plant experiential learning infrastructure and facilities need to be strengthened.
- The website should reflect the real strength of the university including on-line resources.
- Centre for Teaching and Learning Excellence is urgently required in the University campus as is there in Illinois and other US Universities.

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An Agricultural University for Village Regeneration: Anand Agricultural University, Anand

K.P. Patel

Way back, in forties, the Institute of Agriculture, Gujarat, was established by the Iron Man of India, Sardar Vallabhbhai Patel, not as merely an educational institution, but as a mission, a cause, primarily conceived to revitalize agriculture, following Gandhiji's call for village regeneration. In 1972, the Institute was taken over by Govt of Gujarat, which became one of the campuses of Gujarat Agriculture University.

The Anand Agricultural University (AAU), carved out of the erstwhile Gujarat Agricultural University, came into existence at Anand by the Government of Gujarat on 4 March 2004. Through AAU, farming community is being provided support in education, research and extension education activities in agriculture and allied fields. The AAU imparts education in agriculture and allied sciences through residential semester system of undergraduate and postgraduate degree programmes.

The details of degrees offered by different faculties and colleges are given in Table 1. The details of diploma and vocational programmes at the AAU are given in Table 2.

Refinement of Agricultural Education System

Agricultural Education (AE) needs to be redefined so as to equip graduates with subject competency, self motivation, positive attitude, agri-business skills, knowledge of computer and information technology, and communication skills in both English and regional

Table 1. Faculties, Degree Colleges and Degrees offered at the AAU

Faculty/ Name of Colleges	U.G. Degree	P.G. Degree	Doctorate Degree
B. A. College of Agriculture, Anand	B.Sc.(Hon.) Agri.	M.Sc. (Agri./ Horti.)	Ph.D.
College of Agriculture, Vaso	B.Sc.(Hon.) Agri.	--------	-------
College of Horticulture, Anand	B.Sc.(Hon.) Horti.	--------	-------
Sheth M. C. college of Dairy Science, Anand	B.Tech. (DT)	M.Tech. (DT)	Ph.D.
College of Veterinary Science & Animal Husbandry, Anand	B.V.Sc. & A.H.	M.V.Sc.	Ph.D.
College of Food Processing Technology & Bio-energy, Anand	B.Tech. (FPT)	M.Tech. (FPT)	-------
Institute of International Agri-business Management, Anand	M.B.A. (IABM)	-------	-------
College of Agriculture Information Technology, Anand	B.Tech. (AIT)	-------	-------
College of Agricultural Engineering & Technology, Godhara	B.Tech. (Agri. Engg.)	M.Tech. (AET)	-------

Table 2. Diploma and Vocational Programmes at the AAU

Diploma Programme	Duration	Eligibility
Polytechnic in Agriculture, Anand	3 Years	10th
Polytechnic in Agricultural Engineering, Dahod	3 Years	10th
Polytechnic in Agriculture, Vaso	3 Years	10th
Polytechnic in Home Science, Anand	3 Years	10th
Polytechnic in Horticulture, Vadodara	3 Years	10th
Diploma in Nutrition and Dietetics	3 years	10th
Certificate course on Baking Technology	9 months	8th
Certificate course on Food Processing	3 months	10th
Fabrication, Repair and Maintenance of Common Farm Machinery and Implement	1 Year	8th pass
Tools and Techniques for Rain-water Harvesting	1 Year	8th pass
Certificate course on Organic Farming	1 month	8th pass
Certificate course on Integrated Pest Management	1 month	8th pass

languages. The following conditions should be fulfilled towards realizing the desired outcomes.

- Clear proportion for the financial allocation for agricultural education, research and extension education needs to be formulated
- More time and energy to be earmarked by teachers for extension education programmes and activities to be fully aware of the farmers' problems
- Teachers should also help to disseminate the traditional knowhow and technologies of farmers
- Effective System is necessary for quick communication of new knowledge to students in class-rooms
- Flexible course-credit system by continuous internal evaluation will be more useful
- Provide regular specialized training to rural youth, particularly school dropouts and adults
- The university BoM should have adequate powers to give organizational and operational autonomy;
- The successful model of private sector should be studied and adopted, and private-public partnership should be strengthened including through roping in talented scientists of the private agri-research sector as guest teachers,
- Curriculum be regularly updated and specific curricula could be developed for technological and skill development of women in market driven technological enterprises
- AE needs reorientation to cater to the needs of emerging sectors and ensure that excess manpower is not generated
- AE demands for increased emphasis on topics like organic farming, bio-fertilizers, pressurized irrigation, integrated water management, integrated nutrient management, integrated pest, disease and weed management, resource optimization, post harvest technology & value addition, and marketing should be fulfilled.

New Strategies and Reforms to Meet the Challenges

The following guiding principles should be adopted while formulating strategies:

- Initiatives should have long term impact

- Focus should be on ameliorating quality, relevance and reach
- Linkage with market requirements and demand of stakeholders

The strategy reforms must be performance & output oriented, and should ensure optimal utilization of existing infrastructure and resources. Effective partnership linkages with advanced centers of education in the country, including between ICAR and SAUs and abroad should prove helpful. Greater autonomy to academic institutions, SAUs and statutory power to ICAR will be needed for ensuing timely and judicious implementation of policy options.

Education

The following aspects should be given due attention:

- Devising a Qualification Framework and shaping up academic environment through total quality management at all levels. Entrepreneurship development and self-employment orientation in agricultural education, including through infusion of vocational courses;
- Periodic review and revision of curriculum consistent with national and global scenario, market trends, self-employment avenues and industries requirements;
- Emphasis on Distance Education in Agriculture with extensive use of innovations of IT, digitalization of course content, virtual universities, e-learning and video conferencing
- ICAR to play a more pro-active role in initiating, implementing, reviewing and monitoring reforms in education system
- Distinguish AE from training for public service, and preparing students for entrepreneurship
- Ensure the accountability of teachers, institutions and other stakeholders by enforcing a judicious accreditation system.
- Facilitate, promote and support agreements, cooperation and coordination at inter-institutional and international levels
- Develop well trained human resource for doing research in advanced areas of science to become internationally competitive

Research

- Need a paradigm shift from single discipline orientation to multi-disciplinary approach
- Encourage privatization, planning, monitoring, evaluation and assessment as core component of research management process

Extension

- ❖ Harness benefits of new scientific advances such as bio-technology, remote sensing, modeling and IT
- ❖ KVK's to be strengthened as nerve centre for dissemination of technical know-how
- ❖ Extension programmes to be based on rural participatory approach
- ❖ Formation of extension kiosk on food, horticultural crops, livestock, poultry, rabbitry, bee keeping, mushroom, medicinal and aromatic plants, sericulture, tea and value addition enterprises
- ❖ Distance education for farmers and small agri-entrepreneurs need to be explored and strengthened through different effective learning processes

Quality, Relevance and Preparedness

A Total Quality Management (TQM) system, conforming to the expectation of the stakeholders, should be evolved to ensure quality and relevant education, which must generate new knowledge essential for meeting the challenges of new economic environment. Education should lead to development of analytical skills, exposure to international marketing, total quality standards and comparative advantages. In particular, post-harvest technology, value-addition, and electronic communication system deserve greater attention in course contents and practical training. Adopting a human centered development approach, instructional processes and students support services should help build strong work culture among the graduates. Universities should also provide non-formal education and vocational courses including technological empowerment of women and rural youth through distance education, through establishing training institutes of high standards to provide need-based training to both in-service and outside personnel in agriculture.

The formal and non-formal training should prepare trained human resources to promote climate resilient agriculture, strengthen technology-market-policy nexus, and enhance employment security.

Conclusively, agricultural education should be made innovative to absorb futuristic trends and skill orientation and agricultural scientists, teachers and students must play greater roles in protecting the interest of the state in particular and nation at large.

Features and Challenges of Agricultural Education at a Central University: Banaras Hindu University Experience

Ravi P. Singh, A.P. Singh and J.P. Srivastava

Banaras Hindu University was established in 1916. While establishing this University, its founder, ***Mahamana Pandit Madan Mohan Malaviya Ji***, wished:

"It is my earnest hope and prayer that this centre of life and light which is coming into existence, will produce students who will not only be intellectually equal to the best of their fellow students in other parts of the world, but will also live a noble life, love their country and be loyal to the Supreme ruler"

This is a profound message to the humanity at large

BHU is the largest residential university in Asia, having 2 campuses, 3 Institutes, 16 Faculties, 140 Departments, a Mahila Mahavidyalaya and a UGC-Academic Staff College. Over 32,000 students; including over 700 from 34 nations and over 2,500 research scholars for Ph D degree are studying here. Semester system and credit based education is operative at the UG, PG and Ph D levels in all faculties. Admissions in all the faculties are through All India Entrance Test. All Ph D scholars, who qualify Research Entrance Test, conducted by the university, are provided with fellowship and contingency for initial 4 years.

The Institute of Agricultural Sciences is one of the four institutes of the university, which was initially established in 1931. It has 11 Departments - Agronomy (1969), Agricultural Economics (1969), Animal Husbandry & Dairying (1981), Entomology & Agricultural Zoology (1971), Extension Education (1981), Farm Engineering (1981), Genetics & Plant Breeding (1969), Horticulture (1971), Soil

Science & Agricultural Chemistry (1969), Plant Physiology (1969), Plant Pathology (1969), and a newly created Centre for Food Science & Technology (2007). The Institute has an experimental farm at main Campus (65 ha) and another at Rajeev Gandhi South Campus (RGSC), Barkachha (1,000 ha). UG, PG and Ph D programmes are running in all the Departments, and it is intended to start B. V. Sc. & AH and three Diploma programmes from academic session 2013-14. The University has been accredited with grade A by the NAAC.

Constraints in Agricultural Education

Some of the constraints are of common nature at the National level, while others are specific to this Institute. Since teaching, research and extension are the integral components of agricultural education, therefore, attempt has been made to cover the issue in the context of these components.

Quality students admission in agriculture and allied sectors

1. In this Institute less than 2% students are from +2 with agriculture as a subject. Agriculture education, therefore, must be strengthened at the school level. Rather it must be a compulsory subject for all students. All students admitted at the UG, PG and Ph D level must be given fellowship. Number of fellowships provided by the ICAR at the UG, PG levels should be increased. All candidates, who qualify JRF and SRF of the ICAR may be given financial assistance. It is to mention that BHU conduct its own Research Entrance Test (RET) for admission in Ph D programmes in almost all subjects. All those candidates who are admitted through RET are awarded a fellowship of Rs 8,000 per month plus a contingency of Rs 10,000 per annum.
2. In SRF examination, conducted by the ICAR, only those students are qualified to appear who have been awarded M. Sc. (Ag.) degree. Thus the student cannot opt for Ph D programme immediately after finishing M. Sc (Ag.). It would be a step forward to attract quality students in teaching and research if students, who are in their final year of M. Sc. (Ag.) programme are permitted to appear in the SRF examination. SRF qualified students may be permitted to avail the fellowship in the subsequent year only after they complete their M. Sc (Ag.) degree. It is to mention that such a practice is being followed by the CSIR and UGC for JRFs (equivalent to SRF of the ICAR).

Academic

- **Curriculum development:** The curriculum should be more realistic with more on-farm training, particularly at the UG level. Before consideration of revised course curriculum by the Dean's Committee of the ICAR, it may be circulated to all agricultural universities/institutes and the input of individual departments/ division may be taken and discussed in the Dean's Committee. Further, it is our opinion that in each National Seminar essentially there should be a session on teaching methodology/ course curriculum, and the recommendation may be forwarded to the ICAR.
- There is an urgent need to develop e-learning modules for different programmes covering syllabi This Institute has taken initiative in this direction. With the financial and technical assistance of the AIP-USAID, the Institute has set-up a separate server for this purpose and modules are being developed. It is proposed that an e-learning module bank may be established at the ICAR level for easy access and exchange between the needy institutions.
- In the Board of Studies and Faculty meetings of the Universities and in Deans Committee of the ICAR, there may be representatives of private sectors and farming community.
- Courses on gender issues, social awareness, national and international trade and legal aspects in agriculture and allied areas may be given emphasis.
- There must be a provision that PG and Ph D students should spend some time in other labs/public/private sectors of the country for their research programme.
- There may be an essential provision of at least 2 summer trainings, each of at least 30 days duration, for UG students.
- To develop professional skill in unemployed youth, or those who are interested in agricultural education but could not get admission in Undergraduate programme, there is a need to start Diploma and Certificate programmes in emerging and location-specific areas of importance. This Institute has taken initiatives in this direction and starting 3 diploma programmes. It is proposed that to motivate students to join such programmes, there should be some opening for such Diploma and Certificate holders in Government jobs, e.g., some of the technical posts in the universities/institutions/government organizations concerned with agriculture and allied sectors may be specified for such candidates.

Faculty

- There is an urgent need to train newly recruited teachers on various aspects of teaching, research, administration and management. For this a National Teachers Training Centre or Centre of Teaching Excellence needs to be established. Just after recruitment, selected teachers must be given training in curriculum development, teaching methodologies and evaluation of students. They may also be exposed to identification of researchable issues, planning execution of research plan, presentation and publication of findings, and various aspects of management and administration. Banaras Hindu University, being a multi faculty University is an ideal place to establish such a centre.
- There may be a provision for the teachers to spend some time in other university/private sector for exposure to teaching, research and/or extension activities.

Financial

Banaras Hindu University is a traditional university under the UGC. Though the Institute of Agricultural Sciences is getting salaries of employees from the UGC, and meager amount of lab grants, but for all developmental activities it is fully relying on the ICAR. To make teaching, research and extension activities to be effective, it urgently needs strengthening of following.

Hostels

Owing to 27% increase in OBC quota for admission in various teaching programmes, the number of students has increased. In the last few years, number of female candidates has gradually increased and it has reached to about 40%. Therefore, there is an urgent need to construct new boys and girls hostels for the students.

Farmer's hostel

The University has limited guest-houses, and no place to accommodate farmers, who come over for various training and extension activities. In the last few years, influx of farmers has increased. Farmers not only from Uttar Pradesh but also from Bihar, Jharkhand, Chhattisgarh, and Madhya Pradesh are frequently coming to this Institute.

Stipend to Students for RAWE Programme

As per guidelines of ICAR, 25% contribution towards stipend to students of *RAWE* is to be borne by the state government. Institute of Agricultural Sciences is not being supported by the Government of UP. For want of such assistance, the Institute is not getting ICAR fund for this programme for the last 2 years. The Institute of Agricultural Sciences is a part of the Central University BHU, therefore, state Government does not consider to support this programme.

BHU Offers Unique Opportunity

The Institute of Agricultural Sciences, situated in the heart of the Banaras Hindu University, has all the necessary ingredients to become a world class agricultural research and education centre. In the BHU world, co-exist the Institutes of Technology, Medical Sciences, Ayurveda, Agriculture, Basic Sciences, Social Sciences, including Economics, Humanities, Management, Arts, Languages, Communication – the capital of education (*surva vidya kie rajdhani*). All stakeholders, concerned Ministries, Department, Faculties, must take advantage of this unique setting and develop world-class centres of excellence for generating needed discoveries, knowledge, technology and innovation and the trained human resources to use the veritable knowledge domains, technologies and innovations towards transforming agricultural education and agriculture to reshape the region and the nation as a whole.

Agricultural Engineering Education in India – Status and Strategy

Anwar Alam

Agricultural Engineering has been evolved to apply engineering principles and practices for natural resource conservation and development, production agriculture, and agro-processing and rural living. It enables optimum use of natural resources; increases production and productivity with reduced cost of production; efficient handling, processing and storage of agricultural produce and by-products; reducing post-harvest losses; establishment of agro-industries generating additional income and employment in rural areas. It also stands for modernization associated with conventional farming, imparting dignity to work and alleviating arduous labour and drudgery in farm operations; and development of infrastructure, rural water supply and sanitation, and ultimately improves quality of rural life.

Engineering methods were in use in agriculture and allied activities long before the term Agricultural Engineering (AE) came in existence as a subject, derived mostly from civil, mechanical, electrical and chemical engineering. Dr Elwood Mead (Bondurant, 1970 and Domier, 1972), a leader in land reclamation who later became head of the US Bureau of Reclamation is credited to have provided rational for this as distinct profession and discipline. When the Land Grant Institutions were established in the USA, the colleges of agriculture were termed as College of Agriculture and Mechanic Arts. Late in 1909, a Conference was held at the University of Illinois to discuss teaching techniques and to develop instructional materials for the new field in which Prof. F.R. Crane from Illinois; Prof. J.B. Davidson from Iowa; and Prof. C.A. Ocock from Wisconsin participated. In 1910, Iowa was the first State College to confer degree of Bachelor of Science in Agricultural

Engineering in the USA or for that matter anywhere in the world. By 1925, there were 10 such institutions conferring undergraduate and postgraduate degrees, and Ph.D. programmes followed them soon.

In India AE Education started in 1942 at AAI, Allahabad (Jacob, 1970, Pandya, 1970 and Patel, 1970). Since then it has moved a long way (Table 1). There are at present 37 institutions that offer formal education leading to various degree programmes in AE— 27 institutions in public sector offer UG programme, 20 M.Tech/M.E. Programmes and 10 Ph.D programmes. Specializations that have emerged are: Soil and Water Engineering / Irrigation and Drainage Engineering, Farm Machinery and Power, Agricultural Structures and Process Engineering., Agricultural Structures and Environment Control, Agricultural Process and Food Engineering, Dairy Engineering, Food Engineering and Technology, Bio-Engineering and Food Technology etc. Some colleges / faculties can be called world-class. And many have weak infrastructure. Often faculties are not qualified adequately. Their academic programmes lack practicals, hands-on experiences and opportunities. To be employable in the globalized economy there are new skills that are required for which Colleges of Agricultural Engineering have to equip themselves, offer opportunities of learning and acquiring skills to students. Colleges should acquire capacity of proper counseling and placement of graduates.

Growth of Agricultural Engineering Education in India

Allahabad Agricultural Institute, Naini, Allahabad, an affiliated college of the Allahabad University in 1942 has the distinction of starting a course leading to degree in Bachelor of Science in Agricultural Engineering (a two-year course) for the first time in India and also for that matter in Asia. Prof. Mason Vaugh, an American Missionary, is considered Father of Agricultural Engineering in India. He was an Agriculture graduate from the USA and came as a missionary, and was convinced that India needed Agricultural Engineering inputs. He returned to the USA, graduated in AE and came back to India. He played pivotal role in soil conservation, lifting irrigation water mechanization, introduced minimum tillage, steel ploughs and harrows, pneumatic wheel cart etc. Above all he started an undergraduate programme in AE. Ten years later in 1952, as per Dhar Committee, the Indian Institute of Technology (IIT), Kharagpur, the first IIT of the country, started B.Tech. (Agricultural Engineering),

Table 1. Agricultural Engineering Education Infrastructure in India (Yadav and Datta, 1996)

S. No.	Name & address of the college/	Faculty/University/ Deemed University offering degree	Year of start of UG programme	Annual intake capacity		
				UG	Masters	Ph.D.
1	2	3	4	5	6	7
1.	Vaugh School of Agril. Engg. & Tech., Allahabad 211 007 (Uttar Pradesh)	Sam Higginbottom Inst. of Agric., Tech. & Sciences, Allahabad	1942	90 (1465)*	30 (29)*	10
2.	Deptt. of Agric. & Food Engg. IIT, Kharagpur (West Bengal)721 302	Faculty of Engineering. IIT, Kharagpur	1952	35 (875)	90 (1078)	40 (445+85[1$])
3.	Pant College of Technology, Pantnagar – 263 145 (Uttar Pradesh)	Faculty of Technology, GBPUA&T, Pantnagar	1962	35	40	12
4.	College of Agric. Engg. Ludhiana 141 009 (Punjab)	Faculty of Agric. Engg. PAU, Ludhiana	1964	50 (1920)*	36 (506)*	12 (118)*
5.	College of Tech. & Agric. Engg., MPUAT, Udaipur 313 001 (Rajasthan)	Faculty of Agric. Engg., MPUAT, Udaipur	1964	55 (14)*	48 (175)*	25 (5)*
6.	College of Agric. Engg. & Tech., Bhubaneshwar- 751 003 (Odisha)	Faculty of Agric. Engg., OUAT, Bhubaneshwar	1965	40	20	6
7.	College of Agric. Engg. Jabalpur 482 004 (Madhya Pradesh)	Faculty of Agric. Engg., JNKVV, Jabalpur	1967	50 (758)*	20 (75)*	3
8.	Deptt of Agric. Engg., IARI, New Delhi 110 012	Faculty of Agril. Engg., IARI, New-Delhi	1967	-	6	8
9.	NDRI, Karnal 132 002 (Haryana)	Faculty of Dairy Tech, NDRI, Karnal	1967	-	6 (DE)	5 (DE)

Contd...

Table 1 contd...

S. No.	Name & address of the college/	Faculty/University/ Deemed University offering degree	Year of start of UG programme	Annual intake capacity		
				UG	Masters	Ph.D.
10.	Dr Anna Sahab Shinde College of Agric. Engg. Rahuri 413 722 (Maharashtra)	Faculty of Agric. Engg., MPKV, Rahuri	1969	55 (516)*	16 (92)*	-
11.	College of Agric. Engg., Akola 444104(Maharashtra)	Faculty of Agric. Engg. PDKV, Akola	1969	60 (685)*	8 (61)*	-
12.	Agric. Engg. Col. & Res. Instt. TNAU, Coimbatore 641 003(Tamil Nadu)	Tamil Nadu Agric. Univ., Coimbatore	1971	60 (160)	23	8
13.	Agric. Engg. Col. & Res. Instt. Kumulur, Trichi 621 712(Tamil Nadu)	Tamil Nadu Agric. Univ., Coimbatore	1992	60 (577	-	-
14.	Food & Agric Process Engg. TNAU, Coimbatore 641 003 (Tamil Nadu)	Tamil Nadu Agric. Univ., Coimbatore	1998	50	-	-
15.	Energy and Environ. Engg., TNAU, Coimbatore 641 003 (Tamil Nadu)	Tamil Nadu Agric. Univ., Coimbatore	2004	50	-	-
16.	College of Agric. Engg., Pusa, Samastipur 848125 (Bihar)	Faculty of Agric. Engg., Rajendra Agric. Univ., Samastipur	1983	25 (387)	5	-
17.	Kelappaji College of Agric. Engg. & Tech., Tavanur – 679 573 (Kerela)	Faculty of Agric. Engg., Kerala Agric. Univ., Thrissur	1983	46 (140)*	15 (44)*	3

Contd...

Table 1 contd...

S. No.	Name & address of the college/	Faculty/University/ Deemed University offering degree	Year of start of UG programme	Annual intake capacity		
				UG	Masters	Ph.D.
18.	College of Agric. Engg., Karlapelem Road, Bapatla 522 101 (Andhra Pradesh)	Faculty of Agric Engg & Tech. ANG Ranga Agric. Univ., Hyderabad	1983	35 (611)	-	-
19.	College of Agric Engg, Madakasira, Penugonda Road, Anantapur – 515 301 (Andhra Pradesh)	Faculty of Agric Engg, ANG Ranga Agric. Univ., Hyderabad	2008	30	-	-
20.	College of Agric Engg, Old Collectorate, Sangareddy Medak 502 001 (Andhra Pradesh)	Faculty of Agric Engg, ANG Ranga Agric. Univ., Hyderabad	2011	60	-	-
21.	College of Agric. Engg., & Tech., Junagadh 362 001 (Gujarat)	Faculty of Agric. Engg., Gujarat Agric. Univ., Banaskantha	1984	40	30	-
22.	College of Agric. Engg., Parbhani 431 402 (Maharashtra)	Faculty of Agric. Engg., Marathwada Krishi Vidyapeeth, Parbhani	1986	32 (184)*	-	-
23.	College (Institute) of Agric. Engg., Raichur584 101 (Karnataka)	Faculty of Agric., Univ. of Agric. Sci., Dharwad	1987	58	19	5
24.	College of Agric. Engg., & Tech. Hisar 125 004 (Haryana)	Faculty of Agric. Engg., CCS Haryana Agric., Univ. Hisar	1987	30 (431)	12 (81)	-
25.	Instt. of People Sci. & Tech., Chitrakoot 485 331, (Madhya Pradesh)	Faculty of Engineering, MGCGV, Chitrakoot	1992	30 (13)	-	-
26.	Dr. B. R. Ambedkar College of Agric. Engg. & Tech., Etawah, (Uttar Pradesh)	Faculty of Agric. Engg., CSAUAT, Kanpur	1994	40 (520)	-	-

Contd...

Table 1 contd...

S. No.	Name & address of the college/	Faculty/University/ Deemed University offering degree	Year of start of UG programme	Annual intake capacity		
				UG	Masters	Ph.D.
27.	College of Agric. Engg., Tumkur 621 712 (Tamil Nadu)	Faculty of Engg., Tamil Nadu Agric. Univ., Coimbatore	1994	60	-	-
28.	Deptt. of Agric. Engg., College of Agric., GKVK – 500065 (Karnataka)	Faculty of Agric., Univ. of Agric. Sci., Bengaluru	1996	25	6	-
29.	College of Agric. Engg., P.O. Krishi Vishwavidyalaya, Mohanpur 741 252 (West Bengal)	Faculty of Agric. Engg., BCKVV, Mohanpur	1995	20	-	-
30.	Faculty of Agric. Engg., Raipur 492 012 (Madhya Pradesh)	Faculty of Agric. Engg., IGKVV, Raipur	1997	30	12	-
31.	Aligarh Muslim University, Aligarh(Uttar Pradesh)	Institute of Agriculture, AMU, Aligarh	2000	-	10	-
32.	College of Agric. Engg., & PHT Rangpo (Sikkim)	Faculty of Agric. Engg., Central Agric. Univ., Imphal	2006	25 (58)	-	-
33.	CCS University, Meerut (Uttar Pradesh)	Div. of Agric. Engg. PG-Faculty	2006	30	-	-
34.	SKUAST-K, Shalimar, Sgr. (Jammu and Kashmir)	Div. of Agric. Engg.	2006	15	-	-
		Total		1,321	452	137

Source: Information furnished by the Institutions

Note:- There are also private colleges of Agric/ Food Engineering –in Maharashtra(5), in Tamil Nadu (1), Chhattisgarh (1) and Gujarat (1), more are coming up.

a four-year programme; *an important landmark in the development of AE education in India.* Soon after in 1956, PG programme was started for the first time, and then another landmark, when the first Ph.D. degree was awarded in AE in 1965.

Dr. Radhakrishnan Committee recommended establishment of Rural Universities, a concept which gained momentum. An Indo-US Joint-Team came up with the recommendation of establishment of SAUs in each major state on the pattern of American Land Grant Colleges, integrating teaching, research and extension education, Trimester/ Semester system with internal evaluation. The Govind Ballabh Pant University of Agriculture and Technology (GBPUAT) is the first SAU of India that structured itself with Agricultural Engineering and Technology as one of the faculties, starting UG programme in 1962. Subsequently, majority of the SAUs created faculties of AE (Table1). Some have created College of AE, just recently, many years after the establishment of University. By the time most of the AE colleges were established; the SAUs started experiencing financial constraints owing to resultant inflation and two wars. Barring a few, generally Colleges of AE, have poor infrastructure, inadequate faculty and staff, insufficient operational grants, and lack mobility thus adversely affecting on the discharge of mandated functions of teaching, research, extension education and industrial liaison. As of now there is not a single dedicated SAU on AE.

Start of M. Tech. and Ph.D. programmes at the IIT, Kharagpur, and subsequently at the IARI, AAI and SAUs have enabled considerable self-sufficiency in human resource development in AE in India. These post-graduates and Ph.Ds were founding faculty-members in the AE colleges. Faculty improvement under the TCM, USAID, NARP, NATP and NAIP projects have helped in getting a large number of faculty - members, who have foreign degrees or have had an exposure abroad. It is estimated, there are about 15, 000 graduates of AE, 5,000 PGs and about 500 Ph.Ds who have passed out from these 37 institutions. There is a capacity of annual induction of 1,068 UG, 370 PGs and 91 Ph.Ds; of which about 600 UGs, 150 PGs and 50 Ph.Ds pass out each year.

Emerging Scenario

India with population of 1.2 billion and globalized economy is facing daunting challenge of meeting ever-increasing demands of food and nutritional and livelihood security. As a nation we target annual growth of 10%, which is often too difficult to attain; as for this, we have to have an annual growth of 4% in agricultural sector. India with a large arable land, have to have the capacity to share with the less fortunate nations, besides eradicating hunger from its own land. India did succeed in bringing Green Revolution and thus proved prophets of doom wrong by acquiring self-sufficiency in food, and at times with its overflowing granaries. It showed spectacular growth in allied sectors too — achieved White Revolution in milk, Blue Revolution in fisheries and Yellow Revolution in Horticulture. However, it is at present is suffering with new generation of problems of declining factor productivity in Green Revolution areas, yield plateauing, and in certain cases decline due to exhausted soils, erroneous chemical use, overuse of natural resources. There is an obvious trend amongst rural–youth, especially capable, educated men and women to look for alternate job opportunities and are migrating into urban areas for less arduous and less risk-prone livelihoods, shunning agriculture and rural life. It is a social phenomenon that needs to be curbed for peace, harmony and equitable growth in the society. Agriculture has to be made remunerative through increased production, productivity of land, labour, capital, water resources and increasingly becoming costlier inputs of seed, fertilizer, pesticides, energy, and irrigation water. It requires scientific use of land, water, human and animal resources; acquisition of most modern technologies with essential elements of precision in input application, computer-controlled variable rate applicators, computer-controlled drip irrigation systems, timeliness in field operations; computer-aided designs, manufacture, quality control and ICT for assured quality and for keeping unit cost competitive in agricultural produce and processed products. Conservation agriculture and protected farming have become the need of the modern times.

Agricultural Engineering inputs are required in development and optimum utilization of soil-and-water resources, irrigation and drainage, field operations of crops, livestock husbandry, fishery and forestry with the desired level of operational efficiency – achieving timeliness, precision in metering and placement of costly inputs, seeds, fertilizers, pesticides, irrigation water. And application of GPS / GIS, Laser Land Leveling is a must for natural resource management, efficient use of irrigation water through surge irrigation, drip and sprinkler, ridge and furrow farming etc. AE graduates should become fully aware and be skilled enough in these technologies; their use, refinement and innovation.

High production and productivity cannot be sustained without matching harvest and post-harvest technologies to enable conservation of produce and by-products from qualitative and quantitative damages to negotiate appropriately with marketing forces; processing and value-addition; and packaging and transport to remunerative markets.

Highly trained agricultural engineers are needed, who are equipped with knowledge, skills and practices of engineering and technologies along with the knowledge of bio-sciences, ICTs, national and international rules and regulations governing crops and commodities to handle challenges and deal with global markets. Looking at the rapid developments taking place and the demands of the growing private sector, advancement in agricultural production, processing, energy and power and ICT sectors, it is desirable to revise courses and curricula of AE programmes at relatively short intervals. Even remote control equipment and robotics are increasingly finding application to handle hazardous situations in agriculture and allied activities in the developed nations.

The Fourth Deans' Committee (ICAR, 1995) appointed by the ICAR deliberated and tried to update courses and curricula. However, much needs to be done in terms of updating infrastructure and skills of the faculties to bring out changes required in production agriculture, agro-processing and rural living now and in near future. Operational grants need to be scaled up.

The efforts of the ICAR and the ISAE (Indian Society of Agricultural Engineers; the professional body of AE profession) have brought uniformity to a great extent (Tables 2-4) and evolved requisite measures to assure quality. The Accreditation Board of the ICAR and the AICTE (All-India Council of Technical Education) are also playing regulatory and accreditation role in the AE Education. Employment potential of AE graduates, post-graduates and Ph.D.s has been good, and so far they are competing well professionally within India and abroad. Many of them have chosen other allied fields. Still massive modernization, infrastructural development and faculty improvement are needed to meet future challenges. Recently, e-governance, e-management and e-commerce are in vogue, and professionals have to be familiar and be proficient in them. Best brains are needed to fine-tune existing technologies and they should be innovative to be efficient and economically competitive.

Table 2. Relative subject weightages in AE curricula, recommended by the ICAR and the AICTE

Broad subjects	**ICAR (4th Deans' Committee)**		**AICTE**	
	No. of courses	**%**	**No. of courses**	**%**
Humanities and Social Sciences	6	12	2	5
Agricultural Sciences	1	2	6	14
Social Sciences	2	4	10	-
Basic Engineering	19	38	-	23
Agricultural Engineering	24	48	25	58
Total	50	100	43	100

Table 3. Break-up, number and credit hours of the courses recommended by the Fourth Deans' Committee and the AICTE

Subjects	**ICAR**			**AICTE**	
	Course credits		**% of total**	**Course credits**	**% of total**
Basic Sciences and Humanities	18	(15+3)	9.84	26	13.0
Agricultural Sciences	4	(3+1)	2.19	21	10.5
Social Sciences	6	(5+1)	3.28		
Basic Engineering	53	(30+23)	28.96	88	44.0
Civil Engg	20	(11+9)	10.93		
Comp. Sci. & Elec. Engg	14	(7+7)	7.65		
Mech. Engg	19	(12+7)	10.38		
Agricultural Engineering	70	(46+24)	38.25	65	32.5
Farm Power & Machinery	18	(11+7)	9.84	14	
Soil & Water Engineering	18	(12+6)	9.84	18	
Processing & Agric. Structures	19	(13+6)	10.38	15	
Other (In-plant Training)	25	(0+25)	13.66	3	
Project	6	(0+6)	3.28	6	
Seminar	1	(0+1)	0.55		
Electives (5 out of 21 cafeteria courses)	15	(10+5)	8.20	9	
Total credit hours	183	(99+84)	100.00	200*	100
Total contact hours	346			236**	

** Theory of 1 hr. each and practicals– Sciences 2 hr. and Engg. 3 hr. each*
*** Include 37 contact hours of tutorials with credits with practicals of 2 hr. each.*

Table 4. Eligibility of other disciplines to Master Programme in AE (Yadav and Datta, 1996)

Institution	Soil & Water/ Irri. & Drain. Engg./ WM	Farm Power & Machinery	Agric. Processing & Food Engg/ PHT	Food Biotech Engg.	Dairy Engg	Agro-Energy/ Bio-Energy
IIT, Kharagpur	Civil E	Mech. E	Chem. E	-	-	-
GBPUAT, Pantnagar	Civil E	Mech. E	Mech. E Food. Sci. Food Tech. Dairy Tech.	Chem. E Bio-Chem. E Food Tech. Dairy Tech.	-	-
IARI, Delhi	Civil E	Mech. E	-	-	-	-
NDRI, Karnal	-	-	-	-	Chem. E Elect E Mech. E Dairy Tech.	-
RAJAU, Udaipur (Campus)	Civil E	Mech. E	Mech. E	-	-	Mech. E
TNAU, Coimbatore	Civil E	Mech. E	Chem. E Mech. E	-	-	Mech. E
UAS, Bangalore	Agric.		Agric.	-	-	
AMU, Aligarh	-	-	Chem. E Mech. E M.Sc. Phys., M.Sc. Chem.	-	-	

Lead Institutions in Agricultural Engineering

In Agricultural Engineering, B.Tech., M.Tech. and Ph.D. programmes are well in place, producing quality graduates and post-graduates. However, the capacities generated are not being fully utilized. Some of the Employers raise questions of employability for certain jobs for want of skills and communication abilities. There is yet no Agricultural Engineering University or deemed university in Agricultural Engineering Education to play a pivotal role towards continued excellence. However, till such date of possible establishment of the Agricultural Engineering University, there possibly can be elevation of the CIAE, Bhopal, and CIPHET, Ludhiana, to a deemed university status offering M.Tech. and Ph.D. degrees, without involving much additional expenditure. These institutions could acquire excellence and in turn train faculty - members of the colleges of Agri. Engineering.

Privatization in AE-Education

Traditionally higher education in agriculture in India has largely been public-funded, including AE-Colleges. Origin in private started with Christian Missionary institution – Allahabad Agricultural Institute — now Sam Higginbottom Institute of Agricultural Technology and Science, Allahabad (a Deemed University). But higher education in agriculture grew largely in public institutions, State Agricultural Universities, IIT, national institutes. As the national economy experienced pressure consequent to a few wars thrust on the country and also due to inflation, Central and State governments started exercising economy measures, some called higher studies as non-merit subsidy and diverted higher education funds to other sectors. It should be understood that through higher education only resource-poor sections of the society empower themselves. Admissions to government Colleges of Agricultural Engineering became difficult, highly competitive where urban students that failed to compete in coveted fields like medicine, engineering, computer science were selected for admissions in AE-Colleges. Similar situations existed in some other fields too. The SAUs that had only constituent colleges were pressurized to affiliate private colleges in agriculture; AE-Colleges were most popular ones. As a result there are about 10 or more private colleges of AE in India at present. However, quality of education, monitoring and evaluation in private colleges is the cause of concern. Research and extension programmes in these colleges are poor if not non-existent. Private colleges admit students to full capacity, more than government colleges, at times sacrificing academic standards or guided by capitation fees. The ICAR and IAUS both appointed committees to look into education at private colleges' affiliation and academic supervision by the SAUs, ICAR including them in their scheme of financial assistance. Enforced accreditation, based on conformity to norms, regulated admissions, merit-based admissions without capitation, observance of course and curricula of the Agricultural Universities of the State, substantial weightage (40%) for participation in learning practices are some of the measures to improve quality.

Vocational and Supporting Education in Agricultural Engineering

As far as the vocational education in AE is concerned, it is unorganized and relatively less attended to. Trained field and shop supervisors, laboratory technicians, skilled technicians, good mechanics are in short supply. There is also dearth of skilled operators and craftsmen, which are in need in a large number to promote mechanization and agro-processing. The Agri. Engineers as professionals as in other branches of engineering like civil, mechanical, electrical need diploma holders in AE as well as ITI Certificate holders to form a team to execute AE activities in an organized planned manner. Diploma in AE is offered by Polytechnics along with diploma programmes in other branches of engineering. ITIs are turning out craftsmen and technicians trained in various crafts. However, diploma and ITI training programmes are not as well focused for agricultural and AE vocations as in other branches of engineering and crafts. Often they lack requisite skills. In the absence of such manpower, graduate engineers are requisitioned, for whom it amounts under-employment. To benefit from AE technologies, it is imperative to have a massive training of farmers and rural craftsmen and entrepreneurs in modern methods of farming and produce management, utilization of renewable energy sources etc., for which Colleges of Agricultural Engineering, Krishi Vigyan Kendras and TTCs of Govt of India need to be properly equipped and mandated along with stipend for the trainees for their maintenance during the period of training and travel.

Demand and Supply of Graduates

The National Academy of Agricultural Research Management (NAARM), Hyderabad, has studied demand and supply position in respect of agricultural graduates (Table 5). By Year 2020, there will be demand of 3,256 graduates in AE against a current-level supply of 1,507. There is need for strengthening AE Education both in terms of numbers as well as quality and skills. Density of AEs has to be built up in the country to promote adequately mechanized and modernized farming and better quality of rural life. Every State should have Directorate of Agricultural Engineering with full component of activities, funds and development schemes. Employment of AE-graduates is not uniform; varies from State to State and is a function of time. General employment pattern of AE-graduates is as under: Academic Institutions: 8% (5-20); Development Departments: 20% (10-30); Industrial Employment: 30% (20-30); Field Oriented 5% (10-25); Financial Institutions: 5% (5-10); and Others12% (10-20).

Table 5. Demand and position of agricultural graduates in India

Discipline	Supply 2010	Demand 2020	Gap
Agriculture	15949	25000	9051
Horticulture	1465	8618	7153
Forestry	716	1832	1116
Veterinary	2683	7672	4989
Fishery	433	2614	2181
Dairy	310	3315	3005
Agricultural Engineering	1507	3256	1749
Agricultural Biotechnology	734	1039	305
All	23797	53346	29549

Source: Rama Rao, 2011 – NAARM, Hyderabad

Conclusion and Recommendations

Starting in 1942, Agricultural Engineering education in India has made good progress with about 40 institutions, more than 30 Colleges/ Departments, offering UG programmes, 19 PG and 10 Ph.D. programmes. The employment prospects for AE graduates are good.

Indian agriculture is at the cross-roads where many rural-youth, especially educated ones; it is no longer attractive because of arduous labour and hard work required, poor work environment, and with profitability in agriculture reducing day-by-day. Therefore, it is imperative to modernize Indian agriculture and boost its profitability and sustainability through engineering inputs for increasing production, productivity and profitability. For this massive strengthening is required in AE human resource – formal degree holders, diploma holders, mechanics, crafts and skilled operators. The Directorate of Agricultural Engineering with full component of activities, human and financial resources is a necessity in each State. Following recommendations have been made to bring about policy changes in AE education in the country.

1. The existing UG programmes should be strengthened at the annual output of 2000.
   i. Fourth Deans' Committee Recommendations / AICTE norms need to be adhered to reorienting course and curricula.
   ii. Infrastructure of the colleges of AE should be improved in terms of labs, computers, pilot plants, training in field operation etc., to give sufficient hands-on experience and training in various skills required.
   iii. Evaluation should be made more rigorous and transparent.
   iv. Faculty technical staff should be continuously trained in new knowledge and skills.
   v. Career Advancement Scheme should be refined to evaluate faculty and staff based on the proven performance and skills acquired.
2. Existing PG programmes should be strengthened increasing annual output to about 600 postgraduates per year.
   i. Require provision of more junior fellowships in Agricultural Engineering as well as in assistantships.
   ii. Proactive Advisory Committee mechanisms are desired.
   iii. Inbreeding needs to be combated by forcing graduates moving to other institution for PG/Ph.D and also at least 25% faculty from other states.
   iv. Joint programmes should be properly institutionalized between the SAUs and ICAR Institutes.
   v. The CIAE and CIPHET can be elevated to Deemed University status, offering M-Tech./Ph.D. and play a pivotal role
   vi. Higher allocation of grant for thesis work because of cost escalation, say at least Rs 40,000 per thesis.
   vii. PG Labs should be re-equipped with modern equipment.
   viii. PG degrees without course work should be discouraged and derecognized.

3. Ph.D. programmes should be strengthened to an annual output of about 150 Ph.D.s.
   i. Provide more senior Fellowships and Assistantships
   ii. Proactive Advisory Committee system is needed.
   iii. Increase allocation for Ph.D. thesis work, say at least Rs 100,000 per thesis
   iv. Publication / Presentation of research papers based on thesis work in professional journals, seminars, symposia should be encouraged and TA/DA should be provided for participation.
   v. Combat inbreeding; promote joint programmes between the SAUs and ICAR institutes.
   vi. Libraries should be well equipped with access to all national and international periodicals through subscription and other modes.
4. Development of diploma and vocational education in AE.
   i. There should be active linkages between the Colleges of AE and polytechniques and ITIs in the region.
   ii. Provide positions of Training Associate and Training Assistant, Mechanics and Shop Technicians in the AE colleges.
   iii. Every Directorate of Extension of SAUs/KVKs should have AE Training mandate, with at least one Joint Director for overall co-ordination and training units with SMS and Training Assistant.
   iv. Financial assistance to colleges of AE for vocational education and training in Land Development, Agricultural Mechanization and Post-harvest technologies.
   v. Revision of recruitment rules, placement of diploma and certificate holders of AE.

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Revamping Education and Research for Managing Soil and Other Natural Resources for Sustainable Agriculture

P.K. Chhonkar

Management of soil and water resources for sustainable agriculture has been the major objective of soil science and water use research since the very inception of agricultural research in the country. The various soil-health constraints identified in recent times limiting crop productivity are multinutrient deficiencies caused due to unbalanced fertilizer application, soil sickness like emergence of salt-affected soils on a large scale and falling water-table due to gross overuse and misuse of irrigation water. The other problems lately observed are soil pollution due to improper use of pesticides and using soil as sink for industrial effluents. In addition, soil degradation has taken place due to soil erosion and large-scale deforestation caused by population pressure.

There is an increased realization that the soil is one of the greatest endowments nature has provided to mankind from the times immemorial, designated as ' *matra bhumi* ' the mother earth (Rig Veda 1,161; Atharv Veda II 8.3, 2300 – 1500 BC). At the advent of green revolution, intensive cropping and introduction of high-yielding cultivars resulted in reduction of soil fertility. Thus from the very early times, research aiming to find ways and means to maintain fertility status of the soils became the main issue. Soil fertility research in the country began as early as 1907 with the pioneering work of J.W. Leather, the first Imperial Agricultural Chemist at Pusa, Bihar (*cited from* Ghosh, 1984).

Few resource-oriented soil surveys were carried out in the early twentieth century. Accordingly the Imperial (now Indian) Council of

Agricultural Research sponsored an All-India Soil Survey Scheme in 1943. In the same year, a soil-map based on the soil characteristics was first prepared by B. Vishwanath and A.C. Ukil. However, a soil-resource mapping of India was initiated in 1986 using a three-tier approach, comprising image interpretation and field mapping, laboratory analysis, followed by cartography and printing. A soil-resource mapping project developed under the leadership of J.L. Sehgal generated soil-fertility thematic maps at the state and the district as a base unit, which were useful for land-use planning.

To improve productivity of the arid soils and to combat desertification, the Central Arid Zone Research Institute was established at Jodhpur in 1974. In 1954, Govt of India established eight soil and water conservation centres throughout the country. These were integrated with the Soil and Water Conservation and Training Institute, Dehradun, established in 1974. The Central Soil Salinity Research Institute, Karnal, was established in 1969 with the mandate to reclaim salt-affected and saline alkali soils (*usar* soils).

Formal teaching in the disciplines involved in the management of natural resources started in India with the establishment of Agricultural Schools on the recommendation of the Famine Commission in 1903-05 at Cawnpore (now Kanpur) in United Provinces, Saidapet (Madras) later shifted to Coimbatore, Sabour, then in Bengal and at present in Bihar, Nagpur in central Provinces and Berar, Pune, Bombay Province now in Maharashtra and Lyallpur Punjab now in Pakistan. Initially one year diploma course in general agriculture covering several disciplines including Agricultural Chemistry which *inter alia* included aspects relating to soil fertility, water use (irrigation) was started. Later graduate courses leading to B.Sc (Agriculture) degrees of 3-4 years duration which included all disciplines (including social sciences), Dairying and Animal husbandry and agricultural engineering were started. During early 1940s, programmes of PG studies (M.Sc in Agriculture) were started with Nagpur and Coimbatore being the leading centres in Agricultural Chemistry and Soil Science.

The Imperial Agricultural Research Institute at Pusa (Bihar) started giving associateship in Agricultural Chemistry (equivalent to Master's degree) in 1923. With the establishment of the Post Graduate School at the IARI, New Delhi, in 1957, M.Sc and Ph.D programmes were initiated in various disciplines related to natural resource management. It now has separate programmes leading to award of PG degrees in Water Science, Agricultural Physics, which include Agro-meteorology, Environmental Sciences and Agricultural

Chemicals focusing on pesticides development and use. Followed by these developments was the establishment of first agricultural university, based on the land grant pattern of the USA in 1960 at Pantnagar, Uttar Pradesh, now in Uttarakhand. Later state agricultural universities were established throughout the country, at present numbering 65. All these universities have departments of Soil Science, Soil Science and Agricultural Chemistry and Soil Science and Water Management (Palampur). Birsa Agricultural University, Kanke (Jharkhand), was the first university to start PG programme in Soil and Water Conservation in 1961.

Agricultural Education and Research Issues Relevant to the NRM

Some of the important issues considered crucial for revamping agricultural education and research relevant to sustainable management of natural resources are as follows.

Multidisciplinary approach for managing soil resources

The past experience showed strong reactions when one Department had started taking up soil-related work done already by the other. This has amply been demonstrated in case of work on soil microbiology, particularly in the universities having School of Basic Sciences with Microbiology Department or when a separate Division of Microbiology was created as happened at the Indian Agricultural Research Institute, New Delhi. **To counteract this trend we must maintain a degree of flexibility adopting open-door policy to other scientific disciplines like chemistry, botany (plant physiology), physics, zoology, geology for improving chances of success in problem-solving research.** We have the best chance to succeed if Schools of Natural Resources Management are established to deal with problems associated with management of natural resources with the adoption of multidisciplinary approach.

Impediment in Soil Science reduced just to Soil Fertility Science

A scientist's output is primarily reflected through his publications and adoption of technologies developed by him. Analysis done on the papers published in the Journal of the Indian Society of Soil Science with predominantly Indian authorship showed that Soil Fertility and Soil Chemistry related papers accounted for 36.6 and 21.6 % of the published papers, respectively. In contrast Soil Physics accounted for 7.6 % and Soil Mineralogy for only 1.2 %. Soil Biology and Biochemistry related papers were lower down in the ladder. An overwhelming number of papers presented at the various Annual Conventions of the Indian Society of Soil Science were also related to various aspects of soil fertility only. In recent years, the International publication scene has undergone a dramatic change. From an overview of CAB database on papers published in Soil Science revealed more than 50 % of the papers in Soil Biology and related topics. Following Garfield impact factor analysis, the top slot in the recent years amongst the various Soil Science Journals was occupied by Soil Biology and Biochemistry (Chhonkar, 2001). The approach to resolve soil-related problems must also change according to times.

Why we have hit dead-end in soil-resource management

We have seen many merry-go-rounds in Soil Science research - a situation which has kept everyone happy. Most of the research is oriented in defining, highlighting and magnifying gravity of problems rather than making systematic and sustained endeavours to evolve solutions. For example, in the Indo-US Senior Scientists Panel Programme, the stress was laid on developing techniques to measure nitrogen losses more precisely rather than reducing them. An examination of most of the Doctoral theses in the discipline will reveal that they end up suggesting future lines of work rather than giving solution for the problem. We are increasingly becoming less and less aware of area- and location-specific problems in managing soil resources. By and large, Extension Soil Scientists who are the most important link in managing soil resources are becoming extinct species as a fewer Soil Scientists are keen in taking up extension work due to lack of recognition and promotional avenues. This type of work is not only physically tiring but also leads to a fewer publications, which are used as a yardstick for promotion.

Organic Farming: Is this an alternative to keep soils healthy?

The Organic / Biodynamic farming has been touted to prevent soil fertility erosion and for keeping it healthy (Pathak and Ram, 2003;

Menon and Karamarkar, 1994). A climate is being slowly and steadily built up in the country against the use of pesticides and fertilizers, favouring production of the so-called ‘pure’ foods. Many people complain loss of quality produce due to use of chemical fertilizers. This loss of quality is rather hard to determine and is more of psychological in nature. There could be soil factors which have implication in the quality of produce such as flavour, keeping quality, *etc.* (Chhonkar, 2003). This is one area where Soil Scientists can play a crucial role collaborating with plant physiologists in settling this issue once for all.

The issue is of much concern to soil scientists because of its serious implications is its avowed aim of excluding application of chemical fertilizers in our agriculture production system. This is bound to jeopardize country’s food and nutritional security, as organic farming will not be able to sustain food production at levels to meet needs of food and fibre for our burgeoning population. A realistic estimate of the available sources of organic materials also needs to be taken up. In this connection I would like to quote what Nobel Laureate Dr Norman B. Borlaug (Borlaug, 2002) said, “We can use all the organic that is available but we aren’t going to feed six billion people with organic fertilizer. We would level most of our forests”.

Nutrient Flow to the Plant; key to higher productivity

Solubility of nutrients and their consequent availability to plants is known to be altered by microorganisms by reducing soil *p*H at microsites, chelating action of organic acids produced by them and intra-hyphal mobility in the fungal filament. However, it is difficult to prove the extent of benefits derived through these relationships. The possibility of nutrient immobilization through locking of nutrients in the microbial tissues as a result of intense microbial activity in the rhizosphere cannot be ruled out.

In the recent years, there has been a sudden spurt of papers relating to mycorrhizal investigations. These reportedly increase P nutrition and help in plant establishment under moisture-limiting conditions. Other roles of mycorrhizae in rhizosphere remain unclear. Large-scale adoption of this innovation is restricted as these organisms cannot be mass produced independent of host. Nutrient budgeting in mycorrhizal association has not been worked out and it is still not clear as to how much does it cost to the host. The delicate balance between the two symbionts can be disturbed by various soil conditions, turning association from a beneficial one to parasitic one (Bagyaraj *et al.*, 1979).

Harnessing Information Technology Revolution for managing soil resource

At present, the world is experiencing an information revolution which is opening up possibilities of not only improving public awareness to various issues related to Soil Science and sustainability but also for developing technologies for solving these problems. This has found applications in land-use planning, watershed management, soil degradation, deforestation and many other areas. The advent of Geographical Information System (GIS) and rapid development of Information Technology have ushered in scientifically sound development of Soil Datamatics. Super-computing will go a long a way in modelling for more efficient fertilizer and water use. Advent of artificial intelligence, super computers, robotics, cyber communications is going to revolutionize agriculture, and this will revolutionize Soil Science too.

Preventing great soil losses

The main reason of yield decline and the decline in total factor productivity is that we are robbing soil of its native nutrient reserves by taking out more from it than putting back, thereby creating a negative balance. There is a mismatch between rate of population growth and that of food production. At this point of time, it is to be understood that food production cannot be increased indefinitely to meet demands of growing population of the country. We are to produce more and more from less and less area. Scientific community, in general, and Soil Scientists, in particular, must send this message in unambiguous words to policy-makers that there are limits to which food production can be increased without impairing soil health and degrading environment. Dream of realising eco-friendly increased productivity will be possible if it is coupled with a de-acceleration of population growth.

Managing soil resources

All meaningful agricultural research inclusive of soil science must aim at attaining food and nutritional security of the nation. Availability of cereals, milk, egg and fish per capita has increased but the availability of pulses has declined dramatically. This has a very serious consequence for a country like India where the population is predominantly vegetarian and may lead to what Swaminathan (2003) has mentioned as 'Intellectual dwarfism' in developing countries.

This imbalance cannot be corrected through poultry products. Pulses have to come in focus. The mind set of no-nitrogen application to pulse crops has to change. Application of legume inoculants may supplement nitrogen requirement but a chemical input is a must if the yields have to go up and unless that happens the pulses will be pushed out of Indian agriculture.

Soil biotechnology

There have been massive leaps in employing advance techniques for studying plant root microbial relationships some of which have originated from advances made in the field of medico-engineering for developing diagnostic tools. One of the early breakthroughs was the application of electron microscopy. More recent developments include use of fluorescent antibody techniques; enzyme linked immuno sorbent assays (ELISA); use of monoclonal antibodies and recombinant DNA and biochemical techniques for obtaining more agriculturally useful microorganisms. Plants can be modified using traditional breeding approaches and/or recombinant DNA techniques. Conventional breeding approaches are still most successful leading to development of plant types which can mine nutrients from soils more efficiently and adapt better to adverse soil conditions, Influence of long-term application of chemical fertilizers and soil amendments on soil biodiversity can be studied by soil DNA profiling using PCR techniques.

Genetic modification of rhizosphere microorganisms could lead to large potential benefits in terms of increasing crop yields. Recombinant DNA technologies offer some of the most powerful research tools that we have to date and undoubtedly will be responsible for great strides in future (Chhonkar, 2002). The present techniques of insertion of alien DNA into the genetic material may alter genetic expression of the organism which may affect its ability to function in the root zone. The effect of environment on plant root microbial processes is a recognized knowledge gap and has not been adequately addressed. There is a need to develop methods to investigate this important aspect of plant-organism interaction.

Soil biodiversity erosion

Few studies have assessed soil microbial response at the community/population level. However, there is an increasing realization that the maintenance of a diverse and functioning soil biota is important for soil sustainability. Loss of genetic potential also inherently makes biological systems less amenable to adapt to environmental pressures.

We cannot culture a vast majority of naturally occurring soil microbes that seriously limit knowledge of soil microbial diversity. However, recently recombinant DNA and molecular phylogenic techniques have provided methods for characterizing natural microbial communities without the need to cultivate organisms. Total DNA community profile can be fingerprinted by extracting total soil microbial DNA. Much of the diversity in soil would be redundant in the sense that loss of one species would be compensated for by the presence of others which can carry out its function. Fortunately, carbon cycling is one of the least sensitive features of the microbial community. So there will be a little threat to loss of biodiversity, seriously impairing organic matter decomposition. Nevertheless, recent advances in genetics of soil biota and its biodiversity should aid the search for newer microbes with faster ability to degrade lignin and other recalcitrant residues. Depletion of soil organic matter does contribute to the loss of soil biodiversity. It is more crucial in tropical soils.

Green cure for polluted soils

Generally much more dramatic effects on microbial communities and their activities have been observed by toxic substances than by pesticides which have generally undergone extensive screening for ecotoxicological effects prior to their release. Bioremediation of hazardous and refractory chemical waste contaminated soils requires knowledge of metabolism of chemicals by the existing microbes; isolation and utilization of new microbes and rationally designing novel metabolic capabilities using genetic engineering. Bioremediation procedures would be categorized under biodegradation, biotransformation and biostabilization. This is a new area of work which Soil Scientists have to take up as an obligation for the welfare of the future generations.

Soil quality

Biological degradation of soil is less understood, it is caused due to decline in soil organic matter and biomass carbon, decrease in diversity and activity of soil flora and fauna. Soil organisms contribute to maintenance of soil quality in that they control decomposition of plant and animal materials, biogeochemical cycling including nitrogen fixation, formation of soil structure and fate of organics applied to soils. Since they are one of the most sensitive biological markers available, they should be useful for classification of disturbed or contaminated systems. Microbial analysis has often been neglected because of the perceived difficulty involved in analysis. Any good ecological indicator should show prompt and accurate response to perturbation, reflect some aspect of the functioning of the ecosystem and yet to be universal in distribution and show individual specificity to temporal or spatial variations in the environment (Kartar *et al.*, 1992). A better understanding of microbial processes and microbial community structure is needed before the use of bioindicators as this will assist in the establishment of long-term strategies for implementing better management practices.

Dehydrogenase activity has been widely used as a generalized comparative index of microbial activity but it has not always been consistently correlated with microbial activity. In terms of soil quality assessment, metabolic quotient (q.CO_2) is a more sensitive indicator of soil microbial reactions (Masto *et al.*, 2007).

Several attempts have been made to show soil enzyme activity-fertility-crop productivity relationships but strong correlations can be expected only in unmanaged ecosystems or low input agricultural systems as in managed systems other factors may confound or override relationships between soil biological activity and plant productivity. Before soil enzymes can be widely used as soil quality indices, systematic studies are needed across ecosystems and long-term management sites to identify the most appropriate soil quality enzyme assays.

Efficient water use

Out of the 400 m ha-m precipitation in the country, 115 m ha-m is lost as runoff, resulting in drought in catchments and flood in downstream. The watershed-based approaches showed that harvesting of 25% of this runoff water in farm ponds can provide life saving irrigations to entire rainfed region of the country (Krantz 1981). Considering its importance a National Rainfed Area Authority of India was set up in 2007 by the Government of India.

In the post-green revolution era almost 58% of the national groundwater potential has been exploited. For the country as a whole, 226 blocks have been declared critical and 839 as over-exploited. The groundwater table declined in a range of 20 cm/yr to 200 cm/yr in different parts of the country and the per capita availability of water decreased by 63% in the last five decades. Early studies on NRM suggested that soil and water conservation needs to be studied in an integrative way especially in waterlogged and rainfed regions. In 1954, Govt. of India initiated an integrated approach by establishing eight soil and water conservation research centers in different regions of the country for evolving appropriate technologies. As a result, suitable soil and water conservation measures were determined for different soil-climatic conditions. The trend has continued even under Drought Prone Areas Program (DPAP) and Desert Development Programs (DDP) as resource conservation programmes in rainfed areas. During 1990s, soil and water conservation programmes were extended to catchments of different dams with an aim to reduce soil erosion and thus prevent siltation of reservoirs. A significant improvement in the resource conservation was observed and a realization dawned upon that the rainfed areas should be treated in such a manner which could be win-win scenario for both reducing the soil erosion from catchments and improving the resource base in catchments. Thus a thought process put in motion to develop rainfed areas on a watershed basis.

On the other hand, in irrigated area more efficient irrigation water delivery systems have evolved and should be further promoted as described below:

Micro irrigation: After establishing the superiority of micro-irrigation systems, the focus of research shifted to estimate water requirements, modifications of crop geometry, and use of mulches in drip irrigated fields for realizing the potential benefits of the system. A further impetus was given to micro-irrigation systems by the constitution of a National Task Force on Micro Irrigation, which resulted in 30 to 70% water saving in orchard crops and vegetables, along with 10 to 60% increase in yields as compared to conventional methods of irrigation.

Drip irrigation: The use of drip irrigation can be traced back to the ancient custom in certain parts of India for a *tulsi* plant kept in the courtyard. During the summer, the plant was irrigated by a hanging pitcher containing water and a minute hole at its bottom to allow trickling of water on to the plant. The tribal farmers of Arunachal Pradesh practised a primitive form of drip irrigation system using a slender bamboo as the conduit for water flow. In India, there has been a tremendous growth in the area under drip irrigation during the last two decades of twentieth century (INCD, 1994).

Sprinkler Irrigation: During mid-seventies, progressive farmers in Narmada valley (Tikamgarh and adjoining districts) in Madhya Pradesh, southern part of Haryana and north eastern part of Rajasthan started using sprinkler particularly during summer. In sprinkler irrigation, water saving is relatively low (up to 70%) as compared to drip irrigation since sprinkler irrigation supplies water over the entire field of the crop. Over the years, the adoption of sprinkler system penetrated into larger area in states like Haryana, Rajasthan, MP, Maharashtra and Karnataka (INCD, 1998).

Watershed Technology: A model watershed program was initiated by ICAR through selection of 47 watersheds across the country. With the success of this watershed approach in terms of overall productivity improvement in resource base and increased groundwater levels, the Ministry of Agriculture launched a nationwide watershed development program called National Watershed Development Program for Rainfed Areas (NWDPRA). A Silt Yield Index method has been developed for demarcating priority water shed for undertaking soil and water conservation programmes (Sharda and Singh, 1994). A technology has been demonstrated for harvesting intra terrace water and storage on sloping lands in hills for growing vegetables and cash crops or for providing pre sowing irrigation in absence

Farm Pond Technology: This technology has been adopted in villages with low rainfall but with good potential for run-off harvesting. Considering the slopes of the fields, at appropriate locations ponds are dug involving groups of farmers as stakeholders before rainy season and filled during rainy season. Recent research by CRIDA resulted in designing of low lift diesel-run pumps (1.5 HP) which are portable and can be used more profitably to lift water from ponds for marginal farmers. These ponds provide a sustainable livelihood system to the farmers round the year.

Climate Change and Natural Resource Management

Increased anthropogenic activities in recent years have resulted in several environmental problems with considerable implications on the food systems. Global warming due to increased concentrations of greenhouse gases in the atmosphere could affect crop production and livelihood security of millions of people. The small and marginal farmers, particularly in the rainfed regions of the country will be the most affected. Rapid industrialization and urbanization is leading to generation of waste, which is often disposed-of untreated affecting quality of air, water and soil. To sustain the food and nutritional security of the country, it is imperative that Indian agriculture is made more resilient to environmental degradation and climate change. The possible strategies for mitigating methane and nitrous oxide emissions from agriculture have also been identified (Pathak and Nedwell, 2001, Pathak *et al.*, 2003). Assessing the impacts and vulnerability of Indian agriculture to climate change, developing inventory and mitigation technologies for GHGs emission and developing and demonstrating climate resilient technologies have to receive top priority.

Global climatic changes are already adversely affecting crops, soils, water, biodiversity, livestock and fisheries. Increase in temperature, depending upon the current ambient temperature, can reduce crop duration, increase crop respiration rates, alter photosynthate portioning to economic products, affect the survival and distributions of pest populations, thus developing new equilibrium between crops and pests, hasten nutrient mineralization in soils, decrease fertiliser use efficiencies and increase evapotranspiration (Aggarwal, 2003). Indirectly, there may be considerable effects on land use due to snow melt, availability of irrigation, frequency and intensity of inter-and intra-seasonal droughts and floods, soil organic matter transformations, soil erosion, changes in pest profiles, decline in arable areas due to submergence of coastal lands and availability of energy, and on trade and overall economy.

In order to increase resilience to climate change, the Parliamentary Consultative Committee on Agriculture, Food, Civil Supplies and Consumer Affairs, Government of India has suggested the preparation of district-level contingency plans for the entire country for droughts, floods, heat wave, cold wave and pest outbreaks etc., based on the available research information. Over 300 such plans have been prepared for different crops and seasons which are made available to the DAC.

In the changing climatic scenarios and global warming, agroforestry has a potential to conserve and utilize biodiversity and sequester carbon (Pathak and Hegal, 1996). The significance of agroforestry as a land use system has been highlighted extensively in the recent years. Among the many favourable attributes of agroforestry is its suitability for degraded lands (Gupta and Rao, 1994). Large-scale *Jatropha* seed production on common wastelands of India has been highlighted. Leasing of government land for the specific purpose of non-edible oilseed production has been initiated in many states. Other more remunerative agroforestry systems identified in recent years should be rigorously promoted.

Problems to be Addressed

In spite of so much work done for so long, use efficiency of chemical fertilizers has hardly improved resulting in not only high financial losses but also causing environmental pollution. Further, in spite of the country having one of the largest chains of soil testing laboratories, soil tests are hardly used for fertilizer application. A major cause of concern is the emergence of more nutrient deficiencies throughout the length and the breadth of the country. Both factor productivity and response ratios have declined and deserve to be looked into by the Soil Scientists. Climate change is a global concern and cannot escape attention of soil scientists.

Steps for Preventing Deterioration of Soil Health

- A paradigm shift from fertilizer use research to plant nutrition research; reinforce with plant physiology input.
- Develop protocol for site-specific nutrient management; Production of customized fertilizers.
- Minimizing nutrient losses by matching plant demand with supply from fertilizers both in time and space.
- Tackling multiple nutrient problems rather than single nutrient single crop studies.
- Collaborate with breeders to identify cultivars capable of extracting nutrients from soil more efficiently.
- Aim at developing non available soil nutrient pool acting as buffer preventing losses.
- Isolation of more efficient and competitive microbes adopted to local conditions for mobilizing nutrients.
- Better utilization of nutrients from organic sources, and innovation to increase nutrient load of composts.
- Environmental soil research to protect crop-soil environmental degradation.
- Prioritize P use research for increasing its use efficiency; promoting technology for direct use of low grade phosphate rock.

Future Researchable Issues for Better Management of Natural Resources

Following are the researchable issues, which should attract attention of the Soil Science fraternity in the coming years.

- Research should be focused on understanding the dynamics of soil-plant systems, especially nutrient immobilization/release, and movement under stress conditions and development of measures for checking N losses should be high on our research agenda.
- Investigations to improve fertilizer-use efficiency should be appropriately strengthened involving conjunctive use of biofertilizers.
- Development of environment-friendly integrated plant nutrition systems for major cropping systems of the country should constitute priority area of research.
- Suitable models should be developed to predict the emerging nutritional disorders, soil and nutrient loss, kind and intensity of other land degradation phenomena under different climatic, soil, land use and management conditions.
- Rate of soil organic matter decomposition in different soils should be determined, along with the kinetics of decomposition of crop residues and organic materials including green manures, which will help in maintenance/build up of soil organic matter.
- Soil research in relation to environmental pollution should be intensified. This should include investigations on rising nitrate levels in ground water, Cd build-up in soils, quantification of release of greenhouse gases from the agricultural systems; and characterization of soil system as a sink for pollutants with an understanding of mechanism of its interaction with pollutants.
- For refinement in soil testing for fertilizer recommendations, soil chemistry research must relate to precise understanding and defining of the (i) ionic environment in the soil and conditions optimum for crop growth, (ii) available nutrients in soils on activities and solubility product, ion pair formation, *etc.* (iii) the reactions between soil-water-fertilizer-chemicals, (iv) nutrient mobility and uptake-rates and their relation to plant root parameters, *etc.*
- Practicing precision agriculture, a goal for 21st century based on supplementation of nutrients and water determined by mechanistic models shall become possible only with intensified research efforts of soil scientists.

Action Plan for Revamping Agricultural Education for Efficient Management of Natural Resources

To achieve this goal a few of the important action points are listed as follows.

- School students from X th standard onwards should be made aware of the importance of our precious natural resources and its proper use. There has to be reference to this in the syllabi of both humanities and science streams.
- At U.G. level in the agricultural universities, a course of management of natural resources needs to be introduced.
- At P.G. level courses relating to Soil Science need to be upgraded to include safe management practices and conservation of natural resources.
- In the universities where courses in water science and management are not offered at the PG level; the same should be introduced.
- Courses which have local relevance should be developed, creating specific knowledge centres to tackle location-specific problems. For example, courses on Forest and Hill Soils (North Eastern States, Uttarakhand and Himachal Pradesh), Aquifers and Ground Water Recharge Engg. (Punjab, Haryana and West U.P.), Arid Soil Management (Rajasthan and Gujarat), Soils under Tea Plantations (Assam) etc.
- Krishi Vigyan Kendras (KVKs) to conduct training programmes on management of natural resources. Farmers field days and exhibitions need to be organized, highlighting importance and proper use of natural resources.
- Private institutions which have excellent track record and infrastructure that provide quality education may conduct job-oriented short-term courses on natural resources management after accreditation from the competent authority (ICAR).
- Open and distance education programmes on NRM need to be taken up by universities /IGNOU, New Delhi.

Strategic Policy Initiatives for Proper Utilization of Natural Resources and for Preventing Deterioration

There is concern all-over the world for appropriate use of natural resources and for preventing its misuse, which may cause irreparable damage with consequences to be faced by future generations. A few of the strategic policy initiatives for resolving problems are as follows.

- School students need to be exposed to the importance of soil, water and other components of the natural resources by organizing open day for students / kisan melas by Institutions / Universities involved in R &D.

- To sensitize officers belonging to IAS and allied services and IFS. Lectures on the importance of natural resources should form component of their pre-induction training programmes.
- Underground water needs to be declared state property and declared national asset with concomitant legislations regulating its use.
- Water needs to be priced commodity to avoid its misuse in agriculture, and no free supply of power be given for exploitation of groundwater. Similarly urban water supply needs to be suitably priced to restrict its wastage.
- Subsidy should be withdraw on urea, phosphatic fetilizers and micronutrient formulations to encourage balanced use of plant nutrients.
- Disilting and rejuvenation of village ponds and other water-bodies need to be taken as priority activity under MNREGA scheme and under religious trusts to organize similar activities with the help of pilgrims to desilt tanks around places of worship.
- Building plans both private and govt should be approved only when they have provision of rain-water harvesting. No completion certificate should be issued unless it is in place.
- Restriction be imposed on the use of fertile soils for brick making with incentive given for use of material like fly ash.
- For infrastructure projects including industries and SEZ, only land not suitable for agriculture be acquired.
- Reclamation of problem soils and marginal lands should be on priority with easy availability of credit from nationalized banks.
- Legislation to control land degradation and deforestation caused by open cast mining projects in 'no go' forest areas. It should be left in the same condition as before mining operations by filling excavated reas and restoring original plant cover. U.S. EPA has been able to enforce it.

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Mainstreaming Climate Education in Indian Agriculture

H. Pathak and P.K. Aggarwal

Primary determinant of agricultural productivity is climate. Over the past few decades, man-induced changes in the climate have intensified risk of climate-dependent crop production. The most imminent change is the increase in atmospheric temperature due to increased levels of greenhouse gases in the atmosphere (IPCC, 2007). It has manifested in terms of frequent occurrence and repetition of events like droughts, melting of glaciers and rise in sea level. The quantity of rainfall and its distribution has become increasingly uncertain. These changes are already demonstrative, causing serious threat to food security of the nation (Pathak *et al.*, 2012).

Because of the seminal importance of climate on agriculture, there is a need to initiate and upgrade education on climate. People from every section of the society need to understand how climate influences their life and how people influence climate. Climate education would help individuals to make responsible decisions. Climate-educated public would provide improved stewardship for earth's climate and would use and respond to climate services and forecasts better. Climate education needs to be promoted among all stakeholders of agriculture, including farmers, scientists, dealers of agricultural products, industrialists, irrigation-managers and policy-makers.

Article 6 of the United Nations Framework Convention on Climate Change (UNFCCC) explicitly mentions role of education, training and public awareness for climate change adaptation and mitigation (UNFCCC, 1992). The Convention observes that the member-countries (Parties) shall "Promote and facilitate at the national and, as appropriate, sub-regional and regional levels, and in accordance with national laws and regulations, and within their respective capacities (i) development and implementation of educational and public awareness programmes on the climate change and its effects; (ii) public access to information on climate change and its effects; (iii) public participation in addressing climate change and its effects and developing adequate responses; and (iv) training scientific, technical and managerial personnel". *Reducing risks and realizing opportunities of climate variability and climate change requires making good decisions based on the reliable and appropriate information about past, present and future climate, as well as properly integrating that information into decision-making process. The objectives of the paper are to: (i) outline* principles and components of climate education in agriculture, *(ii)* assess initiatives taken in India in promoting climate education, *(iii)* identify key strategies in promoting climate education and *(iv)* develop a model action plan for mainstreaming climate education in Indian agriculture.

Principles and Components of Climate Education in Agriculture

Climate education in agriculture is a process of recognizing inter-relationship between farming and climate. It should be inter-disciplinary and examine major issues of climate change and climatic variability, which affect agriculture from local, national and international point of view. The broad aim of this education is to inculcate among farmers and other stakeholders a sense of responsibility and awareness to develop skills by means of which they can bring about a change in the existing state of agriculture towards a resilient agriculture. Climate education should have the following principles.

- **Climate education should involve everyone:** Because of its very nature and importance, climate education cannot be confined to any one group in the society, let alone farmers. Everyone from government, industry, media, educational institutions, community groups to the level of the individual should be involved.
- **Climate education should be continuous:** As we develop and apply better climate-resilient technologies, ability of farmers and scientists also improves to respond effectively. Therefore, it is essential to continue the education.
- **Climate education should be holistic and about connections:** To address climate-related challenges in agriculture, we need people who think broadly and who understand systems, connections, patterns and causes. Specialist discipline-based knowledge, while contributing critically, is no longer adequate by

itself, holistic appreciation of the context of the environmental problem is essential.

- **Climate education should be practical:** Climate education should lead to actions which result in better understanding of problems and implementable actions. This is the ultimate yardstick to measure effectiveness of the education.
- **Climate education should be in harmony with environmental, social and economic goals:** Effective climate education should provide people knowledge, understanding and capacity to influence mainstream society in a way which progresses along with the environmental, social and economic objectives.

To realize the above principles, the climate education, therefore, should encompass the following for a sustainable and climate-resilient agriculture.

- Raising awareness
- Acquiring new perspectives, values, knowledge and skills
- Making decisions and taking action
- Incorporating formal and informal processes leading to climate-friendly behaviour and practices

Initiatives on Promoting Climate Education

India recognizes that for ensuring country's food security both in short- and long-term and making agriculture sustainable and climate-resilient, appropriate adaptation and mitigation strategies have to be developed. The country has taken very proactive role for developing and disseminating such strategies for making the agriculture climate-resilient through its initiatives such as India's National Communication (NATCOM) to the UNFCCC and National Mission on Sustainable Agriculture (NMSA). The NATCOM initiative quantified various sources and sinks of greenhouse gases (Pathak *et al.,* 2010). The NMSA has identified priority areas, including improved crop seeds, livestock and fish culture; water-use efficiency; pest management; improved farm practices; improved nutrient management; agricultural insurance; credit support; markets; access to information and livelihood diversification for adaptation and mitigation. On 30 June 2008, Prime Minister Manmohan Singh released India's first National Action Plan on Climate Change (NAPCC), outlining existing and future policies and programmes addressing climate mitigation and adaptation. The plan identifies eight core "national missions" running through 2017 to promote development objectives while yielding co-benefits for addressing climate change.

Several Government and Non-Government organizations have taken commendable initiatives in promoting climate education in the country. A few of them are discussed below.

- **Indian Council of Agricultural Research (ICAR):** The ICAR is working on capacity-building on climate change research for more than a decade. It initiated a national Network Project on Climate Change (NPCC) with various Institutes and State Agricultural Universities (SAUs) to develop adaptation and mitigation strategies in agriculture. Lately it has launched a capacity-building programme in climate-resilient agriculture, called National Initiative on Climate Resilient Agriculture (NICRA). The programme aimed to set-up required infrastructure to undertake research on climate change and adaptation and to train India's agricultural scientists in climate-change and resilience related multidisciplinary research, covering crops, livestock and fisheries. At the SAUs, it has introduced Agro-meteorology, Meteorology and Geography courses at the undergraduate level and at the M.Sc. and Ph.D. levels in Agricultural Meteorology. It has proposed some key areas for training that include climate change impact on natural resources, abiotic stress in relation to soil-water-air-plant continuum, crop modeling for sustainable soil, water and crop productivity, development in weather prediction and forecasting, impact of climate change on crop pests and diseases and impact of climate change on horticultural crops.
- **Indian Agricultural Research Institute (IARI):** It is a premier institute of agricultural research in the country imparting climate education to post-graduate students and also conducts trainings and workshops since two decades. It has established a multi-disciplinary, integrated Project Directorate named Centre for Environment Science and Climate Resilient Agriculture (CESCRA) with a vision to enhance resilience of Indian agriculture to environmental change. Capacity-building is one of the thrust areas of the Centre. The institute has specialized courses on climate change, meteorology, agro-meteorology and greenhouse gas emission.
- **Tata Energy and Resources Institute (TERI):** For the last few decades, TERI has been working on assessing risks of climate change and building capacity to protect most vulnerable sectors of the economy through classrooms, demonstrations and web-based learning.

- **Central Board of Secondary Education (CBSE):** To promote climate education, the CBSE has integrated climate change in multiple subjects in the Senior School Curriculum in the Schools of India.
- **Centre for Environment Education (CEE):** The CEE at Ahmedabad and Gujarat University has jointly established the Management Education Centre on Climate Change to work in areas of climate change adaptation and mitigation.
- **Consultative Group of International Agricultural Research (CGIAR):** Many CGIAR institutes are working in promoting climate education and developing capacity in adaptation and mitigation to climate change. It has developed a strategic partnership on Climate Change, Agriculture and Food Security (CCAFS) to address increasing challenge of global warming and declining food security on agricultural practices, policies and measures. The CCAFS is collaborating with all 15 CGIAR research centres as well as with the other CGIAR thematic research programmes.

Strategies for Promoting Climate Education

Climate change has emerged as the gravest challenge across the globe and the search for appropriate mitigation/risk management and adaptation options has become an arduous task. Concerted and continued efforts should be made for developing human resources, appropriate technologies for climate change risk management and adaptation. As the climate change vulnerability and impacts immensely influence prospects of development, it is highly imperative to deign pro-poor, bottom-up and multi-sectoral partnership-based strategy to educate people towards climate-friendly lifestyle. It has become the need of the hour to develop capacity-building individuals and enhance sensitization and awareness of masses for climate-risk management (Kumar, 2012). Some specific strategic points are as follows.

- **Strengthening national agriculture research and education systems in promoting climate education:** State agricultural universities and research institutes can play a pivotal role in making the nation climate-literate. Though the subject of climate is taught at school, college and university levels, there is a need to broaden sphere so that it can reach to masses. Universities and research institutes should take active role in empowering their stakeholders through (1) imparting training to trainers, teachers and students; (2) providing web-based, real-time information on climate forecast, its impact and adaptation options; (3) developing crop insurance programmes for climate-risk management; (4)

developing policy options for promotion of climate literacy; and (5) developing course curricula and teaching and training materials for schools and colleges. Special packages need to be developed for industry, cooperatives, panchayats, and others to enable them to understand importance of soil-carbon and its trading potential. To facilitate appropriate policy response, the level of awareness of policy-makers should be raised regarding the spatial and temporal magnitude of climate-change variables, their probable impacts on different aspects of agriculture, and options that can increase adaptive capacity and mitigation potential of agriculture. A detailed action plan is required to be developed including specific budget allocation and constitution of specialized groups to oversee its implementation.

- **Development of new course curricula on climate change:** There is a need to broaden the sphere of climate education to enable it to reach to masses. This can be achieved through: (1) developing course curricula and teaching and training materials for school and colleges; (2) launching a national publicity campaign to attract young minds for career in climate education at all levels and (3) develop mechanisms for greater academic cooperation between universities and research institutions (Kumar, 2012).
- **Training of trainers (teachers and scientists):** Climate change is an emerging field and is evolving rapidly. Therefore, existing teachers and scientists need to upgrade their knowledge and skills to train young researchers for climate-risk management in the ensuing years. Training to the trainers may include short-term visits to key laboratories involved in climate-change research and education; inviting foreign experts to conduct hands-on training or using sophisticated new facilities; and providing web-based, real time information on climate forecast, its impact and adaptation options**.**
- **Strengthening open and distance education programme:** The open and distance education on climate change may be strengthened to make people more aware of climate. Protection of traditional knowledge for managing climate risks may be duly emphasized.
- **Establishing academia and industry interaction forum:** Academia and industry interaction forum should be established to encourage private investment in climate education, create awareness among farmers and rural masses. The private organizations should also strengthen climate-related research.
- **Sensitization of farmers and masses:** Because of the profound impact of climate on Indian Agriculture, and associated activities

and welfare of the Indian masses, sensitization of the people should go a long way to achieve desired goals of climate literacy among all individuals. Climate change related policy advocacy, protocols, rights and duties, alternative sources of energy, clean development mechanism and technology, carbon credit and sequestration should be popularized. Mobile education programme in stewardship of non-governmental organizations (NGOs) could be initiated to deliver climate change messages to school children as well as to farmers, farm-youth and farm women. Awareness at individual, households and community levels should be promoted to enhance understanding of the dynamics of climate change and its impact as well as the causal factors. Awareness will enable farmers in better comprehension of risks and urgency of advance and contingency planning (Kumar, 2012).

- **Harnessing media and information communication technologies (ICTs):** The media may help in achieving substantial awareness among the masses on climate change and its risk management through TV and radio programme.
- **Harnessing civil society organizations:** Awareness towards climate-risk management can be developed through active participation of civil society organizations and various line agencies operating at local, regional and national levels. A network of community based organizations; Panchayati Raj Institutions; NGOs; line departments of agriculture, dairy, fisheries, forestry, education, health, and water; banks; insurance and input companies could make a significant dent through partnership-based joint ventures. Awareness programmes would help farmers utilize suitable adaptation measures and significantly reduce losses owing to adverse climate.

Model Action Plan on Climate Education

To make Indian agriculture climate resilient, there is an urgent need to initiate and upgrade climate education in the country. Climate education should aim at creating public awareness and empowering farmers to manage agriculture to reduce risks of climatic variability and change. This should be in terms of creating infrastructure for development of human resources and state-of-the-art facilities for climate-change research. During the last few years, climate change has been included in different course curricula. However, these need to be modernized by changing outlook, bringing in more contemporary subjects such as climate change-impacts, adaptations, mitigation, climate and politics, UNFCCC, other UN agreements (ozone), and so on. Also requirement is of guidebooks, textbooks, training materials, etc. on these topics. A detailed action plan is required to be developed including specific budget allocation and system for its implementation and monitoring. A model action plan is proposed below as a guideline for mainstreaming climate education.

Plan for mainstreaming climate education in Indian agriculture

Level/Organization	Action
High School and Higher Secondary School	Inclusion of basic understanding of climate, its components and impacts on human welfare in science and social science subjects
Under-graduation in Agriculture	Integration of climate and its impacts on agriculture in different courses Introduction of elective courses on climate change and its management
Post-graduation in Agriculture	Upgradation of courses on meteorology, agro-meteorology to cover various aspects of climate change and its management Integration of climate and its impacts on agriculture in different disciplines Introduction of disciplines of environment and climate change science in different SAUs and Deemed Universities Initiating research on climate change and its management
Deemed universities in ICAR and SAUs	Introduction of a compulsory course for every graduate student in agriculture on agro-meteorology Conducting training of scientists and line department officials on climate change Workshop and farmers' field days for raising awareness of farmers on managing risks of climate change Developing partnership with public and private organizations for capacity-building and research Strengthening open and distance education programme Enhancing skills of scientists through training in advanced laboratories abroad

Level/Organization	Action
Krishi Vigyan Kendras	Conducting training of scientists and line department officials on climate change Workshop and farmers' field days for raising awareness of farmers on managing risks of climate change
ICAR, DST and MoEF	Providing fund for conducting training of trainers on climate change issues Strengthening research and development programmes in different institutes and universities Monitoring and evaluation of various programmes on climate-change education in different institutes and universities
Private organizations	Establishing academia and industry interaction forum for climate change education Providing fund for conducting training of trainers on climate change issues and strengthening research and development programmes in different institutes and universities in a participatory mode
Civil society organizations	Carry-out awareness programmes for farmers on climate change adaptation and mitigation
Media	Carry-out climate awareness programmes highlighting various issues of climate risk and its management

Conclusions

The basic aim of climate education is to inculcate among farmers and other stakeholders a sense of responsibility and awareness to develop skills by means of which they can bring about a change towards climate-resilient agriculture. This should be in terms of creating and upgrading infrastructure for development of human resources and state-of-the-art facilities for climate-change research. During the last few years, climate change has been included in different course curricula at college and university levels. This needs to be modernized by changing outlook, bringing in more contemporary subjects such as climate change-impacts, adaptations, mitigation, climate and politics, UNFCCC and other UN agreements. Guidebooks, textbooks, training materials are required to be developed on these topics and promoted through various Govt. and civil society agencies and media. The proposed model action plan should be implemented, monitored and evaluated for mainstreaming climate education in Indian agriculture. Such model may not only be desirable but critical in responding to challenges posed by global climate change.

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Technical Session 3

Agricultural Research, Education and Extension Integration for Development (AREE4D)

Technical Session 3, Chair Dr. Uma Lele

Envisioning Agricultural Research and Education for Development (ARE4D) in India

S. Ayyappan and A. Arunachalam

Introduction

Agriculture retains the dominant role in Indian economy (Figure 1) – contributing 14% to Gross Domestic Product (GDP); providing 60% of jobs and 70% of primary source of income in rural areas. During the past five decades, Indian agriculture witnessed a remarkable increase in production from a modest 51 million ones in 1950-51 to a record production of 259.32 million ones of food grain in 2010-11 (MoA, 2013). Initially (1950-67), the growth was attributed to increases in area of cultivation, whilst after 1967, it was mainly due to adoption of new agricultural technologies, popularly known as Green Revolution (Figure 2). It is well recognized that while overcoming the chronic food problem, India also received strong support from the international research organizations and scientific institutions, located in different regions of the world.

Through international cooperation, the research and educational system of India underwent a major reorganization in the sixties and an extensive network of agricultural research and educational institutions were established to infuse modern science and technologies in Indian farming such as crop improvement, integrated pest and nutrient management, farm mechanization *etc.* to address on diverse production problems, and to tap genetic potential of crops, *etc.* for augmenting agricultural production in an integrated manner. Nevertheless, having attained self-sufficiency, complacency set in leading to decline in public investment, but this sector has also not been able to attract private investment to the desired level. However,

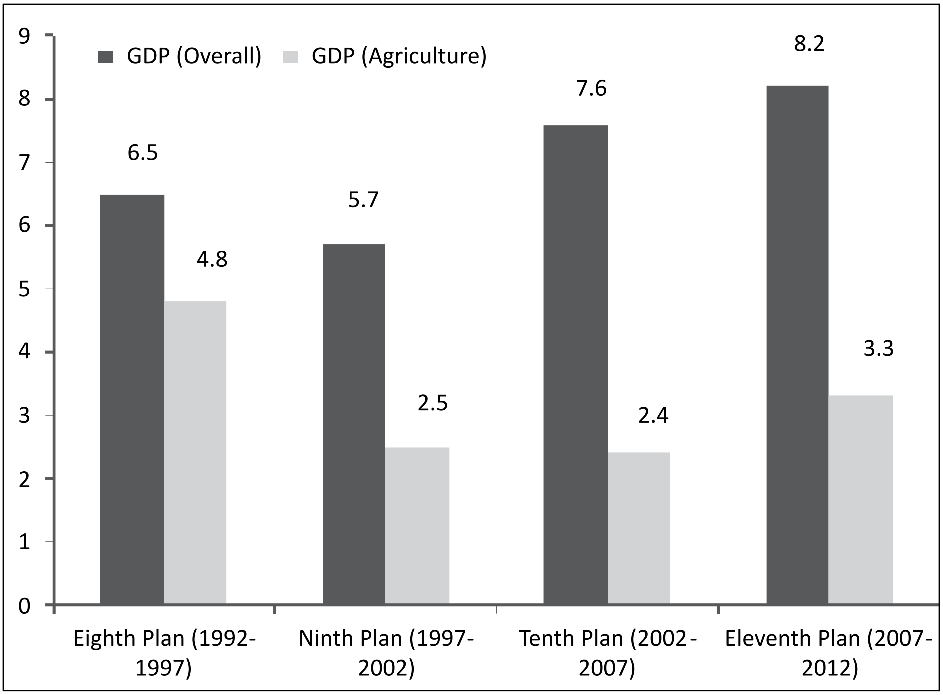

Figure 1. Contribution of Agriculture to Gross Domestic Product (GDP) – India

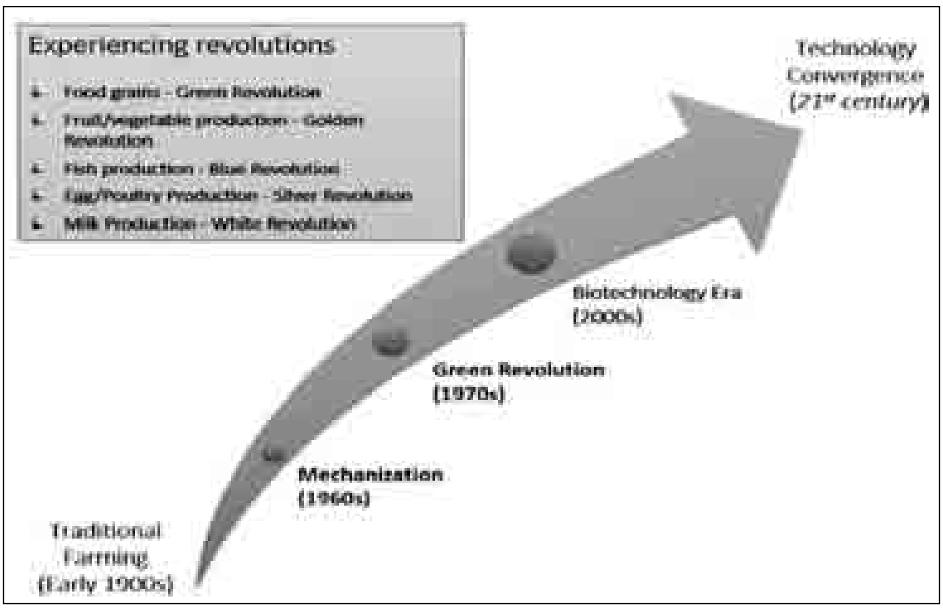

Figure 2. Distinct Transitions in Agricultural Era

since last decade, the situation has largely improved owing to the commitment on Millennium Development Goals towards alleviating poverty and for achieving food-security, which can be met only through applications of science, technology and innovation in agricultural research and extension services. This paper is an attempt to analyze the scoping of national agricultural scenario in the light of investment, market, R & D, education and also from policy viewpoints, to arrive at a strategic framework for evolving Indian agricultural research and education for development.

Food Demand Scenario

Food consumption pattern of Indians is undergoing significant changes (Figure 3). This has diversified the demands for food towards high value products like fruits and vegetables, milk, meat, *etc.* This is again likely to exert pressure on agriculture demanding higher resource allocation amongst competing commodities.

Given the present domestic demand (Table 1), about 1.5 to 2-times of increase in demand is projected towards the year 2050 for

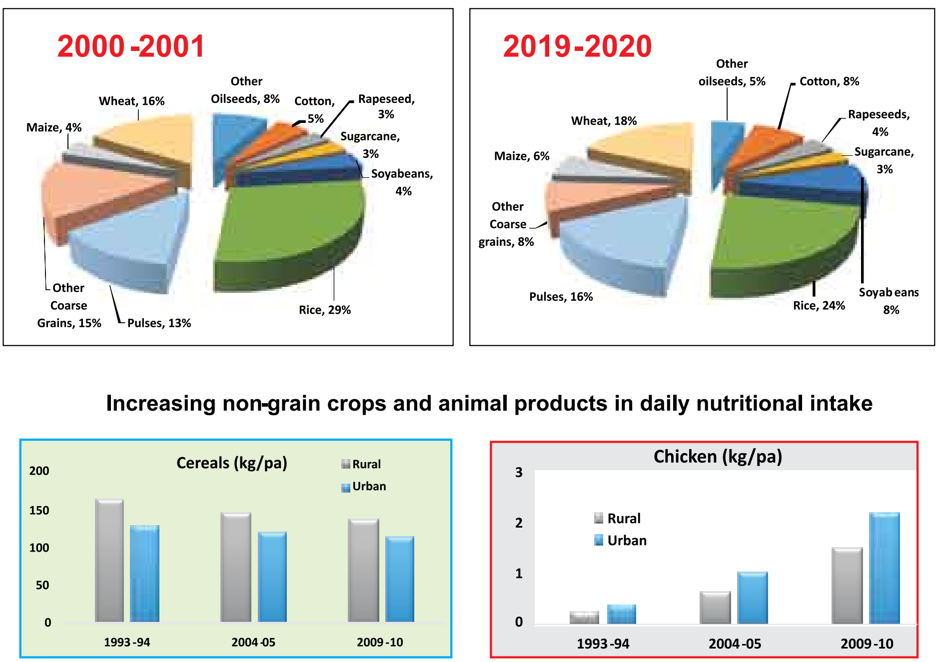

Figure 3. Changing food consumption pattern

various food commodities. Comparing with other commodities, the proportionate demands for fruits, milk, edible oils and eggs are extremely high. For instance, an annual growth rate of 0.67% is anticipated for cereals, 1.84% for pulses, 1.63% for vegetables, 2.9% for fruits, 2.26% for milk, 2.80% for edible oils and 1.72% for fish. This also indicates the possible shift in the food composition in the days to come.

Table 1. Total domestic demands (mt) of different food commodities

Food Items	Present	Projected for 2050		
	2009-2010	BAU	MM	Upside
Cereals	196.4	311.5	358.7	406.9
Pulses	17.8	35.1	46.3	50.3
Food grains	214.2	346.6	405.0	457.1
Edible Oils	15.7	29.5	39.0	45.2
Vegetables	13.2	258.9	342.2	438.6
Fruits	71.2	231.0	305.3	183.4
Milk	111.5	303.7	401.4	483.6
Sugar	22.0	44.1	58.3	58.2
Meat	6.0	10.4	13.8	18.1
Eggs	58.2	139.2	183.9	202.5
Fish	7.1	16.9	22.4	27.0

Source: NCAP (2013); BAU – Business as Usual; MM – Maintaining Momentum

Investment Scenario

To meet the challenges in the 21st century, particularly concerning feeding the growing population of our country, heavy investments for developing the requisite infrastructure and other areas of agriculture are essential. Returns on investment (RoI), *i.e*, return per unit of currency invested are shown in Table 2. In agricultural R&D, India is able to generate better returns for respective investment, *i.e.,* twice that of China. Overall, based on the returns in terms of poverty reduction, India ranks first as far as road network is concerned, second in agricultural R&D, third in education and fourth in health sector (Table 2).

Table 2. RoI in agricultural R&D vis-a-vis other sectors.

	China	India	Thailand	Ghana	Uganda	Tanzania	Ethiopia
	Returns to Agriculture or Rural Income (Local currency/Local currency spending)						
Agricultural R&D	6.8	13.5	12.6	16.8	12.4	12.5	0.14
Education	2.2	1.4	2.1	-0.2	7.2	9.0	0.56
Health	n.e.	0.8	n.e	1.3	0.9	n.e.	-0.03
Roads	1.7	5.3	0.9	8.8	2.7	9.1	4.22
	Ranking in Returns to Poverty Reduction						
Agricultural R&D	2	2	1	n.e.	1	2	n.e.
Education	1	3	3	n.e.	3	1	n.e.
Health	n.e.	4	n.e.	n.e.	4	n.e.	n.e.
Roads	3	1	2	n.e.	2	3	n.e.

Source: Pratt and Fang (2010); n.e. – not estimated

Trade, both domestic and foreign, has been critical for private partnership in agriculture and India is yet to emerge as a significant player in the global agriculture market. Presently, India holds around 1.5% of the global trade in agro-commodities, which is less compared to huge workforce engaged in this field. With the continuing trade discussions under the WTO, it is hoped that, Indian agricultural policy makers will find ways and means to increase the agri-exports without adversely affecting the livelihood security of the large population of small holder farmers. Despite many major structural transformations such as better input facilities and technology changes with regards to irrigation, high yielding seeds and changes in cropping pattern *etc*., the agriculture sector in India is still termed as the `profession of the poor'.

Modern agriculture practices are increasingly turning out to be knowledge-based and hence gaining expertise in them is not an easy task for many of our rural farmers. India does require knowledge and skills at all levels so that Indian farmers are better equipped to handle the global competition. These days, with the entry of Foreign Direct Investment (FDI) in the sector, many MNCs have forayed into the segment with dozens of agro-products; subsequently this has resulted into a threat to Indian farmers who lack professional expertise to cope with the issue. Hence the need of the hour is to give agricultural education including vocational skills a high priority.

Market Dimensions

Indian agriculture contributes to development as an economic activity, as a livelihood, and as a provider of environmental services, making the sector a unique instrument for development. It has unique features in reducing poverty, as it has been largely successful in meeting the world's effective demand for food. Yet more than 800 million people remain food insecure, and agriculture has left a huge environmental footprint. And the future is increasingly uncertain. Models predict that food prices in global markets may reverse their long-term downward trend, creating rising uncertainties about global food security. Climate change, environmental degradation, rising competition for land and water, higher energy prices, and doubts about future adoption rates for new technologies all present huge challenges and risks that make predictions difficult. For instance, in order to meet projected demand, cereal production will have to increase by nearly 50% and meat production by 85% from 2000 to 2030. Added to this is the burgeoning demand for agricultural feedstock for biofuels, which have already pushed up world food prices.

In India, agriculture being a State subject, the state-wise disparities in the agricultural growth must be removed through specific policy and other interventions. Managing the aggregate response of agriculture to rising demand will require good policy and sustained investments, not business as usual. Sharply increased investment is especially urgent in where food imports are predicted to more than double by 2030 under a business-as-usual scenario, the impact of climate change is expected to be large with little capacity to cope, and progress continues to be slow in raising per capita food availability. In other words, improving the productivity, profitability, and sustainability of smallholder farming is the main pathway out of poverty in using agriculture for development. This however will require a broad array of policy instruments and public-private partnerships (Box 1), many of which apply differently to commercial smallholders and to those in subsistence farming that can be used to achieve the following:

- Improve price incentives and increase the quality and quantity of public investment
- Make product markets work better
- Improve access to financial services and reduce exposure to uninsured risks
- Enhance the performance of producer organizations
- Promote innovation through science and technology

- ❖ Make agriculture more sustainable and a provider of environmental services

To bridge agricultural research and education with developmental process, a community driven developmental (CDD) approach has been prescribed. The CDD gives community groups and local governments control over planning decisions and investment resources. It is thus related to decentralization, and the two approaches can go hand in hand. The CDD mobilizes community groups and involves them directly in decisions on public spending, harnessing their creativity, capabilities, and social capital. In Indian scenario, this is quite possible through Panchayat Raj institutions. While doing so, developing accountability is an important condition for enabling communities to implement agriculture-for-development agendas on a large scale.

Box 1. PPP in Agriculture for Development

ICAR finds potential public and private organizations (including NGOs, farmers, organizations) in all sectors related to agriculture; and all these units, depending upon the potential, need to be harnessed. Recently, the Council established AgrinnovateIndia Ltd., a public limited company in 2011-12 for dispensing on four areas that have been identified for potential technology commercialization with private sector: i) Plant Sciences – seeds, planting materials, other selected products; ii) Animal Sciences – diagnostics, vaccines and other selected products; iii) Engineering Sciences – farm implements and machinery, post-harvest engineering and value addition; and iv) Professional services and turnkey projects. While addressing all major categories of agricultural goods and services critical to solve problems of rural people are to be taken up in PPP mode. These major categories are: inputs (water, fertilizer, seed), research and education system, extension system (including services), financial services and produce marketing services. Dimensions of off-farm employment (*e.g.* agro-based industry, agri-tourism) are also being integrated. With a focus on business promotion and development and technology commercialization, ICAR reached out to Industry, NGOs and other relevant organizations and systems through meetings at national, regional and local levels. As on date, we have over 300 private companies in formal relationship with ICAR institutes; thus expanding the horizons of research and commercialization of ICAR efforts. These dimensions are also expanding in the agricultural universities.

Policy Dimensions

Despite rapid strides in the agriculture front, still there exist many grey areas which require immediate attention (Figure 4). Keeping increase in productivity and production as the sole objective of agricultural research, our scientific community should leave no stone unturned for enabling paradigm changes in agriculture education in the country. With achievable targets, the Government of India has come up with the following policy assistance to facilitate better education in agriculture:

- Role of private investment in agriculture
- Awareness on credit facilities to farmers
- Use of water resources
- Strong marketing infrastructure
- Role of effective agro–processing techniques
- Flood and drought management
- Laws and regulations in agriculture
- Soil and water testing laboratories
- Agri-price support

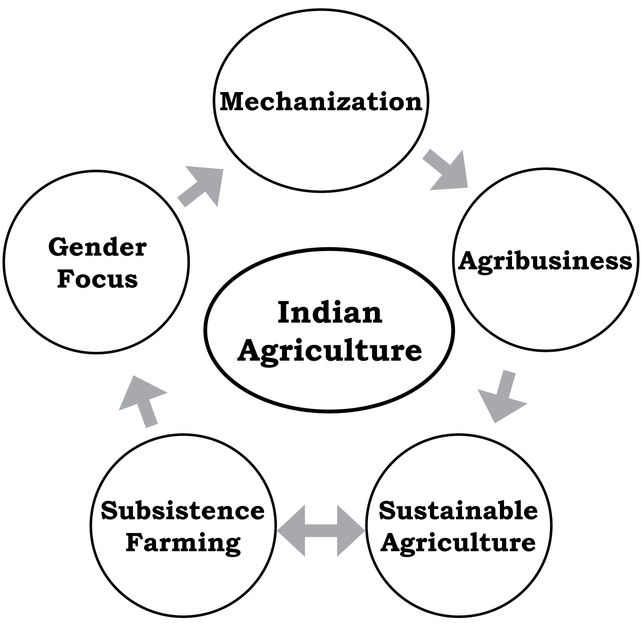

Figure 4. Emerging Priority Areas and Linkages in Agriculture (Linking Agriculture-Food-Nutrition-Health-Environment-Employment)

To effectively capitalize the global competitive advantage, Indian agricultural institutes have to evolve a policy with regard to technology, more market access opportunities, and more transparency (Box 2). With the aim of bringing uniformity in education in agriculture and raising its standards, ICAR is attempting to set new quality standards through steps like accreditation to all the universities and their affiliated colleges.

Box 2. Agricultural R & D Policy – the first of its kind

Goal: *To mainstream Agricultural R&D with National Science & Technology and Innovation Policy to address the challenges of Food and Nutritional Security through enhanced production and productivity.*

Objectives:

To mitigate the shortfall in agricultural produce in view of growing human population and natural resource degradation by achieving climate resilience in Agriculture.

To popularize agricultural education as a business opportunity.

To synchronise technological innovation with farmers' knowledge.

To promote public-private partnership in agri-sector.

In future, India is to face an increased demand for processed food articles, as the market driven agriculture commodity choices will increase the rise of retails and supermarkets. Given this scenario, the education pattern need to be vigorous and futuristic.

The National Academy for Agricultural Research and Management (NAARM) of ICAR located in Hyderabad has estimated future manpower needs in different sections of agriculture. The studies reveal the anticipated decadal (2010-2020) increase in demand out-turn to be between 31-40% for UG and PG students and about 50% at doctoral level (Table 3). This gap could be reduced by accelerating agricultural education through several innovation schemes such as Student READY, ARYA and by promoting agricultural education in the Schools.

The major issue being that the establishment cost of agriculture universities, in recent times, has risen substantially to as high as 87%, while their operational budget has been reduced to about

13%. Although the quantum of agricultural education and research and development has risen, the funding levels have not kept the pace. Further, the number of faculty in agriculture universities has markedly declined, resulting on an average only 50% strength of total faculty positions. There is also the problem of inbreeding and about 51% of faculty members have their all degrees from the same university. In agriculture universities, only 17% recruits are new and 46% faculty has served the same university for more than 15 years. The inter-university mobility of faculty must therefore be encouraged with deputation incentives.

Table 3. Required Annual Out-turn by Education Level in 2010 (supply) and 2020 (demand)

All agricultural disciplines	UG		PG		PhD		Total	
	2010	**2020**	**2010**	**2020**	**2010**	**2020**	**2010**	**2020**
	17316	40188	5553	10638	920	2805	23788	53630

The architecture of the present public extension system is linear and compartmentalised, thus propagating a top-down approach that does not necessarily encourage interaction and cooperation amongst the several stakeholders. Perhaps, a more organised utilization of Information and Communication Technology (ICT) could help disseminating the knowledge and information to the rural people for both forward and backward linkages in technology adoption and management to enhance agricultural production and productivity. Higher participation of young graduates and skilled workers as “pollinators of farming” in scaling up farm-to-fork efforts is required. Private sector must also be involved and regulated for fair practices.

Overall, for attaining global standards of quality and enhance relevance of agricultural education and research in the country, requisite models of public-private partnerships must synchronize education with employment and development. In order to meet the growing challenges, human resources development in application and flow of technologies from lab to the market place *vis-a-vis* strengthening national agricultural research and education systems’ infrastructure needs strengthening through active interface with the industry.

The NARES

Agriculture under constitution is a state subject and the primary responsibilities for agricultural research, education, extension and development are with the States. The central government, however, does the specific responsibilities in coordinating work on agriculture in different states. The National Agricultural Research and Education System (NARES) in the country is a two-tier system, comprising of ICAR at the National Level and State Agricultural Universities (SAUs) at the State Level. The development of agriculture and self-sufficiency in food grain production in the country is due to historic integration of both ICAR (Box 3) and SAUs (Box 4).

Box 3. Indian Agricultural Research (IAR)

The foundation for scientific research in agriculture was laid in 1889 with the establishment of the Imperial Bacteriological laboratory in Poona. This laboratory was subsequently shifted to Mukteshwar, Uttarakhand in 1895. This institution later formed the nucleus of the Imperial (India's) Veterinary Research Institute. It was only in the beginning of the 20th Century, the Colonial government realized the urgency of the establishment of the agricultural research institutes, experimental farms and agricultural colleges to bring about any progress in the agricultural practices. This was manifested in 1905, when the generous donation of $30,000 received from Phipps (America) for the establishment of the Imperial Agricultural Research Institute (IARI), at Pusa, Bihar. It was designed to assist in providing solution to the fundamental problems of tropical agriculture. Since the development of a series of agricultural research institutes in the central and state sectors, it was desired to have a coordinating unit, which can give better leadership. In 1926, the Royal Commission on Agriculture was set up to make recommendations for the improvement of agriculture and to promote the welfare and prosperity of the rural populations. This led to the establishment of Imperial Council of Agricultural Research (ICAR) in 1929 with a mandate to promote, guide and coordinate agricultural research throughout India.

Following a severe earthquake in 1934, the IARl at Pusa was shifted to New Delhi in 1935. At the time of establishment of ICAR, there were also a few commodity committees in the country *viz.*, Indian Central Cotton Committee established in 1929. Subsequently, Indian Lac Committee (1931), Indian Central Jute Committee (1936), Indian Central Sugarcane Committee (1947), Indian Central Coconut Committee (1945), Indian Central Tobacco

Committee (1945), Indian Central Oilseed Committee (1947), Indian Central Areca-nut Committee (1948), Indian Central Spices and Cashew-nut Committee (1958) were established. In 1963, the working of ICAR was reviewed, and related research institutes were brought under ICAR. In 1972, a separate Department of Agricultural Research and Education (DARE) was established under the Ministry of Agriculture that discharges its responsibility through the Indian Council of Agricultural Research (ICAR). Now ICAR has 99 research institutes all over the country, of which 4 are deemed universities and is also managing 79 All India Coordinated Research Projects (AICRPs). In the 12th Plan, the Council is also launching several Consortia Research Platforms (CRPs) for focused research in a network mode.

Box 4. Agricultural Education in India

At least nine decades ago, the importance of agricultural education was realized. However, the concept of State agricultural universities was basically on the recommendations of the University Education Commission (1948), headed by Dr. S. Radhakrishnan. The Commission recommended the establishment of rural universities on the pattern of Land Grant College of USA. A team headed by Dr. M.S. Randhawa in 1959 recommended that each agricultural university should have: (a) autonomous status, (b) location of agricultural, veterinary, animal husbandry, home science, technological and science colleges on the same campus, (c) integration of teaching by offering composite courses, and (d) integration of education, research and extension. At present, the ICAR has established one Central Agricultural University (CAU) and supports 634 Krishi Vigyan Kendras (KVKs) across the country. Overall, the number of Universities rose up to 65 in the country. According to an estimate, about 50% of students in agricultural universities are from rural areas. Though rural participation in agricultural education and research is declining, the more participation of girls is an encouraging sign (Figure 5).

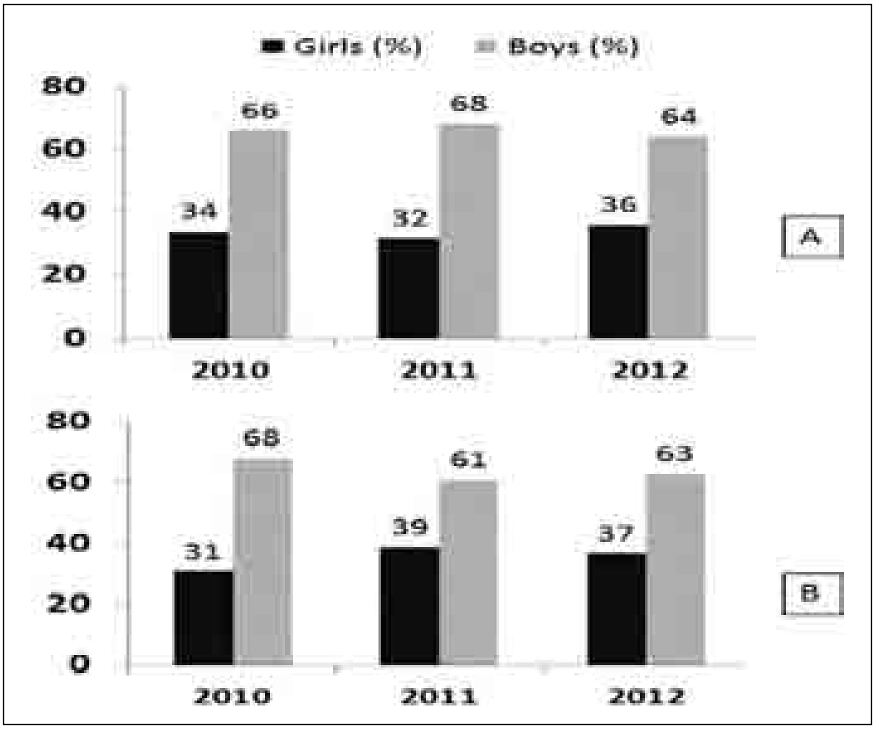

Figure 5. Gender scenario in Agricultural Education; A – UG and B – PG

Source: (Agnihotri et al., 2014)

Several other organizations, such as general university/scientific organizations, Indian Council of Medical Research (ICMR), Council for Scientific and Industrial Research (CSIR), Bhabha Atomic Research Centre (BARC), various departments or Ministries at centre (Department of Biotechnology, Department of Ocean Development and Department of Science and Technology) and private and voluntary organizations do support and compliment research activities in agriculture and food processing sectors. The voluntary agencies and private institutions who are engaged in input production *e.g.* seeds, fertilizers, agro-chemicals, agricultural machineries and implements have developed infrastructure and expertise for agricultural research. These are imparting a supportive role in agricultural research in partnership mode.

Human Resources & Development

Agricultural education in the emerging scenario must produce graduates with entrepreneurial skills who can generate employment and not exclusively depend on public-sector jobs. Priority should be on supporting of self-employment schemes, envisaged to bring extension services to farmers' doors (Samanta, 2010). Besides including subjects on entrepreneurship, courses would also need to be developed to meet demands of diversified agriculture and emerging global markets (NAAS, 2004). A one year composite programme namely, Rural Entrepreneurship and Awareness Development Yojana (READY) with three components: Experiential Learning (EL), Rural Awareness Work Experience (RAWE), and in-plant training/industrial attachment is being contemplated. The main objectives of EL are to promote professional skills, business entrepreneurship, knowledge and marketing skills through meaningful end-to-end approach and working in project mode; and to acquire enterprise management capabilities including skills for project development and execution, accountancy and national/ international marketing.

To ensure efficiency, effectiveness and sustainability in agricultural production, a paradigm shift in education learning system, technology, curricula and infrastructure is essential. Rapid change in life-style, social value and work ethos in every walk of life exerts enormous pressure on our colleges and universities. To meet this requirement, Open Distance Learning (ODL) has become an important option. It is high time to take advantage of this system of education and make use of multi-media, e-journals, e-books for quality mass education and e-governance. Further, rapid growth of information and communication technologies (ICT) in the past decade and use of knowledge as a basic power to deal with global competitiveness have revolutionized all higher education. Technology-enhanced Learning including the emerging Massive Online Open Courses (MOOCs) must be infused in the learning ecosystem to skill the farmers.

With the aim of bringing uniformity in education in agriculture and raising tis standard, the ICAR is conducting an exercise of identifying the lacunae in the system, rectifying them, and also setting new quality standards through steps like accreditation to all the universities and their affiliated colleges. Basically, the Council is working towards a new higher education policy in agriculture. Annually, the students are admitted to the agricultural universities through centralised admission procedure and in the year 2011-12, about 1750 students were admitted to UG programmes in agriculture and about 2000 students in the PG courses. The courses in the universities are designed and accredited under the norms of the Council for educational quality assurance across the country. In order to mainstream agricultural education with entrepreneurship, ICAR has established over 350 Experiential Learning Units in 51 Universities across the country. To provide opportunity to our global partners, ICAR has also instituted ICAR fellowships, India-Africa Fellowship and India-Afghanistan Fellowship, through which students from abroad get admission in Indian Agricultural Universities. For in-house skill development, Executive Development Programmes (EDP) for the research managers and also Management Development Programmes (MDP) for the others are organised by NAARM, Hyderabad. Further, farmers are capacitated through KVKs by vocational training and knowledge resource centres.

New Initiatives

The ICAR has been concerned about the whole lot of issues discussed above and has come out with a few innovative programmes to help bridge the gaps in existing institutional linkages in agri-sector (Figure 6). In the 12th Plan, the ICAR is implementing (a) consortia research platforms on select thematic areas, (b) Farmer FIRST[1] approach to achieve indigenous linkages in agri-sector development, (c) Student READY[2] approach to capacitate the agricultural students to develop entrepreneurial skills and ARYA[3] to attract rural youth in agriculture. It is hoped that these programmes would catalyse and reinvigorate sustainable agricultural development through the powerful tools of potential agricultural research and education.

Presently, the Council is in the process of implementing the National Agricultural Education Project (Box 5). The effort is also targeted at augmenting the human capital of better quality trained scientists, teachers and agriculturists for the country. In order to meet the systemic challenges in R & D, the course curricula in agricultural universities need to be more flexible, relevant, contemporary and inter-disciplinary. Integration of agricultural sciences, with social sciences including management tools and techniques could help reduce the disconnect between the laboratory and the land, on one hand, and between production to supply chains on another.

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[1]Farmer Innovations and Resources in Science and Technology

[2]Rural Entrepreneurship Awareness Development Yojana

[3]Attracting and Retaining Youth in Agriculture

Box 5. National Agricultural Education Project (NAEP) – Supported by World Bank

Goal: *To improve and sustain quality of higher agricultural education for addressing emerging challenges for livelihood security and sustainable development.*

Objectives:

To achieve excellence, enhanced relevance, and high efficiency in the agricultural higher education system, and the agricultural universities to offer enhanced services to benefit farmers, rural women and other stakeholders.

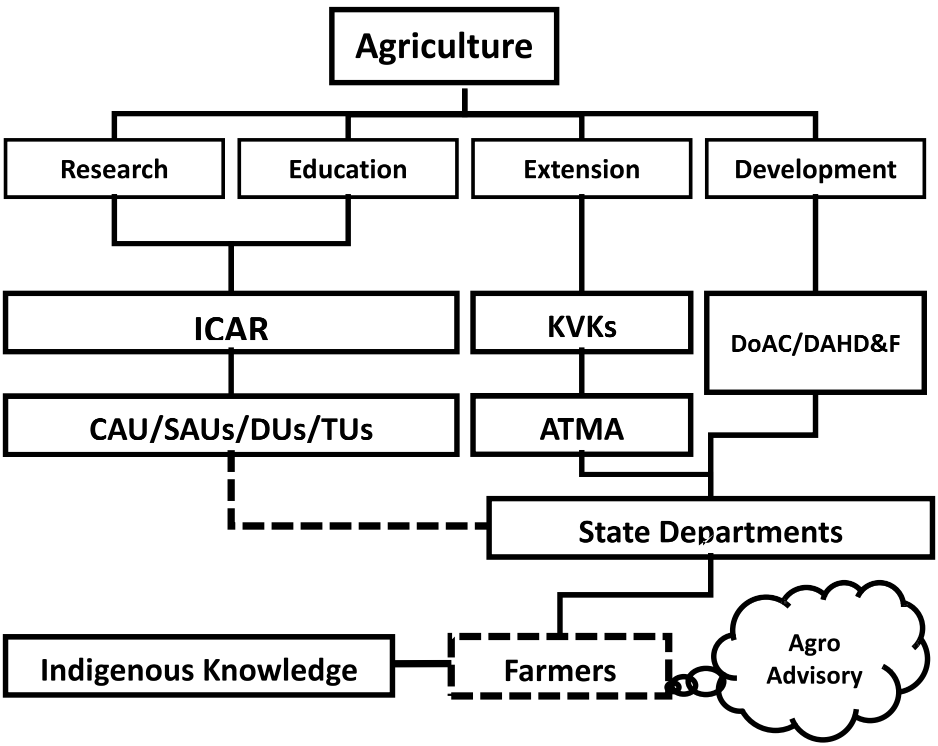

Figure 6. Institutional Framework for Indian Agriculture for Development

Precisely, the Council positions Indian agriculture as:

- Remunerative agriculture (integrated farming systems, dryland agriculture)

- Self-sufficiency in pulses and reduced edible oil imports
- Precision farming and due farm mechanization
- Reduced harvest and post-harvest losses and food wastage
- Generating quality human resource (men & mentoring)
- Achieving comprehensive agri-biosecurity
- Overall Efficiency, Equity & Empowerment in Agri-sector

Further, the country envisions Indian agriculture to be climate-resilient, a sought-after profession through profitable and prestigious partnerships both locally and globally. Meanwhile, ICAR is also addressing the issues of governance by,

- Leveraging a central role of ICAR in the governance of SAUs on the pattern of UGC
- Bringing crop and forestry research more closer to NARS
- Science-based regulations for cost-effectiveness
- IPR policy to incentivize and foster innovations and partnerships and to upscale commercialization of technologies, and
- Policy on sustainable use of natural resources.

Conclusion

In all, ICAR is moving forward with equal opportunity approach to all stakeholders in agricultural sector and is keeping windows for interactions with other departments to accomplish development *per se* in the country (NAAS, 2009). In order to have efficient linkage of agricultural research and farmers' benefits, public-private partnership (PPP) mode is also being advocated. With new and innovative programmes such as Farmer FIRST and Student READY, the Council is foreseeing a better synergy between agricultural education and scientific career options to the youth in the country in particular. It has been projected, with the present proportion of human demography, India is anticipated to have more youth by 2050, amidst alarming aged populations in South Asia and several countries in the north. Thus, India strives to have South-South cooperation to further agricultural research in the region.

Over the past few decades, the policy agenda of agricultural research and education for development has evolved significantly from an initial focus on increasing food production to concerns for the environment, poverty and stakeholder participation. Agricultural research preparedness, in terms of an inclusive bend of basic, strategic, applied and participatory research, and synergistic combination of modern and traditional knowledge, is next to none for a vibrant agricultural research system, and in turn, for a thriving, dynamic and livelihood secure agriculture.

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Agricultural Research, Education and Extension for Development (AREE4D)

E.A. Siddiq

Advancement of science and technology is the key to progressive economic growth. Studies have shown that advances in science and technology depend on the size of investment, given the proportionate development of not only of products of economic value but also of size and quality of human resource and number of publications of basic value in high impact journals. In comparison to the USA and China, India's investment on scientific research is several times less and so are the research findings of applied and basic value. As for agriculture, it is clear under investment; given the size and pace of growth envisaged for the XIth Plan period – the public outlay being just 3.0 % of agricultural GDP. And from the private sector, it is three times (9.2%) more, thus making overall investment somewhat respectable. The proportion of funding on agricultural research and education is, however, a very small fraction of it. Encouragingly, while it is plateauing in developed countries and declining in the countries in Sub-Saharan Africa, it is increasing in China, India and Brazil. With increasing participation of the private sector in conventional and innovative crop improvement research, India's investment is bound to grow at a faster rate in the forthcoming years.

More than the size of the investment, how it is utilized is important. In rationalizing resource utilization, our experience, achievements and lopsidedness in prioritization in the last 50 years on the one hand and challenges ahead and unfolding scientific and technological opportunities on the other should help us plan and implement a realistic road-map. Establishment of commodity-oriented institutions for undertaking research on the problems of national and regional importance, national institutes and State Agricultural Universities for massive human resource development and large extension component for rapidly reaching out technologies to targeted clientele has transformed the country from subsistence agriculture into the one of the fast-growing agriculture economies of the world. The enviable achievement and rich experience gained should not, however, be kept aside as the history.

While planning our future course of action for AREE4D, issues like rampant under-nourishment and malnutrition, rapidly shrinking natural resource base, inevitable adverse impact of climate change, no technological breakthrough as yet to bring hope to vast rainfed ecologies and need to remain increasingly competitive for expanding and sustaining export market for agricultural commodities, reservation against innovative technology-generated crops, limitations of currently employed crop-improvement technologies and sovereign right of countries over their genetic wealth proving germplasm sharing increasingly difficult should find their place of importance for augmentation of research, need-based human resource development and pro-growth policy environment.

Overcoming Constraints to Growth and Development

Human resource development

Till-date, government has been the major employment provider to agricultural graduates. Recruitment being done once in 3 to 4 years leaves many remaining unemployed of late in many states. Entry of private sector in recent years in agricultural research and development has opened up yet another avenue for their absorption. Unfortunately industry finds graduates training not ideally suited to the industrial need; this warrants a relook into and modification of the present curricula of Bachelor's Degree to be employment- and demand-oriented. In US Universities, curriculum of the undergraduate (UG) programme in agriculture includes training on all aspects of agricultural science in the first three years, and last one year is devoted to training on job-oriented specialization and internship. And the degree is awarded according to their last year specialization as B.S. (Seed Technology), B.S. (Horticulture), B.S. (Plant Protection), B.S. (Biotechnology), B.S. (Agri Business) etc, instead of general B.S. (Agriculture).This improves vastly their employability more than post-graduates. Adoption of such a model here at the UG level would make human resource development appropriate for agricultural development.

Need for development of another cadre of human resource for effective transfer of technology has now arisen with increasingly weakening linkage between Agricultural Extension Officers (AEO) and farmers in the rural areas. The position of AEO, unlike in the 60s and 70s, has become a white-collar job today, seriously affecting the pace of adoption of newer technologies. Two-year diploma course in general agriculture, seed technology and horticulture offered by some of the Agricultural Universities need tobe promoted to strengthen weakening linkage between farmers and extension personnel. Such a Cadre is preferred to agricultural graduates by both public and private sector institutions, trusting that they alone would enable speedy and effective transfer of technology.

Development of scientists capable of undertaking research in cutting-edge bioscience areas is the need of the day. The following two strategies would prove rewarding.

Training young and mid-level scientists in large numbers in emerging/cutting-edge science areas in advanced laboratories abroad: It is known that China has trained and continues to train its scientists in thousands in advanced areas of science in western laboratories to strengthen its research base. It is high time, that India taking the cue from China, trains a few hundred of agricultural scientists in the emerging areas. We are not new to this strategy, and we had taken advantage of it long before China in the field of agriculture. It was the training provided to our agricultural scientists in the USA and Europe between 1950s and 1970s that helped country build a strong base for research and postgraduate education and that gained abundantly there from.

Encouraging renowned Indian scientists residing and working in developed countries (NRIs) to return in large numbers and help us strengthen our research in advanced areas: There are already DBT, DST sponsored schemes to attract outstanding Indian scientists working abroad. It covers all disciplines including agriculture. Unfortunately the response is not to the desired level from agriculture discipline. Thus, there is need for accelerated effort to attract scientists of relevance to agriculture. The ICAR should come up with attractive schemes to attract and benefit from the renowned Indian scientists working abroad. Decent salary and attractive research grant and placement at institutes and laboratories of their choice, besides other facilities should enable such scientists to be with us for a period of 5 years or more. The strategy adopted by China in this regard could be worth adopting.

Institution building

For over hundred years, we have been contended with one Indian Agricultural Research Institute (IARI) and one Indian Veterinary Research Institute (IVRI) and subsequently added one National Dairy Research Institute (NDRI) and one Central Institute of Fisheries Education (CIFE) for post-graduate training and research in the advanced areas. When IITs and IIITs are being replicated and Central Universities are added, it is a tragedy that we remain contended with what we have inherited, despite the dire need for more institutes for imparting high quality education and research in the advanced areas. It is time to think of having at least 3 more IARI-like and 2 more IVRI-like and 1 each of NDRI-like and CIFE-like institutes by the next 10 years. Also, there is need for establishment of exclusive National Institutes for Food Science and Technology (like CFTRI), Institute of Plant and Animal Genomics and National Institute of Plant-Animal Virology as well as strengthening and modernizing Central Rice Research Institute and Directorate of Wheat Research to international level.

Demarcating research responsibilities between the ICAR institutes and SAUs

Demarcation of research responsibilities between the ICAR institutes and SAUs remains till date blurred, though attempts have been made in the past to define to an extent. This problem needs immediate resolution, considering the need to rationally utilize resources, increasing participation of private sector, Department of Biotechnology and Central Universities in agriculture-related research and many problems of regional and national importance remaining unsolved still. A high-level Committee of Scientists, Policy-makers and other stakeholders need to be constituted to deliberate and come up with a realistic demarcation of research, education and extension responsibilities between the ICAR institutes and SAUs.The following could be the basis.

ICAR institutes: Strategic/basic and mission-oriented applied research of relevance to region/country and postgraduate training confined to Ph.D.

SAUs: Location-specific applied and adaptive research of relevance to state/region; partnering in eco-regional applied /mission-oriented basic research; human resource development (under-graduate and post-graduate levels).

Policy environment

Steady increase is needed in the size of investment on agricultural research and education and measures for sustaining funding with higher proportion of operational component. In many institutes, especially at the SAUs, proportion of operational expenditure as compared to salary component is less than 15% as against the ideal range of 30-40%.

Clear policy on development/testing of GM crops and socio-economic niches for their commercial planting must be in place.

ICAR National Institutes should be shaped as autonomous institutions, granting autonomy in respect of recruitment of scientists and budget management.

Institute management

More realistic criteria are to be chalked out for career advancement of scientific staff; giving emphasis to research contribution in terms of products/processes of economic value and research publications of basic and applied significance and IPRs. Transparent and effective monitoring, evaluation and accountability system should be in place, particularly for granting incentives to the high performers.

Research, Extension and Human Resources for Development: Brazil's Case[1]

Marcio Porto

Introduction

Brazilian agribusiness is a US$500.0 billion business that generated 22.7% of the country's Gross Domestic Product (GDP) and grew by 5.7% in 2011 and -1.4 % in 2012. The agribusiness trade balance showed a surplus of US$76.0 billion in 2011 and US$79.0 billion in 2012 (CEPEA). Besides, the country is the largest exporter of sugar, coffee, orange juice, alcohol and chicken; the second largest exporter of soybeans and the third largest exporter of beef (MAPA). The total factor productivity (TFP) increased by 119% between 1970 and 2006 and presented an average growth rate for the period of 2.2% per year (Mendes *et al.*, 2010). Considering the period 1975 to 2011, Gasques and Bastos (2012) found a TFP average growth rate of 3.56 % a year. Such growth in agribusiness is strongly linked to research, extension services, trained human resources, agricultural policy, and to the Brazilian farmer entrepreneurship.

The paper describes the research, extension and international cooperation components of the AREE4D system and finally summarises the Way Forward.

National Agricultural Research System (NARS)

Organizational setup

Anchored by Empresa Brasileira de Pesquisa Agropecuária

[1]Full text of the presentation was not available. The rich and important information contained in the power point presentation is contained in an abridged version in this chapter.

(EMBRAPA) – the Brazilian Agricultural Research Corporation, the Brazilian National Agricultural Research System (NARS) comprises Universities, APTA, other state research organizations and other Government Research Organizations and Foundations. Their shares in Brazil's total public investment in Agricultural R&D and in total number of Agricultural Researchers is given in Figure 1a and 1b, respectively. It may be seen that Universities and Other State Organizations are prominent components of the NARS.

EMBRAPA, established in 1973, is one of the premier world's public sector agricultural research companies. Comprising 47 Research and Service Centres, each state hosting at least one of these (Figure 2), EMBRAPA employs 9600 staff, of which 2,400 are research scientists,

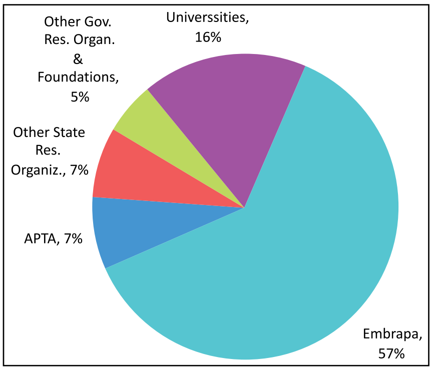


Figure 1a. Share in Brazil's total public investment in R&D (2006)

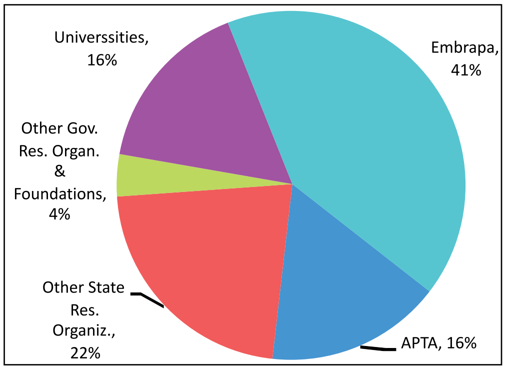


Figure 1b. Share in Brazil's total number of Agric. Researchers (2006)

Figure 1. Organizational setup of the NARS

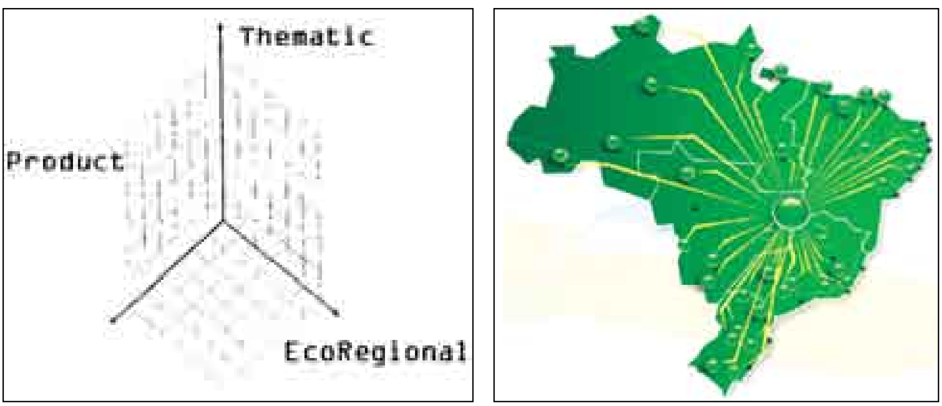


Figure 2. Organizational Setup of EMBRAPA

and 74 percent of them are Ph.Ds Annual budget of EMBRAPA is USD 1.2 billion and steadily increasing in real terms (Table 1). The Research Centres are organized on the bases of thematic areas, products and eco-regions (Figure 2). Access to EMBRAPA research funds is essentially through competitive research funding system which ensures effective outcomes.

Table 1. EMBRAPA funding sources (1000 USD)

Sources of financial resources	2011	2012
National Treasury	1,009,413	1,197,461
Embrapa	957,623	1,119,738
Special Goverment Programs	24,909	5,445
Congressmen Amendments to Union Budget	26,881	67,326
OEPAS		4,950
Own revenue	20,378	19,614
Financial investments	370	645
Agreements private/public institutions and companies	6,809	6,002
International loans - BIRD, IDB, etc.	5.149	-
Total	**1,042,119**	**1,223,722**

Source: Embrapa

As regards linkages among various components, centers and services, system coordination is strong among EMBRAPA units. But, the same is not true for other subsystems and units and the need for synergistic and smart coordination among the various institutions, organizations and units can hardly be overemphasized.

Embrapa's organizational model, summarized below is conducive to greater efficiency and effectiveness.

- ❖ Public corporation affiliated to the Ministry of Agriculture, Livestock and Food Supply (MAPA)
- ❖ Advantages: flexibility to:
  - ♦ Administer resources and personnel
  - ♦ Plan
  - ♦ Assess performance
  - ♦ Implement the budget

- Disseminate results
- Subject to relatively low political influence.

Main features of Embrapa's human resources development strategy which has significantly contributed to education are listed below:

Continuous corporate educational effort

- Training program: graduate and post-doctoral levels. In terms of capacity building, EMBRAPA's effort was to train primarily Ph.D. and M.Sc. researchers, several of whom end up with universities as professors (Figure 3).

Figure 3. Institutional Capacity Building under EMBRAPA

Source: Embrapa, DGP

Educational activities provided by Embrapa

- National and international training courses
- Internship and research assistant scholarships – high school and university students
- Mini libraries in rural schools and communities
- "Embrapa and School" project

The excellent performance of the Brazilian NARS is closely linked with Embrapa's major ingredients of Institutional Innovation, as enumerated below:

- Continuous support from Government
- Presence throughout the country
- Critical mass of researchers
- Evaluation and Award system by Results
- Focus on results
- Training programs for its staff in centers of excellence
- Research units specialized in products, resources and themes
- Professional interaction with public decision makers and politicians
- Close relationship with the media

Rural Extension System

Major challenges

As seen from Table 2, 66% of the total farms in Brazil are family farms falling in the lowest monthly income wage class and their share in total gross annual value of production is only 3.3%. On the other hand, the top wage class accounted for only 0.62% of the number of farms, but their share in total gross product was 51.2%, a highly inequitable possession of the land and other production resources. Therefore, the foremost challenge is to incorporate family farms into modern productive processes.

Table 2. Brazil: Distribution of gross annual value of production and number of farms by monthly minimum wage classes, 2006

Monthly minimum wage class	Number of farms	Share in total number of farms (%)	Share in total gross annual value of production (%)
(0 a 2]	2,904,769	66.01	3.27
(2 a 10]	995,750	22.63	10.08
(10 a 200]	472,702	10.74	35.46
>200	27,306	0.62	51.19
Total	4,400,527	100	100

Source: Alves et al. (2012)

Performance evaluation is built into the extension system both for extension service provided by state companies (EMATER) and for projects funded by federal funds (MDA). The former is primarily at the individual extension agents level. Federally funded projects are monitored at project implementation level. Impact evaluation at state level of the set of technical assistance and rural extension activities is also carried out.

The human resources development strategy of the Extension System supports:

- ❖ Access to short-term and specialization courses in partnership with universities,
- ❖ Thematic network for capacity building of technical assistance and rural extension agents – exchange of experiences, and
- ❖ Participation in field days carried out by research institutions.

Scaling up of technology transfer to millions of farmers is assured through:

- ❖ Combining state and federal funds,
- ❖ Funding AT and RE services through agricultural credit loans, and
- ❖ Carrying out technology transfer activities by universities and research institutions.

Specifically, Embrapa's technology transfer activities include:

- ❖ Radio program "Rural Talk"
- ❖ "Field Day on TV"
- ❖ WebAgritec; WebAmbitec
- ❖ The tree of knowledge: food technology
- ❖ Videoteca Embrapa (www.embrapa.br/videoteca)
- ❖ Training courses, publications
- ❖ Technology Fairs

A new extension agency, "Inova Rural", has been proposed by EMBRAPA. Its main features are:

- ❖ Public autarchy with especial regime affiliated to MAPA
- ❖ Manage an innovation support fund
- ❖ Priority: smallholder farmers
- ❖ Key characteristics
    - ♦ Demand driven: producers protagonism
    - ♦ Continuous and frequent technical advice to farmers
    - ♦ Progressive responsibility for paying advisory services
    - ♦ Small administrative structure

- Lines of action:
  - Enhancing advisory capacity of professionals with university degree: technology use; rural administration; social capital development.
  - Fund technical advisory projects presented by farmers organizations

Accent on Developing and Transferring New, Cutting-Edge Technologies

Modern scientific advances, particularly in biology and informatics are being harnessed as depicted below:

Incorporating new tools from advanced biology into agriculture

As shown below, advances in molecular biology and genetic engineering are being effectively harnessed for crop and livestock production.

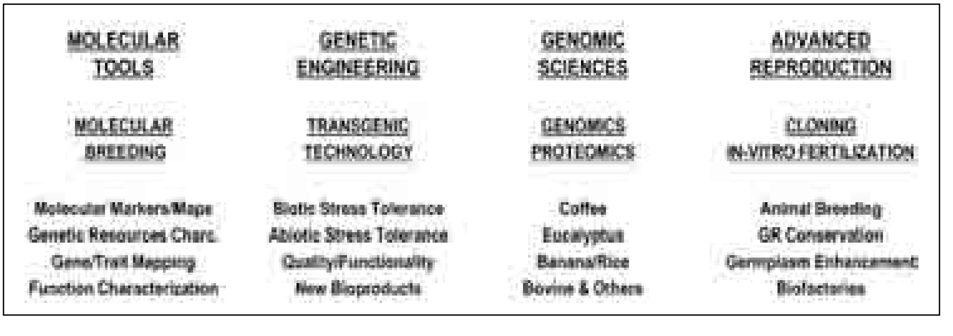
Biosafety, Bioinformatics, Proteomics, Metabolic Engineering, etc. are converged for agricultural development. Towards the development of GMOs the following legal framework and governance mechanisms have been put in place and are performing satisfactorily.

Legal framework

- Biosafety laws (Jan. 1995; March 2005): safety rules and monitoring arrangements
- Cartagena Protocol of Biosafety

Governance

- National Biosafety Council: higher advisory body



- ♦ National Biosafety Technical Commission (CNTBio): issues technical authorization for research activities and commercial use
- ♦ Internal Biosafety Commission (CIBio)

The above provisions have been instrumental in making Brazil as one of the world leaders in commercialization of GM crops (Table 3).

Table 3. Commercially approved GM events and their use

Crops	Events (1998-2012)	Area with GM crops in total cultivated area (2012)
Cotton	12	40-50%
Corn	18	85%
Soybeans	5	95%
Edible beans	1	

Source: Ministry of Science & Technology - CNTBio

In the process, the following lessons were learned:

- ❖ Evaluation must be done by scientists and in a scientific manner. In this task, the national commission on the subject should be closely associated at all steps.
- ❖ The country must have the capacity to anticipate technological changes/demands.
- ❖ Finally, despite precautions, it was found that it is difficult to control illegal cultivation of GMO crops. For this, an intensive campaign and sensitization is called for.

International Partnership and Virtual Laboratories Abroad (LABEX)

A unique feature of the Brazilian NARS is its structured international partnership programme known as LABEX – Virtual Laboratories Abroad without Walls operating in partnership with USA, Europe, Republic of Korea, China and Japan.

Embrapa has given high priority to international partnerships as enumerated below (Figure 4):

- ❖ CGIAR centers
- ❖ International organizations and development banks

Figure 4. Embrapa International Cooperators and Collaborators

- ❖ Labex in several countries
- ❖ National Agricultural Research Institutions
- ❖ Regional and global research networks

As from 2013:

1. Cooperation through regional programs
2. A closer partnership with FAO for support to Africa
3. Full evaluation of international cooperation

The Way Forward

Research system

In addition to the institutional innovations required for strengthening the research system, the following strategic approaches are needed:

- ❖ Anticipate and plan instead of being reactive; A multidisciplinary national team should be entrusted with this responsibility
- ❖ Expand the production of innovation assets
- ❖ Strengthen international partnership and cooperation
- ❖ Consolidate the practice of continuous HR development and

training; need for diversified skills

- Enhance coordination among NARS units

Extension system

- Overcome the traditional vision "I do the research, you transfer the results, and farmers adopt them" - adopt a process approach
- Enhance the use of IT to share research results and information
- Create articulation nucleus of technology transfer at state level
- Overcome/solve the conflict of interest: TARE x sales made by input corporations
- Establish a new public extension agency

The Role of Agricultural Research and Extension in China's Agricultural Transition[1]

Ren Wang

Introduction

Employing over 300 million farmers and accounting for 10 percent of the arable land worldwide, China meets food needs of its over 1.3 billion people – 20 percent of the world population. Food and nutritional status of this foremost agriculturally important country and most populous nation in the world greatly impact the global food and nutritional security.

The details are organized in two parts:

- New Development Trends, Challenges and Opportunities
- China's agriculture research and extension system and CAAS (Chinese Academy of Agricultural Sciences)

Trends, Challenges and Opportunities

A series of infrastructural, technological, institutional and policy changes have been underway towards transforming China's agriculture during the recent decade. Some of the initiatives are briefly described in this section.

Recent Trends

The vast coastal belt extending halfway eastward constitutes the main grain production area of China (Figure 1a). About 56 percent of the cultivated area is rainfed dry land and is concentrated in the North Western region (Figure 1b).

[1]Full text of the presentation was not available. The rich and important information contained in the power point presentation is contained in an abridged version in this chapter.

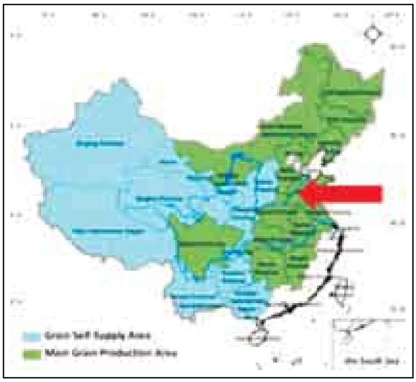


Figure 1a. China's Main Grain Production Area

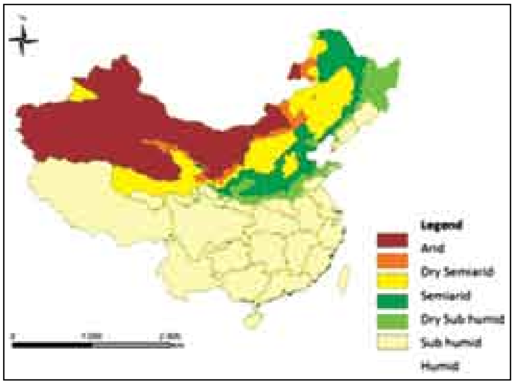


Figure 1b. 56% of cultivated farmland in the dry land area

Infrastructure

In order to attain sustainably enhanced agricultural production, the Government has started a new campaign of infrastructure improvement. In particular, investment in irrigation and farm land improvement and in development of large scale "resilient and high yielding" fields has increased substantially. "Modern Agriculture Demonstration Parks" have been constructed and designated by the ministries and local governments. Towards connecting the farmers with markets, the Government has invested heavily in building efficient rural transportation system (Figure 2).

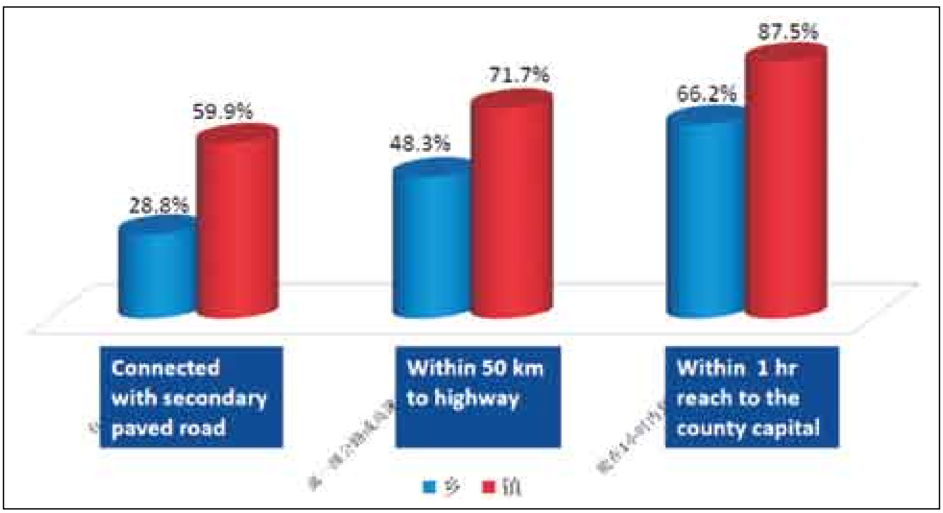


Figure 2. Status of investment in rural transportation

Investment

Public finance expenditure on agriculture amounted to RMB 1,040 billion in 2011 and the same has been increasing steadily. In relative terms also the agricultural share had increased from about 8% in 2000 to about 10% in 2009 and has remained at that level during the past few years (Figure 3).

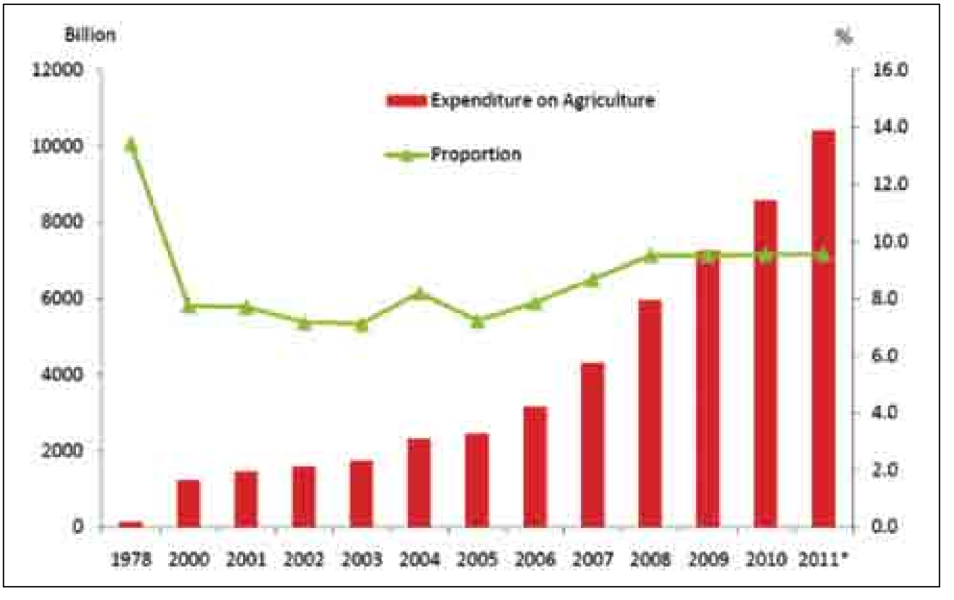


Figure 3. Public finance expenditure on agriculture amounted to RMB 1,040 billion in 2011.

Agricultural industrialization

Agriculture in China has rapidly been transforming from traditional agriculture to market-oriented agricultural industrialization. Main drivers of the transformation were increasing input costs, changing consumer demands and appropriate policy support strengthening agribusiness development and industrialization as depicted below (Figure 4).

Among various agroindustries, the seed industry grew very fast as summarized below:

❖ Currently there are about 8,700 seed companies, and 180,000 retailers, where only 10 are stock market listed companies.

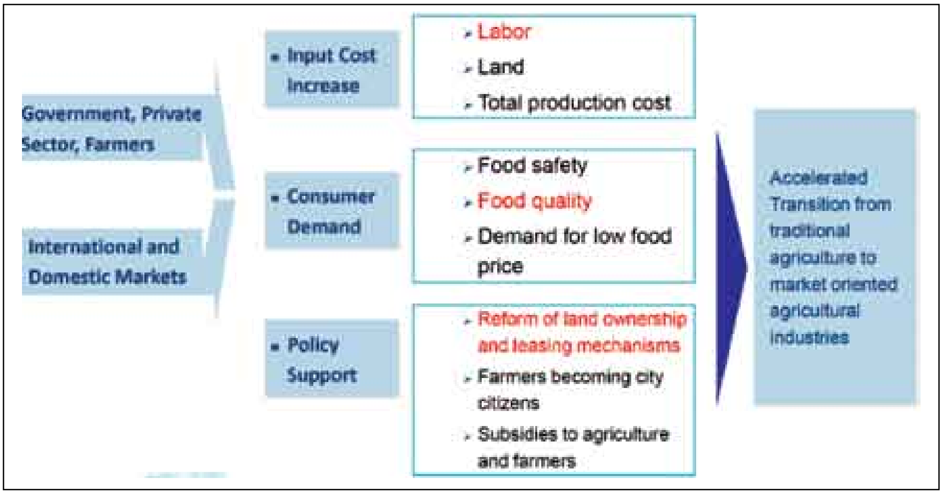


Figure 4. Main Drivers of Agricultural Industrialization in China

- ❖ Estimated total market value in 2011 was 53 billion Yuan (US$ 8.4 billon). Annual seed production of crops and vegetables is nearly 8 million tons.
- ❖ 60% of rice varieties and 40% of maize varieties were developed by public institutions.

China's seed industry has undertaken the following steps to further consolidate the industry:

- ❖ Strengthened R&D capacity in the private sector,
- ❖ Closer collaboration of public and private sectors, and
- ❖ Improved IP legislation and management.

Consequently, potential scope of the seed market will be double of the current market value in the next 5 years.

Livestock revolution

China's progress in the livestock sector is equally promising. It is number one in the world in meat and poultry production. The production and market demand have rapidly been growing. The proportion of large scale production vs. small holding farm production is expected to increase rapidly (Table 1). Per caput availability of livestock products has increased manifold during the past two decades. Between 1990 and 2011, per capit availability of milk and milk products increased almost eight fold (Table 2).

Table 1. Percentage of large vs. small production livestock sectors

	2010	2015
Dairy cow (>100 cow annual stock per farm)	28%	>38%
Pigs (>500 producing animals per farm pa.)	35%	50%

Source: State Statistics Bureau, 2011

Table 2. Animal, Dairy and Fishery Products Per Capita (in kg/year)

Year	Total Meat	Milk	Poultry	Fisheries
1990	25.2	3.7	7.0	10.9
2000	47.6	6.6	17.3	29.4
2011	59.3	26.7	20.7	40.2

Source: State Statistics Bureau, 2011

Rapid development of farmer cooperatives and farm land consolidation

"Farmer Cooperative Law" was promulgated in 2007

- ❖ By the year 2011, 440,000 farmer cooperatives were established, involving 35 million farmer households joining memberships, accounting for 10% of the total farmer households in rural China
  - ♦ Farmer cooperatives provide service in purchase of production input materials (seeds, fertilizers, etc.), storage and sales of products, technical extension for product processing, transportation and market information.

Promotion of urban agriculture and multi-functional agriculture

As depicted below in Figure 5, urban agriculture and multifunctionality of agriculture, including agricultural tourism were strengthened. Greenhouse and hydroponic production of vegetables was widely adopted. Farmers' greenhouses in Beijing suburbs of only 1.2 mu yielded 40,000 Yuan per greenhouse per year (Figure 6).

The major implications of this development are listed below:

- ❖ Life style change in urban and peri-urban environments,
- ❖ Direct supply of "organic" vegetables from the city for the city,
- ❖ Development of "vegetable and flower center/garden" in the subdivisions and residence complexes,

Figure 5. Horticulture-based multifunctional agriculture

Figure 6. Vegetable production in farmer's greenhouses and hydroponics

- Development of web-based information, marketing, and distribution systems,
- Quality standards and branded production and processing, and
- Flourishing rural tourism.

Mechanization

- Mechanization was strengthened to enhance productivity, precision and competitiveness. For instance: level of mechanized land preparation, planting and harvesting reached 53% in 2011, an annual increase of 3% during 2005-2011. Wheat production was 91% mechanized.
- Government subsidy for farm machine purchase increased to RMB 15.5 billion Yuan in 2010.
- Significant quality improvement was attained in small farm machines.

Rapid development of food processing industry

Agricultural processing industry in 2011 was valued at RMB14.7 trillion Yuan, registering an impressive annual growth rate of 14.7%. It employed 25 million total employees, accounting for 28% of the total industry employment in the country (Figure 7).

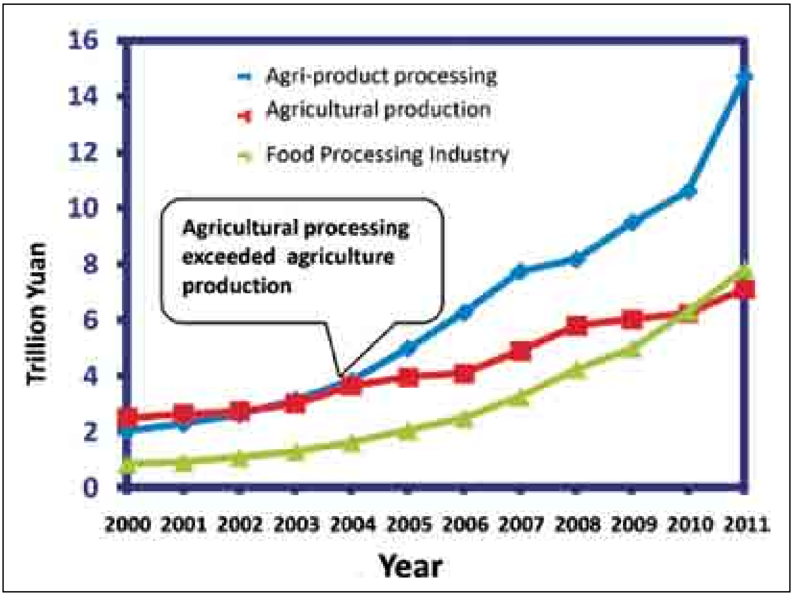


Figure 7. Trend of agricultural processing in China

Water productivity

As globally, in China also water is the most vital and limiting factor for accelerated and sustained agricultural production and livelihood security. High priority is assigned to water saving agriculture, such as through drip irrigation (Figure 8) which has been expanding to meet the productivity goal.

Figure 8. Drip irrigation in Wheat and Cotton

In 2009, 4.6 million ha was already under drip irrigation, which accounted for 7.7% of the total irrigated agricultural area. It was used mainly in horticultural crops and greenhouses, with exceptions of Xinjiang and pilot plots in some provinces.

The area under drip irrigation is proposed to be doubled to 15% of the total irrigated area by 2015, and redoubled to 30% by 2020. This will lead to profound changes in farming systems and associated services.

Main Challenges

Some of the main agricultural development challenges in China may be summed up as below:

1. Demand and supply paradox
   a. Quantity and quality, safety
   b. Stagnating productivity increase rate
2. Constraint in natural resource base: land in both area and quality, water, climate change, environmental pressure
3. Poverty alleviation: 128 million people under poverty in 2011 (based on China's new poverty line of RMB2300 Yuan per year per person).

4. Predominantly small holding farming, with structural change of the labor force across the country
5. Market risks and globalization
6. Other structural problems, e.g. low technology transfer rate

Strategies

The above challenges could be met by the following key strategies for transforming China's Agriculture:

1. Transform the mode of agricultural development from quantitative increase to efficiency, quality, industrialized and market orientation
2. Achieve three inter-dependent key objectives: food security and safety; sustainable development; and continued increase of farmers' income
3. Strengthen four capacities: integrated production capacity; resilience of the production system against risks; science & technology innovation; and market competitiveness
4. Develop standardized production systems and sustainable intensification
5. Strengthen policy support, research and extension, infrastructure and human capacity development.

China's Agricultural Research and Extension System and CAAS

Research and Education

The rate of contribution of science and technology to increased agricultural production in China has been phenomenal, 28 to 53 %, over the past 30 years or so (Table 3).

Table 3. Contribution of science and technology to increased agricultural production

1981-1985	1986-1990	1991-1995	1996-2000	2000-2005	2005-2010	2011
35%	28%	35%	42%	45%	50%	53%

During 1981 to 2011, over 6000 new varieties of major crops were released, resulting in to 4 to 5 times of nationwide replacement of crop varieties, and yield increase of 10 to 20 percent each time of replacement. Thus, agricultural research is a national priority. As seen from Table 4, 35% of all public R&D organizations are in the agriculture sector.

Table 4. Numbers of total and agricultural R&D institutes and staff, 2011

Category	No.
Total No. R&D Organizations	3,696
Total No. Agricultural R&D Organizations	1,293
Total No. R&D Staff	664,155
Agricultural R&D Staff	103,539

Source: Annual Statistics of China's Science and Technology, 2011

Likewise, China has built a robust Government funded agricultural extension system (Table 5). The country has the world's largest number of organizations and staff, nearly 7.2 million, working in the extension system.

Table 5. Numbers of organizations and staff in Government funded agricultural extension system in China, 2011

Sector	Organizations Number		Staff	
	10,000	%	10,000	%
Crop Production	4.7	35.4	360.7	49.4
Livestock	4.0	30.1	240.0	32.2
Fisheries	1.3	9.8	30.7	5.0
Mechanization	3.3	24.7	90.9	13.4
Total	13.3	100	722.3	100

Note: Not including veterinary agencies

Source: Annual Statistics of China's Science & Technology, 2011

Public research organizational structure in China is depicted in Figure 9. It is important to note that Universities and Academies play an important role in national reconstruction.

The Primary core funding mechanisms for agricultural research for personnel, general operations costs, major infrastructure and equipment are shown below (Figure 10).

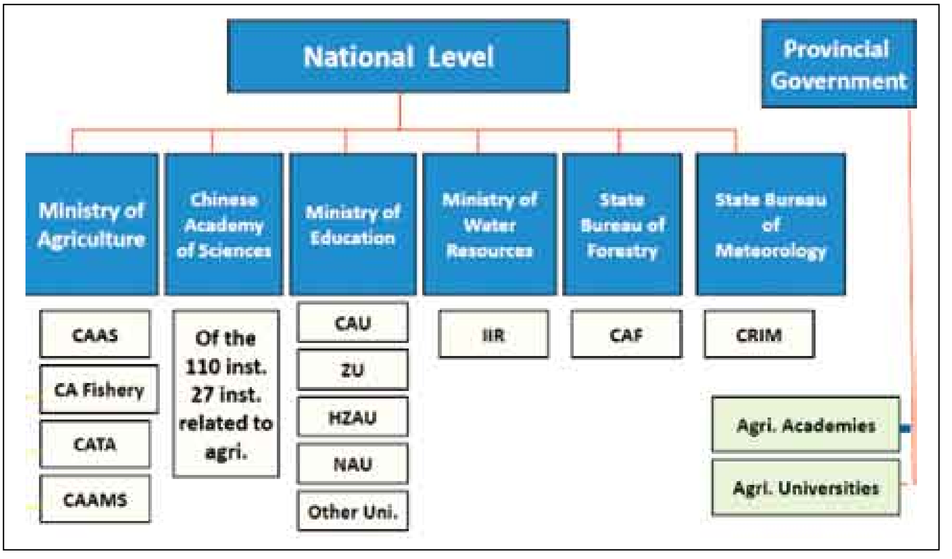


Figure 9. Public research organizational structure in China

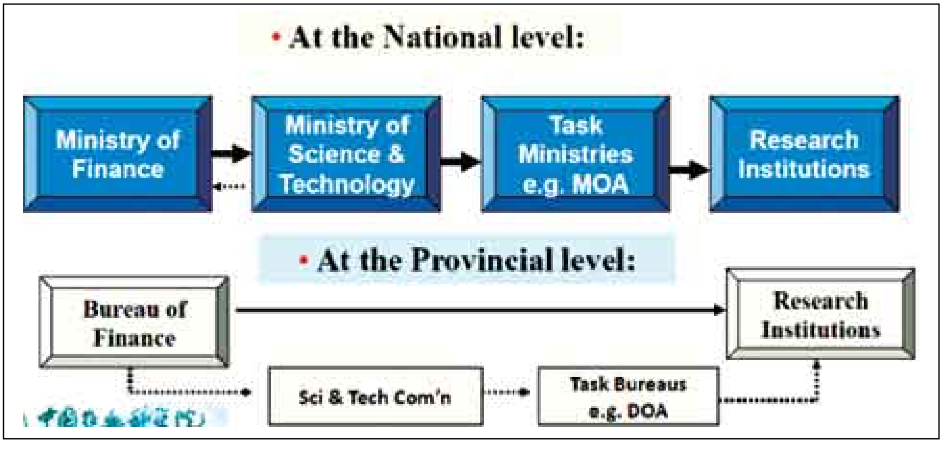


Figure 10. Primary Funding mechanisms of agricultural research in China

Further, all concerned Ministries, Commissions and Foundations through their Special Programs and Competitive Grants also feed into the national and provincial research institutions and universities, as diagrammed below (Figure 11).

Chinese Academy of Agricultural Sciences (CAAS)

The Mission of the Chinese Academy of Agricultural Sciences

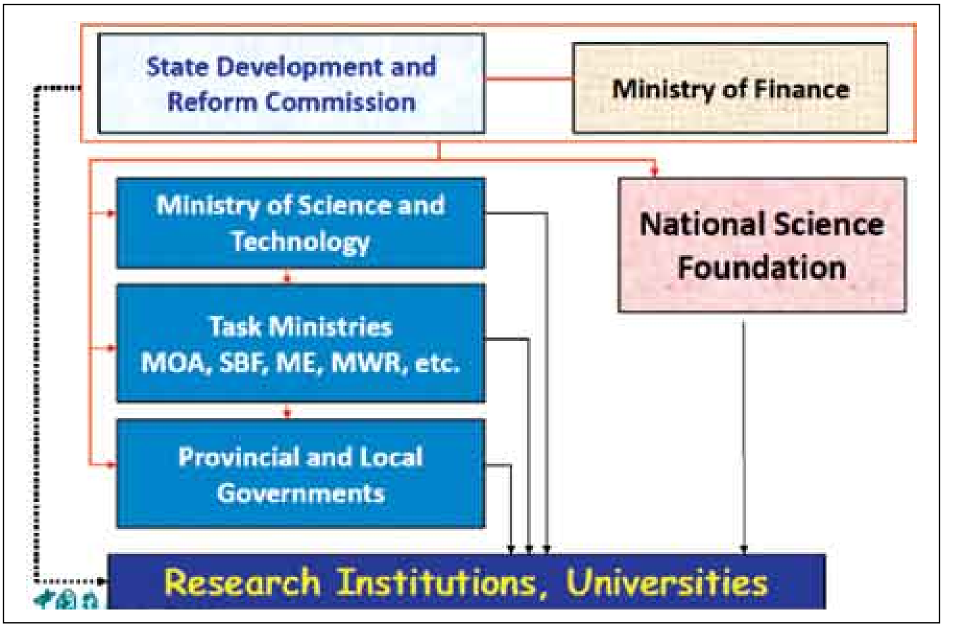


Figure 11. Channels of supplementary support to higher research

(CAAS) is to "Contribute to China's food security, safety and poverty reduction through research, partnership, capacity building and policy support".

The CAAS Vision is:

- ❖ A world-class center of excellence in agricultural research
- ❖ A source of new thoughts and theories, new ideas for research themes and strategic programs and new technologies for China's agro-industry development
- ❖ A training center for the next generation of agricultural scientists and extension experts
- ❖ An incubator for technical innovation and agro-business development, and
- ❖ A think tank on agricultural, rural and farmers issues and agricultural R&D strategy.

Towards realizing the above Vision, CAAS undertakes research, technology development and training in all major areas, viz. Crops, Livestock, Microbiology, Natural Resources, Environment, Food Technology, Quality Assurance, Agril. Engineering, Social Science and Economics (Figures 12 and 13).

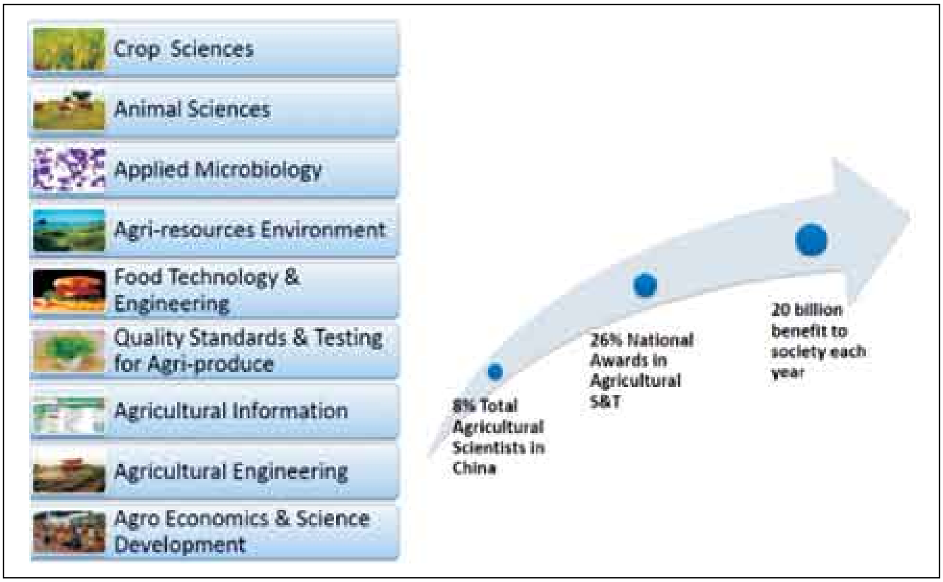


Figure 12. Research areas and Capacity

Figure 13. CAAS Training of Farmers and Extension Agents

The above research, technology development and training efforts had yielded about 20 billion Yuan benefit to society each year. The productivity of an agricultural scientist in China is greater than those of other scientists.

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Agricultural Research, Education and Extension Integration for Development: Status, Elements of Successes, Issues, Challenges and Prospects-The United States Experience

Paul Heisey and Keith Fuglie

The US system of agricultural research, education, and extension is complex. Multiple institutions - Federal, state, and private sector - fund and perform agricultural research (Figure 1). The locus of the agricultural education and extension has been traditionally in the state-level universities, in particular, land grant universities associated with the state agricultural experiment stations (SAES).

Changing Federal-State Relationship in Financing and Conducting Agricultural Research

The present US system has resulted from a long period of evolution. Despite being primarily an agrarian society at its inception, the United States did not have an agricultural department until 1862, more than 80 years after its founding, and the department did not have a Cabinet rank until 1889. Nonetheless, there were early institutional precursors to the system that eventually developed. These included the US Patent Office, which had an agricultural division; earlier colleges of agriculture, primarily represented by fields of study within private universities; and private agricultural societies. Scientific experimentation in agriculture in many respects began in Europe, and the German model of the research university, in particular, was an important forerunner of the US system (Huffman and Evenson, 2006).

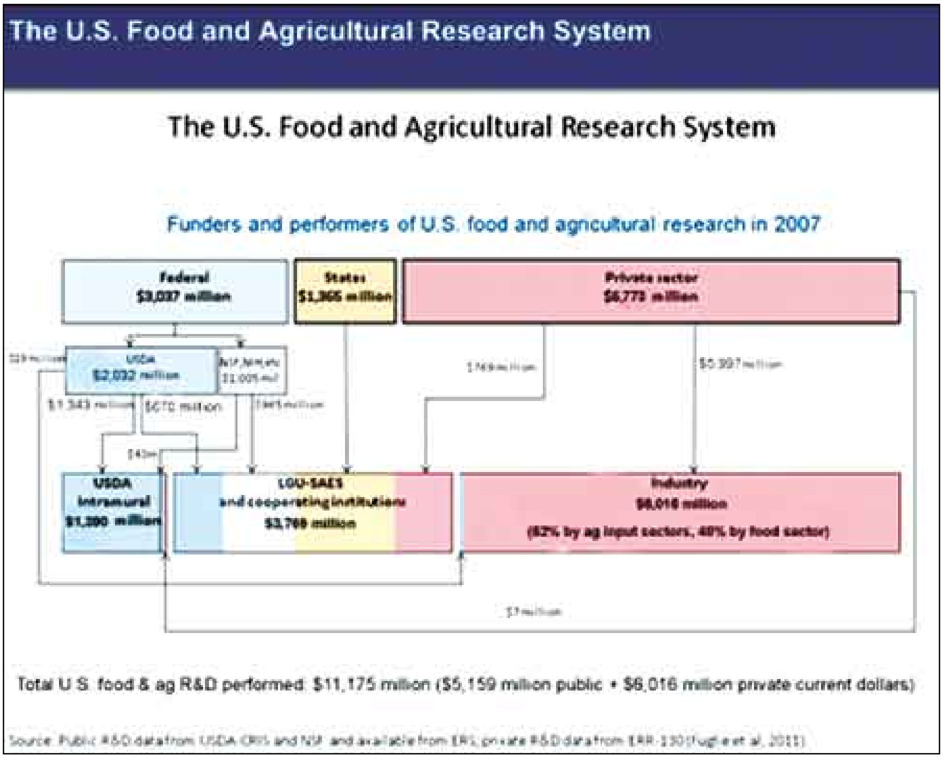

Figure 1. Funders and performers of U.S. food and agricultural research in 2007

Although many pieces of public legislation were important in the creation of the US system, three were particularly notable for the creation of the Federal-state model. The Morrill Act of 1862 (in the middle of the American Civil War) established the US Department of Agriculture and provided public land to each state for establishment of agricultural colleges, which thus became known as the "land grant" colleges. The Hatch Act (1887) provided funding for the state agricultural experiment stations (SAES), which were usually associated with the land grant colleges. Finally, the Smith-Lever Act (1914) created cooperative extension service. Both the Hatch Act and the Smith-Lever Act established the model of joint funding of the state-level agricultural research and extension. Each state was required to match Federal contributions to become eligible.

Despite this long institutional history, Vernon Ruttan (1982), a leading scholar of the institutional innovation in agricultural research, noted that initial scientific capacity was quite limited, particularly in the states. "It was not until the early 1920s that it was possible to claim with some degree of confidence that a national agricultural research and extension system had been effectively institutionalized at both the Federal and state levels." One indication of this institutionalization was the emergence of the coordinated Federal-state commodity research programmes in the years between two World Wars. Although a number of states had forged strong land grant universities, which were at the forefront of agricultural education, in this inter-war period much of the scientific leadership came through intramural Federal research. Federally-performed agricultural research rose to 60-70% of the US national public sector total.

Changes in public research performance, in research funding sources and mechanisms

In the years following World War II, research funding by the states rose sharply. Although funding never reached more than about 40 % of the US public sector total, this strong state support and continued development of the land-grant SAES system moved centre of research performance markedly from the Federal government to the states immediately after the World War, where it has remained ever since. Over 60 % of US public research was conducted at the state level since the War; and since the late eighties state-level performance has been over 70 %of the US public total.

Performance of public agricultural research in the US Federal-state partnership may be determined by a number of considerations; many of which have arisen more through institutional evolution than by design. Furthermore, the location of research performance, the sources of public research funding, and the instruments by which public research is funded may all interact in complex ways.

- More fundamental or "pre-technology" research—with greater spillover potential—may be concentrated in universities. However, this creates an incentive problem as state legislatures are unlikely to consider spill-out research benefits when they fund public research at the SAES.
- Thus, the effectiveness of the state-led system depends on the regional and inter-regional co-ordination that is provided by the USDA.
- Furthermore, there are applied research problems that are important nationally that may receive minimal attention from the SAES or regional research programmes and so need to be

addressed by intramural USDA programmes (Fuglie *et al.,* 1996; Schimmelpfennig and Heisey, 2009).

- For any particular research problem area, the balance of research performance among Federal, state, and private institutions may differ. This may be difficult to discern simply by looking at funding allocations alone (Heisey *et al.,* 2010).
- As a result, the question of research substitution—between Federal and state research institutions, or between the public and the private sector—compared with research complementarity may be difficult to determine.

Both funding sources and funding instruments for US public agricultural research have continued to shift over the past 40 years. States have maintained over 70 %of research performance, but state funding of research has fallen both in real terms and as a percentage of public agricultural research total since 1990. This trend has been counteracted by flat or sometimes rising real Federal research funding, as well as with an increase in research funding from other sources. Over the last decade funding from Federal and non-governmental sources has become somewhat more volatile, which has increased uncertainty about the future of public research funding.

There have also been shifts in Federal funding of public agricultural research. Most of this funding has flowed, and has continued to flow through the USDA. However, the USDA share of Federal funding has fallen from over 90 % of the Federal total in the seventies to about 75 %of the funding at present. Although research funding from other Federal agencies such as the National Institutes of Health (NIH), National Science Foundation (NSF), the Department of Energy (DOE) and so on is not generally directed towards agriculture; scientists in land grant and other universities have increasingly tapped funding from these sources to support research in areas with potential agricultural applications.

Public research funding continues to be provided through a wide variety of funding mechanisms. However there has been a slow but discernible trend towards competitive and other grant funding mechanisms as opposed to block grants, particularly in the Federal funding of state-level agricultural research. Figure 2 shows that the USDA formula funds administered by the Cooperative State Research, Education, and Extension Service (CSREES) fell over a 25 years period, and at the same time competitive and special grant funding rose. These formula funds include those instituted by the Hatch Act in 1887 as well as subsequent Acts designating

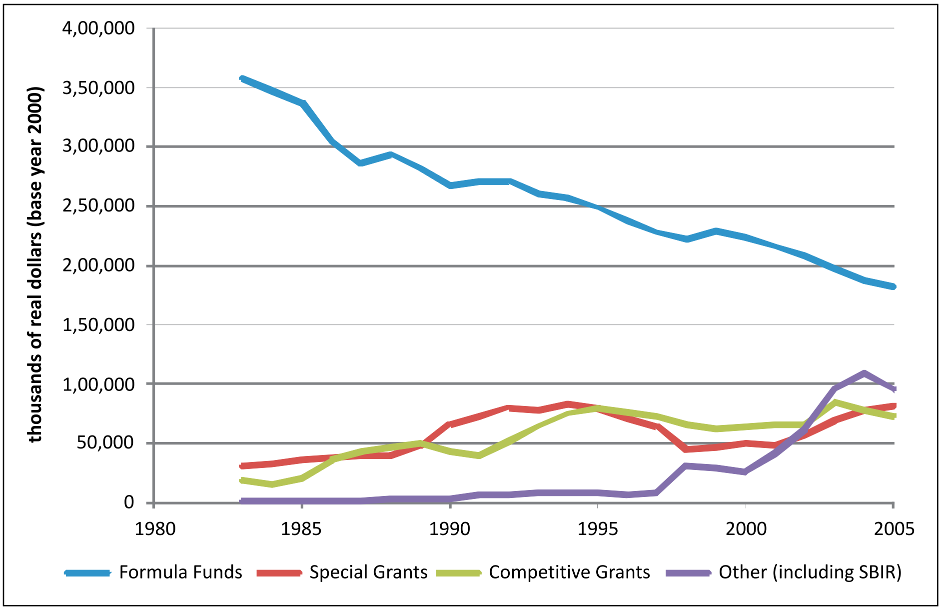

Figure 2. CSREES administered funds, 1980-2005

Source: CRIS, USDA, as reported in Schimmelpfennig and Heisey (2009)

formula funds for particular research areas. Indirectly, the fall in formula funding may be related to some of the fall in the state-level funding of public agricultural research, as the USDA formula funding to a state usually requires a matching investment by the state. In 2008, the Farm Bill initiated the National Institute of Food and Agriculture (NIFA), which replaced CSREES. This signaled an intention to continue to develop competitive funding mechanisms for agricultural research. Furthermore, much of the funding obtained from non-USDA Federal sources is also allocated through competitive programmes.

Trends in agricultural education and extension

Education in the agricultural sciences has centred in the land-grant universities. In keeping with Ruttan's (1982) observation that scientific capacity in the US public system was somewhat limited for many years, only about a quarter of the scientists in the SAES were Ph.D. degree holders at the beginning of the 20th century. From 1920 to 1980, it rose to about 80 %. Over the same period, the top 15 land-grant universities awarded over 70 % Ph.D. degrees in applied agricultural sciences and in “pre-invention” sciences relevant to agriculture (Huffman and Evenson, 2006).

Since 1990, the number of Ph.D.s granted in sciences directly related to agriculture have fallen. This has been driven particularly by declining Ph.D. numbers in core areas as agronomy and crop science, agricultural and horticultural plant breeding, animal science, and agricultural animal breeding.[1] At the same time, Ph.D. degrees in agriculturally-related “pre-invention” sciences have grown, particularly, genetics, environmental science, and since 2000 in the statistics and the related fields.[2] The number of Ph.D.’s in biological/ biomedical sciences and health sciences increased rapidly over the past thirty years (Figure 3). This suggests that although the land grants are still at the centre of the agricultural science education, other institutions may increase their role in science that could be relevant to agriculture.

Agricultural extension is playing prominent role in the SAES. It is not uncommon for university professors to hold two- or three-way appointments in teaching, research, and extension. In addition, county-level extension agents are often employees of the SAES. Since 1980, the real public spending on agricultural extension in the US has been flat or fallen (Alston *et al.,* 2010). To a certain extent, advice from private agricultural input suppliers may be substituting for some publicly provided extension services; this requires deeper study.

Biotechnology and emergence of private-sector R&D

Private sector research has been important to US agricultural production for a long time, dating back to mechanical inventions as of cotton-gin (1793), mechanical-reaper (1831), the first steel moldboard plow (1837) and improved seed drills (1841). By 1900, the farm

[1]Although we use NSF data to analyze Ph.D.’s granted, our agricultural science total differs slightly from the agricultural science aggregate sometimes reported by the NSF. This is because we follow Huffman and Evenson (2006) in the allocation of specific fields to “agricultural” sciences. For example NSF usually categorizes Ph.D.’s in general environmental science to the “agricultural” category, but we (and Huffman and Evenson) include these Ph.D.’s in the “pre-invention science” category.

[2]As defined by Huffman and Evenson, pre-invention sciences overlap with biological sciences, but they also include non-biological areas such as meteorological/atmospheric science, hydrology, and probability/statistics/ econometrics.

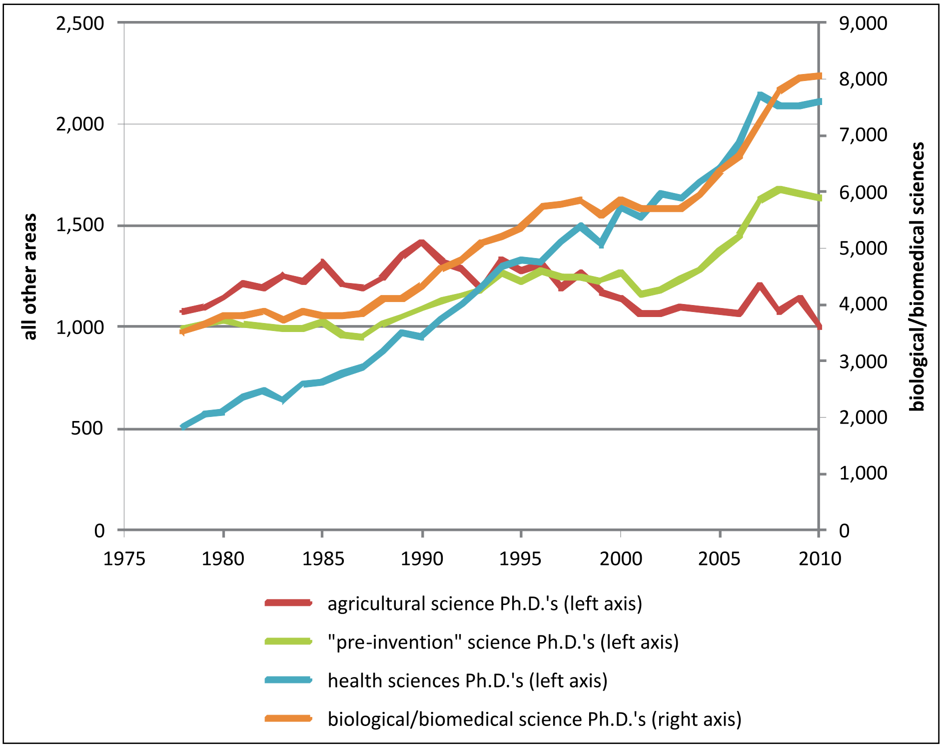

Figure 3. Ph.D. recipients since 1978, agricultural/related and other life sciences

Source: National Science Foundation (NSF)

machinery industry was the single largest manufacturing industry in the US. To the extent data are available, public agricultural research expenditures were observed for many years to be larger than private expenditures. By the mid-fifties, the largest private investment area was in engineering and management (farm machinery), followed by utilization and nutrition (food) (Huffman and Evenson, 2006). The latter area concentrated on the post-harvest activities that, in general, did not increase farm-level productivity. Another important area was of agricultural chemicals, particularly for weed and insect control. Private sector research expenditure for food and agriculture rose relatively to public sector expenditures in sixties, and by the late seventies, private research expenditures surpassed public research expenditures, and have remained higher for the most part ever since. For much of this period, food manufacturing research has constituted roughly half of the US private research total. Greater insight into the importance of private research for agricultural productivity can be gained by focusing on the private research on agricultural inputs, in other words, research aimed at the development of the farm-level technology. Herein, the composition of the private research investment has markedly shifted. In sixties and seventies, farm machinery and agricultural chemicals continued to dominate private agricultural input research. As late as eighties, these two sectors accounted for more than three-fourths of the total. In the eighties and nineties, private investment in crop-related seed and biotechnology research began to grow rapidly, and by late nineties, private crop seed/biotechnology research was the largest agricultural input research sector. In 2006, seed/biotechnology made up nearly 45 % of the total (Figure 4). This in turn increased research in crops, in general, while animal health research was the only growth area in the private animal research. Some of the increase in seed/ biotechnology research represented a substitution from agricultural chemical research with the development of genetically engineered (GE) crops for insect resistance and herbicide tolerance, but the total of seed/biotechnology and agricultural chemical research also increased.

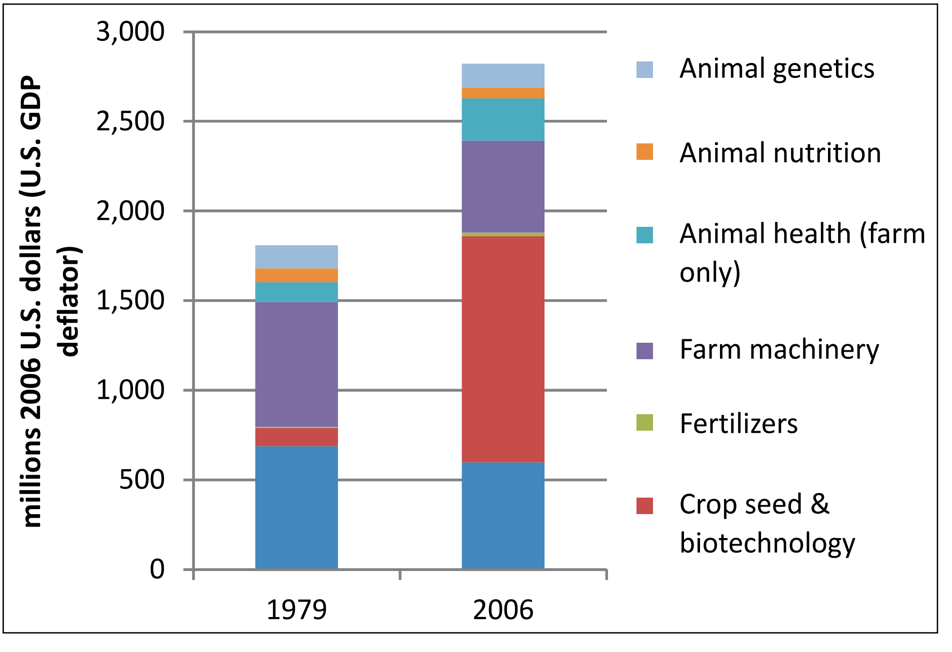

Figure 4. Composition of private agricultural input research in the U.S., 1979 and 2006

Source: Fuglie, et al. (2012)

A number of factors drove this increase in US private sector seed/ biotechnology research. Advances in molecular genetics opened up new technological opportunities in biotechnology. These included many steps over a long period of time, but one of the notable developments was production and replication of DNA recombined from multiple organisms.[3] At the same time, strengthened intellectual property protection over biological inventions also stimulated growth in the private sector crop improvement research. The US instituted a Plant Varietal Protection Act (PVPA) in 1970, and expanded its scope in 1994. More important, however, was the extension of utility patent protection for microorganisms in 1980 through the. Supreme Court decision (Diamond vs. Chakrabarty), and to higher plants and animals in 1985 and 1987 respectively through internal U.S. Patent Office decisions. Finally, continued globalization of agricultural input markets resulting from increased global demand for agricultural products and falling barriers to trade has provided opportunities for private sector research expansion in the US and worldwide (Shoemaker *et al.,* 2001; Fuglie *et al.,* 2011).

We have focused particularly on measuring the impacts of public research. Nonetheless it is clear that private agricultural research has had major impacts on U.S. agricultural production. In the area of seed/biotechnology, at present 88 %of U.S. maize area, 93 % of U.S. soybean area, and 94 % of U.S. cotton area are planted to genetically engineered (GE) varieties (USDA-ERS, 2012).

Considerable debate has surrounded the extent of production and environmental impacts of GE varieties (NRC, 2010). There is evidence, however, that GE crops can and have increased crop yields. In maize, for example, Iowa yields were higher than European yields, but were growing slightly less rapidly until the mid-nineties. Since 1996, European maize yields, where GE crops are not used, have been essentially flat, while Iowa yields, where GE maize covers more than 90 % of the area, have accelerated (Figure 5).

These data are only suggestive, as the use of GE maize may not be the only factor. European production was hampered by drier weather for many of the years from 1996-2007Other management factors as well as continued advances through conventional breeding may have also played a role. One of the large seed/ biotechnology companies anticipates that between 2010 and 2020, GE technology

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[3]Much of the research for recombinant DNA took place first at Stanford University.

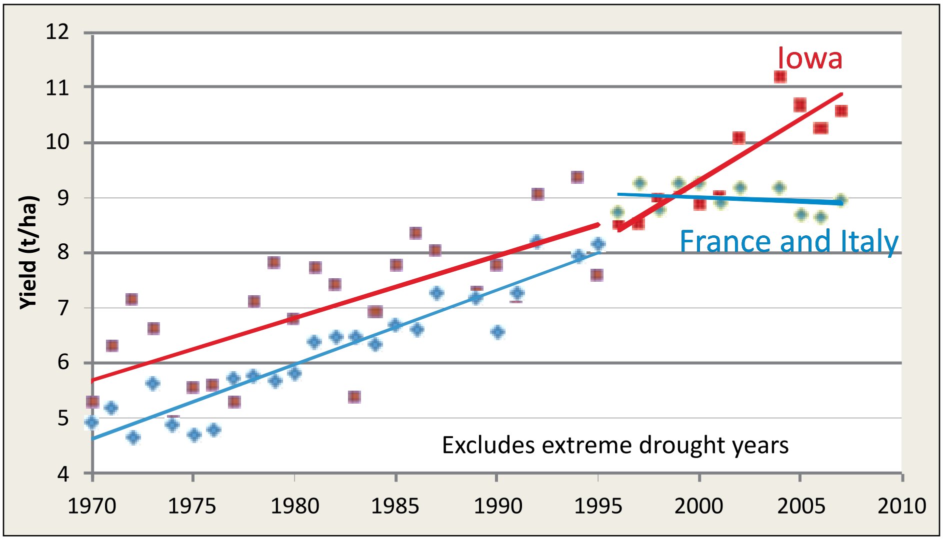

Figure 5. Maize yields in Iowa (U.S.), and Europe (France and Italy), 1970-2007

Source: Fischer, Byerlee, and Edmeades (forthcoming)

will contribute over half the total gains (genetic plus management) in U.S. maize yields (Edgerton, 2009).

New Institutional Relationships for Public-Private Collaborative R&D and Technology Transfer

Increased incentives and capacity for research in the private sector changes role of publicly-funded research and creates new opportunities for public-private research collaboration and technology transfer. Public research may focus more on upstream, fundamental science, leaving more applied research and market development to the private sector. But to transform advances in fundamental sciences into commercial opportunities quickly and efficiently may require close collaboration between the public and private institutions.

In the United States, new laws and regulations have been put in place to encourage the transfer of technology between public research laboratories and the private sector. These laws affected ownership rights to new technology developed with government funds and established mechanisms for direct research collaboration between public and private sector scientists. The primary goal was to increase the economic impacts of public R&D by moving rapidly public research findings that have commercial possibilities into the marketplace (Day-Rubenstein and Fuglie, 2000).

The U.S. Department of Agriculture (USDA) and state agricultural universities responded to this new framework by strengthening ties with the private sector. The traditional model of technology transfer from public sector institutions was by providing technologies and knowledge to users (farmers, processing companies, agricultural input suppliers) directly through agricultural extension service, or indirectly to through normal publication channels. With the rapid expansion of private sector capacity in agricultural R&D by large, specialized, agricultural input firms, new opportunities for public-private partnerships in agricultural technology development were created (Fuglie *et al.,* 1996).

Changing environment for technology transfer

The development of technology transfer policy in the United States has been incremental. The Congress has enacted successive pieces of legislation aimed at creating new institutions for technology transfer between the public and private sectors and over time has introduced modifications to improve or strengthen them. Some of the major pieces of technology transfer legislation enacted by the U.S. government are listed in Table 1.

One of the first major changes dealt with was patent policy. The Bayh-Dole Act (1980) gave institutions "certainty of title" for inventions resulting from research funded by the Federal government. The legislation allowed universities, non-profit organizations, and other institutions receiving government funding for research to obtain, own and license the patents on any invention they discovered. It also expanded the right of U.S. government laboratories to issue licenses for patents of their inventions.

Other legislation sought to promote greater research collaboration between Federal government laboratories and private companies. The 1980 Stevenson-Wydler Technology Innovation Act mandated that each Federal government agency develop specific mechanisms for disseminating government innovations. Further incentives were provided in the 1986 Technology Transfer Act. This Act spelled out conditions under which government laboratories could work directly with researchers employed by private companies. This involves developing a specific agreement between the public and the private research partner, including responsibilities and resource commitments

Table 1 Major United States Legislation Encouraging Public-Private Research Collaboration and Technology Transfer

Year	Legislation	Action
1980	Stevenson-Wydler Technology Innovation Act	Encouraged government laboratories to increase cooperation with the private sector. Each major government laboratory was directed to create an "Office of Research and Technology Applications" to facilitate technology transfer to private companies
1980	Bayh-Dole Act	Authorized government agencies to grant exclusive licenses to government-owned patents and allowed universities to own patents on research developed with government funds
1981	Economic Recovery Tax Act	Tax credit for R&D grants to universities for basic research
1982	Small Business Innovation Development Act	Established the Small Business Innovation Research (SBIR) Program. The program requires a minimum percentage of each federal agency's extramural R&D budget to be allocated to small businesses
1984	National Cooperative Research Act	Encouraged companies to conduct joint research by providing exemptions to antitrust (competitiveness) laws for technologies developed in research consortia
1986	Federal Technology Transfer Act	Authorized government research laboratories to enter into Cooperative Research and Development Agreements (CRADA) with private companies
1988	Omnibus Trade and Competitiveness Act	Created the Manufacturing Extension Partnership (MEP) to assist small companies to access knowledge and technologies developed in government laboratories. It also created the Advanced Technology Program (ATP) to provide seed funding, matched by private-sector investment, to companies or consortia of universities, industries and government laboratories to accelerate development of generic technologies that have broad applications across industries. The ATP was terminated in 2007.
1993	National Cooperative Production Amendments Act	Extended antitrust exemptions to include joint manufacturing (not just joint R&D)

Source: Schacht (2012).

of each. These agreements are referred to as Cooperative Research and Development Agreements (CRADAs).

Other initiatives were the Economic Recovery Tax Act (1981), which provided tax credits for research grants given by companies to universities; the Small Business Innovation Act (1982), which required Federal government agencies to earmark a portion of extramural research funds to small companies through the Small Business Innovation Research (SBIR) grant program; and the Cooperative Research Act (1984), which provided some antitrust exemptions and liability limits on companies collaborating on pre-commercial R&D. In 1988, Congress created incentives for public-private research consortia through the Advanced Technologies Program (ATP). The ATP was replaced by the Technology Innovation Program (TIP) in 2007, which was finally terminated in 2012.

Models of technology transfer

The legislation described above governs exchange of information and resources between public and private collaborating institutions, and, in general terms, states how rights to new inventions are to be owned and benefits shared. Figure 6 presents a stylized model of the various mechanisms available to government research agencies for cooperating with the private sector and other non-government institutions.

***Research grant model*:** With this model, the simplest mechanism for collaborative research, the government provides monetary resources for private in-house research. In this situation there is no formal research collaboration between a government lab and a non-government partner; the grant recipient has sole ownership over any patentable technology. This type of arrangement characterizes the SBIR program, and the Advanced Technology Program run by the Department of Commerce.

***Patent licensing model*:** Here, a public research institution develops and patents a technology and then assigns rights to use the patented technology to non-government institutions or private companies. The rights may be exclusive, partially exclusive, or nonexclusive (Heisey *et al.,* 2006).

***CRADA joint-venture model*:** With this model, both sides contribute in-house resources to R&D. Government laboratories may provide personnel, equipment, and laboratory privileges, but not financial

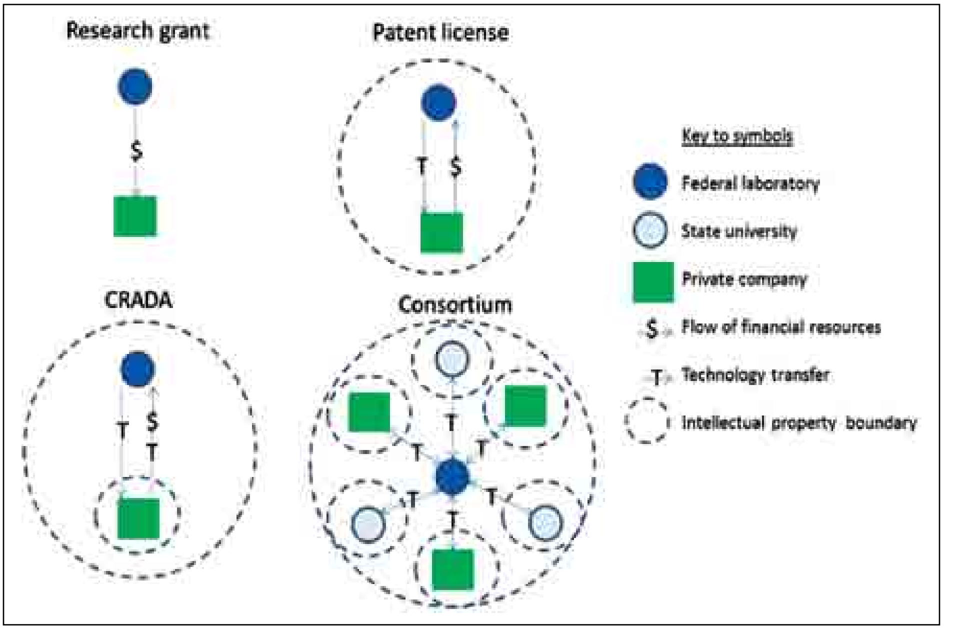

Figure 6. Models of public-private research collaboration and technology transfer

resources, to a non-government partner. The partner may give funds directly to the government lab (Day-Rubenstein and Fuglie, 2000).

Research consortium model: It is a somewhat more complex model. Unlike the CRADA, which involves only one private and one public partner, a consortium brings together several private companies to undertake joint research with or without a public sector partner. Consortium members contribute resources for research, which is usually precommercial, and have first rights to technologies developed by the consortium. Companies can protect spinoff technologies through trade secrets or new exclusive patents. Research consortiums have proven useful for increasing support for strategic research and research that is considered to be long term and high risk. Additional applied and adaptive research is often required to develop and diffuse technology to farmers.

Public and private goods

Ideally, these new mechanisms and models permit allocation of public resources to research that has characteristics of a "public good".

Such research has value to society, but is unlikely to be undertaken by profit firms. By definition, a "public good" has two essential characteristics – it is nonrivalrous and nonexcludable. A good is *nonrival* if one person can use it without reducing what is available to others. A good is *nonexcludable* if others cannot be prevented from using it after it first becomes available. Information can be replicated through photocopies at negligible cost, for instance, although a firm may have invested heavily in developing the information. Many goods may have elements of both public and private goods. Patents and other protections can make results of some research partially excludable by restricting information use for a limited period of time, but patenting is difficult with more basic or fundamental research that may not have specific commercial applications. Important areas of applied research may also lack commercial interest, such as technologies designed to address environmental pollution or to improve food safety and nutrition. In these cases, market forces may not reward firms adopting these technologies since the costs are largely born by the society and not by the firm. But when adopted, these technologies provide important social and economic benefits to society at large.

Most private in-house research as well as research performed by the SBIR grants to small businesses is likely to have private good characteristics. But the government grant can reduce investment risk and speed development of new industries like biofuel. At the other end of the spectrum, most in-house public research is likely to focus on advancing fundamental science, which has strong public good characteristics. Joint public-private research endeavors, such as CRADA's and research consortia, are likely to fall somewhere in between (Figure 7). They include both precommercial research (often performed by the public partner, but with funding from the private partner) as well as applied research aimed at commercialization of new products and processes (mainly by the private partner).

Evaluating Performance of Public Spending on Agricultural R&D

How economists evaluate returns to agricultural research

Economic evaluations of agricultural research are based on comparisons between (i) public and private investments in agricultural knowledge creation and dissemination, and (ii) long-

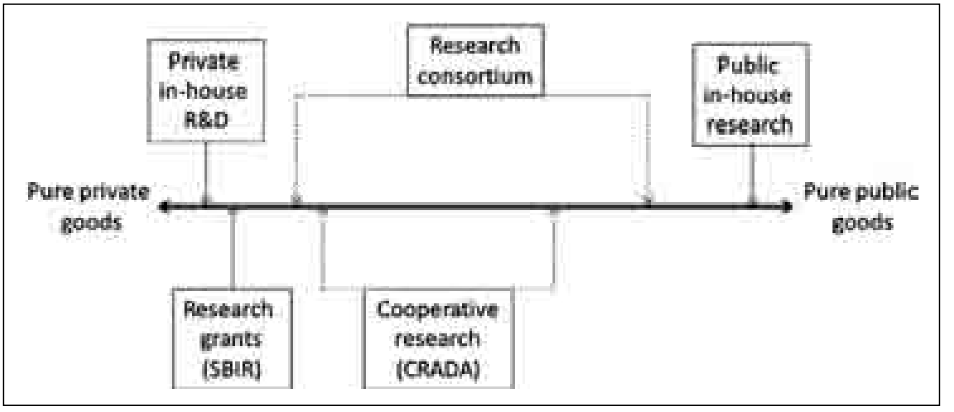

Figure 7. Technology transfer mechanisms along the public-private good continuum

term changes in agricultural productivity. The way this process is conceptualized is:

- Expenditures on agricultural research generate new knowledge that eventually leads to improved technology that is adopted by farmers;
- adoption increases average productivity (the output of crop and livestock commodities per unit of land, labor, capital and intermediate inputs employed in production);
- higher productivity of agricultural resources leads to lower costs, higher production and/or exit of some resources (such as labor) from the agricultural sector;
- given physiological limits to per capita demand for food, higher agricultural production leads to lower commodity prices, passing some of the technology-induced cost reductions on to the food industry and consumers. Thus, benefits of productivity-enhancing agricultural research are shared between the farm and the non-farm sectors of the economy.

An economic evaluation of the research endeavor weighs the size of the research and extension costs against the economic benefits from technology adoption, discounting the benefit and cost streams to measure them in terms of their "present value."

There are two main approaches used to estimate economic returns to agricultural research:

1. ***Statistical analysis*** relating past expenditures on research to current changes in productivity. These models try to establish

a statistical correlation between when, where, and on what research was done and productivity gains in agriculture. It is usually done at a fairly aggregate level and covers a long period of time.

2. ***Project evaluation methods*** tracing the development and dissemination of innovations.

   A good and early example of this approach was a study by Zvi Griliches (Dept. of Econ., University of Chicago) in the fifties on the returns to research on hybrid maize.

The case study method provides a clearer cause-and-effect relationship between agricultural research and productivity growth. But the method has largely been limited to analysis of research "success stories." Regression methods, on the other hand, assess system at a more aggregate level and take into account expenditures on research that may or may not lead to successes, and therefore tend to give a more balanced measure of average returns to a research system. Both approaches involve estimating relationships between the size of investment in research and the economic value of increased productivity, taking into account the appropriate time dimension between when research is done and when economic benefits are realized (Figure 8). Estimates of social returns to research may be overstated if undesirable outputs (e.g. environmental degradation) are not taken into account. Similarly, social returns may be understated if new technology reduces undesirable outputs.

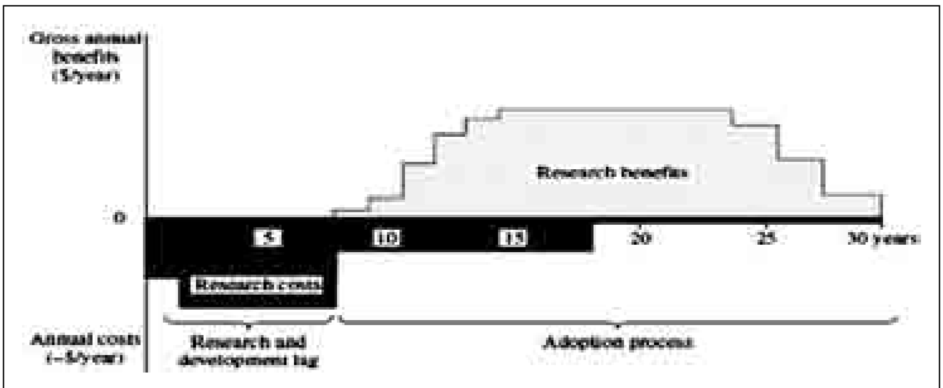

Figure 8. Research costs and benefits over time

Source: Alston, Norton, and Pardey 1995.

Some of the most challenging aspects of these models are as follows.

- ***Lags***: identifying the appropriate lag relationship between when research is done and when productivity growth occurs;
- ***Spillovers***: accounting for knowledge or research "spillovers" across geographic space. "Spillovers" occur when research done in one state, region, or country contributes to new knowledge or technology that is used in another geographic area.
- ***Attribution***: Many elements come together to contribute to development and application of new technology to agriculture. In addition to publicly-funded agricultural research, there are contributions made by basic sciences, innovations from the private sector, farmer education, the training role of extension services, improvements to rural infrastructure, and so on. These institutional sources often act in complementary ways, and failure to account for the contribution of one source may over-attribute observed gains in productivity to the another source.

High social returns to investments in agricultural research[4]

Economic assessments of payoffs from public investments in agricultural research have attempted to determine the "social rate of return" to this expenditure. This is reported as a percent return on each dollar spent on research. The return is "social" because it includes economy-wide benefits from higher productivity –not only benefits to farmers, but also to food industry and consumers who gain from more abundant and lower cost commodities. Economic studies have found that public expenditures on agricultural research have yielded real returns; several magnitudes higher than assumed opportunity costs of public funds. Some of these studies have estimated returns to research on particular commodities or in particular states, but several have assessed returns to investment in the Federal-State public agricultural research system as a whole, for various periods of the 20th Century. For 35 studies published over 1965-2005 that were reviewed Huffman and Evenson (2006), the median estimate of the social rate of return was 44 %/year (Table 2). As a rough approximation, this

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[4]This section of the paper draws heavily from Fuglie and Heisey (2007).

[5]An internal rate of return can be converted (approximately) into a benefit-cost ratio by dividing the social rate of return by the opportunity cost of capital. If we allow 4 percent (the long-run real yield of U.S. government securities) to represent the cost of social capital, then a rate of return to research of 40 percent would imply a benefit-cost ratio of about 10 to 1.

implies that each dollar spent on agricultural research returned at least $10 dollars of benefits to the economy.[5]

Table 2. Summary estimates of the rate of return to U.S. agricultural research

	Number of studies	Mean estimate	Median estimate
Social rate of returns to public agricultural research	35	53%	45%
Social rate of returns to private agricultural research	4	45%	45%

Source: Huffman and Evenson (2006, p. 294-5).

Several other conclusions can be drawn from the literature on returns to agricultural research:

- Returns to research have been high for most crop and livestock commodities.
- There appear to be significant social returns to private agricultural research.
- Agricultural research generates long-term benefits.
- Agricultural knowledge or research "spillovers" across state and national boundaries are significant.
- There are conjectures but little empirical evidence that returns to agricultural research have fallen over time.
- There have been little empirical work assessing returns to agricultural research on non-market objectives (natural resource quality, food safety, economics and policy).

Long-term prospects for US agricultural productivity growth

One key factor that will shape future growth in US agricultural productivity is the nation's investment in agricultural research, both in amount and how well this research investment is used. Based on the strong statistical relationship between historical spending on agricultural research and productivity growth rates in US agriculture, it is possible to project future rates of productivity improvement from alternative levels of public investment in agricultural R&D. Heisey, Wang and Fuglie (2011) made projections of US agricultural productivity growth from 2010 to 2050 under three long-term funding scenarios for public agricultural research. The first scenario assumed research spending would remain constant in nominal terms (declining real spending due to inflation); the second scenario assumed constant real funding (making up for inflation), and the third scenario assumed research spending grew in real terms by 1% per year.

The projections about future total factor productivity (TFP) growth for U.S. agriculture under these alternative R&D investment scenarios are shown in Figure 9. The figure shows actual TFP growth trends between 1980 and 2010 and then projections under each scenario out to 2050. Under the low investment scenario (constant nominal R&D funding), the growth rate in agricultural TFP slows from about 1.5% on an average between 1980 and 2010 to about 0.75% by 2050, and accumulated TFP increased by about 40 % during 2010-2050. Since virtually all growth in U.S. agricultural output comes from TFP, increase in agricultural production of 40 % between 2010-2050 would basically just meet projected growth in food demand in the United States (due to population growth), but leave no surplus for further expansion of export or biofuel production. Under the scenario 3 (real increase in R&D spending), TFP increases twice as quickly; rising

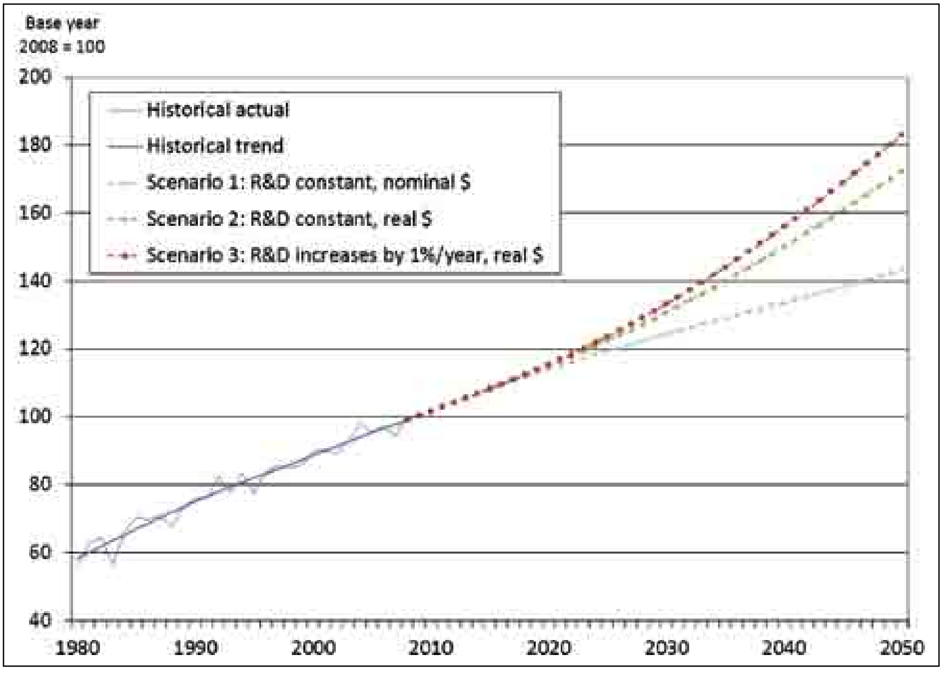

Figure 9. R&D funding and future productivity growth in U.S. agriculture

Source: Heisey, Wang, and Fuglie (2011) by a total of 80 % between 2010 and 2050. This is about the rate of increase in global food demand projected by the FAO, and would allow the U.S. to maintain its share of global agricultural production.

Conclusions

The current U.S. system of agricultural research, education, and extension represents 150 years of formal institutional development since the creation of the U.S. Department of Agriculture and the land grant university system in 1862. Over time, both funding and performance of public agricultural research have changed in response to increasing scientific capability and the general public funding environment. Private agricultural research has played an important role in the U.S. system for much of this period, but the impact of private research has accelerated in the past two decades with the development of private seed/biotechnology investment. Increased private research capacity and incentives for private sector research both changes the role of public sector research as well as creates new opportunities for public-private research collaboration. The economic performance of the U.S. system has been very strong, with most studies finding high social returns to investments in public agricultural research. There is less evidence on social returns to private investment, but the evidence that does exist suggests they are significant.

The growing complexity of the U.S. system for agricultural research, education, and extension has been marked by many important changes. Among the most notable are:

- A shift from a strong central government (USDA) role in research to a mixed Federal-state-private sector system
- An evolution in public research policy
  - From institutional block grant funding to diversified competitive funding
  - From a public sector focus on farm-oriented production research to a focus on more fundamental research and a broader research portfolio
  - From clear public and private roles to a variety of integrated and collaborative relationships
- An evolution in human capital with less reliance on traditional agricultural sciences and more emphasis on a broader set of fundamental and pre-technology sciences

At the same time, the system faces considerable challenges, including reducing the environmental footprint of agriculture and growing food in a changing climate. Following years of essentially flat investment in public agricultural research, increased uncertainty regarding the total public budget means public agricultural research funding is likely to face heightened volatility. Furthermore, public agricultural research budgets have large impacts on the U.S. system of agricultural science education. Finally, there are calls for an even greater increase in competitively funded research and more effort to cover important research areas while at the same time reducing duplicative research effort between the public and private sectors (PCAST, 2012).

The combination of continuing and new research challenges, funding uncertainty, and calls for further research reorganization in the light of these challenges and uncertainty, imply it is highly likely that the U.S. system will continue to evolve. Although it is difficult to predict the exact nature of the institutional changes that may result, it is likely that the core of the system—Federal, state, and private sector research—will remain constant while the nature of research funding and research partnerships may undergo a period of considerable turbulence before settling on a new institutional equilibrium.

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Reforming Extension and Advisory Services in India – Policy Options and Implications

Suresh C. Babu and P. K. Joshi

Over the last decade, developing countries worldwide have embarked on reforming extension and advisory services, albeit with various levels of intensity and scope. These reforms were necessitated by the neglect and decline of extension services over the past 30 years, and recently have gained further interest due to food and fuel crises in the mid-2000s. With the increased emphasis on enhancing productivity of agriculture sector in the developing countries, the need to increase timely access to the right kind of knowledge is seen as an important strategy. India's approach to reforming its extension and advisory services are typical (Babu *et al.*, 2013). Although Indian policy-makers recognized the need for extension reforms over a decade ago and have been actively pursuing formulation of reform measures to improve its efficiency and effectiveness, pressure to continue reforming public extension system is mounting for several reasons. Firstly, reform measures have not shown the kind of impact seen during the Green Revolution. Secondly, increased funding over the next five years is contingent on to demonstrating returns and tracing impact. Thirdly, information sources that farmers have access to have increased tremendously, and are competing for seeking attention of farmers. Fourthly, the reform measures have not been seriously evaluated to identify their impact pathways, and only limited efforts have been made to learn from reforms thus far. In the meantime, the nature of extension and advisory services has changed from public-oriented, top-down approach to a pluralistic approach that caters to needs of different categories of farmers.

This paper has reviewed reform efforts in India over the past 20 years, and has suggestive areas for future reforms. It is guided by field research on various aspects of extension reforms in the past decade. A conceptual framework has been developed to form a set of indicators for assessing extension reforms. And information needs of the farmers have been looked into to provide the context for review. Insights from the major public sector reforms, the development of the Agricultural Technology Management Agency (ATMA), are discussed next. Then policy implications have been drawn for enhancing public-private partnerships using agri-clinics as a case study. Specific steps forward are suggested for future reforms of extension and advisory services in India.

A Conceptual Framework for Assessing Extension Reforms in Developing Countries

Assessment of the performance of agricultural extension system reforms and recommending refinements and policy options requires answering to several basic questions: What challenges or impediments are faced when attempting to improve efficiency, effectiveness, and sustainability of extension systems? What reform measures have been proposed to address these challenges? Who are the stakeholders involved in developing reform measures? What is the level of involvement of private sector and third sector in the reform process, and how are they organized and supported? Who is responsible for funding and managing reform process? Who is responsible for implementation at different levels (national, state, district, or block)? Who are the beneficiaries and how have the reform measures altered flow of information to them?

Several conceptual approaches have recently been proposed in the literature to analyze and evaluate reforms of agricultural extension and advisory services. One approach is to identify state, market, and community failures, implement experimental redesigns of the previous programmes, and determine if the new models reduce or eliminate one or more failures, yielding system-wide benefits (Birner and Anderson, 2007). A related approach is to categorize various types of goods that research and extension systems produce, analyze type of externalities that arise from their production, and study use of such goods and how reformed extension systems could address their externalities (Birner *et al.,* 2009). Another model looks at improving the demand driven nature of the public extension system to make them farmer-led and/or farmer-driven, with the aim of improving accountability of the system to farmers or farmer groups and making delivery of extension services more efficient (Feder *et al.,* 2001). An audit of the demand-driven nature of an extension system could provide insight into the potential benefits of improvements in the efficiency of service delivery (Swanson and Rajalahti, 2010). Recent studies have attempted to analyze organizational issues related to service delivery in the public sector, included in the research and extension systems (Ekboir *et al.,* 2009). However, there have been minimal systematic efforts to study challenges facing implementation of extension reforms in the developing countries. Conceptual problems abound in delineating specific characteristics of reform packages, in studying them for the level of their implementation, in tracing deviation of implemented reforms from the original objectives, and in associating such deviance (both negative and positive) with a set of causal factors.

Given that the focus of this paper is to understand how and why reforms occur in agricultural extension and what factors constrain implementation of reform objectives, we combine elements from above to construct a conceptual framework to study extension reform efforts in India (Figure 1). As mentioned above, there have been major reforms in extension worldwide over the last few decades, which have transitioned extension systems from a traditional linear approach to one that embraces innovations such as decentralization, demand-driven processes, farmer participation, group-based approaches and cost-recovery mechanisms. These changes will be further explored in Section 3, in the context of public extension systems.

Figure 1 presents a conceptual framework to study extension reforms from an organizational development and delivery science perspective taking into account several issues identified recently in the extension-reform literature. A primary objective of public organization that provides extension services is improving their organizational development. Organizational development for the purpose of this paper is defined as the process of improving ability and performance of an organization to effectively and efficiently achieve its goals (Israel, 1987).

The conceptual framework begins with identifying triggers of research and extension reforms (Box 1). In the context of the Indian system reforms, these triggers are reflected in the past research and extension policy statements as well as commissioned committee reports. They are also linked to the national agricultural policy and agricultural development strategies and frameworks that guide investment priorities in the Government of India's five-year resource allocation plans. Lack of effectiveness in reaching the targeted goals, stakeholders concerns, and associated inefficiencies (allocative,

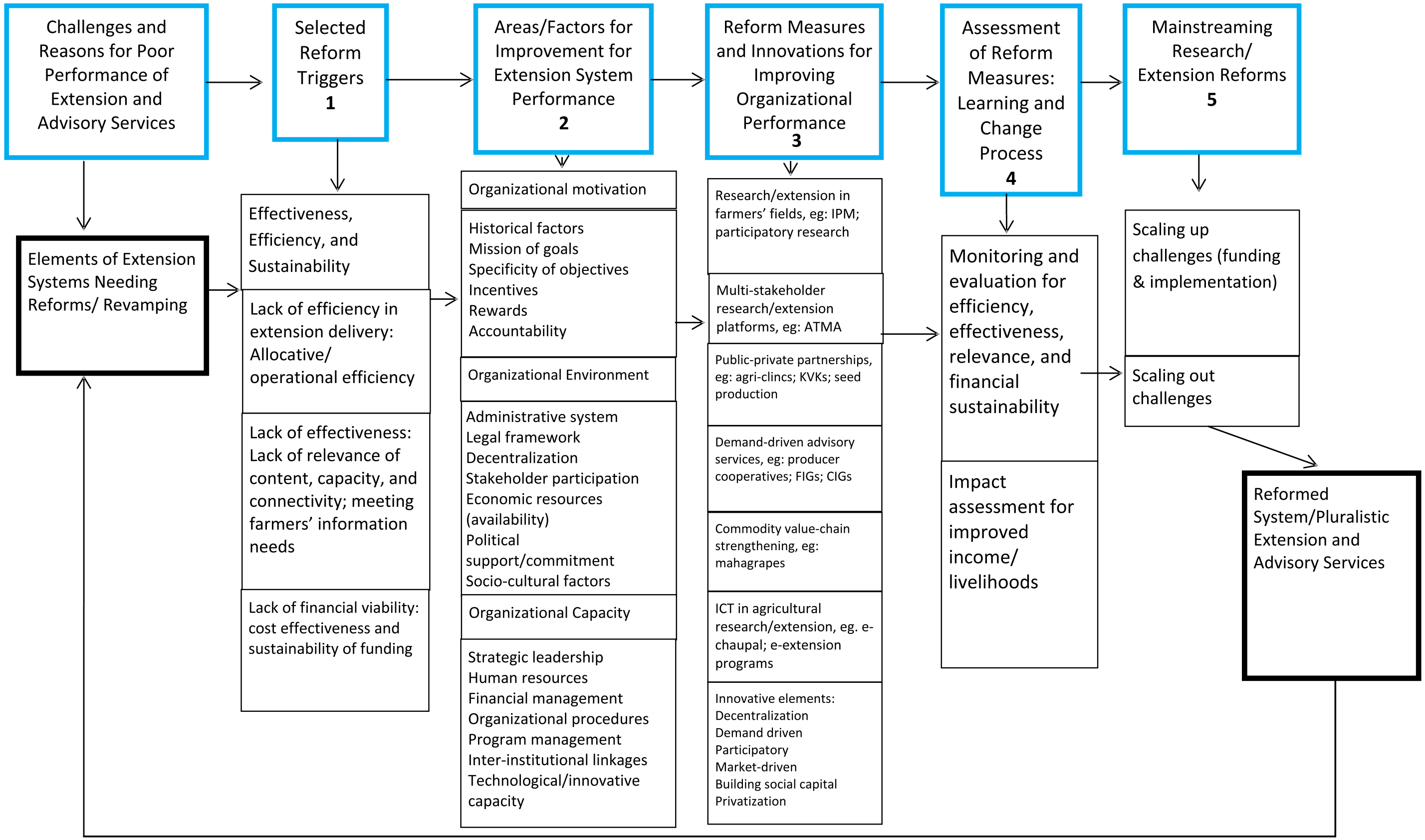

Figure 1. Conceptual framework for studying agricultural extension system reforms

Source: Authors - Based on Israel, 1987; Feder et al., 2001; Lusthaus et al., 2002; Birner et al., 2009; Swanson and Rajalahti, 2010 operational, and financial) in service delivery are the main triggers for the suggested system reforms. In addition, discussions on research and extension reforms tend to be initiated by problems related to scale and complexity of the system, presence of external factors affecting system's functioning, state and central government policies, untenable links between actors in the knowledge sector, and concerns about sustainability.

Box 2 contains factors and areas that can improve organizational performance of research and extension systems. Following Lusthaus *et al.* (2002), three sets of organizational performance indicators have been identified including organizational motivation, organizational capacity and external environment. Factors that affect organizational motivation include historical factors, such as the role of government in defining importance of research and extension over years and in allocating resources to support research and extension. Clear specification of the mission and the goals set for the system as a whole is also a component of the organizational motivation. Further, specific objectives and targets, a system of incentives and rewards to reach targets, and accountability at all levels influence motivational level of the system. The second set of organizational performance indicators relate to improving organizational environment. Administrative systems, legal frameworks, and the level of decentralization provide context for studying organizational environment. In addition, socio-cultural factors, political support and commitment at the national level and local level, and the availability of economic resources to implement strategies determine organizational environment. Indicators of organizational capacity form the third set indicators of organizational performance, including capacity for strategic leadership, human resources management, financial management, programme management, inter-institutional linkages, and technological innovation. Many of the reforms advocated for that aim to enhance organizational performance of the systems, revolve around these factors. The factors identified in Box 2 also provide an opportunity to understand innovations and experimentation. For example, innovations in extension and advisory services in India, which resulted in a pluralistic extension system, can be better understood using these organizational performance indicators, especially their role in reducing state, market, and community failures. We use this framework to examine current implementation and organizational challenges of the extension system reform in the form of the ATMA in Section 4, and research system reforms as they relate to improving research-extension linkages in Section 5.

The main characteristics of the reform elements in terms of innovation and experimentation are given in Box 3. Innovations include decentralization of decision-making to local levels, making research and extension systems more demand-driven, involving farmers and other stakeholders through participatory processes, orienting extension and advisory services toward local, regional, and international markets, strengthening networks and associations of farmers to increase their social capital, and finally, privatizing extension services or implementing other cost-recovery mechanisms. Several models of extension have emerged in the last fifteen years, in India and globally, that incorporate some of these principles. Farmer field schools were an innovation that moved extension from an individual-based approach to a group-based approach, while broadening the role of extension to empower and facilitate farmers' learning (Davies *et al.,* 2012). Participatory research programmes where researchers work with farmers to identify traits of needed technologies is another example of taking the system to final user. An example of a decentralized extension system, ATMA provides a multi-stakeholder platform for connecting farmers' needs to extension service delivery mechanisms. Agri-clinics and agribusiness centres are an innovative example of public-private partnerships for service delivery (Glendenning *et al.,* 2012). Strengthening commodity value-chains and connecting them to markets has been the approach taken by several private companies and farmer-based organizations. Research and extension services are provided by these private companies as part of their contractual engagements with farmer groups.

While rigorous evaluations of the above mentioned innovations and experimentations remain limited, organizational assessments and reviews of these models could provide evidence of how the learning and change processes occur (Box 4). Effective monitoring and evaluation (M&E) of systems provides information on the performance of these models in terms of their efficiency, effectiveness, relevance, and financial sustainability. Impact assessment studies can further guide process of learning and change by providing information on changes in welfare indicators due to extension services. However, it should be noted that conventional impact assessment studies only measure impact and rarely discuss learning and institutional change issues. There is an urgent need to analyze process of implementing extension reforms, the challenges in doing so, how these challenges are addressed or not addressed, the reasons for not being able to address certain challenges, and what needs to be done to improve reforms further. Lessons from monitoring and evaluating pilot models can help mainstream these innovations through policy and planning process. Further, the scaling up challenges in terms of funding and implementation could be understood through M&E (Box 5). The use of results from M&E can help in the continued refinement of the research and extension system while taking into consideration that optimal solution may be a combination of approaches.

We use this conceptual framework as the basis to examine reform measures undertaken thus far in the context of the pluralistic extension system in India. A major constraint to this effort, however, is the limited quantity of rigorous research on various extension approaches in India, as well as the limited national-level data that examines farmers' access to extension services.

Why Reform Extension Services? What are the Key Reform Measures?

The Indian system of extension has experimented with several approaches to reach farmers, which has resulted in the evolution of organizations, their inter-linkages, and their involvement with research and extension (Babu *et al.*, 2013). Following the lackluster performance of the training and visit (T&V) model of extension and the failure to scale-up to include non-irrigated regions of India, several reform measures were proposed and implemented at the national level and at the state level. They aimed to achieve a common set of goals to increase relevance, efficiency, effectiveness, and sustainability of providing extension and advisory services with the ultimate objective of increasing productivity of farming systems and income of farmers.

The Indian extension system has continued to face criticisms. Among them are the top-down approach, high level of centralization, commodity focus, technology transfer paradigm to information dissemination, low accountability to stakeholders, poor linkages to research, neglect of marginal groups (including women farmers), and failure to reach farmers in remote areas. In addition, the approach to extension remains unresponsive to fluctuations in the farming system's needs, agro-ecological conditions, and resource constraints of farmers. The inadequate training of extension personnel and their poor capacity to deliver messages of emerging problems faced by farmers were major impediments. Funding for extension from state governments declined after the termination of the World Bank funding for T&V system. Several studies that reviewed extension systems after the termination of the T&V system called for revamping of the public extension system, particularly for a system that is more demand-driven, decentralized, cost-effective, efficient in reaching smallholder farmers, and reaches out to remote and marginal areas (Antholt and Zijp, 1994; Singh *et al.,* 2006; Birner and Anderson, 2007; Sulaiman, 2009; Raabe, 2008). In addition, they called for addressing the need to increase public funding, for improving organizational and staff capacity both in quantity and in quality, and for an overall improvement in the management and performance of extension systems (Birner and Anderson, 2007; Sulaiman and Holt, 2004; Farrington *et al.,* 1998).

In addition, structural problems faced in implementing extension systems were also identified, including low levels of interest and involvement of scientists in adaptive research, an absence of performance evaluations that emphasize relevance of research to farmers' problems, low capacity of scientists to work with farmers and farming communities, and funding challenges for adoptive, farm-level research trials. In the meantime, the variety of actors and players involved in the provision of extension outside of the public system has been increasing, with declining relevance of the extension providers to farmers' challenges (Pal and Byerlee, 2003).

In the last twenty years, four reforms addressed the problems identified above. The Agricultural Technology Management Agency (ATMA), agri-clinics and agribusiness support for rural entrepreneurs, Kisan Call Centers, and the Soil Health Card Programme are the key elements of reforms. These reform measures were initially supported by several projects including the National e-Governance Action Plan (NeGAP), initiated in 2003, the Support to State Extension Program for Extension Reforms (SSEPER), initiated in 2005, and the National Agricultural Innovation Project (NAIP), initiated in 2006. These projects collectively aim to reform extension system in India. The reform measures address both the demand and supply factors that required modifications and improvements. They specifically define new approaches to governing extension delivery and identify areas for improving organizational performance of relevant entities and their linkages for delivering extension.

The reform measures were expected to increase decentralized service delivery, accountability to farmers, transparency in resource allocation and spending, and better reporting of accomplishments at all levels. In the recent five-year plan, support to extension reforms focused on improving the convergence of extension operations, increasing human capacity for extension at various levels, empowering farmers by organizing them into groups, increasing funding and infrastructure at the block level. Technology dissemination, promotion of private-sector involvement and public–private partnerships in agribusiness development, development of rural infrastructure and marketing support, and project management and capacity-building for economic policy analysis remain the key goals of the reform measures.

The reform measures related to administrative decentralization included the transfer of managerial and technical decision-making authority from the central to the district level. The Diversified Agricultural Support Project (DASP) operated two implementation mechanisms: the District Project Implementation Committee (DPIC) and the Agricultural Technology Management Agency (ATMA). Both mechanisms were designed to strengthen co-ordination of activities of different agencies serving farmers at the district level and to improve research–extension–farmer linkages.

The ATMA aims to improve interdepartmental coordination in technology dissemination. In its pilot programme, it attempted to make district administration the nodal agency to connect line departments, farmers' representatives, and the NGOs. A governing board oversees development of a strategic extension plan, which is implemented by the line-extension workers. Additional expertise was hired for implementation. ATMA encourages collaborative partnerships with private sector and other service providers.

Increasing relevance of new technologies is a key element of improving demand-driven nature of the extension system. By bringing various stakeholder groups and service providers together through participatory planning, the ATMA approach attempts to increase decentralization of implementation and service delivery mechanisms. Such a decentralized planning process helps ensure better accountability at the block, district, and state levels. Participatory planning processes are intended to address region-specific challenges of farmers and better coordination of the role of various actors and players including researchers, extension workers, input dealers, and farmers' organizations. Addressing specific challenges of women farmers is another objective of the reforms. Reforms measures aim to safeguard role of women in the planning process by requiring women members constitute 30 % of governing boards and block-level- farmer-action committees (Reddy and Swanson, 2006).

What Information and Services Do Farmers Need?

Many of the reform measures that were designed and implemented in India rely on traditional assumptions and understandings of farmers' needs. They are primarily based on the technology transfer paradigm, although farmers' needs for information have changed over years and vary depending on the nature of their farm, resource constraints they face, and agro-ecological environment in which they operate. Without a full understanding of farmers' information needs, their information search behaviour, the most important sources of their information and their willingness to pay for such information, extension programmes may not be highly relevant or effective.

High level of heterogeneity among farmers in terms of land ownership, resource constraints, agro-ecological conditions, and the crops grown increase complexity of extension systems. Farmers differ in their information search behaviour depending on their socio-economic characteristics. For example, farmers with low search behaviour primarily rely on interpersonal relationships with progressive farmers, extension workers, and input dealers to obtain information (Babu *et al.,* 2012). Thus, extension systems need to be carefully targeted. Yet the provision and targeted delivery of agricultural information to small and marginal farmers remains a challenge of extension programmes (Swanson, 2008; Swanson and Rajalahti, 2010). Farmers who are part of farmers' organizations exhibit high information search behaviour. Extension reforms such as ATMA reach and target farmers through formation of farmer groups. However, challenges in forming farmer groups and sustaining farmers' interest in being members of such groups are not yet fully understood.

The results of studies on farmers' information needs have not been consistent. For example, a national survey on farmers' information sources (NSSO, 2005) indicated that 60 % of farmers did not access any information on modern technology to support their farm enterprises. More recent studies, however, indicate that provision of relevant, appropriate, and contextualized content for various agro-ecological zones is the current challenge. Further, information must be provided in local language to reach a wider range of farmers. There is heavy reliance on private input dealers although conflict of interest inherent in this service remains a concern. The key information needs of farmers relate to pesticide and fertilizer application and pest and disease management (Babu *et al.,* 2012). Private input dealers, state department of agriculture officials, local farmer cooperative banks, newspapers, and television are the most accessed information sources for farmers while interpersonal methods of information sharing are preferred mode of dissemination (Babu *et al.,* 2012). In order to meet these changing needs, agricultural extension and advisory services in India have become increasingly pluralistic. The challenge, however, is how to strengthen various components of pluralistic system to interact and, at times, compete at the farm level.

Use of information and communication technologies indicate much promise in reaching out to farmers in ways that could not be imagined just only a few years ago (Richardson 2006a, b). Are farmers willing to pay for such services? A contingent valuation exercise showed that fee-based delivery of information via a mobile phone is not in high demand (Babu *et al.,* 2012). This may pose a serious challenge to expand ICT approaches to smallholder farmers. However, given the increasing use of cell phones, Kisan Call Centres may become a valuable source of information for farmers. Farmers' group discussions on their information needs indicated that there is a need to improve the performance of the Kisan Call Centres and farmers indicated that they are willing to use mobile phones to seek information if the information is given free of cost (Babu *et al.,* 2012). The Kisan Call Centres have not been evaluated for their operational effectiveness or the value of the messages they convey to farmers. Extension policy reforms need to recognize rapidly changing trends in information access by farmers and modify systems accordingly.

How is ATMA Implementation Progressing? How it can be Improved?

Since agricultural growth remains a key pathway out of poverty (Ahluwalia, 2011), reforming agricultural extension is critical for improving productivity and income of smallholder farmers. Over the last two decades, the effectiveness and efficiency of public sector extension have come under increased scrutiny (Rivera, 1996; Haug, 1999; Birner *et al.,* 2009; Swanson, 2009). The Indian extension system has been carefully monitored for its contribution to the target agricultural growth rate of 4% per year (Parsai, 2010). Recent five-year plans recognized need to strengthen agricultural extension to achieve this target (Planning Commission, 2001; Planning Commission, 2005; Planning Commission, 2006). The central government sets policy and programmatic framework for extension reforms in India. The Support to State Extension Programmes for Extension Reform (SSEPER), which functions at the district level through ATMA, has been the most significant programmatic framework for extension reforms in the last 10 years. In April 2010, the Government of India allocated an additional Rs 2,866.02 crore to the 11th five-year plan to strengthen SSEPER.

ATMA aims to address several challenges faced by the traditional extension system. It is designed to be a semi-autonomous, decentralized, participatory, and market-driven extension model (Swanson *et al.,* 2008). Integrating extension programmes across state-level departments, linking research and extension activities in a district, moving away from the mono-crop technology dissemination to diversified outputs, and decentralizing extension decision-making through participatory planning are among the key objective of ATMA (Singh and Swanson, 2006; Anderson, 2007; Davis, 2008; Swanson *et al.,* 2008). However, weak organizational capacity and low quantity and quality of human resources continue to impede successful implementation of the ATMA (Sulaiman and Holt, 2002; Raabe, 2008; Sulaiman and Hall, 2008). ATMA revision in 2010 addressed human resources challenges by recruiting new staff. However, poor organizational culture, problems of decentralized bureaucracy, and poor accountability continue to affect ATMA implementation (Alsop, 1998; Swanson, 2006; Swanson and Rajalahti, 2010). In 2010, the DAC released new guidelines for ATMA, which included a revised structure (MoA, 2010). In what follows, we highlight the challenges faced by ATMA in its implementation and potential for further refinement.

Through its decentralized approach, ATMA aims to increase relevance of extension activities through participatory planning and execution of plans (Swanson and Samy, 2003). However, successful decentralization requires organizational, managerial, and technical capacity strengthening to implement bottom-up approaches; currently missing in the ATMA (Swanson and Rajalahti, 2010). A well-defined strategy for human and organizational capacity development is required to increase effectiveness of decentralization under the ATMA.

The pilot implementation of ATMA showed success in several areas of reforms since it had assured funding from the National Agricultural Technology project (NATP) (Swanson, 2008). Regular training of staff, continuous monitoring and evaluation, executions of quarterly reviews, and follow up on learning helped to hold project directors accountable for the results (Raabe, 2008; Singh, 2003). Funds were made available for implementation (Singh *et al.,* 2006) and public-private partnerships for implementation increased (Birner and

Anderson, 2007). These positive outcomes suffered when the ATMA pilot programme ended (Singh *et al.,* 2006). This hindered ability of ATMA to address local needs of farmers (Singh *et al.,* 2006). Without much change in organizational culture and capacity, ATMA continued to be implemented as another centrally-run project (Sulaiman and Hall, 2008). However, 2010 directives for ATMA provided more financial resources and exclusive staff, which is likely to increase effectiveness of the programme (DAC, 2010). Additionally, Rashtriya Krishi Vikas Yojana (RKVY) programmes such as the National Food Security Mission and the National Project on Management of Soil Health and Fertility (Planning Commission, 2007) will function in close collaboration with ATMA at the district level. However, monitoring and evaluation of these measures need constant support and transparency in sharing information for further reform process.

The sustainability and success of ATMA at the district level depends on the strength of its leadership. Project directors, the governing board, and the ATMA management committee are mainly responsible for planning, implementing, and reviewing project activities and the progress of ATMA. The leadership had also suffered when funds were limited after the pilot programme ended. Even during the pilot phase, successful implementation depended on the personal initiative of the project directors (Singh and Swanson, 2006). Further reforms and directives are needed to increase accountability of leadership at the district level. Setting district level targets and holding ATMA leadership accountable will help monitor progress at the district level.

The ATMA attempts to reach smallholder farmers through farmer interest groups and farmer-based organizations. Formation of farmers' groups, sustaining funding, maintaining interest, and delivering valuable, relevant information to farmers continue to be challenges. Unless farmers' groups are made more effective, the extension system may continue to be top-down and information dissemination supply-driven (Sulaiman and Holt, 2002; Lenin *et al.*, 2009). Farmer friends (FFs), identified under new guidelines, may address these challenges and could resolve problems of contact farmer selection faced during the T&V era (Anderson *et al.,* 2006).

A re-examination of the centre-state relationship with respect to funding, monitoring and evaluation, and long-run sustainability is needed. Research, extension, and farmer linkages are still weak. Implementation linkages at the district level and the accountability of the organizations involved remain unclear, although there are clear directives on how central and state departments will function. The implementation challenges continue due to poor accountability. A well-designed monitoring and evaluation system is needed to identify implementation challenges.

During the pilot phase, ATMA experimented with going beyond the technology transfer mode to market-let, demand-driven processes. However, this objective was not seriously pursued during the expansion to national level. This was partly due to low capacity of the technical staff (Sulaiman and Hall, 2008). The guidelines for scaling up ATMA also do not emphasize the original objectives of bottom-up planning, gender mainstreaming, multiagency extension, and convergence of allied departments (DAC, 2010).

The financial sustainability of implementing ATMA once the support of the central government runs out is a serious issue that states are facing. It is not clear how long central government will continue to cover 90 % of the costs. When the central government stops or reduces its contribution, the states may abandon ATMA as it is considered a scheme of the central government. Educating the states and being transparent with them about the plan to reduce funding in the future will help them prepare and make alternate plans.

ATMA has not been evaluated thoroughly for its impact due to a lack of baseline data to determine changes due to its implementation. The current monitoring and evaluation system monitors only implementation processes, tracking inputs and activities rather than outputs and outcomes. As Anderson and Feder (2004) point out, a well-functioning monitoring system is a prerequisite to ensure that the impact of the programme can be demonstrated and that the programme continues to learn and get political support needed for continuous implementation.

Public–Private Partnerships: What Have we Learned from Agri-clinics?

Given the inherent weakness in the coverage and functioning of the public extension system, effective use of private sector involved in extension can be a complement. The Agriclinic and Agribusiness Centres (ACABC) programme provided government-funded stimulus packages for young entrepreneurs through subsidies to start a business. Beginning in 2002, ACABC is a public-private partnership that aims to provide quality inputs along with advisory services for their effective use (Planning Commission, 2006).

An *agri-clinic* provides expert services and advice on soil testing, cropping practices, technology dissemination, and crop protection from pests and diseases. An *agribusiness centre,* on the other hand, provides inputs, farm equipment for hire, and other services. Through the ACABC programme, a trained and qualified potential entrepreneur can have 25 %of his/her cost met by the government subsidy, receive free training for two months on running a business, and be eligible for obtaining credit from national banks or other financial institutions serving agriculture.

Recent figures available for the ACABC programme indicate that by 2010, close to 8,300 agri-clinics or agribusiness centres were in operation (MOA, 2011). General lack of awareness of the centres and their services, and poor support from financial institutions for their establishment impede success of the ACABC programme (WGAE, 2007). Limited studies on the impact of the clinics and centres show that there are positive gains to farmers in using them (Global AgriSystem, 2008; Shekara and Durga, 2007).

State departments of agriculture use the subsidy given by the central government to implement scheme to fit their strategy. In Tamil Nadu, the Tamil Nadu Agricultural University had initiated the programme with a focus on soil fertility (GoTN, 2008a). Primary Agricultural Cooperative Banks have also effectively used scheme to establish agri-clinics. Independent entrepreneurs receive 50 % of the establishment cost which is approximately Rs 600,000. The Tamil Nadu government used funding from the RKVY to support subsidy costs. Soil testing is the primary service provided to farmers. They are given recommendations on a soil health card to track soil fertility levels (GoTN, 2008a).

A recent study (Glendenning *et al.,* 2010) of the agri-clinics indicated that combining advisory services with input sales is useful to reach farmers with information needs relating to inputs and their use in crop production. The integration of services in one location increases convenience for farmers, who highlight proximity as an important condition for selecting input vendor and advisory services. Success of the ACABC programme depends on farmer demand for services and the capacity of the entrepreneurs to provide value-added services to farmers. The public–private aspect of the agri-clinics needs to be enhanced by providing support to farmers for soil testing and enabling agri-clinic operators to provide effective advice.

Policy Implications for Further Reforms

Studies that evaluated extension reform measures and continued consultation with policy-makers on accelerating reform process suggest several implications for further extension reforms. There is a general consensus that smallholder and marginal farmers, women farmers, and farmers in tribal areas continue to be left behind by the public extension system. In addition, the private sector does not serve these farmers unless they are involved in commercial agriculture, growing hybrid varieties of crops.

The technology mission of the public sector extension reform process must be expanded to include processing and marketing without overburdening the system. There is a need to strengthen extension workers to become problem solvers and knowledge disseminators who can communicate effectively to a wide range of service providers. This will require strengthening effective communication skills and coordination of the entire information value cycle including providers and users of information at various levels such as researchers, extension functionaries, and other knowledge intermediaries.

At the district level, effective use of farm science centres (KVKs) to conduct adoptive research demanded by farmers and the funding of the KVKs should be tied to the performance of the scientists and the extent of the problems faced by the farming community they serve. The KVKs need capacity strengthening to meet farmers' challenges which may be done by linking them to the ICAR and state-level research institutions including state agricultural universities (SAUs). The KVKs need to go beyond demonstrations and become research-based knowledge centres linking global and national knowledge to local problems. An external evaluation team consisting of various stakeholders should review progress and performance of KVKs. Such reviews should be made public to make scientists accountable to farming communities.

Developing private sector extension through public sector-sourced incentives will fill gaps left by the public extension system. Agri-clinics are a good example of this approach. Sustained incentives and credit to support agri-clinics will help in better knowledge dissemination. Private input dealers are heavily relied upon to solve pest and disease problems. Yet the knowledge base of private dealers is insufficient to address challenges faced by farmers.

Increasing innovation in service delivery and competition among private sector will provide farming community better services. For example, private dealers should hire certified agricultural specialists who are on call to support the use of the product purchased from the dealer. Farmers' transactions with the private sector regarding the purchase of inputs and recommendations by input dealers must be recorded for verification. Improving capacity by certifying the input dealers could help farmers receive correct solutions to their problems. Innovation and knowledge sharing among farmers must be encouraged through FFs under ATMA. Scaling up innovations of successful farmers and should be adopted by other cropping systems needs to be supported through district-level knowledge summits.

State-level programmes implemented under RKVY such as the national food security mission and the national pulses mission tend to be disconnected from ATMA at the district and block levels. These programmes keep the traditional extension functionaries under the state department of agriculture busy but do not create synergies with the extension system, including ATMA. Further reform measures are needed to harness resources spent on RKVY to fully benefit farmers. Recent experiences in Bihar show RKVY funds could be strategically used to create momentum in the extension and service delivery process. However, this requires effective leadership at the state level. RKVY funds are in general seen as an opportunity for ruling state governments to reach out to their supporters. Some of the programmes have serious implementation and accountability challenges and the clients rarely benefit.

The organizational and individual capacities of extension functionaries need to be strengthened continuously. The state extension training institutions need to be held accountable and should come under the purview of the SAUs for research and curriculum linkages and for imparting current knowledge to extension personnel under the ATMA. Innovations are needed to improve the capacity of extension personnel to effectively use information and communication technology tools to connect with the farmers.

To support emergence of private extension professionals, a certification process need to be established. The national system of extension in collaboration with the leading management schools, should offer this certification to help extension professionals to distinguish themselves and enable them to charge a consultancy fee. Similarly, a system to improve the quality of human resource should be established for the state level extension workers including the ATMA functionaries so that regular updates of knowledge can be assured. Certification will improve quality of extension services. Such knowledge improvements need to be tied to the promotion of extension staff at the central and state levels.

Internal annual reviews of the system are helpful to identify implementation challenges, but do not raise issues for open discussion. States within India are experimenting with and modifying the ATMA model of extension to fit their own technical and financial planning needs. This flexibility needs to be encouraged for the ATMA model to become state owned. The experience of the states could be shared through national fora organized by academic institutions supported by the ICAR and should be published periodically.

Rigorous evaluations of extension approaches are needed to learn from the failures and successes and to identify causal factors of each. For example, the organizational effectiveness of the KVKs and the Kisan Call Centres has not been fully evaluated. An effective extension reform process requires continuous information on the performance of the reform measures. ATMA has been scaled up to all districts in India even though evidence on the positive impact of ATMA on farming systems is minimal. Research on extension approaches will also require transforming curriculae of agricultural extension at the post-secondary levels.

Concluding Remarks

The major reforms of the extension system introduced in the last decade include ATMA and the agri-clinics. ATMA continues to face implementation challenges that are inherent in the implementation of any public programme. Pre-existing processes, structures, cultures, and incentives affected the implementation. The financial sustainability of ATMA is seriously questioned since the state governments currently treat ATMA as a scheme of the central government. The ATMA model has been scaled up without adequate analysis of the challenges faced and lessons learned during the pilot phase.

The revised guidelines issued in 2010 provide additional staff and financial resources. The success of the extension reforms crucially depend on how state governments take advantage of policy packages and internalize processes to meet their extension needs. Learning from the wide range of experiments implemented by the states would help further refining extension reform measures. However, this requires rigorous performance monitoring systems and impact evaluations of extension reform measures.

Extension reforms attempted thus far in India address the process of reaching farmers through various information channels. However, implementation issues and the delivery of extension services still continue to suffer from poor organizational and management capacity at the central, state, district, block, and village levels. Several policy and programmatic issues for further reforms have been identified based on recent studies of extension reform programs. The importance of continuous evaluation of the extension reform measures and learning from such evaluations cannot be overemphasized.

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Agricultural Research, Education and Extension Integration for Development (AREE4D)

B.V. David

Is agricultural research, education and extension in tune with the changing scenario? It appears that we have a long way to go. At present, there are many issues that the country is facing in increasing agricultural productivity — erratic monsoon, water scarcity, labor shortage, power crisis, pest outbreaks, farmers' suicides, controversy over GM crops, reduced productivity in oilseeds and pulses. And also the following are some of the challenges.

i. Mechanization, modernization, more diabetes incidence due to food habits, malnutrition, high cost of horticultural and agricultural products.
ii. With no water in the dams owing to monsoon failure, there seems to be urgent need for alternative strategy and research to raise non-rice crops in delta regions.
iii. Efforts are required to raise low-moisture crops like gingelly in the absence of assured water instead of keeping the land fallow.
iv. Israeli methods of water conservation/ utilization may be explored. Sprinkler irrigation and drip irrigation approaches need to be intensified.

Education

- India has a very strong agricultural education system.
- The ICAR has revised syllabi to make agricultural education more field and commercial oriented.
- Routine methods of teaching are still followed. Acquisition of practical knowledge and skill at the UG level is minimal.

- PG research, except for certain cases, is stereotyped with a very little scope for creativity.
- More refresher courses and trainings are a must for young teachers.
- Agricultural graduates are at present well exposed to field- and farmer-oriented problems because of the recent introduction of the RAWE (Rural Agricultural Work Experience) during seventh semester in the UG final year. Benefits of practical implementation of industrial tie-up with agro-industries for two months are to be looked into (S. Manickavasagam – personal communication; Anon., 2012).
- Interaction with industries such as pesticides, seeds, fertilizers and irrigation companies may be explored in the final semester of the under-graduate course by having their local representatives to explain their products and use of the products with literature, which would be a good training before the students leave the academic institutions for taking up a job.

Extension

- Students should be able to connect to reality of farming.
- Techniques like FGDs [focus group Discussions] need to be taught to talk to small farmer groups to understand their practices, problems, expectations. This technique will help validate certain hypotheses.
- Small projects should be given to students to understand what value proposition the current practices are giving to end-user. These projects will help the student to be clear to interact with farmers and understand their problems to prepare the student ready to enter the industry.
- At the undergraduate curriculum level itself the student should be prepared with the management aspects. Then at master's level, a core subject should be on management. This will reduce separate need for management education, as IIMs are becoming more and more expensive, and all students cannot have access to them. This management education will also help students to be an entrepreneur.
- Management education will also teach students basics of finance, which is the need of the hour for agricultural graduates.
- This will help every agricultural student to be a techno-commercial person, expanding horizon of their employability (G. Shankar – personal communication).

Research

India has a fairly advanced Agricultural Research System called NARS (National Agricultural Research System). This is one of the largest systems in the world and functions in close association with agricultural education and extension. At present, the research is done mainly through two streams: The ICAR at the national level and the SAUs at the state level (Rita Sharma, 2003).

Research in many universities is just churning of the same topicby changing the title with a different crop. This has to change. The advisors should come up with novel and challenging topics.

To take up such challenges, advanced instrumentation / facilities are to be provided. In many of the institutions crore of rupees worth instruments are rusting without technicians/operators. Strict audit on utilization of these facilities at periodical times must be done. This scenario does not occur in contract research laboratories.

At present very little accountability is evident in the SAUs. With frequent transfers, there seems to be no continuity in research and accountability. Scientists winning competitive research funds are also very few. If at all funds are available, often they are controlled by non-performers, who are stoppers of academic freedom (P. M. M. David – personal communication).

To cite a few prevalent systems, it may be pointed out that it appears to be mandatory for scientists in the SAU/Research stations to have 3 research projects, and those in the agricultural colleges to have one project. And their transfers result in discontinuity and lack of accountability. It is suggested that a scientist may be given freedom to have an optional research project out of the three projects to enable him to continue his/her research even when he or she shifts to a new position. Continuity of research in his/her specialized field of research ensures the scientist to be an expert and develops excellence in his/her area of research and also ensures continuity of research through research scholars. The second project can be institutional project, and the third one can be *adhoc* research, needing immediate attention (P. M. M. David – personal communication).

A system to separate performance from non-performance needs to be evolved so that non-performers may not control research and academic activities. They can be deployed in extension-related activities (with 'career advancement' now in place, all are Professors in a stipulated time!). A system of rating based on their performance irrespective of the cadre is the need of the hour to promote quality in research and teaching. The rating can be on the lines of the NAAS for fellowship – publications, patents, concepts, processes, products, technologies, books, awards and honors and PI of scientific schemes. A minimum rating is required for such people to promote research and competition. *This is crucial for innovative research and development.*

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Shaping the Future Together: Transforming Agricultural Research Education, Extension and Enterprise for Development

Mark Holderness

The global trend shows that Sub-Saharan Africa, the Caribbean and Pacific lag behind in total factor productivity growth. South Asia has performed better through the green revolution, but this is offset by population growth, and there are concerns now that yield increases of some crops such as wheat, are reaching a plateau. There is an urgent need to better harness agricultural research and knowledge to help eradicate hunger and malnutrition, alleviate poverty and ensure sustainable productive environment.

Agricultural Research for Development Impact

We must address reasons why apparently effective technologies have not been adopted by poor and yield gaps remain so large, and explore how knowledge and innovation can more directly target the poor, and improve the linkage between international public goods, meeting national demands and developing capabilities for national self-determination and self-reliance.

Institutions in and beyond India are often publicly criticized for being under-resourced and ineffective, yet we are slow to change them. Why? Because we have lost connection with societal demand, we have lost ability to show the importance of agriculture and value of agricultural research and education to the people, who should really see it. We hear far too often that research has done its job, but that farmers aren't taking up products. It is time, we start listening more to farmers as innovators and partners. After all, farmers are at the centre of the purpose and existence of agricultural research and education.

To reach desired development outcomes it is no longer good enough to think of a technology pipeline with 'someone else's job' to turn innovations into field impacts. We must consider how complex actions and interactions that enable innovations to be generated, accessed and used can be brought together with enabling environments and inputs required to enable change and manage risks (credit, insurance etc) and with policies that promote agricultural development for smallholders. Put together, these indicate a very strong need to move towards integrated, transformed and strengthened innovation systems that are geared towards achieving agreed and desired **development outcomes** in eliminating poverty, ensuring food and nutrition security for all, sustaining environments and creating resilient systems that will be able to deal with changing climates (see Box 1).

There is a huge amount of research knowledge. But the information is tied up, constrained by many different barriers to its flow. Who wants to share it, and with whom? Is it in the right media, the right language? Is it accessible? Can it be understood? And re-used in farmer-relevant forms? Are our very institutions creating walls that constrain information from being shared because doing so represents a loss of power, rather than an added value to be cherished? We have to identify and address barriers that are stopping these processes from happening in practice.

Breaking down these walls requires development-centred thinking, with different sectors learning and innovating together, managing benefits and risks. Underpinning these requires institutional reorientation and changed values and a convergence of R&D, education and business policies and resources. It is not good enough to just think about our universities or our research institutions or our extension agencies. We have to think also about their linkages and the wider enabling environment of policies, credit access, inputs and returns, rights and ethics, all of which form part of the frame for change.

And we know that we have to deal with this right now; because the world is changing, and the poor farmers will be the first to face the changes. A four degree temperature rise is now seen by many experts as inevitable. The implications for all of us, and the rapid changes we are going to have to make, are enormous. We need institutions and systems to have the ability and flexibility to deal with these issues, and to think about what outcomes we're really looking for.

Box 1. Why we need to rethink for systems of agricultural research, extension, education and enterprise

- nearly half of all smallholder farmers now are **women** - yet often they are not even recognized as farmers
- **rural youth** see little future in agricultural careers – leading to massive urban drift and resultant social problems
- despite India's overall self-sufficiency in food, **child stunting** remains a major scourge, with direct linkage to poverty, nutrition and health
- malnutrition and its diet linkage are also seen in the rapid growth of **obesity**
- future challenges will not necessarily be of a country's overall economic development and food availability, but of how to ensure bottom quintile within a country **are lifted out of poverty and hunger**
- 22 countries, a growing number, are now in **protracted crises**, resulting in agricultural research, extension and education systems that are weak or collapsed
- research is very often focused on yield potential alone, yet poor farmers are last to benefit from such interventions and can even be further disadvantaged if left behind
- our ability to measure yields alone skews thinking and focus compared to challenges of measuring **nutritive access, environmental sustainability and societal gains**
- public, private and civil organizations remain divided and disconnected and in some cases opposed on key issues.
- we live in times of a changing global economic order: the emergence of the **BRICS,** and other fast- growing economies are rapidly changing old pathways that assumed that countries of the North were the prime source of agricultural innovations
- the low hanging fruits of green revolution have already been harvested– complex innovation pathways require us to build **the mosaic of associated actions required to deliver change in a more complex world than ever**

The need for these changes is also recognized in the reform of the CGIAR and of the FAO. Both are now working on outcome-focused programmes. They have set ambitious targets in their new strategic objectives for delivering tangible outcomes towards eliminating hunger and poverty, in ways that are environmentally sustainable. Addressing these objectives requires actions and interactions of multiple partners at many levels, towards outcomes that benefit the poor - in particular the 500 million resource-poor smallholder farming families of the world.

Change and the GCARD Roadmap

Particularly important is the Strategy and Results-Based Framework that sets out a new operational basis for the CGIAR. Doing that has involved a lot of rethinking in the Centres about whom they're serving, the solid actions their work feeds into and who is able to take up their work. The GFAR thus undertook with the CGIAR an outcome-focused process of reflection and change called The Global Conference on Agricultural Research for Development (GCARD). In effect, The GCARD holds a mirror-up to each one of ourselves and asks: how well are we really doing? How we can all hold ourselves to account to our greater purpose as we go forward?

The GCARD conference events provide a regular means of public awareness and accountability for establishing how the changes are working in practice. Cycles of learning, reported publicly through the GCARD Conferences, allow stakeholders from all sectors to mobilize and bring together their own commitments to progressive change, a responsibility shared by all of us. It is a learning process and one that operates in cycles: every two to three years we have a gathering of the GCARD, and in between we're all going out and doing the work that makes changes happen.

The Roadmap developed through massive consultation in the first GCARD contains six core principles which we're now working to deliver on towards clear outcomes.

1. farmers and national stakeholders empowered to better negotiate their own agricultural futures
2. equitable and effective demand-driven partnerships transform agricultural research and innovation into meaningful impacts at scale
3. transformative investments provide opportunities for the world's poor

4. collective initiatives improve capacity in AR4D
5. agricultural research and knowledge embedded into rural development agenda
6. accountability and development impacts in AR4D systems increased through greater and more transparent stakeholder involvement

The GCARD process has had marked impact in shaping international research and national systems across all sectors; 80% of GCARD2 participants recognized that they would change design or implementation of their work as the result of the GCARD processes. This shift is a beginning to bring a coherent alignment of international research priorities with national and regional priorities and investment plans and create need-driven processes towards desired development changes.

Whose research and education priorities, and for whom?

Our starting point must be in working back from desired outcomes. When we start from the needs of the poor farmers and the poor consumers, we understand who is generating demand. Putting the emphasis on how we get those demands through to bear on our innovations will help us create effective innovation pathways to reach those people at the local level. As set out in the Roadmap, we need to take a fresh look at our agricultural future. None of us has a *wrong* view of the future; in fact everyone has a *perspective* on the future. What we *can* do is think about what the future might contain and what we would wish to see happen, and, therefore, what research we must be putting in place now if we're going to deliver our desired future aims.

We have the power to shape agricultural futures we wish to see in our societies. The Global Foresight Hub, which already includes over 40 different foresight approaches, focuses many lenses on our agricultural futures, combining both projections and potential scenarios. This collective foresight approach recognizes that different assumptions underlie different projections and scenarios, enabling us to create alternative visions of ***what kind of world*** we would like to see in future, recognizing that smallholders themselves must have a say in envisioning their own futures.

This Global Foresight Hub has now been endorsed by the G 20 Agriculture Ministers, and collectively asks some key questions on the future of smallholder farming: if farm sizes get further divided, are they still viable? What would it take for true viability? If we follow certain models they will tell us one thing; if we talk to communities they will tell us something quite different. We have to reconcile these perspectives. Sustainable production and sustainable consumption are other issues. Do we really want a world where we need productive capacity of several planet earths to sustain humanity? Is that really realistic? By envisioning agricultural futures we wish to see, and the implications of alternatives, we can ensure research works towards delivering desired aims and inform policy choices at any level.

Partnership, the essential ingredient

Partnership is a key mantra of changes underway in agricultural research for development systems. The international research systems new focus on their work contributing to wider development outcomes require effective partnership and complementary actions from partners of all kinds, if research outputs are to be transformed into innovation products and national impacts for resource-poor smallholders.

The new CGIAR Research Programmes are large-scale partnership initiatives covering span of areas in which CGIAR centres are active. They seek to bring new forms of integrated action between the Centers and, in turn, with their partners, geared around achieving not just research outputs but establishing these in effective innovation pathways towards development outcomes. The underlying assumption is that the CGIAR is **accountable** for its international research outputs but has a **shared responsibility** with national partners for ensuring these are translated into products that can impact in terms of development.

What is also changing is the nature of the questions we're asking, that require new partnership with other sectors, even beyond agriculture. Are we thinking in the way of a development challenge, or are we thinking in terms of technical disciplines? One of the big features that came out of the GCARD2 was a reframing of nutrition. When we consider nutrition at the household level, we come away with a very different picture of food security from that measured in terms of gross grain tonnage. Most of the states of India are now food self-sufficient; and yet we still have, depending on the figures quoted, 25 or more of all Indian children growing up stunted. Over a quarter of the population is disadvantaged for life by early childhood growth inhibition. We have to look at nutrition not just in terms of production, but in terms of poverty and consumption and in its interaction with health.

Investment and demonstrated returns are essential

We know we need to strengthen these systems: IFPRI estimate indicates tripling of AR4D investment by 2025. It's very encouraging that we're seeing a positive trend in investment, but that positive trend is driven by certain countries. China and India are investing more in the sector, but it is disturbing to see that Sub-Saharan Africa—the other big area of greatest development need—is falling further behind in the development and use of agricultural innovations. How development needs will be met when populations are growing so fast?

What can India and China help share with Africa about the changes required? We're seeing quite significant growth now of investment in the international system, and we have to match that at the national level or international outputs will go nowhere. It is important to increase advocacy and government commitments in this regard, which means demonstrating the value and returns from agricultural innovation. The GCARD 2 showed that investments in Uruguayan research have given a return on investment of $17-20 per dollar invested.

It is essential to link research priorities with wider development commitments of governments and the roles of the private and civil sectors, so that research is embedded within a wider enabling environment of policies, input and credit access, advisory support etc. This is well seen in Africa, where a series of steps catalyzed initially through the GCARD discussions have now led to the CGIAR aligning its work with the Comprehensive African Agricultural Development Plan and the country compacts developed through CAADP; the research elements of which are mobilized through FARA. Asia so far lacks such regional or sub-regional coherence.

Meeting the new capacity needs

It is not enough just to strengthen and create new forms of partnerships, the scale of the challenges we face also require the development of capacities throughout the AR4D system, from farmers to research, recognizing that we are combining two forms of knowledge and innovation – that from **science** which is reductionist, trusted and validated by its method and that of **farmers own innovations** and take up new ideas, which are holistic and trusted and validated by experience. To succeed in reaching the poor, we need to value **both** approaches; linking and reconciling these knowledge and trust bases.

There are many barriers constraining information from being transformed into innovation. It is clear that research itself is highly fragmented, with very little cross referencing in practice between agricultural researchers and social science. There is now a wealth of information available, yet farmers are starved of knowledge. There are many new forms of advisory services yet the sector is grossly under-resourced. However, the use of ICT is now opening out entirely new ways of sharing knowledge to reach through to farmer in usable forms and new career opportunities in the process. To do so now requires new ways of making data inter-operable between different forms and accessible through to farm level.

This also requires much greater attention to the role of those who broker agricultural knowledge and technologies into development realities. Among other initiatives, GFAR has played a key role in creating the Global Forum on Rural Advisory Services, to help re-think and rebuild capabilities required of advisory services in today's contexts, through collective actions and greater cross-linkage with other providers and the use of an array of new communication tools.

More directly, we must recognize that university training affects only those at the tip of a pyramid of capacity needs. When we consider the enormous numbers of people we seek to benefit at the farmer level we need to scale out new ideas and learning much more effectively than at present, and this will require both direct contact, experiential learning under the farmers own conditions and making much better use of ICTs than before.

Rethinking who are the farmers – and their education and innovation systems

One major need is to rethink some central premises of agricultural research in terms of who are the farmers of today and how we reach them. Smallholder farmers now include a high proportion of women farmers, in some countries they are the majority. Many rural communities are now seeing men work in distant cities or countries and youth deserting agriculture for what are seen as better opportunities elsewhere - a quiet revolution in rural societies. Yet despite this, research is still focused on the needs articulated by men such as input provision and productivity, rather than those voiced by women, such as labour-saving measures, post-harvest value-addition and returns or child nutrition.

The Global Conference on Women in Agriculture, organized by the ICAR and APAARI with GFAR, brought together a collective voice for women and leveraged further commitments to gender-based research from a number of governments, including that of India. This has led to a major collective action fostered through the GFAR, the Gender in Agriculture Partnership (GAP). The GAP now brings together all the major agencies involved in agricultural development, working together to foster gender equity in agriculture. In research terms, the GAP is reframing agricultural research and innovation needs to address issues that women farmers care most about; often a very different view from that of men of even the same households.

Gender is a social construct. We also have to think right down to the gender dynamics in households. A 2000 study of developing countries by the International Food Policy Research Institute[1] found that as much as 55 % of the reduction in hunger from 1970 to 1995 could be attributed to improvement in women's status in the society. Progress in women's education alone (which explained 43 % of gains in food security) was nearly as significant as increased food availability (26 %) and health advances (19 %) put together. Are our universities paying attention to these needs?

Innovation into enterprise

A further key dimension in improving livelihoods of smallholder producers is their ability to access markets and grow their incomes. The GFAR has been actively working through programmes led by farmer organizations to mobilize actions around a range of farmer-driven models - cooperatives, producer companies etc that can open out market chains and enable more equitable access. This also requires attention to career opportunity related to value chains and the need to draw young people back into agricultural professions.

To these ends, attention must strongly be focused on curriculum reform to consciously include enterprise training and create attractive opportunities for young people in agriculture. There are many new

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[1]http://www.ifpri.org/publication/overcoming-child-malnutrition-developing-countries

tools available to build a more effective relationship between public and private sectors and a growing recognition of the value for each. We must now incorporate those values into university curricula and rekindle the excitement and opportunity of agriculture in the hearts and minds of the brightest young people, so that they can seize opportunities that agriculture and agriculture-related enterprise have to offer.

We must also make better use of practical examples and successes. Innovation platforms are being successfully linked between public, private and international research, such as in linkage with the ICRISAT. The producer companies approach is directly empowering farmer groups and cooperatives with expert technical advice. Corporate social responsibility models such as those of Unilever or Jain are changing the face of the linkage between private sector and farmers. We need to build better on examples of successes such as these and learn from them into many other applications.

Research is essential, but not itself sufficient to deliver impact. Achieving impacts requires our continued efforts together and commitment to practical actions. This means fostering greater coordination among and within sectors – farmer organizations, CSOs, small enterprises, cooperatives etc.

Within universities there is a pressing need for new skill-sets that will draw young people into agricultural careers and enterprise, whether in farming itself or in the plethora of opportunities to be found in areas such as ICTs, producer companies, food and market chains or in input supply. Our young people are moving away from agriculture and rural environments at a speed, and we must act fast to reform curricula and reward systems in ways that will attract them back to viable careers in agriculture and agriculture-related and food industries.

Technical Session 4

Quality Assurance and Governance in Agricultural Education

Technical Session 4, Chair Dr. S. Ayyappan

New Frameworks for Evaluation of Agricultural Research and Education

Javier Ekboir

1. Introduction

Three factors have changed the context for evaluation of agricultural research and education. First, the context in which research and education operate has considerably changed. Second, stakeholders demand that evaluations should support organizational change rather than focus only on the accountability. Third, scientific advances have enabled a better understanding of complex processes and causal chains.

Globalization, innovation and changing social expectations are transforming the environment in which professionals work. In particular, actors in innovation processes are demanding professionals with less academic backgrounds and stronger problem-solving capabilities. New types of educational organizations have emerged to fill the gaps that emerged as traditional universities could not adapt fast enough to the new demands (Davis, Ekboir and Spielman, 2008).

Also, a demand for new frameworks for evaluation has emerged. The traditional framework followed a mechanistic, linear vision of science that rested on two principles—(a) scientific findings are approximations to a truth that can be discovered through objective observation and experimentation; and b) mathematical logic and language are the models for clear reasoning and explicit statements. The two principles were seen as the basis of the scientific method. Today it is recognized that there is no unique "scientific method", and that each discipline has its own rules for conducting research and for validating results; and that the linear vision of science is a model of simple causalities that does not represent actual scientific practice (Machamer, 2002; Miller, 2000). In fact, the linear vision had no influence on the "hard" sciences but strongly impacted the social sciences that tried to become "hard." Most policies followed the trend and recognized the unique status of scientific claims and the possibility of obtaining "true and objective" knowledge.

Section 2 discusses changes in the research and educational environments. Section 3 presents issues critical for the understanding of new evaluation frameworks; in particular, it discusses the main features of complex processes, the notion of causality and attribution of effects to interacting causes. Section 4 introduces new frameworks for evaluation. Section 5 concludes.

2. The Changing Roles of Agricultural Research and Education Systems (ARES)[1]

In most developing countries, agricultural research and education systems (ARES) followed the land grant model of the USA or the French model of the "Grandes Ecoles." In the eighties, many countries demanded that universities should strengthen their research activities and public research organizations should link with extension. In the 2000, ARES were demanded to support innovation processes and to produce more relevant scientific information. Yet, the ARES of most developing countries only changed a little, and could not produce technically- and professionally-qualified human resources, and conduct high-quality research and produce appropriate scientific information. This vacuum was filled by the private sector and foreign research and educational institutions. In recent years, technical and organizational innovations (including better communications and on-line universities) have further revolutionized the global research and educational landscape.

The ability of developing countries' ARES to adapt to the new environment is constrained by factors such as inadequate physical infrastructure, equipment, and communications facilities; limited teaching and research capabilities; poor incentives for personnel; and limited funding. However, a few teams have been able to integrate into global networks, which provided funding and collaboration opportunities. These problems have been exacerbated by three issues—first, teaching and research approaches remain organized along a

[1]This section draws heavily on Davis, Ekboir and Spielman (2008).

linear vision of science; second, many researchers operate in isolation, with little mobility across organizations and insufficient linkages to other organizations; and third, ministries and donor agencies strongly influence the visions, mandates, priorities, curricula, research agendas and operations of many ARES.

Evaluating ARES requires understanding of the new environment in which they operate, and also development of new frameworks that explicitly recognize complexity of innovation processes.

3. Bases of Rigorous Evaluations: Complexity, Evidence, Causality and Attribution

3.1 What is a complex process?

The study of complex processes is relatively recent and covers all sciences (Axelrod and Cohen, 1999). *Complex Adaptive Systems* (CAS) are a type of complex processes where each agent tries to adapt to environmental changes and to the actions taken by other actors. CAS have many feedback mechanisms operating at different scales (micro, meso and macro) and speeds (i.e., slow and fast changing variables interacting permanently) (Gunderson *et al.,* 2002). The interactions enable emergence of structures that are not possessed by the individual agents. For instance, life results from an infinite number of chemical reactions. Age is a property of the body and not of any particular reaction but age influences the reactions. This feature is known as *self-organization.*

CAS are characterized by the simultaneous occurrence of many events, driven by initial conditions, multiple interactions, trends and random variations in the individual agents as well as in their interactions. The majority of the events have minor consequence, a few have significant outcomes and, very rarely, catastrophic effects (Gunderson *et al.,* 2002). While trends predominate, the probability that minor events occur is greater whereas close to the point of bifurcation, the probability of catastrophic events increases. The evolution of the probability of events reflects changes in the variables that drive the process and in their interactions. For example, after a forest fire, it is highly unlikely that another fire will occur because there is no combustible material on the ground. After several years, dead wood accumulates and the probability of a fire increases. While it is possible to estimate the probability of a fire, it is not possible to determine exactly when one will occur.

An important feature of complex systems is that the same results can be achieved with different interventions, or similar interventions can have very different results in slightly different settings (Axelrod and Cohen, 1999). For example, tomato losses during transportation can be reduced with sturdier varieties, better packaging, better trucks or better roads.

Self-organization and randomness prevent individuals from predicting or controlling the system's evolution. Thus, CAS cannot be analyzed with simple, linear causalities, and evaluations should consider multiple and changing causal links (see sections 3.3 and 3.4).

3.2 Understanding the nature of evidence

Most people believe that reality can be objectively known. Cognitive sciences and philosophy of science, however, have shown that even in the hard sciences the relationship between observation, data and knowledge is far from straightforward. The reason is that understanding even simple events requires complex interactions between the cognitive and the perceptual apparatus (Miller, 2000). Also, as what a person knows influences what she expects to occur, knowledge depends on past experiences and social conventions; in other words, knowledge is both an individual and social phenomenon. If both a child and a biologist see a petri- dish, they do not "see" the same thing. The child sees a transparent object, while the biologist sees a shallow dish used to culture cells. The more that is known about a process, the more scientific theories, general knowledge and personal beliefs condition the generation of new data and their interpretation by guiding observations and the design and analysis of experiments. In other words, data can only be evaluated within a theory; this feature is known as the theory-ladenness of data (Bogen, 2002).

The relationship between data and knowledge is further complicated by the under-determination thesis: every set of experimental data can be "explained" by an infinite number of theories, and there are no objective procedures for defining which one is correct (Miller, 2000). "When Newton's celestial mechanics failed to correctly predict the orbit of Uranus, scientists at the time did not simply abandon the theory but protected it from refutation by instead challenging the background assumption that the solar system contained only seven planets. This strategy bore fruit, notwithstanding the falsity of Newton's theory: by calculating the location of a hypothetical eighth planet influencing the orbit of Uranus; the astronomers Adams and

Leverrier were eventually led to discover Neptune in 1846. But the very same strategy failed when used to explain the advance of the perihelion in Mercury's orbit by postulating the existence of "Vulcan", an additional planet located between Mercury and the Sun, and this phenomenon would resist satisfactory explanation until the arrival of Einstein's theory of general relativity" (SEP, 2012).

Often scientists do not accept strong data as compelling proof against a theory. For instance, recognized researchers in the hard sciences (including Poincare, Planck, Einstein, Feynman and Gell-Mann) rejected apparently devastating facts that contradicted their theories and asked for additional data, to be proven right later (Miller, 2000).

These remarks do not mean that knowledge is totally subjective, but that the link between observation, theories and interpretation is not straightforward and depends on many factors, including whether the phenomenon pertains to the natural, social or personal environments, whether they can be observed under experimental conditions and whether the underlying processes are stable (i.e., they do not change essentially during the relevant period of time).

The traditional model of science is based on experimental exploration of stable natural processes. In such cases, data gathered under controlled conditions restrict the number of theories that can be used to explain the data. In some stable processes, such as the movement of celestial bodies, experimentation is not possible but the regularity of the processes allows comparison of the relatively few observations that can be gathered. These data combined with information from other sciences restrict the number of competing theories that can be fitted to the data. For example, cosmological theories are constructed with astronomical observations combined with mathematics and quantum theories.

Explaining unstable processes (e.g., the evolution of large ecosystems or markets) is particularly challenging. Sometimes relatively large datasets can be gathered, but these cannot be compared across locations or between relatively short periods. Also, the processes' dynamics are determined by a large number of variables whose influence changes often. In these cases theories play a major role in the collection of information and its interpretation. For example, theories guide the design of a survey and the model and techniques that are used for the data analysis.

The processes' stability and the possibility of running experiments also influence the conditions for considering a proposition true.

For experimental sciences, experiments have to be independently replicated. For non-experimental, stable processes, the data have to be verified independently and most scientists must agree on the interpretation of the data. In both cases, the power of the explanation is greatly enhanced if it unifies apparently unconnected phenomena and if it yields unexpected predictions that can be empirically verified (Miller, 2000). For unstable processes, the restrictions imposed by data are weaker and the main validation principle is that a majority of researchers agree with the interpretation of facts (Bogen, 2002).

The impossibility of objectivity in science means that the criteria that define what rigorous scientific work is are conventions accepted by the majority of researchers in the discipline; in the field of evaluation, the criteria are set by practitioners, researchers and decision makers. The main implication of the social nature of rigorousness is that there is no unique scientific method or golden standard, but that each discipline defines its own standards (Machamer, 2002). The set of agreed standards and practices within each discipline have been defined as a paradigm. Paradigm changes are processes of argumentation and counter-argumentation, where data provide partial answers and define new questions.

Empirical evidence is not necessary to develop scientific theories. Even in experimental sciences, scientists use “thought experiments”, i.e., they develop theories without empirical support by imagining idealized conditions that cannot be replicated experimentally (Miller, 2000). Examples of important scientists that used thought experiments are Copernicus, Galileo, Newton and Einstein. Their theories were empirically validated many years after they had been widely discussed and accepted.

The examples show that data are only one factor in building scientific theories. In fact, scientists have used non-empirical criteria to guide their work. For instance, Copernicus believed that his theory provided a simpler explanation than the geocentric theory; Einstein used aesthetic considerations to develop the theory of relativity; some scientists relied on philosophical principles or scientific expediency; and, most scientists just accepted prevailing paradigms. The value of data vis-à-vis theories and thought experiments is a personal decision. For Einstein, thought experiments were essential for transcending sensorial perception, common sense and the simple accumulation of data (Miller, 2000). For Edison, experimentation was essential.

3.3 What is a cause?

Since evidence is not objective (see section 3.2), rigorous evaluation amounts to establishing a credible causal link between the intervention and the intended or unintended effects. However, making the case for a causal link is not simple when a) the effects take several years to manifest themselves; b) many factors outside the intervention contribute to the observed outcomes; and c) several causes, including concurrent interventions, influence the process.

A cause is a link between two events where the cause precedes the effect, and altering the cause alters the effect. This statement, however, has many nuances (Hicks, 1979). The simplest case is when the cause is almost always associated with the effect, i.e., moving a switch turns a light on. A cause can also prevent something from happening, e.g., a vaccine prevents an illness. A problem with this case is that sometimes it is not possible to know whether the intervention was effective or other factor prevented the effect, as exemplified by the lack of consequences of the Y2K computer bug. Another type of causality is when something is necessary for an event to happen, but its occurrence does not trigger the effect; for instance, infrastructure is needed for economic growth, but by itself, it does not cause growth.

Causality is often discussed in terms of necessary and sufficient conditions (Mayne, 2012). A cause is necessary if the effect can only occur when the cause is present; for instance, AIDS is only caused by the HIV virus. However, necessary causes are rare as most effects can result from different interventions (see section 3.1). For example, nitrogen can be provided to crops with chemical fertilizers, manure or leguminous plants. A cause is sufficient if it always results in the desired effect; i.e., the HIV virus is not sufficient because a few individuals are immune to the virus. Contributory causes are neither necessary nor sufficient, but still are part of the process that generated the effect; e.g., infrastructure is a contributory cause of growth. Since most processes of interest are stochastic, causes should be stated in probabilistic terms; for instance, we can assert that it is almost certain that the HIV virus is a sufficient cause for AIDS.

Usually effects are not produced by separate causes but by sets of interacting causes and these sets are not unique. For example, a short circuit can cause a fire, but only if oxygen and flammable materials are close by. At the same time, other sets (e.g., an arsonist with fuel) can also cause the fire. These sets are known as INUS: Insufficient but

Necessary part of a condition that is itself Unnecessary but Sufficient for the occurrence of the effect (Mackie, 1988).

An important issue in establishing causality is the definition of a causal set's limits. As mentioned above, sometimes the presence of a factor (not its change) is necessary for an effect to happen. For example, a short circuit can only occur if the house is connected to the electric grid and if the house was built in the first place. The list can be infinite. In such cases, it is usual to distinguish between causes (the direct factors that generate the effect) and context (the less direct factors). However, there is no objective way of deciding what is context and what a cause is. Even more, different people usually select different sets of causes for the same process, as, for instance, when an issue is analyzed from the perspective of different disciplines. In other words, causality sets cannot be objectively determined and are defined by the individual analyzing the phenomenon, based on what is known about it and social and personal beliefs.

An important approach for establishing causality is based on hypotheses testing (Machamer, 2002). However, Pierre Duhem showed in 1906 that hypotheses cannot be tested because every test involves three elements - i) the hypothesis itself; ii) a theory from which the hypothesis is derived; and iii) auxiliary assumptions. As there is no objective way for separating the theory, hypothesis and the infinite set of implicit and explicit auxiliary assumptions, the test is a joint test of the three elements. For instance, economic theory posits a link between income and education. A hypothesis could be that the link is positive. The auxiliary assumptions include the location where the data are collected, how many years after the end of education the link is measured and how the relationship is represented (e.g., a simple correlation or a non-linear econometric model). Many implicit assumptions are also involved in the test; for example, that the relationship is the same for all individuals included in the analysis, and that the variables have been measured without error (or that the errors are not systematic).

Causality is frequently stated in terms of counterfactuals. A counterfactual is defined as a situation in which if A had not occurred, *C* would not have occurred. In policy discussions, the counterfactual is usually defined as what would have happened if a policy or project had not been implemented. In such cases, the counterfactual is defined by the evaluator because the fact that a policy is not being implemented does not mean that other interventions will not be implemented. Another problem with the definition is that statements about what would have happened are probabilistic assertions. And according to the second law of thermodynamics, anything that can be imagined as happening in nature, can happen although some events have a much lower probability than others, and some have a probability very close to, but different from 0 (Miller, 2000). Thus, a large number of counterfactuals can be defined for each event, and it is not possible to select among alternatives with similar probabilities of occurrence.

3.4 Interacting causes and attribution

Until a decade ago, the dominant paradigm for attributing outcomes (effects) to interventions (including agricultural research and education) was framed in terms of economic benefits calculated by means of static economic models and econometric methods (see, for example, Alston, Norton and Pardey, 1995). The perceived shortcomings of this paradigm and scientific advances, especially complexity theories, led many stakeholders to explore new approaches for evaluating complex interventions.

As explained in section 3.4, most real-life processes have many interacting causes, and in those cases it is not possible to separate their effects. In the example of the house fire, the short circuit was the direct cause, but without electricity, there would not have been a short circuit; without flammable materials close by, the sparks would have just died, and so on. In the absence of any of these causes, there would have not been a fire at all. But it does not make sense to attribute 100 % of the fire to each of the causes; also, it does not make sense to attribute portions of the blame to individual causes, because each cause can prevent 100 of the effect. The solution that has been suggested to this issue is to attribute the effects to sets of causes (Ragin, 2000).

Statistical methods, especially econometrics, have been used to attribute effects in non-experimental settings. However, LaLonde (1986) showed that econometric methods cannot replace experimentation; in other words, econometric models cannot separate the influences of individual causes. Even if it is always possible to get an estimate, it does not mean that it reflects "true" causal links. In the statistical literature, the issue is known as "spurious correlation".

While it is impossible to objectively identify causal links, it is possible to make compelling cases that the intervention made a contribution to the process. The argument should combine factual evidence with a theory of change that is credible, given prevailing scientific information, socio-economic theories and stakeholders' and beneficiaries interests (Mayne 2012). A theory of change is a model of how the intervention is expected to act as a contributing cause (see section 4.3). The credibility of the theory of change can be enhanced by developing it with stakeholders and reviewing it during the intervention.

4. Evaluation Frameworks

Evaluating interventions in complex settings requires developing a narrative that describes causal links between the intervention and the outcomes. The context in which agricultural research and education operate is very complex because a) innovation systems are complex; b) the relationship between research and innovation on the one hand and innovation and social well-being on the other is not linear; c) the impacts of research and education depend on many concurrent factors; and d) the impacts take many years to materialize. As was explained in the previous sections, convincingly establishing causality in such contexts is not straightforward, and appropriate methods should be used.

4.1 When are quantitative or qualitative methods appropriate?[2]

Qualitative methods emphasize in-depth analysis of one or a few cases to show how the different aspects interact. Quantitative methods, by contrast, seek broad patterns by studying a small number of dependent variables across a large number of cases. Qualitative methods rest on the following assumptions: a) populations are sets of heterogeneous cases; b) cases are configurations of aspects that should be understood at the level of the specific instance; and c) causation is contextual, plural, nonlinear and non additive – causes may combine in different ways to generate the same outcomes, or the same causes may have opposite effects in similar situations. In contrast, quantitative methods assume that: a) populations are homogeneous with well-efined distribution functions; b) populations are defined prior to the collection of data and analysis; c) the individuality of each case is not relevant; and d) causation is predetermined and stable, often additive and linear, making the approach insensitive to causal complexity.

[2]This section draws heavily on Ekboir *et al.* (2009).

Both approaches use theory and data to build narratives but in different ways. Initially, theories and prior knowledge guide qualitative researchers in the identification of important issues that must be explored. As the study progresses, alternative theories and causal links are checked against collected information on a large number of variables and interactions. Based on this knowledge, new theories are developed until a satisfactory narrative is built. Quantitative researchers, on the other hand, use a-priori information and theories to build a concise representation of the phenomenon, usually in the form of a mathematical model. With this representation, large data sets of a few variables are collected, and then analyzed with statistical tools to find correlations, which are seen as confirmation of the theories. For the qualitative researcher, confidence comes from depth; for the quantitative researcher, it comes from breadth.

In qualitative research, cases are deliberately selected because they show a particular behaviour. Despite their lack of statistical validity, in depth case studies provide the basis for constructing generalizations that hold, at least, for the cases analyzed; often these generalizations have wider relevance. For example, although Freud's study of hysteria was based on a single patient, it was considered as representative of a large number of individuals. Quantitative analysis also has its drawbacks as was explained in section 3, in particular that a) good statistical properties do not constitute a valid explanation; b) having a relatively large random sample is no guarantee that the inferences will be valid for the whole population (Deaton, 2010); and c) in complex processes, causality links are multiple, non-additive and change as the process evolves.

The question an evaluator should answer is which approach is more appropriate for the project's objective and the problem under study. Quantitative approaches are useful for the study of relatively stable, simple relationships that hold for a large number of cases; examples of such relationships are crops' response to fertilizer. Qualitative approaches, on the other hand, are appropriate for the analysis of complex relationships that change over time or space, such as political processes or economic development. Methods that combine both quantitative and qualitative approaches are increasingly used (see section 4.4).

4.2 Randomized controlled trials

Supporters of randomized controlled trials (RCT) posit that they set a methodological 'gold standard' that ensures rigour and scientific validity in the estimation of an intervention's impacts by eliminating the evaluator's personal bias. It has also been suggested that RCT allow identification of "what works and what doesn't". These statements have generated a strong reaction from many institutions, scientists and people in the evaluation profession who contend that RTC supporters overstate what these can do, that RCT do not meet the criteria for valid statistical inference and that other methodologies can be at least as rigorous as RCT (Barahona, 2010; Deaton, 2010).

RCT were initially developed in the context of agricultural research and gained recognition in clinical trials, where they are used in phase III trials after the effectiveness of a new treatment has been demonstrated. The main features of RCT in clinical trials are: a) RCT compare the relative effect of the new and current practices; b) RCT do not establish causality; they only measure relative effectiveness of two interventions that are known to work; c) trial participants are selected because they present a specific condition for which the treatment was developed, and the selection follows a detailed protocol; d) participants in the trial are not allowed to receive any treatment for the condition for which they were selected other than the treatment being evaluated; and e) the effects of the treatment on one individual do not influence the effects on other individuals (Barahona, 2010). These conditions are also valid in agricultural research, with the exception that it may not be known if the new practice works.

In recent years, the use of RCT in the evaluation of complex interventions (including research and education) has been strongly criticized for several reasons. First, RCT are implemented under strictly controlled experimental conditions. In development interventions, on the other hand, it is impossible to control the experiment, thus, it is not possible to assert that the difference between treatment and control is only due to the intervention. Second, in clinical trials, the treatment and control groups differ only in the treatment they receive; this is achieved by carefully selecting the participants prior to their assignation to the treatments. In development interventions, careful selection is not possible because participants differ in many relevant traits (e.g., assets owned, human and social capital and access to markets). Third, while RCT can estimate the correlation between the treatment and the effect, this is not equivalent to establishing causality, especially when several causes influence the results. Fourth, RCT can only be used when indicators can be measured with enough accuracy. However, many indicators (e.g., income) can only be measured with significant errors. Fifth, it is often impossible to avoid contamination of the control group, for example, when non-participants learn strategies introduced by the intervention.

Sixth, it is not possible to ensure that the intervention was implemented correctly, a problem common in complex interventions. For instance, it is impossible to ensure that all programme officers involved in an intervention apply the same effort. Seventh, having a control group does not establish a unique counterfactual since RCT only measure the impacts that were selected by the evaluator. For example, the Mexican Progresa programme was considered successful because the participating children gained more weight than non-participants. But the evaluation did not show that the conditional transfer was more effective in reducing undernourishment than an employment programme for the parents. Eighth, it is not possible to assert that the relatively small projects that are usually evaluated with RCTs, still work when scaled up. Ninth, participants in clinical trials who do not receive a treatment receive a placebo; this is very different from not receiving any treatment at all, which is usually the case when situations with and without project are compared.

Although some of these problems can be minimized by taking special precautions during implementation, section 3 showed that it is impossible to eliminate them completely.

4.3 Theory-based approaches for evaluation

Theory-based approaches for evaluation (TBA) include theories of change, impact pathways, realistic evaluations and contribution analysis. In contrast to approaches based on simple causalities, mathematical models and econometrics, TBA's main feature is a narrative of varying intricacy that states how an intervention has produced or is expected to produce the outcomes; the causal chain may be confronted with empirical evidence. When TBA are used in the context of implementation the theory is developed before the start of the intervention, is validated during implementation (which may include revisions) and guides the evaluation after completion. TBA often include complex and changing causalities (see section 3) and follow the principles of qualitative methods (see section 4.1). A TBA should make explicit— a) a causal chain linking the intervention to outcomes; b) the assumptions used to build the causal chain; c) the risks inherent to the intervention; d) the identification of unexpected effects; and e) a discussion of alternative explanations, i.e., possible rival causal chains (Mayne, 2012).

It should be noticed that using a theory-based approach is no guarantee that the intervention will be effective and that the evaluation will be rigorous. For example, the linear vision of science is a causality chain but it does not capture the complexities of the relationship between science and innovation. Sometimes TBA have been used simply to fulfill bureaucratic requirements; in such cases, researchers and supervisors did not critically assess the causal logic of the intervention. To avoid these problems, it is usually recommended that TBA should be formulated with the input of the main stakeholders, and that it should capture the main variables that influence the process dynamics. However, as was explained in section 3, causal chains cannot be objectively identified and their acceptance is a social process. Data and evidence to validate the TBA should come from applying logic, critical thinking and prior research, and asking relevant stakeholders about each link, and whether they believe there are other causal factors beyond the package at work. If there answer positively, the evaluator should ask about evidence for their belief.

4.4 Mixed methods

Mixed methods do not refer to just one methodology but to a number of approaches to combine quantitative and qualitative information. Mixed methods were developed to overcome the limitations of one type of analysis with the strengths of the other. Mixed methods can give more importance to one of the two approaches or balance both of them. For example, qualitative information can be used to validate econometric results, or quantitative information can be used in a case study to inform about the relative strength of different factors.

The two types of data can be collected simultaneously or sequentially. An example of the first case is when a closed questionnaire is combined with observations about the process. In the second case information collected with a survey is used to design a case study. Additionally, the two types of data can be collected separately and be combined for analysis and interpretation or the two methods can be integrated from the start. For example, a questionnaire can collect qualitative information about a process (e.g., a person's judgment about the quality of a product) and then use all the responses to construct quantitative indicators.

5. Final Remarks

Evaluation of agricultural research and education has changed due to the new dynamics of innovation systems, technical change (in production, research and education) and new social demands regarding the use of public funds. In the 1990s, decision makers and evaluators called for evidence-based policies and evaluations. The main underlying assumptions of such claim are that evidence can be objectively collected and analyzed, and that there is a research (or evaluation) method that is superior to all other methods in all circumstances.

However, philosophy of science, cognitive sciences and complexity theories have shown that objectivity is not possible, that rigorousness is not absolute and that there is no golden standard for evaluation and research. Also, it was shown that knowledge is a social construct; in other words, what is accepted as credible evidence depends on the questions being asked, the context of the evaluation, the assumptions on which the analysis rests, the theory of evaluation stakeholders are prepared to accept and the resources available.

As the limitations of the "objective evidence" paradigm became evident in the 2000s, a new paradigm has been gaining ground. This paradigm emphasizes participation of different stakeholders in the construction of knowledge, flexibility of methods and sources of information to respond to different demands and issues, and the use of evaluation as a learning tool, rather than just information for accountability. To compensate for the shortcomings of single approaches, mixed methods are being increasingly used.

Remaining challenges for the evaluation of agricultural research and education include a) understanding the new dynamics of agriculture, poverty and management of natural resources, in particular the expansion of high value agriculture, the integration of small farmers into labor markets, and economies of scale in the production and marketing of commodities; b) how these dynamics are changing the role of public and private research and education institutions; and c) how evaluations can be used to foster organizational change in public research and educational organizations. The responses to these challenges should focus not only on evaluation methods but also on developing capabilities to facilitate organizational change.

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Governance and Management in University Education

Panjab Singh

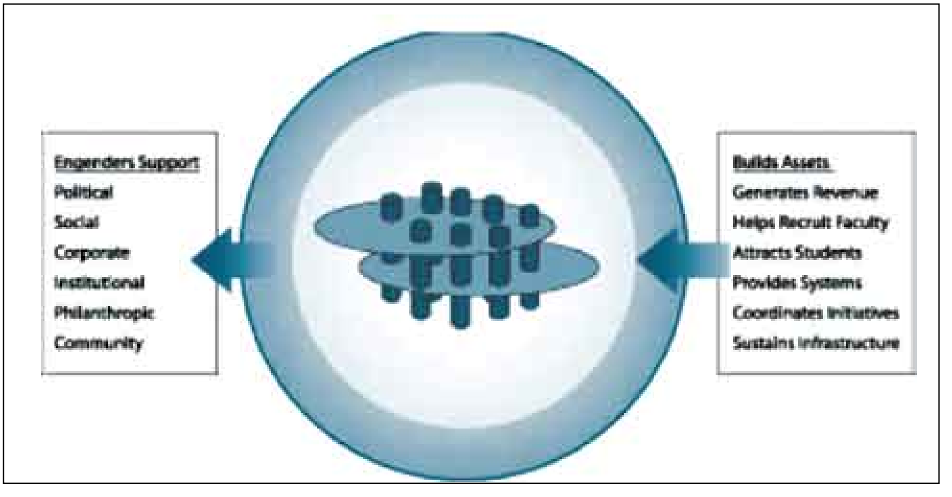
Lack of appropriate institutional structure and framing proper policies and practices has eroded institutional autonomy, governance and management system in colleges and universities. This, over a period of time has adversely impacted the higher education system. The governance of the higher education system involves a large number of public bodies, under the union and the state governments and also autonomous and private bodies. They include a variety of policy makers, regulatory, executive and advisory bodies. Besides the Union and the state governments, there are as many as 16 professional bodies established by the government viz. ICAR, VCI, UGC, AICTE, National Council for Teachers Education (NCTE), Medical Council of India (MCI), Dental Council of India, Bar Council of India, the National Assessment and Accreditation Council etc. to deal with accreditation and coordination in higher education. Yet it is widely felt that the system of higher education is highly regulated and least governed. The several bodies also could not prevent the opening of fake universities, parallel colleges and teaching shops offering fake degrees and diplomas, or the recognized private institutions from running unaccredited degree programmes (Tilak, 2013 pp 6). The three problems, namely access to education, quality of education and management of education are confronting our universities today. Access to education is something about which those involved in educational process can do very little. Students come to colleges not necessarily because they are interested in what is called higher education. They do so basically because nothing worthwhile can become available to them unless they have a college degree. The situation today has become so difficult from the point of employment that, broadly speaking, something like half of those graduate failed to find any job and many who find the job is not the worth to call a job. This is not the time, however, to go in to the detailed analysis of the problem except to say that it cannot be solved by the universities. The universities today are the victims of policies, or indeed the lack of them, which the government is pursuing. The problems dealing with governance, management and organization of the universities are of great consequences in promoting the very cause in higher education and, therefore, needs our utmost attention. Much of it is possible to legislate and get the result in relatively short span of time provided there is concern to implement the same in right and honest spirit at each level of functionaries within and outside the university system who have their say in the affairs of the universities governance and management.

The Word 'University'

While everyone agrees this refers to an institution of post-secondary education, the range of such institutions that use this term is large. Small private and public institutions with modest to almost invisible graduate programs and a narrow range of disciplines as well as major research universities with extensive graduate and professional programs and an extended array of disciplines all carry the same name: University.

Equal variety attends the designation of campus officers above the level of dean. Presidents, chancellors, executive vice presidents, vice-chancellors, pro-vice-chancellors, rectors and other titles serve purposes of significance to local participants in the institutional culture. In some institutional settings the president/chancellor presides over the system and vice-chancellors preside over the individual institutions; in other the chancellor serves the system as chief executive and the presidents/ vice-chancellors serve the universities. Most private universities have chancellor as chief executive officers, but some have vice-chancellors. Second-order administrators take the title from their superiors. When institutions and their systems become complex, universities identify intermediaries in their hierarchies and titles such as rector or pro-chancellor or executive vice president.

A "campus" is an important concept in most universities. The campus defines geography, a location that in some original sense represented the institution. When colleges and universities were small and self-contained, the notion of college and campus coincided. With the advent of large single institutions, remote branch locations, and multiple-campus university systems, the precision of the concept of campus coinciding with university blurred. Many large universities have separate campuses in the same city and out of city, sometimes physically connected sometimes not. The universities function as quality engines. They accumulate resources of all kinds to support the highest possible levels of faculty and students quality. Faculty and students, pursuing their individual goals within the context of the university's academic programs and guilds, develop their skills and use them to create additional value either in the form of enhanced capabilities as graduates (at all levels from undergraduate through professional school to the PhD) or of contributions to new knowledge through research. An active administrative "shell" positions the Institution as a whole, builds resources and helps to attract faculty, students and benefactors (Tamboli and Nene, 2011).



Governance structures take on forms that adapt to the challenges of external environments rather than respond primarily to the needs of the academic guilds they govern. Among private institutions, governance models change little over a long period. For many public institutions, however, governance mechanisms that link the institutions to the state that sponsors and own them often change – sometimes dramatically.

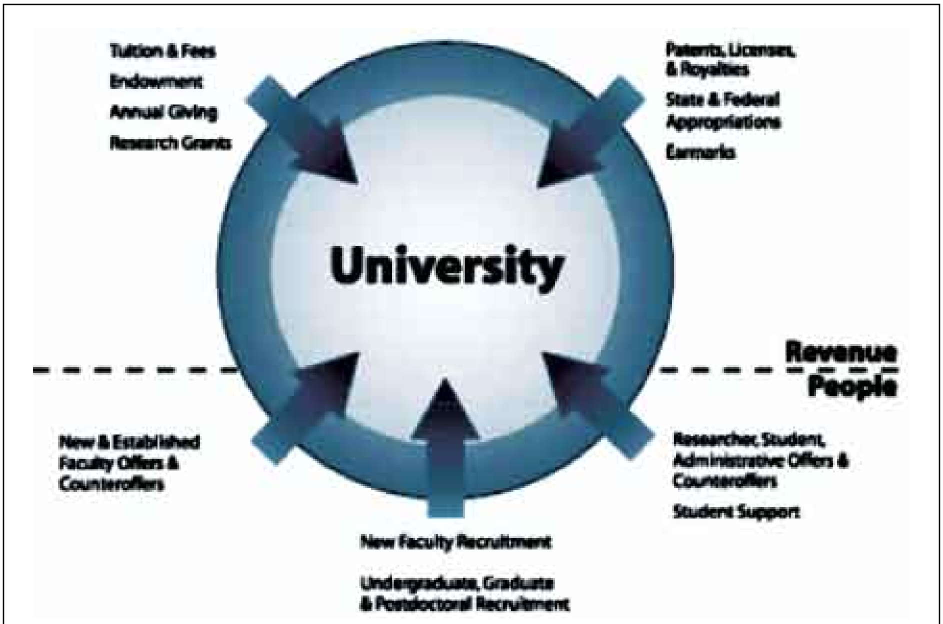
Universities generally fall into three main groups containing a number of sub-categories:

The first group includes those universities that have a single governing board for a campus-based research institution with direct authority and responsibility for the operation and management of the institution. Some institutions in this group, primarily private, have self-perpetuating governing boards with complete authority and responsibility for all aspects of the university's operation. Others, primarily public, have mostly politically appointed governing boards with an obligation to report to governors, presidents, statewide boards or commissions that may limit the institutional board's authority and responsibility in various ways.

The second group includes multiple campus-based public institutions governed by a common statewide board. In this group, the campus-based institutions may report to the statewide board directly or through a system executive.

The third group of public institutions has a local governing board for the campus institutions, and this local board has a subset of powers derived from or delegated by a main campus board. The distribution of authority and responsibility between the statewide board and the local board, and between state-level executives and campus-level executives, varies widely. These relationships tend to change with some frequency in response to challenges, opportunities, personal ambitions of individual actors, and legislative and executive branch preferences.

A competitive university must continually fuel its quality engine with people, capacity and resources



Governance

Governance in higher education refers to the means by which higher educational institutions are formally organized and managed, though often there is a distinction between definitions of governance and management. Simply, university governance is the way in which universities are operated. Governance and management of postsecondary institutions becomes even more diverse with the differences in defining the relationships between higher and tertiary education (university education), postsecondary education, technical and vocational education, and community college models of education.

The concept of governance for postsecondary education predominantly refers to the internal structure, organization and management of autonomous institutions. The organization of internal governance is generally composed of a Chancellor, governing board, Vice-Chancellor, the university with a team of administrative staff, faculty senates, academic deans, department chairs, and usually some form of organization for student's representation (Thakur and Patel, 2010).

Academic freedom is sacrosanct, and in the exercise of that freedom, rests the abilities of the universities to innovate and promote creativity and excellence in teaching and research. Therefore, good governance requires setting up of appropriate institutional structures, framing policies and practices for promoting academic freedom. Accordingly, academic autonomy is key ingredient in the exercise of academic freedom and self assessment is a necessary condition for ensuring accountability. Importantly, autonomy does not start and stop at the institutional level, i.e., the university. It percolates through the entire university system of higher education and concerns the relationships, external as well as internal, to the university. Centralisation and concentration of power is antithetical to autonomy. Most constraints that are feced in university governance and management fall in the following catagories:

Financial issues and funding practices,

Bureaucratic hurdles,

Political interferences, and

Legal and regulatory framework.

The effective and efficient governance should:

(a) Establish effective ways to govern while respecting the culture of decision making in the academy;

(b) Approve a budget and establish guidelines for resource allocation using a process that reflects strategic priorities;

(c) Should ensure open communication with campus constituencies;

(d) Should manifest a commitment to accountability and transparency and should exemplify the behavior it expects of other participants in the governance process;

(e) Should have the ultimate responsibility to assess the performance of the executive head;

(f) Should clarify the authority and responsibilities of the system head, campus heads, and any institutional quasi-governing or advisory boards; and

(g) Should play an important role in relating their institutions to the communities they serve.

About governance, two approaches shall enable us to tackle the problems of higher education institutions governance.

The first one is current. It consists of rationalizing, valorizing and modernizing both the university foundations and their various systems of functioning. It supposes to put on better the whole university structure: better management, transparency in the decision-making and the participation of all actors in the decision-making.

The second approach of governance fundamentally questions the efficiency of the systems of functioning of universities, too much centered on the hierarchical authority of the State, and on that of the university and academic administration, whether it is to define the financing, programs, the qualifications and even the courses of training. The governance of higher education will succeed only if it allows creating a common space of meeting between the actors: political, socioeconomic, students, teaching and civil society.

Teachers and Students Management

Adam Smith, rightly called the father of modern economics, and a university professor for major part of his life and was a teacher of one sort or another through his working life says 'I have thought a great deal upon the subject, and have enquired very carefully in to the constitution and history of the several of the principal universities of Europe', and have come to the conclusion:

"The discipline of colleges and universities is in general contrived, not for the benefit of the students, but for the interest, or more properly speaking, for the ease of the masters, and whether he neglects or performs his duties, to oblige the students in all cases to behave to him as if he performed it with greatest diligence and ability". This is more pronounced in Indian university system today than 200 years ago when education in Nalanda, Takshila system of parting education was in practice. One of the processes of reforms proposition is that the teachers in the colleges and universities should cease to be salaried employees and that, instead, they should become independent professionals like the engineers, architects, doctors, lawers, musicians, singers, commercial artists and a host of others who live not on assured monthly salaries but earn their living by their service to the society, in particular, to their clients say students. In corollary to this the student should pay the full cost of their education. By this process the teachers will become accountable and the students more responsible to their studies, because if they neglect them, it will be at their own cost. In this system of higher education, the primary function of colleges and universities would be to provide needed physical facilities, class rooms, laboratories, library and study rooms etc. The research will have to be funded either by users such as the interested industries or the government. The government support to weaker section of the society should supplent the process through its ongoing programmes to take care of the equity issues and also make provision for liberal and long term loan to any body who desires to persue higher education at any university or college. It should be left to the colleges and the universities to decide what facilities they may provide and what fees or rent they may charge to the researchers and the students. This shoul not be regulated, the only strict condition being that the colleges and universities remain non-profit-making or rather non-profit-distributing institutions; they may make profit provided they plough them back into building up their assets in order to stabilize and improve their facilities and services. Competition among them will keep their charges competitive. There is concern regarding the nondescript character of the graduate that the universities are turning out every year and the large unemployment that prevails among them.

To save the system from this pressure, there could be a proposal worth considering and that is to delink university degrees with employment. There is a total disconnect between industries and universities and it time for us to have university-industry handshake and have regular and meaningful interaction (Singh, 2013).

Essentially it means admitting that the higher education presently being imparted is useless and all the public expenditure on it is a waste. There is an element of truth in it, but the remedy may not be to delink degrees from employment. The remedy lies in making higher education recognisably more useful, and making the students bear its full cost so that they may decide whether what they get is worth its cost. We also need to make a distinction between, say, primary education and higher education. Primary education is investment in human beings with an emphasis on human beings. Higher education is also investment in human beings, but now with emphasis on investment and, as investment, it must be judged by its economic returns. In other words, the market must support it vis-à-vis other forms of investment. The proposals are radically different from the present system and change may be impossible but it can be brought in gradually and not in one sweep.

University Autonomy

At this point of time, when the university system in India is being subjected to harsh criticism, it would be worthwhile to examine the underlying processes that influence the functions of our universities. The Kothari Commission recognised the imperatives of university autonomy and cautioned that "only an autonomous institutions, free from regimentation of ideas and pressure of party or power politics, can persue truth fearlessly and build up in its teachers and students, habits of independent thinking and a spirit of enquiry unfettered by the limitations and prejudices of the near and the immediate which is so essential for the development of a free society" (GOI,1966). The report of the Knowledge Commission states that the autonomy is eroded by the interventions from government and intrusions from the political parties. It further says that implicit politicisation has made governance of universities exceedingly difficult and much more susceptible to entirely non-academic intervention from outside.

The erosion in the university is caused mainly through manipulating the two key instruments of governance, namely the governing boards and the appointments of key functionaries of the university such as vice-chancellors, registrars and others. Further erosion is caused by competition to get political control of students and faculty bodies. It is well realised unless political and bureaucratic intrusions are eliminated, no amount of reform in other function will yield result. Take the appointment of the vice-chancellors in the universities, their levels and calibre and the process of pull and pressure or at times through illicit payment, one gets lost to understand as where are we heading for. All our reform talks go useless unless we bring some surgical reforms in this intrusion process. In state funded universities the situation is pathetic. The governance structure varies from state to state and even with in the state. With some rare exceptions, they are all faced with severe interference effects from the political system and bureaucracy . There are several known instances of incompetant persons nominated to the governing boards/syndicates or appointed as vice-chancellors mainly on the basis of personal relationship or political patronage or illicit financial consideration. This has deeply penetrated in our blood and that is why I said only surgical method could possibly bring some reform. Earlier we do better it would be or else we should stop lecturing and conferencing of reforms in governance and management in higher education system. It is time to establish a set of enforceable national norms for the constitution of governing boards and selection and appointments of vice-chancellor, registrar and deans and directors in public as well as private institutions, alongwith an indigenous system of ranking to promote competitiveness valid for our society.

Financial crunch in the universities especially the state funded ones forces them to resort to running correspondence courses and self-financing programmes, causing the diversion of talents from their core functions. For this reason alone some universities have put ban pof recruitment of faculties for many years adversely affecting the quality of education. Government should seriously think over the recommendation made by various committees to allocate 6% of its GDP to education and 1.5 to 2.0% of it on higher education and resolve these serious impedimentds in the growth of education in general and higher education in particular.

ICAR Model Act for Agricultural Universities

Indian Council of Agricultural Research (ICAR) undertakes planning, development, coordination and quality assurance in higher agricultural education in country through partnership and efforts of the components of the ICAR-Agriculture Universities Systems. ICAR has put in a number of initiatives for quality assurance in agricultural education. To provide legal base for establishment, functioning and uniformity in governance and management of universities, ICAR developed the first “Model Act” in 1966. With changing educational environment due to establishment of more than one university in the state, creation of multi-campus and sectoral universities and changing research, education and extension priorities, the Model Act was revised in 1984 and then in 1994 and lately in 2009. Adherence to the provision of the Act related to uniform tenure and retirement age of the vice-chancellors, selection and tenures of university officers, constitution, powers and functions of the statutory officers, integration of education, research and extension and coordination committee/council at state level deserve consideration. Since ICAR does not have any statutory authority to regulate the university performance, there is need to consider legal empowerment of ICAR not only to ensure the implementation of Model Act in letter and spirit but also of Model Code of Statutes for university functioning to regulate education.

While there has been some positive response from the states in adopting and implementing the recommendations in the Model Act, but there is a vast variation across universities and states. The following needs to be addressed and seriously persued for implementation:

- SAUs must respect and implement the provision of Model Act, particularly with respect to the selection of Vice-Chancellors, and constitution of the board of management.
- Constitute a national level panel of eminent academicians and scientists available from which the states can choose their state level panel for appointing the vice-chancellors. The panel should be updated regularly.
- Autonomy in functioning of the universities should be ensured by the state government.
- Financial support to the universities should be contingent to providing financial autonomy and meeting norms and standards as per Model Act.
- ICAR be vested with necessary statutory authority to enforce academic, research and extension education regulations.
- Agriculture education should be accorded professional education status and treated in similar ways for resource allocation by the planning commission.
- Each state should create a separate Department of Agriculture Research and Education (DARE), like that in ICAR, in the ministry of agriculture for effective coordination, good governanced and implementation of the programs.
- Agriculture education need to be placed as a subject under the concurrent list of the constitution of India. May be there is a need to setup a National Agri-education Council on the lines of the UGC.

- Participation of vice-chancellors in the plan process must be ensured and separate allocation be made under Research and Education for each university.
- Creation of sectoral universities must be stopped as a policy and those already created be converted in to multi-faculty university.
- A strong center-state partnership for funding in the ratio of 50:50 between center and state for the financial health of the university.
- The universities be permitted and encouraged through policy intervention to attract private funding and create endowment funds. The government should extend tax exemption benefits to such donors.
- Since agriculture and agriculture education are state subjects, the accreditation board of the ICAR does not have statutory power or mandate to regulate the higher agricultural education. It is important to create a central statutory authority for the regulation of higher education to make the agriculture sector science and technology based.
- ICAR may assume responsibility and authority to regulate agricultural education in the country with statutory powers.
- Mode Act be made more open and supplemented with following regulations/rules to promote quality of agricultural education.
    - Minimum standards of Agricultural education (Curriculum, Human Resources, Infrastructure facilities)
    - Regulations for affiliation, approval and accreditation of government and private institution imparting agricultural education.
    - Regulations for professional issues – Ethics, code of conduct etc.
    - Regulation for creation of new universities (SAU) and their autonomy.
    - Programmes for entrepreneurial development and self employability to cater to the needs of large number of students completing 10+2 education.
    - Critical assessment of quality of institutes and stringent accreditation process.
- Systematic manpower need assessment, faculty upgradation and competence development.
- Inter-institutional linkages (networking) for strengthening agricultural edcation and regulations.

- ❖ Considering the requirements and demands of various stakeholders, education in agriculture and allied sciences by private sector need to be permitted provided the requirements of registration, infrastructure facilities, man power and technical expertise, quality education, accreditation etc. are necessarily met out by the institutions concerned.
- ❖ In multi-university and multi-sectorial universities in the state, a coordinating body like UPCARE and MCARE be established and given enough authority to integrate and coordinate the functions to avoid serious duplications and multiplication of efforts. DARE created at the state level can also take up this important responsibility.
- ❖ In case of temporary vacancy of vice-chancellor, the charge of the university should necessarily be given to university authority/ officers viz. dean/directors, registrar so as to sustain the academic environment till the new incumbent assumes the position.
- ❖ The Model Act prescribes that that the vice-chancellor should be a person who has attained "academic excellence and demonstrated leadership quality" is quite vague and largely misutililized or not given merit. This needs to be qualified and made more specific so as to avoid mis-use of freedom given.
- ❖ Tenure of the Vice-chancellor should invariably be 5 years across universities and be limited to one term in a particular university.
- ❖ Suggestions for Good Governance and Management (ICAR Policy document on Higher Education,2013):
- ❖ Academic freedom is absolutely essential for academic excellence. Academic autonomy shall not be without autonomy in administrive matters, and decision-making processes. Further, academic and adininstrative autonomy shall have no meaning and will not be effective unless the academic institutions enjoy autonomy in financial matters.
- ❖ Academic, administratie and financial autonomy does not mean a blanket freedom to universities and their constituents the students, teachers, staff, schools, faculties, departments, centres and colleges to do whatever they want. Instead, the autonomy must mean to achieve academic goal.
- ❖ Academic institutions funded through public exchequer are established with the sole purpose of pursuing academic excellence and must meet the expectations of the souciety in this regard. However, their ability to impart quality teaching and to create new knowledge through excellence in research and publication rests on academic, administrave and and financial autonomy.

- It is necessary that all overt and covert attempts to erode or corrode autonomy must be as much resisted as the blatant and clandestine tendencies to evade public accountability. It cannot be over-detrimental to academic excellence as the loss of autonomy.
- University autonomy is often seriously hampered, curbed and curtailed by overloading the decision making bodies of the universities (the AC, the EC and the Court) with political and bureaucratic nominees and people with vested interest and thereby vitiating the decision-making process and adversely affecting the quality of decisions made. While the composition of these bodies may give representation to various stakeholders, the nominees must be people with requisite qualification and high integrity.
- Political and bureaucratic interference in the appointment of vice chancellors and such key university functionaries, as registrars, finance officers and controller of examinations, etc. shall have to be avoided with concurrence of political and bureaucratic leadership.
- The vice-chancellor is the leader of the university system. The appointment norms must adhere to the minimum qualifications prescribed in the ICAR/UGC Regulations. The vice-chancellors should have experience of academic administration and should be able to provide academic administration and academic leadership. The process of appointment of vice-chancellors should be fully transparent and information on nominations received, short listed panel and final selection should be publicly available in all cases. Finally, the vice-chancellors should be selected on national basis.
- Provisions in the Acts and Statutes of several state universities restrict autonomy and have not been revised over long periods. It can also take a very long time to change them and bring them in sync with the regulations of the ICAR or policy directives of the central government. The centre should create model Acts and Statutes and rules of governance and, if necessary, these could be implemented through appropriate constitutional reforms.
- There is close link between the adequacy of financing as well as the financing modes available to the universities and autonomy available to universities. Starving universities with a resource-crunch are compelled to resort to such modes and mechanisms of funding that further incapacitate them for taking sound financial decisions and jeopardises their academic autonomy. There is an urgent need to enhance overall funding to higher education and center should provide adequate finances to state universities and

for reduction of disparity between the allocation of grants between central and state funded Institutions.

- While timely availability of adequate resources is important, it is equally necessary that the universities are given necessary freedom and flexibility to best utilise the available resources for realising the larger objectives of the universities. To this end:-
- The budgets should be allocated at the beginning of the financial year and subsequent releases should be automatic.
- The conditionality attached to grants and allocations of funds need to be simplified.
- There should be clear move towards a predictable norm based funding with powers to universities to allocate and utilise available resources in various competing priorities of the university.
- The norms should provide for incentives for performance and disincentives and penalties for non-compliance and non-performance.
- Special state priorities, if any, should be limited in number and should be addressed through an additional funding window.
- Universities often lose out on the argument for greater autonomy on account of their inability to accord autonomy to their own constituents, internal organs and sub-units. It is necessary that both autonomy and accountability be extended to all constituents and stakeholders within the university system and must not be restricted to the relation between the university and the external spheres of governance. Autonomy should percolate to all levels including the lowest.
- Issues of internal accountability should be built in the following principles:
- Evaluation of teaching performance by students;
- Strengthening assessment through the IQAC and obtaining feedback on the assessment of the University by its constituents;
- Introducing a "Code of good practices", on the lines recommended by the MHRD Committee;
- Restricting inbreeding in recruitment at all levels;
- Subjecting institutions to mandatory accreditation and external reviews every five years;
- Systems of governance focusing on sound financial management and practises;
- Effectives systems of decentralisation at all levels;

- Fairness and transparency in decision-making processes; and
- Highest standards of probity of the academic and administrative leadership.
- At the other extreme, growing numer of sectoral, small single stream or specialised universities also create a special class of issues for governance. Proliferation of such universities should be discouraged and universities should preferably be multifaculty and "comprehensive" in character.
- Reforms are needed to cut down the time taken in routine administrative decision making and in other non-academic tasks which regularly engage and take up a lot of time of the administrative as well as the academic staff of the universities.
- E-governance should be used to improve the efficiency, transparency and responsiveness of the university governance system.
- Respect for divergent in discourse by the academic faculty and their creative deviance need to be encouraged in the university system to create an academic climate of insightful outputs in teaching and research.
- There should be a class of very eminent academics for whom there should be no age of retirement.
- Teachers should have the freedom to design innovative courses. Inter-disciplinarity should be encouraged.

Students should have much greater choice as between courses and institutions. Hence, the reforms towards a credit based system, semester, modular courses, etc. must be strenghened.

Epilogue

True potential of India's can be harvested only through quality higher education. Higher education in India has recorded impressive growth since independence. ICAR, with constant commitment of both the central and state governments, has played a 'flag-ship' role in promoting higher agricultural education through establishment of colleges and universities of higher learning. No doubt excess to education is the primary route to develop human capability and there by the prosperity of agriculture and the socio-economic growth but the quality of education offers determines the kind of human resource generated and their capability to be the part of the development process. Needless to say that on this front we have not made much improvement and, perhaps, it may not be wrong to say that our quality of higher education has declined. One of the main reasons has been the absence of sustained reforms in policies frame work and governance and management systems in colleges and universities. We are still quite away from developing human resource through quality education, which should attract our utmost attention. Quality education captures capability of acquiring knowledge, communication and participation in community life and thus alters an individual's or even community's collective perceptions, aspirations, goals as well as ability to attain them. This may lead to play a critical facilitative role in the demographic, social and political transition of these societies and then, what we call, the real inclusive growth. Quality education with appropriate frame work of policies and governance in higher education in the answer to this important and unavoidable mechanism.

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Quality Assurance and Mechanism for Ensuring Performance of High Standards

S.L. Mehta

Quality assurance and mechanism to ensure performance of high standards holds the key for global competitiveness. The world we live-in today is quite different from the one when the Green Revolution ushered in. Today's global enterprise stretches beyond the farm to encompass multitude of entities involved in production and distribution of food and other agricultural products worldwide. Together with the public institutions that regulate and support them, these highly diverse enterprises generate economic activity of staggering magnitude and breadth. In order to bring in livelihood security and nutritional security keeping sustainability of agriculture in the new world economy, the programmes in agricultural education must have a sea-change to develop agricultural work-force, which should be capable of meeting challenges of tomorrow. Institutions need to position themselves at the cutting-edge and should offer students the opportunity to learn about complexities of agriculture and new challenges due to globalization and be able to address increasing demands on agriculture systems. It is, therefore, important that agricultural education be reoriented in such a way to develop qualified human resource equipped with skills, entrepreneurship, strong global dimension and vision, analytical abilities to face new challenges of agriculture, and meet expectations of stakeholders. Global skills and global perspective are now fundamental prerequisites for success in agribusiness careers.

Agricultural Education Development

Realizing the importance of agriculture in propelling Indian economy, the Govt of India initiated many steps immediately after independence. Self-sufficiency in foodgrains production became an over-riding priority. Pandit Nehru said, "Everything else can wait but not agriculture". The cornerstone of policy was establishment of institutions of higher agricultural education for taking advantage of science and technology in increasing agricultural production. Granting Deemed University status to IARI and establishment of Postgraduate School in 1958 was an important milestone in the development of skilled human resource in agriculture. Based on the Education Commission recommendation and the first Indo-American Team report, the first Agricultural University was set up in Pantnagar in 1960 on the Land Grant Pattern of the USA. The second Indo-American Team (1960) supported the recommendation of the first team that at least one agricultural university should be established in each state with a caution that assistance to establish such institution should be granted only when there is adherence to basic principles of autonomous status, location of related colleges in the same campus, integration of education, research and extension (Cummings 1962). This was followed with establishment of five more universities in 1962 in Rajasthan, Punjab, Andhra Pradesh, Odisha and Karnataka with collaboration of US Land Grant Universities. Subsequently agricultural universities were established in all the states. Up to 2000, there were 28 SAUs and now, there are 55 State Agricultural Universities, five Deemed Universities (four of them are constituent institutes of ICAR), four Central Universities with strong Agriculture Faculty(BHU, AMU, Vishwa Bharti and Nagaland University) and, one Central Agricultural University for the States of North-eastern region (HPC Report, ICAR, 2014).

Initially agricultural universities were multi- faculty and mono-campus types. This gave way to making them multi-campus to meet aspiration of different regions, and in many cases single discipline universities. As of now 39 universities are multi-faculty, while 12 represent Animal and Veterinary Sciences, 2 Fishery Sciences and 5 Horticulture and Forestry. The extensive spread of Agricultural Universities and Colleges have opened opportunities for higher agricultural education throughout the country. The Central Agricultural University established for North-Eastern states has played a key role in generating human resource for north-eastern region.

Expanding Access

In the last two decades in India, agricultural higher education has expanded considerably. At the time of independence, there were 17

Agricultural Colleges which increased to 199 by 2000, and presently stand at 588 (325in SAUs/DUs, 160 colleges affiliated to SAUs and 103 colleges affiliated to general universities and other institutions). Presently there are 110 agriculture, 52 veterinary, 37 horticulture and 25 agricultural engineering, 22 Fisheries,14 Dairy Technology, 12 Forestry, 8 Biotechnology, 7 Agribusiness management, 7 Basic sciences, 4 Food Technology and 7 other constituent colleges (ICAR, 2014). This number is increasing each year as more and more agricultural universities are created. These institutions admit more than 40,000 students annually. The proportion of the girl students has shown increase over years, and presently accounts for 36%. Despite increase in colleges and agricultural universities, the gross enrollment ratio at present is less than 1% in agriculture and allied sciences of the total enrolment. It compares poorly with general education given the fact that 55% of the population is dependent on agriculture and only 10% of institutions offer higher education in agriculture and allied sciences.

A recent study conducted by the Institute of Applied Manpower Research and National Academy of Agricultural Research Management projected manpower requirement in agriculture sector of nearly 54,000 every year by 2020 as against the present of 28,000 (Rama Rao *et al.* (2011). The shortfall will be high of rapidly growing sectors such as horticulture, dairy, food technology, veterinary, fisheries and agricultural engineering; these sectors are future engines of growth. To achieve inclusive growth, it is essential to enhance enrollment rate, create educational facilities for backward and disadvantaged groups, and promote education in areas where manpower requirement is expected to grow. Processing and value-addition, besides reducing post-harvest losses, leads to higher income to farming community. In urban areas, home-made food is giving way to ready-to-eat and processed foods. The processing, at present, accounts for less than 7% of the produce that needs to be increased to at least 20% for higher share in the global markets. This calls for establishment of world class centres for Food Technology in the NARS. The Colleges offering Food Technology programmes hardly meet the accreditation standards. The ICAR needs to establish such centres in DUs and SAUs for developing world-class expertise in processing and value-addition.

Education, Research and Extension Education Integration

The agricultural education system nurtured has paid rich dividends because of integration of education, research and extension education.

It was a major departure from traditional system of education. The Land Grant Pattern Model of USA was also successfully implemented because of the initial support from five Land Grant Universities — University of Illinois, Ohio State University, University of Missouri, Kansas State University and University of Tennessee of USA. The Inter-University contract programme involving these universities laid emphasis on the following.

(i) to improve administrative, professional and physical features of agriculture and veterinary colleges

(ii) to coordinate teaching, research and extension work of participating institutions and

(iii) to increase numbers and capabilities of college graduates who will contribute to increased production and better utilization of agricultural products in India.

This enabled development of proper curriculum and delivery, training of faculty in USA and support from the faculty from five Land Grant universities by working in India (Singh, 2009).

Importance of Agricultural Education Quality

With the globalization of economy, Indian agriculture is facing far too many and newer challenges. Despite the contribution of agriculture to GDP declining at present from 36 to 14.5 %, it still has a very important role in supporting industrial growth and in driving national economy, since 55% of the population depends on agriculture. Agriculture in many areas is becoming non-remunerative. With the opening of world economy, our farmers have to be globally competitive in terms of quality and cost. The only hope is use of knowledge, new technology and innovative ways to integrate traditional knowledge with modern science for increasing production and profitability of Indian agriculture. This alone can bring inclusive growth and social equity.

World is changing at an accelerating pace and unleashing complicated set of problems, challenges and opportunities. With the rising population and enhanced income, food demand and supply scenario is changing to more of nutritious food. Changing consumer demands, increasing international competition in agricultural products, declining levels of public research support, emerging constraints of natural research base, climate change etc are important challenging issues that need to be addressed through enhancement in education quality. The next-generation human resource in agriculture should be equipped and prepared to address new demands on the agricultural system, especially of preservation of natural resource base. Addressing the influence of climate change on agriculture will require sharing insights of a group of experts from different disciplines, policy -makers and other stakeholders. The new breed of graduates will need to have knowledge and ability to communicate across disciplinary domains on these issues and work together to explore solutions.

With the coming in of the IPR, the knowledge sharing among different nations has also shrunk, necessitating technology development by the scientists. This puts enormous responsibility on the National Agriculture Education and Research System. The technology-led agricultural growth can be possible only by strengthening institutions of higher agricultural education with quality assurance.

Issues and Concerns

During Xth and XIth Plan, the agriculture growth was quite low (around 2.8%), was below the targeted growth of 4%. Since agriculture is a driver of economic growth, it is important to propel agricultural growth by new technology and strategies. As has been said earlier, skilled human resource is the key to address new challenges faced by Indian agriculture. Globally technologies are changing very fast and in view of the IPR and other trade-related issues coming up-front, it is necessary that a new innovative approach for producing globally competitive and skilled human resource should be in place not only for developing cutting-edge technologies but also for bringing major transformation in agriculture to give higher economic returns to farming community. Commercialization of agriculture is on the ascendancy. Every farmer has not only to be an efficient producer but a well informed market strategist. "New agriculture" too demands higher level of education and training prerequisites. To many of the educated job-seekers, 'modern agriculture' especially that linked with the world outside, is becoming a source of attraction, including a fairly remunerative and salaried job-career. Therefore, it is necessary to restructure education in a manner that meets expectations of all stakeholders.

Faculty Attraction, Retention and Competence Improvement

Educational institutions world over are known because of competence and adequacy of faculty. During 1960 to 1970 almost all SAUs had the distinction of recruiting faculty based on the national talent and every one supported efforts at attracting the best faculty. With proliferation of universities, lack of adequate financial support, curtailment of autonomy and parochialism, extensive inbreeding has taken place in most of the SAUs, and this is the single most important factor for decline in quality of education. The situation has further compounded with serious shortage of faculty. In most SAUs, 40 % of the posts are vacant and universities are not filling these posts because of financial constraints (ICAR, 2014). Even in national institutes (IARI, IVRI) there has been considerable erosion in cadre strength of faculty, further compounded by nearly 30-40% post being unfilled. This is seriously impacting on the quality of education. Another tragedy is that despite ICAR decision in 1996 to recruit faculty at the entrance level with net qualification, many universities have not adhered to this requirement. Attracting and retaining talented faculty in agricultural universities is, therefore, a challenge and the most important one. It must be made mandatory that 25% of the faculty must be from outside state in SAUs based on the national competence. There should also be a provision to directly invite competent faculty from overseas for a period of five years on attractive terms and build schools in frontier areas. The National Institutes of importance, IARI, IVRI, NDRI, CIFE, must receive full autonomy for recruitment of faculty and no faculty should be transferred to these institutions without assessment of performance. Director General, ICAR and Directors of Deemed Universities should have the power to invite/recruit 5 distinguished faculties from overseas for a period of 5 years during which they could be absorbed based on their contributions.

Recruiting qualified faculty is the first essential step, and continuing updating in knowledge and skill of faculty holds the key for quality education. Therefore, career development planning including building and rebuilding of faculty competence through regular need-assessed training in best of the institutions in the world should be an over-riding priority for quality assurance in agricultural education. Lifelong learning needs to be inculcated in the faculty and mechanism should be developed whereby each faculty member undergoes mandatory training at the regular span of 5 years. The investment in building the competence of the faculty is not only critical but essential to ensure continued high quality of education. Besides, implementation of schemes like post-doctoral fellowship, visiting faculty, adjunct faculty and sabbatical leave for work overseas can go a long way in getting rid of the constraints in quality enhancement. Inviting distinguished professors and researchers in new and emerging areas from overseas to Indian AUs and research institutes for varying periods of time is another important approach for capacity-development of a large number of faculty and students in cutting-edge technology and promoting international cooperation for research programmes. For attracting and retaining better brains in agricultural education innovative approaches will have to be in place through more substantive awards for excellence in teaching and learning.

ICAR Efforts Towards Institutional Development

ICAR has put in motion a number of initiatives towards quality improvement in education. These include establishment of Accreditation Board for quality assurance, course curriculum revision through 3rd and 4th Deans Committees, filling of 15% seats at UG level and 25% seats at PG level through All India Entrance Examination, providing National Talent Scholarship, Junior Research and Senior Research Fellowship, faculty training, establishment of Niche Area of Excellence, supporting experiential learning units, modernization of class rooms, providing access to information through CERA, developing e-learning modules etc. Based on Swaminathan report (1997) further initiatives were taken for gender mainstreaming, strengthening partnerships and human resource development. These measures have improved quality of education at UG level considerably. Quality of post-graduate research is largely a matter of serious concern. The pace and quality of technology generation and human capacity building in most of the SAUs have not matched with global change mainly because of inadequate state funding, lack of research grants, extensive faculty inbreeding, faculty shortages, poor governance, lack of autonomy, lack of environment for nurturing and retaining talent, lack of inculcating lifelong learning habits, mismatched infrastructure for quality education and research and opening of universities and colleges and programmes without commensurate financial and faculty support. There are many universities where total faculty strength is far below the accreditation norms. To improve quality of instruction and research and make agricultural universities globally competitive following steps are suggested.

- Recruit adequate and highly competent faculty on the national talent basis;
- Availability of state-of-art equipment, excellent research, teaching and learning facilities as well as student amenities;
- Ten Central Agricultural Universities, one each in different agro-eco regions and in the tribal and disadvantaged areas of the

country, should be established to act as nucleus to promote excellence in other SAUs of that region;

- Strengthening partnerships among SAUs, ICAR institutes, CSIR institutes, IITs, Public and private sector industries, universities and institutions overseas;
- Curriculum to reflect national and global vision of food and agricultural farming system involves stakeholders in curricula development, integration of basic, biological and social sciences and flexibility;
- Use of ICT in knowledge empowerment;
- Attracting and retaining talented faculty through better working conditions, opportunity for training, combined with substantive incentives for performance;
- Networking and access to information;
- Centre of Excellence fully supported by the ICAR, faculty recruited by the ASRB, state-of-the-art infrastructure and 75% admission on the basis of examination by the ICAR;
- Centre and state to earmark 2% of their Ag-GDP for agricultural education;
- Provision to invite distinguished faculty from outside for training and joint research development.

Improving University Governance

One of the essential requirements for the establishment of agricultural university was functional autonomy and integration of education, research and extension. The universities established earlier were provided with full autonomy in their functioning, and Vice-Chancellors had powers for making universities a centre of excellence by attracting and retaining best faculty. The ICAR also developed Model Act in 1964 which was revised in 2009 and this provides framework for university establishment and functioning. However, with passage of time much of the functional autonomy eroded, and universities are at the mercy of state governments because of financial dependence on them. In many of the universities, Model Act provisions have been altered to suit political exigencies. This has been one of the important reason for decline in quality of education. To bring some semblance of adherence to important provisions of the Model Act, the central support to SAUs should only be if necessary for ensuring autonomy and conformity to Model Act. Presently most universities are more bureaucratic than academic. There is a need to bring major reforms in university governance to improve efficiency in their functioning. For this purpose following steps are essential.

- ❖ Selection of Vice-Chancellors strictly based on the academic and research excellence and leadership quality;
- ❖ Functional autonomy, financial adequacy and decentralization at every level;
- ❖ Decentralization of power at different levels
- ❖ Computerization at all levels
- ❖ Faculty carrier development:
  - ♦ Motivation of faculty to offer best to students
  - ♦ Inculcating lifelong learning as a mission
  - ♦ Training in best of institutions globally
  - ♦ Linking career development plan with performance rigour
  - ♦ Professor's selection based on excellence in research and teaching
  - ♦ Recruitment of 15% of the posts at the entry level be mandatory by open national selection from outside the state.

Accreditation

To have quality assurance in agricultural education, ICAR established in 1996 an Accreditation Board. Through three sectoral committees, the Board decides on norms and academic regulations, course curriculum revision, personnel policies, equivalence of degree and accreditation of colleges and universities (Padda and Maurya, 1999).

Presently the accreditation is voluntary but most universities have come up for accreditation. There is a need to introduce rigour in accreditation by confirming to accepted and laid out norms. Many of the colleges accredited do not conform to norms, and this goes contrary to objective of quality assurance. There is a need to strengthen the Accreditation Board and make it independent to be effective for controlling quality of education. The sectoral committees are at present practically non functional, and need total revamping to be effective.

Experiential learning

For bringing entrepreneurship, skill, confidence, professionalism and practical work experience in real -life situations to graduates, the IV Deans Committee recommended a new flagship programme of experiential learning in all degree programmes to take-up self employment, orientation for starting and running an enterprise, skills to fight an intellectual battle for self confidence and self assertion as equal players in the globalized world.

In order to bring in high quality entrepreneurship skills and professional competence, adequate budgetary support for necessary infrastructure facilities has been built and provided to universities by the ICAR during the last six years. As a result of this support state-of-the-art infrastructure has been developed in many colleges. This has brought new change and more and more students are attracted towards agriculture now than ever before. The new programme is modeled on corporate culture with necessary end-to-end approach. The new breed of students coming out of the programme now have confidence, better skills, entrepreneurship and management skills for enterprise (IV Deans Committee Report, 2007).

Reducing inbreeding

Inbreeding in SAUs is a serious issue affecting both quality and relevance of education. The proportion in faculty of persons obtaining all three higher degrees from the same university has rapidly increased. This trend needs to be arrested by appropriate policies and support. Some beginning has been made by way of filling 15 % and 25 % seats respectively in UG and PG programmes through entrance test conducted by the ICAR and providing Junior Research and Senior Research Fellowship to talented students who move out of their university. This initiative can be made further effective by providing fellowship/scholarship to all the candidates who move out. The ICAR has introduced the National Talent Scholarships for all candidates who move out of their State for admission in the UG programmes through ICAR examination, and this is making difference and leading to national integration at the SAU level.

Human resource planning and management

Human resource development is largely based on ad-hocism in total disregard to manpower need assessment in different sectors of agriculture, for example large state like Bihar has a very limited intake in agriculture compared to Maharashtra, which admits disproportionately high number of students. Rama Rao *et al.* (2011) made a detailed study of the man power requirements in different sectors of agriculture. In Dairy Technology, Food Technology, Horticulture, Fisheries, Agri

Business Management and Veterinary and Animal Sciences, there is a high demand for competent human resources but the number of graduates from these disciplines is lower than the requirement. This is mainly on account of lesser colleges in these disciplines because of high investment requirement. These imbalances need to be corrected for taking major advantage of technology development, pushing agricultural growth and catapulting India as a major global power.

For proper and adequate development of human resource, it is necessary that human resources planning is undertaken on the scientific basis. This would require need assessment for professionals in specific subject areas, review of their training needs for sustainable performance and career advancement. It would also be important to consider knowledge and skill profile needs of prospective job-market.

Performance-linked support: Despite many efforts, quality of undergraduate and postgraduate students does not conform to expectations of different stakeholders. The efforts made under the AHRD project has reversed the trend in decline of quality education but only partially, and need for quality improvement in agricultural education is far greater than ever before. The IV Dean Committee made several important recommendations in this regard. To motivate faculty and bring total quality management in agricultural educational institutions, it is critical and important to build in performance linked support systems, which include incentives for performance and disincentives for non-performers.

Research quality output: Global competitiveness among comity of Nations in the emerging knowledge economy is often assessed from the quality of the research outputs originating from the country. Relative strength and competitiveness of India globally in research and development in science, technology and innovation has decreased during last two decades and serious concerns have been expressed at different levels. Department of Science and Technology, GOI, studied parameters for assessing the global impact of the national S&T system. One of the parameters was the share in the top 1% of the impact making journals; the share of Indian publications was as low as 0.54%. The number of papers in agricultural sciences in top 1% impact making journals increased from 89 to 226 from 2001 to 2010 but it is meager . Therefore, strategies need to be in place for specifically addressing issue of increasing global share of publications. Besides, the overall non-cited publications for agricultural sciences were 61% in 2006-10 as against 67.4% in 2001-05. Given the global perception of scientific strength, India enjoys a large number of publications remaining non-cited, does not augur well. To bring in significant improvement in quality parameters of scientific publications in the years to come following strategy is suggested.

- ❖ Adding quality to doctoral training, providing grants for research in select areas;
- ❖ International cooperation for PG research and for increasing impact profile of researches in the university;
- ❖ Introducing post doctoral schemes;
- ❖ Introducing competitive grant mode of funding based on performance record;
- ❖ Interconnecting all universities and colleges through electronic digital broadband network with adequate speed and access for sharing resources and collaborative research;
- ❖ Incentives and reward for excellence in doctorate research.

Industry partnership in developing qualified manpower: One of the important stakeholders now is also industry, many industries have strong R&D and our SAUs can benefit considerably by forging partnership with the industry. They need to be involved in sharing teaching, joint research guidance for post-graduate students, internship/in-plant training, course curriculum development, industry personnel on University Research Council, Sponsoring Chairs in the selected areas

Curriculum development: New breed of human resource has to be equipped with national and global vision of agriculture. In view of globalization and development of new technologies, it is essential that the students meet international quality standards. One of the pillars for quality assurance in agricultural education is the curriculum, which takes care of contemporary needs, provides for analytical skill, entrepreneurship and experiential learning for confidence to do profitable farming and contributors of sustainability of agriculture. Students and faculty are generally unaware of multidimensional and challenging nature of agricultural disciplines and exciting career opportunities open to them due to globalization. Agriculture is intertwined with other disciplines in basic, natural and social sciences. Therefore, the curricula should take care of the quality demands of different stakeholders. Today the curriculum at UG level developed by the ICAR is one of the best in the world since based on the 4th Dean's Committee experiential learning has been introduced. In future there would be need to have more engagements with industry and other stakeholders in curriculum development.

Globalization and partnership: Globally technologies are changing very fast and we cannot afford to remain behind. One of the essential steps is to forge partnerships with best of the institutions overseas for joint programmes, improving quality assurance mechanism, faculty exchange and development, internship of students, joint degree programmes, and extending or sponsoring education and research opportunities. Rapid changes in information and communication technology and globalization make networking, collaboration and partnerships increasingly feasible for promoting agenda for reforms, and restructure knowledge, innovation and experience sharing across geographical, political or even institutional boundaries.

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Quality Assurance in the Third-Generation University: the Impact of Graduate Schools

Gab van Winkel and Rudy Rabbinge

Continuous upgrading of the knowledge and innovation system is a prerequisite for uplifting society. Third-generation universities train the new generation of highly skilled people and by their position in the knowledge network contribute to a variety of goals in society, among these innovativeness and competitive power of the economy. In agricultural sciences such a role is pivotal as their societal goals of food security and food safety, sustainable growth and of a healthy environment are crucial.

During the last decades in Netherlands, the evolution of the knowledge and innovation system in agricultural sciences is characterized by the development of Wageningen University and Research Centre as a third-generation university (Rabbinge and Slingerland, 2013). A third-generation University is oriented towards societal goals – in the case of Wageningen UR, it is food production, nutrition and health, environment, lifestyle and livelihood. However, such an orientation to societal goals will only be successful when the science itself is excellent and well-focused. Good science requires good quality assurance. This is especially important now, as the main part of university research is carried out by PhD candidates. The introduction of graduate schools in the Netherlands, and in Wageningen in particular, has professionalized the PhD programme and facilitated the development of a solid quality assurance system. This has had a huge impact on scientific achievements and on the economy and society.

Agriculture, Life Sciences and Economic Development

In almost all countries in the world, economic development got a kick-start through agricultural development (Johnston & Mellor, 1961). Research and innovation are critical in development, as they promote efficacy, efficiency and sustainability of agricultural production. The dramatic increase in land productivity, labour productivity, efficient water use, high contribution of food safety and food quality, and reduction in negative environmental effects are all due to a higher knowledge intensity of agriculture.

Analyses in many countries around the world have demonstrated that cost: benefit ratio of investment in agricultural research and extension is higher than in other investments such as infrastructure, direct subsidies or price support. Continuous upgrading of the knowledge system is needed to attain a competitive agricultural sector that leads societal development towards sustainable systems. Such a development requires unifying concepts, unifying methodologies, strong and supporting environment, internalized conviction of the major actors, an appropriate financial system and strong leadership. When such conditions are fulfilled, agricultural sciences can contribute in the development of effective, efficient and sustainable productive systems.

In the development of the Wageningen model as a third-generation university, the unifying concept was exemplified with the mission 'Exploring the potential of nature for the quality of life'. The University stimulates synergy of natural and social sciences to create, as our rector Martin Kropff coined it: 'Science for impact'. The integration of the knowledge chain and its orientation to ultimate societal goals eliminates the traditional distinction between fundamental, strategic and applied science, and replaces the traditional linear view of science and application with the concept of the knowledge carousel (Wissema, 2009).

Quality Assurance System in the Netherlands

Until the 1990s, universities in the Netherlands, like in other western countries, operated according to the Von Humboldt model as second-generation universities. Gradually, however, their 'elite' character came under pressure when number of students began to rise as a result of emancipatory developments and the general increase in wealth in 1960s and 1970s. Two different political developments happened nearly at the same time and influenced universities.

- In the 1970s, the 'ivory tower' character of universities came under pressure from emancipatory movements that criticized universities' lack of societal relevance. Science for its own sake, as in the Von Humboldt model, was no longer found good enough. It led, among others, to the establishment of 'Science shops' where small non-profit organizations could ask for an inquiry into, for example, an environmental issue in their neighbourhood. But in the 1980s, industry also became aware of the research potential of universities and started sponsoring research (Hessels, 2010). This, in its turn, gave rise to discussions about independence of university researchers – an issue that nowadays frequently pops up.
- Mass enrolment in higher education forced government to find ways to manage exploding costs of higher education in 1980s. At the same time, government wanted to improve universities' efficacy, efficiency and quality. In the 1970s, many new staff were employed, most of them, however, were without a PhD degree because so many PhD holders were simply not available. The new staff were hired primarily to assist in the steeply rising teaching load, and if time permitted to pursue a PhD. Not all of them turned out to be gifted researchers and their heavy teaching load limited the research capacity at universities.

One of the measures to resolve increasing costs in higher education was in reducing nominal duration of studies in 1980s. Then government acknowledged (and accepted) that a shorter *doctorandus* and *ingenieur* study would lead to a lower level of research competence of graduates. To compensate for the loss and at the same time to restore the research capacity at universities, a selected group of graduates were meant to gain research competence by doing a doctorate. This led to the introduction of the *assistent in opleiding* (AIO, or research trainee). AIO research trainees are employed for four years full-time and besides doing research for their thesis they take courses, attend seminars and international symposia and carry out teaching also.

Enrolment of AIO research trainees started in 1986 and grew to over 2,500 per year nationally. In Wageningen, enrolment was around 100 per year, and has increased recently to 200. AIO research trainees make up about 40% of all PhD candidates. Other types of PhD candidates are guest PhDs, sandwich PhDs and external PhDs (Figure 1).

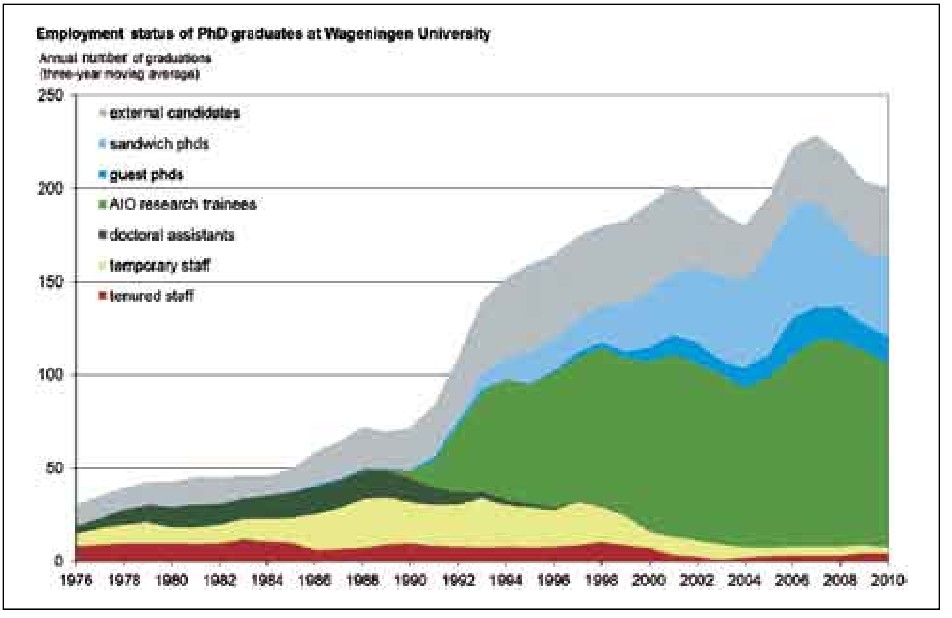

Figure 1. Increase in PhD candidates at Wageningen University, and diversification of the PhD population.

Initially, AIO research trainees were funded mainly by university funds, but funding from the national research council (NWO) and from other sources such as industry, foundations and EU (contract funding) increased in the 1990's. Universities realized that it was more effective to use university funding mainly for tenured staff and attract research trainees from external sources. The effects of this change were as follows.

- The labour division in research changed: tenured scientific staff no longer carried out research themselves but designed it, pursued funding and supervised it, while growing number of PhDs (and postdocs) carried out nearly all university research.
- All AIO project proposals either funded by university or by external sources were subjected to quality control by external peers. Any criticism from peers about the quality or the feasibility of the proposed research was to be resolved before the project could start. Universities felt that the new AIOs, who were lower paid than other temporary researchers, deserved the guarantee of a 'doable' project.

The combination of these two changes meant that after 1986, university research was carried out by a large part by PhD candidates;

it increased considerably in volume and output, and was for a large part subjected to *ex ante* quality assurance at the project level.

Graduate schools for quality assurance

To provide a facilitating network structure, seminars and courses for the fast-growing population of AIO research trainees, government introduced graduate schools following advice of a state committee (Rinnooij Kan, 1990). New graduate schools could submit for a start-up fund from the national research council (NWO), and they could apply for accreditation by the national academy of sciences (KNAW). In 1995, more than one hundred graduate schools were accredited (Bartelse, 1999). Graduate schools have their own budget to organise courses, seminars and workshops.

In most other countries in mainland Europe, graduate schools were introduced later, and several countries in South and Eastern Europe are still in the process of setting up such structures (Powel and Green, 2007).

Tasks of graduate schools are as follows.

- Quality assurance of PhD research and supervision.
- Providing disciplinary and skills-related courses for PhD candidates.
- Creating critical mass by stimulating research collaboration and a joint research strategy.

Besides catering for the fast-growing population of PhD candidates, the tasks given to the new graduate schools represented an important next step in quality assurance. This was not received by all stakeholders in the same way. Initially, the first task (quality assurance of PhD research and supervision) was regarded by many supervisors as interfering with professional responsibilities and as bureaucracy (Sonneveld, 1997). The second task (providing PhD courses) was less debated. Particularly the last task (joint research strategy) was seen by some university and faculty leaders in the Netherlands as interfering with their own responsibilities. Graduate schools were at first tolerated, after several years accepted, and now are valued for their work by most university leaders.

At Wageningen University, six following graduate schools exist now for about twenty years: Experimental Plant Sciences (EPS, 1992); Food Technology, Agrobiotechnology, Nutrition and Health Sciences

(VLAG, 1992); C.T. de Wit Graduate School Production Ecology and Resource Conservation (PE&RC, 1993); Wageningen Institute of Animal Sciences (WIAS, 1993); Wageningen Institute of Environment and Climate Research (WIMEK, 1993); and Wageningen School of Social Sciences (WASS, 1994).

From the viewpoint of quality assurance, the introduction of graduate schools in the Netherlands had enormous impact. Graduate schools not only took over *ex ante* peer review of AIO research trainee projects from the central university administration, but the peer review was extended also to all PhD projects.

A new element introduced by graduate schools was the admittance of scientific tenured staff. That is not only important because staff is involved in research, but also because staff is involved in the supervision of PhD candidates. In the old Von Humboldt model, PhD candidates had typically one promoter; nowadays supervision is done by teams (Figure 2). Staff has to meet certain criteria to be admitted to the school. These are: Holding a PhD degree; Sufficient output of scientific publications; Experience in supervising PhD candidates; Ability to attract external funding; Sufficient impact of

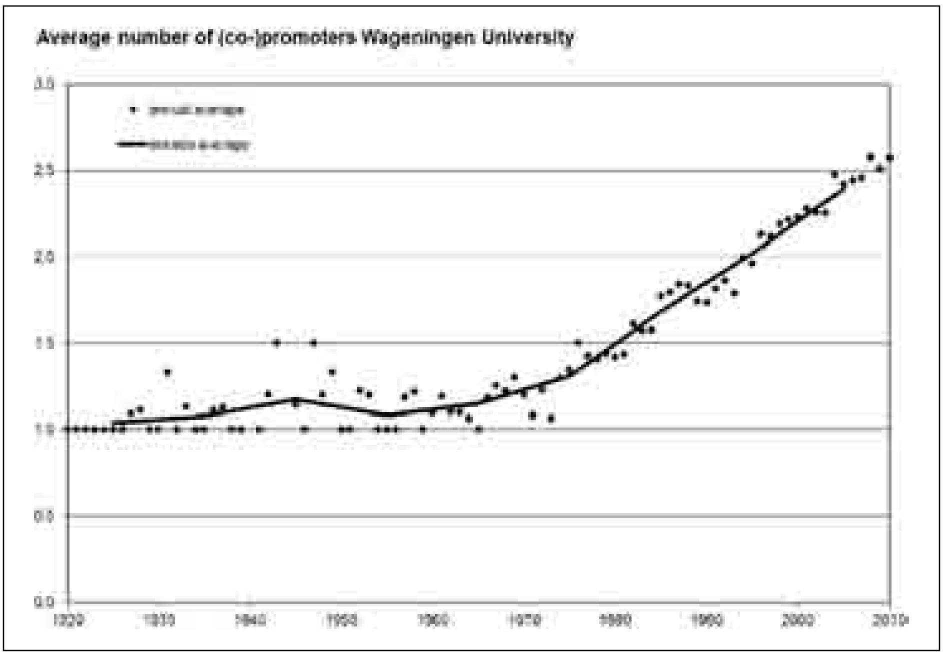

Figure 2. Development of team-wise supervision at Wageningen University. At present, two or three (co-) promoters are the norm

their publications, in terms of citations; Contribution to PhD seminars and courses; and Other proof of the academic esteem, editorship and awards.

Junior staff has to meet four of these criteria, senior staff, six of the seven criteria. Staff that is not admitted to a graduate school are not expelled from the university immediately. They get a chance to improve their performance in due course, but this is no *laissez faire* policy. Looking back on to past twenty years, the quality level of tenured staff has considerably improved. Those who couldn't follow, either moved to a different job, quit from university or retired. Such changes in personnel take time, of course, but most of all such a continuous improvement policy of staff requires a committed management. Therefore, the graduate school's director meets with each chair annually as well as with the director of the overarching department.

Other steps in quality assurance

Further incentives for PhD candidates and supervisors, introduced by Wageningen University to improve its PhD programme were as follows.

- ❖ Introduction of a Training and Supervision Plan by each graduate school in the 1990s, in which training and teaching activities of the candidate are planned. The plan also contained agreements on supervision and thus helped make mutual expectations explicit to both supervisor and PhD candidate.
- ❖ As a stimulus for good supervision, Wageningen University introduced a 'graduation bonus' for chair groups for each successful PhD graduation. This bonus increased from k€ 19 in 2000 to k€ 56 in 2012.
- ❖ As a stimulus to PhD candidates to take courses, Wageningen University introduced in 2006 a k€ 15 difference in graduation bonus depending on the completion of the candidate's Training and Supervision Plan. Even the few supervisors who initially doubted the usefulness of courses and workshops for their candidates, now advocate taking them.

In Wageningen, all graduate schools have an international advisory board that consists of five or more internationally renowned scientists covering all disciplines in the school. They bring a site-visit every year and meet with the school management, chairs and PhD candidates. Often, a representative from industry sits in the international advisory board, but some schools have a separate stakeholder committee.

All graduate schools have an independent council of PhD candidates. Representatives of the six PhD councils form the Wageningen PhD council. There is also a national PhD students' platform, and even a European one. These structures ensure that graduate schools are aware of what their stakeholders and peers find important.

Another part of the continuous upgrading of academic training is an intensified alumni policy. Alumni networks do not only function as an effort to strengthen scientific support, but are also used in the policy for continuous updating of skills and scientific level of former graduates. The Wageningen Academy has been installed to organize that permanent learning opportunity. It is a well-respected and strongly supported activity. This alumni policy is also leading to a strong international policy as may be concluded from the number of international students at MSc and PhD levels and their continued relation with the university (Figure 3).

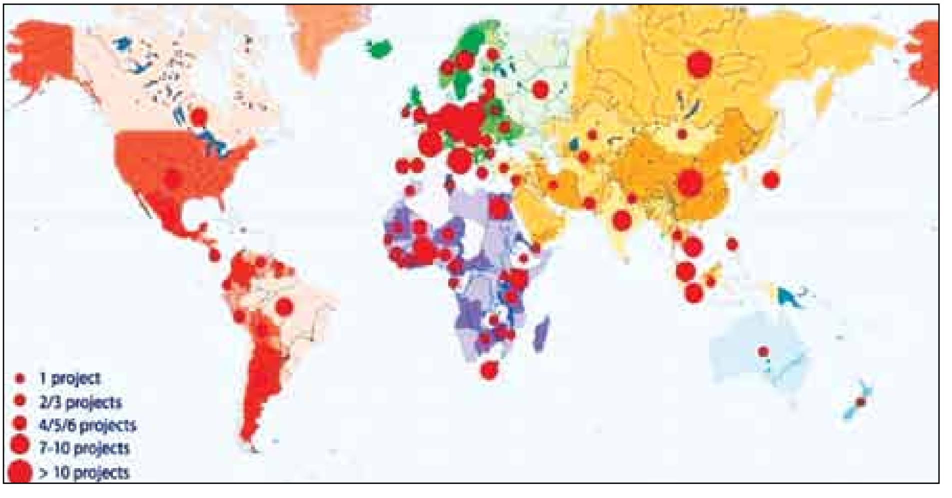

Figure 3. Wageningen UR has students and staff from over a hundred countries

Quality in science can only be guaranteed by integrity of scientists involved. Recently, the Netherlands experienced a dramatic, large-scale case of fraud, by a professor in social psychology, which led to further awareness among university leaders and scientists. Integrity in science has also become an issue since collaboration with industry and other stakeholders has increased. Wageningen UR, as a third-generation university, is fully aware of its responsibility to stay independent. It has a scientific integrity protocol, a data storage protocol, and mechanisms to investigate accusations and complaints in this respect. PhD candidates, being the researchers of the future, are offered several workshops on scientific ethics and integrity.

National disciplinary peer reviews

Shortly after the introduction of graduate schools, universities in the Netherlands introduced a national system of periodical peer review of research, organized by discipline. A team of external peers, mostly from abroad, is invited to assess quality of research in a particular discipline. In 1993, Biology was one of the first disciplines to be assessed, among it over a dozen Wageningen chair groups participated. In 2012, the fifth national peer review in Biology was carried out, with 19 groups from Wageningen (QANU, 2012).

Assessments are done at two aggregation levels:

- Individual chair groups
- Institute or graduate school.

Research is assessed on four aspects:

- Quality
- Productivity
- Relevance (for science and society)
- Viability (prospects for the future).

On each aspect, a score is given on a five-point scale:

5. Excellent: world leading group
4. Very good: internationally competitive, nationally leading
3. Good: internationally visible, nationally competitive
2. Satisfactory: nationally visible, solid but not exciting
1. Unsatisfactory: neither solid nor exciting, flawed.

Chair groups that perform below 'good' are not immediately terminated. They get a chance to improve their performance in due course. Like in the quality assurance on an individual level, looking back on the past twenty years, we can see that the quality level of chair groups has improved considerably. Some poor performing groups have disappeared, others were reorganized or merged with stronger groups. Again, long-term commitment of the university management is crucial.

In the peer review, the institute or graduate school, including its PhD programme is also assessed. This assessment, in turn, can be used by a graduate school to submit for accreditation by the national academy of sciences (KNAW). All Wageningen graduate schools are, from their start, KNAW-accredited and periodically re-accredited.

Initially, research assessments and re-accreditations were organized every five years. Now it is every six years; in between the institute or graduate school carries out a self-assessment. Wageningen graduate schools submit their self-assessment to the international advisory board and receive an independent advice that is used to improve performance before the next external peer review.

Impact of Quality Assurance

During the last two decades, the graduate school system and accompanying quality assurance systems have bloomed fully. It marked the change from a completely individual-based system, dominated by relation between individual professors and PhD candidates, to a more professional system with shared responsibilities. As a result of that, scientific output of PhD research has increased substantially while the time to award a degree to PhD candidates decreased (Figure 4). Wageningen University is now high ranking in the international system of academic institutions, and enjoys a much increased recognition in the international scientific community.

- Nationally, Wageningen University has been chosen for the eighth year in a row as 'best university in the Netherlands' (Keuzegids, 2013).
- In the most recent peer review of all Biology research in the Netherlands, Wageningen University ranked first (Van Maanen, 2012).
- In the Times Higher Education (THE) Ranking (2013), 12 of the 14 Dutch universities are in the top 200. Wageningen UR has climbed to a 70th position worldwide.
- In the Leiden Ranking (2013), which primarily measures research performance and impact, Wageningen UR is 78th worldwide.
- In Essential Science Indicators, Wageningen UR ranks in the top 10 worldwide in its main fields: Agricultural Sciences, Plant & Animal Science, Environment & Ecology.

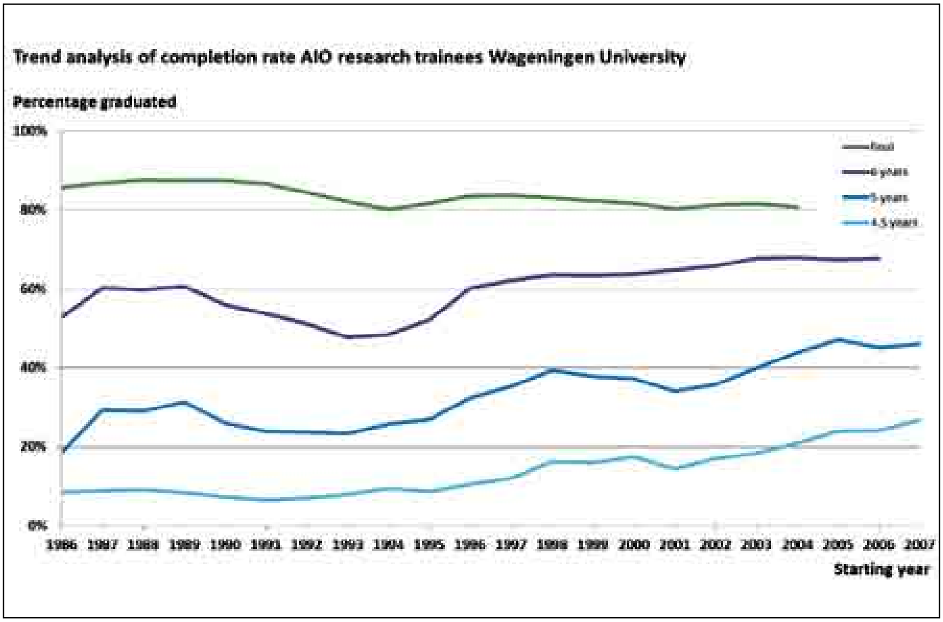

Figure 4. Time to degree of AIO research trainees at Wageningen University. From 1994 onwards, shortly after the introduction of graduate schools, the percentage graduated within 4.5 and 5 years steadily increased, while the final completion rate stayed above 80%. These figures compare favourably with other countries.

- In the Shanghai Ranking (2012), Wageningen UR is 39th in the combined field 'Life and Agricultural Sciences'. In the Taiwan Ranking (2012), Wageningen UR is second in the field 'Agriculture', between the universities of Davis and Cornell.

This road to scientific excellence did not lead to less societal impact. The strengths of the various components of the agricultural sector have increased enormously during the last decades. A compendium of the various components of the economic activity of the Netherlands making use of Porter's diamond model (Figure 5) shows that this policy has led to a powerful sector with eight of the twenty components leading internationally.

The contribution to the export value is impressive. Although the Netherlands is a very small country, its position as export in agriculture-related products is second of the world (Figure 6). That is due to a strong knowledge-intensive and innovative system, leading to very competitive positions; for example the seed and bulb industry, the plant and animal breeding industry etc.

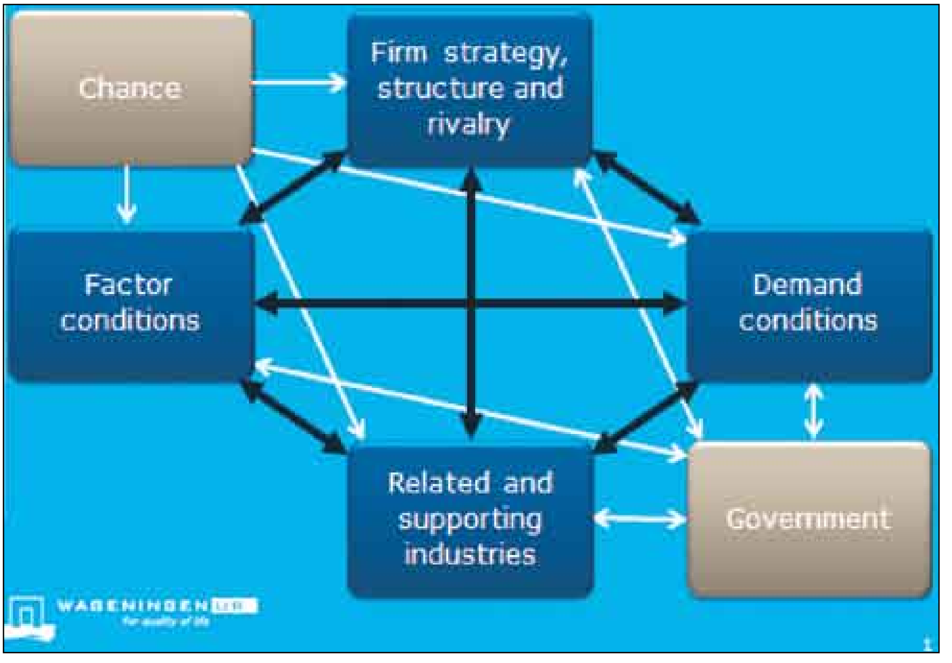

Figure 5. Porter's diamond model (Porter, 1990)

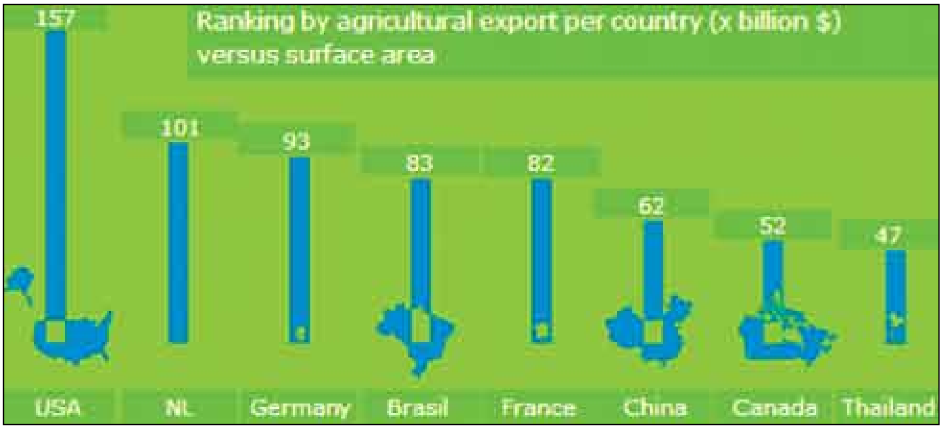

Figure 6. Agricultural export per country versus surface area

Source: pbl.nl 2012

In its policy to strengthen economic impact based on knowledge-intensive activities, the Netherlands recently has adopted a 'top sector' approach where public-private collaboration determines research agenda and finances activities of participating research groups. Wageningen University as third-generation university has participated in these top sector programmes. The basis of these activities is also promoted by the sector plans for scientific fields, such as biology. Five graduate programmes in biology belong to the top five of the world, and that is mainly due to strong promotion of graduate schools with their explicit mission to promote excellence.

Epilogue

Continuous updating, upgrading and quality control are of pivotal importance for a university system and a knowledge and innovation system that is oriented to impact in scientific terms and in societal terms. The graduate school system adopted in the Netherlands and most explicitly stimulated in Wageningen has shown its value for such a policy.

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Quality of Higher Education in Agriculture: A National Perspective

Gautam Kalloo

According to G.K. Chasterton (1924), Education is simply the soul of a society as it passes from one generation to another and is the major source of livelihood, promotion and welfare of the society. Since ancient times, India has been the forerunner of the higher learning; Takshila, Nalanda and Patliputra were the main sources of higher education and learning. In 1948, Ministry of Education took initiative to appoint a Commission of University Education under the Chairmanship of Dr S. Radhakrishnan to prepare a report on the University Education. In 1949, the University Education Commission recommended the setting-up of the Rural Universities (Radhakrshnan, 1949). This was endorsed by two Joint Indo-American Teams in 1955 and in 1959 as well as by the Ford Foundation Study Team in 1959. In 1960, the Agricultural Universities Committee constituted under the Chairmanship of Dr Ralph W. Cummings prepared guidelines for the establishment of Agricultural Universities in different States, and the necessary support was given by the ICAR (ICAR Report, 1960).

The first Agricultural University was established at Pantnagar in Uttar Pradesh (presently in Uttarakhand) in 1960, on the pattern of the Land-Grant System of the United States. The Second Education Commission (1964-66) recommended establishment of at least one Agricultural University in each State, and the ICAR prepared a Model Act in 1966 and revised it in 1994 and 2009 (ICAR Report, 2009). Agriculture Education System (AES) is one of the largest national networks of AES in the world, comprising 54 State Agricultural Universities (SAUs), 5 Deemed- to- be Universities, one Central Agricultural University in the North-Eastern Region and four Central Universities with agriculture faculty. Some Agricultural Universities, as in Maharashtra and Chhattisgarh, have affiliated colleges. The ICAR works in a partnership mode with SAUs, and has contributed significantly in developing first-rate resource by way of co-ordinating, supporting and guiding various aspects of higher agricultural education. It provides fund and scholarships / fellowships to students for quality assurance.

Agricultural Universities have the intake capacity of 35,000 students and impart education in 11 major disciplines at the undergraduate level and about 93 subjects at the post-graduate level. In higher agricultural education, it is heartening to note that about 55% students are from rural background, and on an average 36% are girl-students, and every year the number of girl-students is increasing. Higher education in agriculture in the country has made significant contribution in the food security as well in the overall growth of the country, and thus there is a dire need to enhance quality of higher education in agriculture.

Components of Quality Education

Higher education system in the country has been evolved over a time with consistent efforts. The Universities and the Institutions with long experiences of working have evolved system or academic practices, and at many places these practices are highly vibrant, effective and functional, and are being followed by many other organizations also. To impart education to students, UGC has designed action plan main steps for consideration of the Central and State Universities, Colleges and other educational institutions of higher education; these areas are given in the following paragraphs.

Semester system

For a long time, traditional system, spread over to 10 to 12 months, was followed, but this system has shown certain limitations, because of which the United States and Western Europe has introduced semester system, and this, at present, is being largely followed. It has been realized and analyzed that semester system has many advantages and this supports accelerated learning opportunities for all concern. As a result many universities, technical and professional institutions have adopted this system, and now it has been made mandatory for all institutions of higher education. Number of student-faculty contact hours, revision of course curricula, credit points to be earned by students, and Choice-Based Credit System (CBCS) are important features of this system. Throughout the country, this system is followed for higher education in agriculture.

Curriculum development

Revision of curricula from time to time should be an integral contemporary part of teaching. Curricula should be updated with current national and international developments of the knowledge in the field of concern subjects and disciplines. To achieve this, faculty members have to make lot of efforts and continuously draw upon the books, journals and internet; to facilitate this UGC and ICAR have promoted INFLIBNET, INFONET and e-Journals. Realizing the importance of the revision of curricula at the UG and PG level to improve skill and relevance of education, the courses have been restructured. Now unified course-curricula at the UG and PG levels are available, and are being followed in the entire country. Revised course curricula have new courses and revised courses in most of the disciplines and the subjects, especially, biodiversity, IPM, INM, Environmental Science, Agribusiness Management, Marketing, Banking, Biotechnology, Agri-meteorology, Agro-ecology, GIS application, Computer Application, Bioinformatics, Precision Farming, Post-harvest Technology, Seed Technology, WTO-related issues and Intellectual Property Regime etc. Generally, universities offer Bachelor Degree programme for four years duration through semester system. Agricultural University across the country offers unified course curricula programme for Bachelor, Master and Doctorate degree programmes, as is recommended by the ICAR. Structure and components of the course curricula are unified courses, specialized courses, capstone courses, rural agricultural work experience programme (RAWE), experiential learning programme (ELP), commercial agriculture etc.

The ICAR gives financial support to RAWE programme, and in this programme students of B.Sc. (Ag.) final year are attached and placed in the rural area for effective work experience of rural agriculture for a semester. They participate in most of the rural agricultural activities and understand rural life and socio-economic conditions of the farmers. This gives clear understanding of the village life, which helps students in making future programme of the village development. RAWE and FEW (Forestry Work Experience) are important activities to produce well-trained agriculture graduates.

Another initiative taken by the ICAR was experiential learning programme during Xth plan for students. The major components of this scheme have been to establish instructional farms for crops, animals and fish production, protected cultivation of vegetables and flowers, model plants for food processing and value-addition, farm machinery and equipment's operation and maintenance, modules of plant tissue culture, high-tech horticulture, mass production of bio-agents and bio-pesticides, fruits and vegetable processing etc. And students are being involved in all operational activities which generate confidence, competitiveness and competence.

At post-graduate level, about 95 subjects are covered; major are agriculture, veterinary, animal science, fishery, agricultural engineering, forestry, home science, basic science, business management, agribusiness management, post-harvest technology and environmental science, etc. Besides undertaking various courses as per the requirement for the degree, two major activities at the PG levels are seminar and research. To promote communication skill, expression and confidence, a number of seminars have to be given by each student. This, in fact, enhances quality of students. Regarding research work, the topic for curricula researches is based on the current need of the subject which is decided by the advisory committee, mainly by major advisor. Student has to complete all requirements for completion of research and submission of thesis.

Admission procedure

Quality of education depends largely on the admission procedure followed by the organization to admit students. Admission should be objective and procedure followed should be transparent. Earlier admission was mainly based on percentage of marks and division obtained in the previous classes. Now, written test is the main, accompanied by interview, group discussions or any other competitive examination; results of which are communicated.

The Indian Council of Agricultural Research (ICAR) has also made an arrangement with the Agricultural Universities to set aside 15% of their seats for bachelor's programmes and 25% seats for Master's degree programmes to be filled through the All-India Entrance Examinations (AIEE). Accordingly, ICAR conducts two All India Entrance Examinations for Admission (AIEEA) - one for a Bachelor's degree and another for Master's degree programme every year. For the ICAR – Deemed-to-be-Universities, IARI, IVRI, NDRI and CIFE, 100 % seats are filled through above examinations. The students/ candidate for undergraduate, postgraduate or doctoral programme who have cleared JET, NET, SET etc. may be exempted from the written test. Strategically it is being felt that students at the very young stage should be motivated and sensitized for agricultural education. In some states the students who are getting above 85%

marks in secondary examination incentives are being given to them for admission in agriculture.

Examination reforms

At the end of academic session or year, very often annual examination with external evaluation along with percentage and division have been followed, which have not been so functional and successful. In Western Europe and North America, universities and institutions of higher education follows internal evaluation. Considering the prevailing condition in India, the students' performance may be assessed through a combination of internal and external evaluation system. There are specified components for internal evaluation (e.g. essay, tutorials, term papers, seminars and practicals) which have a time-frame. In the end following the integration of internal and external evaluation or otherwise the results can be expressed in marks, grade or both or as per the university policy. However, unified grading system following Cumulative Grade Point Score (CGPS) may be based on a point scale; this may vary from institution to institution. Most of the agricultural universities have three-tier system of examination at the Bachelor degree programme, involving midterm, practical and final theory examinations. After completion of course work, students attend RAWE and pass Experiential Learning Programme to complete requirement of Bachelor degree.

The ICAR has improved the quality of education at post-graduate level by introducing written comprehensive examination conducted by an external examiner at the M.Sc. level, and after clearing the comprehensive examination, students can defend synopsis, present results and submit thesis for evaluation by an external examiner. At the Doctorate level, both written and oral comprehensive examinations are essential and after that the students can defend synopsis, present results and submit thesis for evaluation by two external examiners

Teaching

Earlier teaching material used was only notes prepared by the teacher, but at present, in the age of electronics, a large number of options have been evolved for effective teaching. And a teacher can generate information bank, slide bank and question bank. Regularity by the teacher in taking the classes and by the student in attending the classes is most important for quality education. Conventional way of teaching by chalk-duster is very effective in certain cases; however, this is being replaced by electronic presentation. The limit of credit hours per semester is fixed for all such three degree programmes. Generally high percentage of attendance and regularity in classes may certainly improve quality of teaching.

In agriculture, most of the courses are practical's-oriented. Practicals and undergraduate teaching should be preferably performed by senior teachers as they are expected to have clarity of basic fundamental issues and acquaintance of instructional farms and laboratories. For effective teaching following modules can be considered: (i) Development of information bank of the subject; (ii) Updating of class-notes by the teachers; (iii) Preparation of teaching manuals; (iv) Development of instructional farm; (v) Development of slide bank and PowerPoint presentation; (vi) Preparation of manual for research and thesis writing; (vi) Development of question bank.

Education and research

There are four different classes of research - basic, strategic, applied and anticipatory. For enhancement of quality of education, there should be concomitant enhancement of research quality. In most of the agricultural disciplines applied research is having upper hand, and there is lack of basic and strategic researches. Most of basic and strategic results and information have been exhausted, and in many disciplines, there is an urgent need to undertake research in them. Each department/institute needs to establish activities milestone of different topics and establish information bank, which should be used by post-graduate students as well teachers and scientists. This will generate great knowledge to enhance quality of teaching. Many departments have a large number of national and international projects and students are associated with these projects. This gives good financial support to Ph.D. students and also enhances quality of research.

Education and extension

The Indian Council of Agricultural Research has established 630 Krishi Vigyan Kendras (KVKs). Their main activities are to impact training to farmers, to conduct on farm trials and to promote frontline demonstrations. There are certain other activities which can be linked with KVK such as crop cafeteria, Technology Park and promotion of innovative technologies. Crop cafeteria and Technology Park will give a great strength to farmers, students, teachers and scientists. Almost all varieties and technologies, irrespective of location, are delivered to nearby KVK, which can be easily accessible to all concerns. Students, teachers and scientists must know the rate of spread of technology on the farmer's field as well as the promotion of marketing of certain products. For this E. Rogers (1962) model of diffusion of innovations is important to all concern students, teachers and scientists. ATIC, PPP, ATMA and IVLP are also serving in transfer of technology and other extension activities.

Students counseling and placement cell/centre

There are number of students' welfare activities like campus interview, competitive examination, industry linkages and placement, and such cell look into these activities in the university. At many places evening classes are also arranged by these cells for preparation of competitive examinations. Placement cell is enriched and equipped with all kinds of information which are in the interest of students.

International and national conferences

Many institutions/universities organize congresses, conferences, seminars, group discussions, series lectures at the international and national levels on different topics. This is one of the activities to enhance quality of students and teachers.

Infrastructure facilities

Infrastructure facilities available for the students and teachers are the basic requirements for quality education. Academic organizations should have well established and enriched following facilities: Enriched library facilities; Upgraded classrooms; Equipped seminar rooms; Well-furnished ICT centre; Well-equipped modern laboratories; Students' academic museum; Well planned instructional farm; Students counseling and placement centre; Stadium and gymnasium (sports complex); Students' hostel facilities; Guesthouse facilities

Some universities and institutes have established good infrastructure facilities. In the country, there is a fast change in the development of academic infrastructural facilities, and in this ICAR, Education Division is playing an important role. Regarding library facilities, constant support is given by the ICAR to purchase textbooks for graduate students and CERA facilities for post-graduate students, teachers and scientists. It is being realized by many students and teachers that there is no substitute for hard copy, which should be made accessible to all concerned, besides electronic library facilities.

Some organizations have upgraded classrooms which are equipped by electronic system; similarly seminar-rooms and ICT centres are also well equipped. For high quality practical and research, laboratories are to be fully equipped. Recently Council has given financial supports for academic museum. Instructional farms, which are important for quality practical classes, are still lacking at several places. Regarding sports complex, recently ICAR has supported stadium and sports facilities for university on the region basis.

Regarding students' hostel and guesthouse facilities, priority needs to be given to girls' hostels. Considering the revised course curricula, it is important to set-up facilities like Academic Staff College or Teacher Orientation Center in some universities/ institute, where orientation programme for teachers is to be organized periodically.

National Knowledge Commission

Main objective of this commission is to raise the status of education in the country. This has recommended to improve the infrastructural facilities especially, proper maintenance and functioning of library and laboratories, change of curricula once in three years and to attract the talented teachers. The ICAR has taken initiatives to implement the recommendation of this commission to improve quality of education and research.

Publications

This is an important activity of the university or institute to meet requirements of quality education, research and extension. Scientists/ teachers of many universities are bringing out good research publications in the international and national journals. Continuous efforts are needed for upgradation of the quality of publication by students, teachers and scientists, as high impact factor of all the publications are being considered to measure quality work and merit of students, teachers and scientists.

Spirituality and Higher Education

For this, teachers have a great responsibility for moral and character building of the students, so that student's life should be more transparent and meaningful. All the universities and institutions should have the course on Spirituality, Ethics and Human Value. Value and Social Responsibilities (VSR) is an important component of education. The components of VSR are Yoga, Pranayam, Jeevan Adarsha and Shramdan etc. which should be followed regularly. Swami Vivekanand has written a book on "The Road to Wisdom" where there is a sharp reflection of education towards wisdom. According to Swami Vivekanand (1989), education is not the amount of information that is put in your brain but has life building, man making, character making and assimilation of ideas.

Accreditation

Three-tier system of accreditation has been introduced by the ICAR in which departments, college and universities are the components. The duration as decided for accreditation is 5-10 years. Institutional requirements of accreditation are for academic programme, faculty, physical facilities, financial resources, teaching, research and extension education activities etc.

Linkages

Establishing linkages with agribusiness sector and networking with the national and international organizations will give good exposure to students. There are spectra of institutions associated with higher education at the international and at the national level, and linkages with such institutions would be highly beneficial. State agricultural universities, Central universities, private universities, universities outside the country, ICAR institute, CSIR, Government sector UGC, DST, private sectors and nongovernmental organization and farmers may be considered for linkages. They may support agriculture education, and depending upon the need MoU (Memorandum of Understanding) can be signed.

Impact of Quality Education

Education and knowledge are the major forces for development and enlightenment of the society. Higher education in agriculture has made significant contributions to provide qualified human resource in various organizations. This has led to bring out tremendous increase in production of foodgrains, horticultural crops and animal sector, witnessing first green revolution, yellow revolution, golden revolution, white revolution and blue revolution etc. Considering food, nutrition, employment, economic and social security, food security has been ensured by producing 252 million tonnes of foodgrains. Per capita availability of foodgrains, fruits, vegetables, milk, eggs, and processed foods has increased considerably which has led to increase in quality of life and life expectancy. Besides food production, tremendous improvement has been made in the breeder seed production and planting material. There has been spectacular growth in higher education to develop a legitimate knowledge society and knowledge economy. This may be because of tremendous growth of agricultural education in the public sector. Now private sector is also coming forward for undertaking higher education in agriculture to create impact in the country.

Now it is a matter of debate as to whose responsibility is to maintain the quality of education, whether policy-makers, administrations, universities, teachers, society or students? It is, in fact, a joint responsibility of all stakeholders.

Future Strategies

- Institutions involved in higher agricultural education should redefine their mission taking into consideration the present status of Indian agriculture. Effective mechanism for impact assessment and evaluation should be devised, including accountability.
- The present practice of creating multiple universities out of existing and well-functioning university in the name of specialization and on the basis of region should be seriously looked into for overall impact, instead of taking a simple route of dividing an existing institution.
- Considering challenges being faced by the Indian agriculture, student-faculty ratio in academic institutions, updated course curricula, and overall complexity of agriculture scenario; it is an acknowledged fact that there is a wide gap between required and available faculties in the academic institutions. The vacant posts should be filled up and where there are no vacant posts, new posts should be created and filled up according to the requirement for the subjects.
- Initially, most of the SAUs had adopted a progressive policy in recruitment of teachers as well as admission of students, which enabled cross-fertilization of ideas and enhancement of academic standards. Gradually, inbreeding and lack of proper linkages

among academic institutions have resulted in deterioration in quality of teaching and research (NAAS, 1999). Hence, the appointing authority of Agricultural Universities/Institutions should think in national perspective rather than regional basis for staff recruitment and for admission of students.

- ❖ In many States there are more than one agricultural university and to establish coordination and bring out efficiency a State Agriculture Education Council (SAEC) should be established.
- ❖ Various parameters of the quest for excellence in higher education should be analyzed, and accordingly national action plan should be prepared to address issues, especially of employment, economics and social security of the village, scope of small-scale industry, rural entrepreneurship, vocational education and women empowerment.
- ❖ Higher education in agriculture in the past achieved satisfactory growth owing to the funding it received from the Government. However, looking at the present scenario, more financial support is needed in higher education.
- ❖ A course on spiritual, ethics and human value should be made compulsory at the UG and PG level.
- ❖ Social and behavioural science components need to be given specific emphasis in view of the understanding of the interdisciplinary problems of the farming community.
- ❖ In many departments there are large numbers of basic courses but no competent teacher. Therefore orientation programme for teachers is a must on the pattern of UGC academic staff college. Many universities have engaged teachers on contractual basis; this also does not meet requirements of quality teaching, and should be discouraged.
- ❖ There is a wide gap in the quality of agricultural graduates and post-graduates and thus there is a need to develop strategy to minimize this gap. There are many graduates and post-graduates from different organizations; they are not competing at the national level test, they must be brought out in the main stream at the national level test.
- ❖ Scientists and teachers in the agricultural universities should be more trained through summer-institutes/refresher courses so to be better equipped for assigned tasks. Facilities available for training in advanced countries through bilateral and multilateral agreements should also be availed.

- Country is producing 24,000 graduates, of which Crop Science is contributing approximately 66%. While analyzing additional manpower requirement in future, expected number is 9,335 in Agriculture, 7,153 in Horticulture, 1116 in Forestry, 3005 in Dairy, 4989 in Veterinary and Animal Husbandry, 2181 in fishery, 1749 in Agricultural Engineering and 305 in Agricultural Biotechnology. In view of this, there is an urgent need of increasing seats for admission at the graduate and post graduate levels.
- To train and educate women in the country is the major task to strengthen rural sector. Therefore establishment of women study centres aimed to empower women will give real service to rural sector. Higher education in agriculture has set its mind to serve largely villages to make them self-contained through village industries with rural resources.
- International co-operation has played a significant role in strengthening research and teaching in Indian agriculture. Many developed countries have also benefitted from these linkages. Institutions involved in higher education of agriculture in India would have to ensure that there are proper linkages with international organizations as per the requirements.

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Monitoring and Evaluation of the ICAR Grants to Agricultural Universities—New Initiatives and Innovations

C. Devakumar

The Education Division of the Indian Council of Agricultural Research carries out coordination and determination of standards in the institutions for higher education relating to food and agriculture including animal husbandry and dairying, the mandate of the Department of Agricultural Research and Education, Government of India. Since early sixties, various initiatives and innovations such as need-based financial support, capacity-building, roadmap for partnership, Model Act of the agricultural university, common course curricula, accreditation mechanism, etc. have been underway. Further, Monitoring and evaluation (M&E) of the system of higher agricultural education in general and various schemes in particular is of paramount importance in the development and strengthening of the quality of the functions of the universities in general and higher education in particular have been introduced.

Fundamentals of Monitoring and Evaluation

Monitoring is a systematic collection and analysis of information as the project progresses. Its aim is at improving efficiency and effectiveness of the project or organization. It is based on the targets set and activities planned. It helps in keeping work on track, and the management can know when things are going wrong. If done properly, it is an invaluable tool for good management, and provides a useful base for evaluation. It enables one to determine whether the resources including human capital are optimal and are being used to the maximum, and whether one is doing what is planned.

Evaluation on the other hand, is the comparison of the actual project impacts against the agreed strategic plans. It evaluates at what one had set out to do, at what one accomplished, and how one accomplished it. It works out the results of the project aiming designing of the future projects.

Although the term "monitoring and evaluation" is used in conjunction as if it is only one, they are, in fact, two distinct sets of related but not identical organizational activities. Monitoring is performed while a project is being implemented, with the aim of improving its design and functioning while in action. It is "an internal project activity, designed to provide constant feedback on the progress of the project; the problems it is facing and the efficiency with which it is being implemented". M&E can assess the extent to which the project produced intended impacts and reached to benefit target groups, and can also evaluate cost-effectiveness of the project as compared with other options. What monitoring and evaluation have in common is that they are geared towards learning from what one is doing and how one is doing it, by focusing on: Efficiency, Effectiveness and Impact.

Efficiency suggests that the inputs (in terms of money, time, staff, and equipment etc.) into the work are appropriate in terms of the output. *Effectiveness* is a measure of the extent to which a programme or project achieves specific set-out objectives. *Impact* shows that whether the project / programme made a difference to the problematic situation being resolved. In other words, did our strategy work?

Proper impact analysis will enable pursuing further scale-up and replication of the projects elsewhere. It must be noted that M & E tools are not *per se* a solution, but are valuable to identify problems and their causes; suggest possible solutions to problems; raise questions about assumptions and strategy; analyse processes and pathways of progress; provide us with information and insight for remedial and causative actions and also increase probability of making a positive development difference.

Good M&E design during project preparation is a much broader exercise than just development of indicators. It must encompass the following.

1. Clear statement of the **measurable objectives** for the project and its components, for which indicators can be defined.
2. **A structured set of indicators**, covering outputs of goods and services generated by the project and their impact on the beneficiaries.

3. **Provisions for collecting data and managing project records** so that the data required for indicators are compatible with existing statistics, and are available at the reasonable cost.
4. **Institutional arrangements for gathering, analyzing, and reporting project data, and for investing in capacity-building**, to sustain M&E service.

The M&E plan should have the following.

- ❖ Describe implementation strategy including participatory M&E, and estimate personnel needs for implementation (along with training needs);
- ❖ Specify use of M&E by project managers for reporting implementation progress, and discuss ways in which M&E system will contribute to planning for improved project impact;
- ❖ Explain how those who gather and use M&E information will have a voice in refining M&E system, indicators and decision-making;
- ❖ Adequately incorporate results and Impact Management System (RIMS) guidelines;
- ❖ Make coherent distinction between 1st level results (outputs), 2nd level results (outcomes) and impact;
- ❖ Establish a balance between quantitative indicators and qualitative information at all levels;
- ❖ Ensure narrative M&E Plan is fully consistent with logical framework.

Project cost tables should include an M&E sub-component under the project management with appropriate line items (such as personnel, field visits for regular monitoring, three impact surveys, etc.). M&E costs should generally approximate 3 - 5% of the project budget.

Recent examples of innovations

Some of the initiatives introduced in the XI Plan period by the Education Division have been strengthened with the arms of the M&E, outlined as follows.

- ❖ **Special and institutional grants:** From time-to-time, these grants are being announced in the Union Budget to certain agricultural universities for strengthening their research and higher education capacity. So far, 13 universities have benefitted from this. To make this scheme effective a concept of an Oversight Committee has been built for regular monitoring of its implementation. This has been found useful in meeting M&E objectives.

- **Niche Area of Excellence:** The main objective of this is to build on the already established niche areas in certain departments of the universities to become centres aimed at priming these centres to reach level of excellence in teaching, research, consultancy and other services. And the level of excellence should be capable of updating itself with the best of global experiences and trends and should be responsive to regional, national, social and economic needs. The basic elements of this scheme are quality of human resource available; adequate infrastructure; access to latest information; attitude and commitment of faculty, staff and students; recognition and interaction with best of the peer groups in India and abroad; shared vision and well-developed educational technology system. As a mid-course correction, at the 4th year of this scheme, peer review mechanism was introduced right at the evaluation stage of the proposal and at the annual review meetings. Robust guidelines have also been put in place and are accessible online. This has helped in the field of M&E of this scheme. Over, 75 such centres have been created and given opportunities for upgrading their capacities. Some of the centres are maintaining exclusive web pages also; attracting attention of the global community.
- **Data management - National Information System of Agricultural Education Network (NISAGENET):** This network was initiated in the X Plan but was abandoned thereafter. It was revived in the mid-XI Plan to provide a unified information system for collection, compilation and analysis of data of the activities of the agricultural education system in India. The NISAGENET acts as a single Window Information Delivery System, and is an effective solution to check overlapping and parallel flow of information from the same university, but from different sources. An independent information system operational at the SAUs/Organization level complements as a useful tool for agricultural education data management of the university and its affiliated/constituent colleges. Given the progress of this network, it will be an effective solution for various stakeholders, from common man to administrators and managers, and will act as a comprehensive information source of the Indian agricultural education system and HRD in agriculture with benefits such as creating a process for university/college level decision support system at the universities level and also a tool for decision making for agricultural education, research, development and manpower

planning helping planners, policy makers, administrators and others. As a part of M&E exercise, capacity-building of the nodal officers at the college level through customized workshops including data validation process has been completed. In addition, the existing system of management has been streamlined with the provision of guidelines and coordination. A case in point is the function of the Board of Management (BOM) of the university: As per the Act of the university, there is a provision for the ICAR's nominee in the BOM. To make nominations effective, guidelines have been formulated. This has equipped the ICAR's nominees in facilitating effective monitoring of the ICAR development grants.

- **Merging Rural Agricultural Work Experience (RAWE) and Experiential Learning Schemes (EL):** The RAWE scheme, began as a pilot study in 1979 to give a real-time experience of working in the rural milieu and gaining valuable insight and plough-back leads for relevant research for development, has now become a part of course curriculum for the UG programme with the recommendations of the 3rd and 4th Deans committees. Two review workshops on each of the scheme were organized involving stakeholders and many of the recommendations that emerged are being suitably incorporated. A Task Force is revisiting the EL themes and schemes. Meanwhile, one of the overarching recommendations is to merge them into a single scheme with an attractive name of Student READY so that the scheme prepares and equips students with rich rural experience and entrepreneurship skills.
- **Independent evaluation** of any centrally sponsored scheme has become the accepted norm, and a High Power Review Team consisting of proven academic leaders has been constituted to study impact of the ICAR development grants provided during the last two Plan periods and to suggest future course of action for improving the impact. The Team has developed a robust set of monitoring indicators, visited randomly chosen constituent colleges, and interacted with the faculty and students and key functionaries of the universities to gauge progress and future roadmap.

The Government of India is geared up to meet quality standards of governance and performance evaluation. The recent initiatives for achieving Sevottam compliance by organizations having a citizen interface such as Citizens Charter, Clients Grievance Cells, the instruments of Results Framework Documents (RFD) for each of the Department augur well.

Experience with Implementation

- Even with a good design for M&E, **success during implementation depends heavily on a sense of ownership by the staff, adequate capacity in the institutions, and sustained interest from the task leadership throughout the life of the project.**

For monitoring and evaluation (M&E) systems to be meaningful, several underpinning conditions for system design need to be fulfilled.

- All stakeholders must be involved, and their information needs specifically addressed.
- M&E should be seen as a key management tool to track implementation progress and improve project planning for impact rather than an exercise in data collection.
- Simpler M&E systems tend to be more effective.
- Formulation Reports of all investment projects should include a summary of the M&E plan, which should be supported by details in an Annexure. There should be a direct link between the project's logical framework and the M&E plan.
- Balance between quantitative indicators and qualitative information is necessary at all levels. A small set of objective, quantifiable indicators should provide the base of evidence around which qualitative information can complete the explanatory framework.
- M&E need not be expensive or complex, and can be customized to suit specific needs of a project or a programme. The tool kit of M&E must be incorporated within the project design itself to perform the following services:
- **Provide constant feedback** on the extent to which the project is achieving its goals.
- **Identify potential problems** at an early stage and propose possible solutions.
- **Monitor the accessibility of the project** to all sections of the target population.
- **Monitor the efficiency** with which the different components of the project are being implemented and suggest improvements.
- **Evaluate** the extent to which the project is able to achieve its general objectives.
- **Provide guidelines** for planning future projects.
- **Influence sector assistance strategy**. Relevant analysis from project and policy evaluation can highlight outcomes of previous

interventions, and the strengths and weaknesses of their implementation.

- **Improve project design**. The process of selecting indicators for monitoring is a test of soundness of project objectives, and can lead to improvement in the project design.
- **Incorporate views of stakeholders**. Participation by project beneficiaries in design and implementation brings greater ownership of the objectives of the project and encourages sustainability of project benefits. Ownership brings accountability. Objectives should be set and indicators selected in consultation with stakeholders, so that objectives and targets are jointly agreed upon. The early success helps reinforce ownership, and similarly early warning of emerging problems allows timely action to be taken before the costs escalate.
- **Show need for mid-course corrections**. A reliable flow of information during implementation enables managers to keep track of progress and adjust operations to take account of experience.
- **Proposals** for the ways in which M&E findings will be fed back into decision making.

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Monitoring, Evaluation and Accountability in AR4D

Mruthyunjaya

Principle

Investment in any portfolio or in any activity should result in impact and performance. To ensure impact and performance, systematic prioritization, monitoring, evaluation and accountability are required. Prioritization helps maintain focus. Monitoring helps in mid-term or on-course corrections/adjustments, and evaluation helps in future investments. And accountability ensures open communication and reporting on the results obtained, and use of inputs for the outcomes. The act of P, M, E and A within AR4D system is a reflexive practice that catalyzes experience-based learning underlying all technical and institutional innovations. Attention to P, M, E and A is, therefore, required critically in the AR4D systems to have information to answer important questions, how policy and investment in research, education and innovation processes have achieved or surpassed their objectives, how do stakeholders know that scarce resources for innovation are allocated and managed effectively, what lessons about institutional adaptations are informing new technical changes, and how can assessments strategically inform future decision-making and interventions.

Practice

Every institution under the ICAR and the State Agricultural Universities has formal or informal mechanisms of monitoring most of its research programmes. The results of a study to review existing monitoring mechanisms in the NARS have indicated that the mechanisms are highly varying, weak in mandate, composition, periodicity, instruments and lack well-defined indicators of monitoring and effectiveness (Sharma et.al.2003). The result outcomes of monitoring are not very explicit and clear (Mruthyunjaya and Ranjitha, 1998). Even in externally-aided projects, which are generally well-monitored, M, E and A is rated as low (Mruthyunjaya, 2009). As compared to monitoring, evaluation of research projects in the AR4D is further weak; mostly internal, informal, less -rigorous and use of results is unclear (World Bank, 2012). In view of the generally weak documentation and communication skills in the NARS, accountability also remains poor. A review of the efforts to institutionalize PME system in the NARS at the time of completion of the NATP (2003) indicated that main reasons for poor performance of the PME system then were the lesser clarity and limited blessings from the top management on the PME, lack of the PME skills in the NARS, lack of resources and lack of interest among the agricultural economists to engage in PME activities in the institutions (Bisalaiah, 2004). The experience of further interest and investment in institutionalizing PME system and PME culture under the NAIP (2006-2014) is also not encouraging. Thus, there is apathy, less commitment and underinvestment on P, M, E and A in the AR4D. Among other reasons, P, M, E and A is also inconvenient, and therefore, generally resisted (Jha, *et al.*, 1995; Jha and Kumar, 2009). It is mostly considered as a necessary evil. But it is said that it has failed but it must succeed soonest.

Proposal

In view of the higher investment, complex research agenda to address challenges including climate change, economic shocks, energy crisis, serious shortage of human resource both in number and quality, it is imperative that P, M, E and A system should be strengthened and streamlined to cover research, education and extension activities by overcoming continuing systemic weaknesses. Let the message of seriousness on P, M, E and A be conveyed to all by making M, E and A to be mandatory and dedicated, and budget support for it should be ensured (at least Rs 5 to 10 lakh for each institution for 5 years). It is welcome that ICAR has decided to establish PME Cells by amalgamating similar bodies in all of its institutions. But the mandate and composition of these are not in order and hence needs relook. It is also important that proforma, process should be simple, should cover only key performance parameters and M&E should never be overdone as it may become counter-productive. Every EFC Memo of the ICAR institution during

12 FYP should have a clear cut M&E and improved documentation and communication framework with quantified base line as insisted while approving NAIP sub-projects, and every institution should come out with an evaluation report by an externally appointed team of suitable experts at the end of the FYP. The M&E proforma developed by the NCAP may be appropriately used. Let this report be used for future planning and investment along with the QRT report which also is planned/to be planned to coincide with the end of the FYP. But the system has to strengthen PME skills in the system by liberally supporting/funding agricultural economics discipline in the system by creation of posts, and national and international trainings to motivate agricultural economists to undertake PME work, incentives and suitable changes in the assessment/recruitment system are necessary.

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Achieving Excellence in Agricultural Education through Development of Competency

B. Raju, S.B. Dandin and S. Alur Ashok

Though agricultural education was intensified greatly during the Green Revolution, today it fails to match the present-day requirements. Course curricula revision, infrastructure, student intake, entrepreneurship building and employability are the issues of concern. In addition, there are challenges for suitable production and competitive market of agricultural produces in the globalised world. Hence, agricultural education and extension activities need to be changed to meet emerging issues and recent global challenges of unemployment, competitiveness, climate change and sustainable development. Moreover, modern agricultural practices are increasingly turning out to be knowledge-based and gaining expertise in them is not an easy task for many of our farmers. Thus "Leaders in agricultural education must be able to synthesize technical agricultural information and plan programmes to help solve problems associated with energy, productivity, and world trends in agricultural industry" (Shin and Cheek, 1981). On the other hand, the academic side of the profession should not be overlooked, "agricultural education be further developed as a profession. We need leaders in our profession who will work together in charting a new course for future. We need leaders in our profession who will work together in charting the nature of our program... this intellectual discussion and debate will require of us that we become academicians and philosophers" (McCracken, 1983).

Agricultural universities in India are facing serious problems of quantity and quality of investment, establishment costs averaging about 87% and leaving hardly 13% for operation purposes. Further, the number of faculty personnel in the agricultural universities has markedly declined; on an average only 50 % strength of the total faculty position. There is also a problem of inbreeding. Majority of the farm universities are not fully achieving the purpose of their existence and the human resources development programme has not kept pace with the demand, especially in terms of quality. Hence, some immediate measures are desired, such as increased allocation of resources, quality assurance and accreditation, faculty up-gradation, adopting ICT in teaching, promoting networking in higher education and review of Center-State relations in higher education, besides setting-up of the National Agricultural Education Council.

Major Challenges Faced by Agricultural Education, Research and Extension

Integration of research-education-extension is envisaged as the main strength of SAUs. But, the synergies are sub-optional, and extension is the worst sufferer (Warner *et al.,* 1996). The knowledge generated by the research gets often obsolete by the time it is disseminated through education / teaching, and finally trickling down to farmers and practitioners through extension after a big time lapse. In economic liberalization and WTO regime, there is a demand for manifold reorientation in agricultural education and extension system by harnessing benefits of new scientific advances in biotechnology, cloning, remote sensing, modeling, information and IT for farmers and rural communities. E-Extension or Internet-aided extension networks have to be materialized by strengthening KVKs and RSKs, which are nerve centres for dissemination of technical know-how. There is a need of change in extension from Transfer of Technology Mode to Technology Application Mode by initiating group approach and farmers' participatory approach. Inclusion of community-based producers' interest groups/organizations, training of self-help groups and extension through rural location-specific knowledge centres should help technology refinement and adoption. Extension education and training must be need-based and problem-solving and should strengthen skill-based vocational enterprises for self-employment for farmers, farm-women and rural-youth. Present-day Agriculture is shifting to commercial farming and agri-business mode. Formation of commodity-specific extension kiosk on indigenous food, horticultural crops, livestock, poultry, bee -keeping, mushroom, medicinal and aromatic plants, and sericulture, tea and value addition enterprises would lead Indian Agriculture towards profitability and sustainability. Distance education for farmers and small agri-entrepreneurs need to be explored and strengthened through television, radio, interactive audio and video systems, besides print and programmed learning materials.

There has been a dilution in the quality of agricultural education with mushrooming of agricultural universities and colleges with inadequate infrastructure, financial support and autonomy. Dilution in quality has mainly been due to imbalance in academic staff structure. Recruitment policy and also policy of freezing new recruitment needs to be reviewed, as presently about 40-50 % of posts are lying vacant. Centralized planning of Agricultural education system and curricula is not addressing local needs to the required extent. There is a need for establishing more Central Agricultural Universities like IIT's. Rural students need to be encouraged to study in agricultural universities. Steps may be taken to promote such admissions because urban-based agricultural graduates are not so comfortable in rural environment. Market-oriented agricultural education and extension along with changes in agricultural marketing policy for national and international markets is the need of the hour. A cadre of social scientists with clear insight into agricultural related disciplines, such as agricultural economics, agri-business, marketing management, rural sociology, agricultural anthropology, agricultural ethics and politics, needs to be built up to provide back-up for resolving problem of globalization in agriculture. This implies total reorganization of agricultural education with emphasis on agriculture related social sciences and effective agricultural policy research. Such a re-organization will empower agri-graduates and scientists to face challenges posed by national and international markets.

Aim of Higher Agricultural Education

Upgrading institutions of agricultural learning to world-class institutions of higher learning through balancing international academic standards with national needs and local identity and culture is essential. The focus on higher agricultural institutions should manage their separate and collaborative programmes and resources in a coordinated manner to create Agriculture human resources in the context of current concerns for the development of national knowledge economies and "higher agriculture education for the knowledge economy."

The aim should also be to develop agriculture through science and education and to enhance the awareness of innovation. Economic creativity is driven by quality of 'technology linkages', and 'knowledge flows' among and between economic agents. Thus an effective agricultural innovation requires a network of inter-institutional linkages involving actors across the whole value-chain from concept to adoption and realization. Thus, to bridge this gap, new ideas and methods and crucial measures are required to bring about major breakthroughs in agricultural science and technology.

Technology innovation strategy in the agriculture sector requires an integrated, systemic and participative approach in the management of agriculture among all stakeholders:

(a) Government, to establish and implement a national (also regional) policy/strategy conducive to an "enabling environment" for all stakeholders to adequately play their role,

(b) Scientific/Technical/Higher Education Communities, to generate "agricultural technology packages," to diffuse and to share relevant knowledge among students and practitioners, as well as to sensitize societies, and other stakeholders on innovations and new research achievements in agriculture and related branches,

(c) Economic Enterprises, both private and public, to transform "agricultural – technological - packages" into goods and services to be absorbed by local, regional or international markets,

(d) Funding Agencies, such as agricultural banks, to assist in investments in programmes for agricultural primary production as well as for processing and adding value to agricultural crops and products, and

(e) Civil societies, such as consumers or ecologists associations, to watch on and alert on people's rights and interests protection.

Targets Groups for Institutions of Higher Agricultural Education

The important target groups are: (a) Agri-business and industry community, (b) Farmers community, (c) Agriculture policy-makers, (d) Public community, (e) Research and development community, and (f) Agriculture education community.

Agri-business and industry community

Institutions of higher agricultural education should focus on addressing needs of industry workforce, ranging from (a) attracting and preparing young people for agricultural careers, (b) providing in-service training for agricultural workers in the industry, (c) establishing linkages with relevant private and public agricultural agencies, (d) addressing local needs and adapting curricula to employment needs, (e) integrating or closely collaborating with research and extension; to be open to professional environment and make use of resources from private sector.

Farmers' community

Institutions of higher agricultural education must play a developmental role by (a) establishing close links with farming communities (farmers and farmers institutions) to develop an agricultural education and training system that can constantly improve scientific and cultural qualities of farmers, and (b) research and dissemination of best practices and case studies that illustrate contribution of education to sustainable agriculture, rural development and food security.

Agriculture policy-makers

Agriculture institutes must contribute to community development by (a) improving their service for policy-makers and by contributing in placing agricultural education at the core of regional and national development agenda and by (b) training policy-makers and managers for rural development, food security, natural resource management and sustainable agriculture.

Public community

Agriculture institutes must encourage (a) growth of outreach programmes, (b) greater institutional involvement in rural development of the surrounding communities, and (c) setting public awareness programmes about sustainable agriculture.

Research and development community

The institutes must (a) conduct research and development for industry, (b) create their own spin-off firms, (c) involve in capital formation projects such as technology parks and agribusiness incubator facilities, and (d) introduce entrepreneurial training, and encourage students to transform research into enterprises. The agriculture learning institutes should gradually be transformed into (a) technology development organizations of science-knowledge based enterprises or enterprise groups and (b) agricultural science and technology and information intermediary consultant organizations.

Agriculture education community

The institutes should promote (a) agricultural education programmes that are job-oriented and meet actual needs of communities, regions and countries (b) agricultural education systems including youth education, adult training and continuing education in a co-ordinated way to make best use of facilities, equipment and staff.

Elements of Improving Agricultural Education

To improve agricultural education quality focus should be on (i) regular reforms in curricula (ii) teaching methods and technology and (iii) promoting strong agricultural research and development

Curricula reforms

They are essential to create an adaptive generation of professionals and 'work ready' graduates. Agricultural universities and constituent colleges need review of subject-matter content critically and plan courses to fit various opportunities and to address problems and issues pertaining to sustainable enhanced agricultural production and rural development.

Teaching methods and technology

The Distance Education System could be an ideal tool to deal with the challenges faced in institutions of higher agricultural education, including accessibility, quality and cost with aim to create effective human capital. Distance Education System can help accomplish needs of on-job people and/ or those unable to get enrolled in the conventional system of education. It may also deal with the unsuitability of the conventional learning schedules in agriculture.

Promoting agriculture research and development

The research is currently not delivering the type of knowledge required by end-users, especially private sector and farmers, as it doesn't embody traditional and indigenous knowledge. Tertiary agricultural institutions must be at the forefront of the change process with more focus on regionally-focused, demand-driven approaches. Advances of ICT, BT, and nanotechnology are prominent among current and future technological options for improving agricultural productivity. The expanding role of biosciences in development illustrates need to build scientific and technical competencies in functional genomics and bioinformatics to resolve disparities with regard to scientific knowledge, skills and technologies that divide our country from the rest of the world. This has to be accomplished by improving institutional frameworks wherein scientific investigations are undertaken as well as capacities are build of scientific personnel. Greater improved competency is required for managing intellectual property. New systems of knowledge creation and diffusion that take into consideration needs and experiences of the client are required.

Transforming Agriculture Learning Institutes into Centres of Excellence

Actions for this mainly include, (a) curricula development that is locally relevant and adopts multidisciplinary approach, (b) development of online directory for agricultural education resources, (c) developing independent and local need-driven agenda for research and development, (d) setting-up intelligence system for promoting investments in agriculture sector, (e) establishment of agribusiness incubators, (f) setting-up "Initiative for strengthening capacities in agriculture policy-making," (g) setting-up Agropedia--an online repository of agricultural education for all.

Locally relevant and multidisciplinary curricula development

This will produce graduates appropriately trained for local employment, and not for US or European market. Thus curricula must include cutting edge sciences / technologies, viz. Agro-biotechnology, Agro-nanotechnology, Agro-information and communication technologies, Agro-space technology, and Natural Resource Management. Increasing attention must be given to theory and practical aspects of Forest Sciences, Desert Science, Earth science, Sustainable farming practices and livestock management, Agricultural indigenous knowledge, Role of private investment in agriculture, Awareness on credit facilities to farmers, Use of water resources, Marketing infrastructure and technology, Role of effective agro-processing techniques, Flood and drought management, Soil and water testing laboratories, and Laws and regulations in agriculture.

Online directory for agriculture education

The online repository aims mainly to provide teachers and scholars who don't have access to relevant and updated agriculture scientific information with the necessary tools and means to present science to students in an effective way. Such initiatives include "Science Super Course Project" of Bibliotheca Alexandrina in Egypt that was launched in January 2009. It is an attempt to improve access to science education in developing countries by targeting a total of 100,000 Golden PowerPoint lectures from scientists worldwide within a year, and one million in three years. Another example is the initiative called Blended Learning Open Source Science or Mathematics Studies (BLOSSOMS) to produce low-tech videos for classroom use in a bid to motivate developing countries students to pursue careers in science, mathematics and engineering. The Massive Open Online Courses (MOOCS) hold great promise. Yet another initiative is the Mainstreaming Environment and Sustainability in African Universities (MESA), which comprises more than 77 universities and sub-regional networks, and has developed over 65 university courses that facilitate practical approaches to applying environmental knowledge in fostering sustainable development. For example, the African Network of Agriculture and Forestry Education is working with agricultural universities to develop learning materials based on indigenous and local agricultural knowledge. Such schemes will eliminate 'ivory tower' universities which are detached from the environmental realities in their locality.

Suggestions for Achieving Excellence in Higher Education

- Food processing, storage, marketing and resource management have become increasingly important to agriculture producers, and thus for agricultural education.
- In the recent years, the pace and quality of technology generation and human capacity building in most of the agricultural universities has slackened(need to be uplifted), mainly on account of inadequate public funding in several states, lack of even minimum strength of faculty in certain disciplines/faculty, inadequate faculty development programs in new and emerging areas, lack of incentives and rewards, extensive inbreeding in regard to student-intake and faculty recruitment, lack of modern infrastructure for education, research and farms, unmindful opening of new state agricultural universities and colleges without adequate financial resources.
- The policy issues relating to higher education in farm sector mainly include: Empowering ICAR with regulatory powers on the pattern of the UGC and AICTE; Involving Vice-Chancellors of the farm universities in the state's planning process for agriculture; Facilitating regular interface meetings between the ICAR, farm universities and the state governments; Providing greater

autonomy to farm universities and their constituent colleges and providing enhanced budgetary support from both Centre and States; Starting of new farm universities/colleges to be linked with assured funding, human resource and other physical resources; Ensuring compliance with ICAR's quality assurance policies, criteria and procedures, strengthening accreditation and quality monitoring capacity and adherence to ICAR Model Act /Norms; Constantly enhancing management capacity and improvement in administrative processes in farm universities.

- ❖ Promoting public-private partnership in agricultural education; establishing separate division at the university level to build capacities of the faculty, creating specialized programmes for faculty capacity enhancement apart from increasing system's internal efficiency; and Strengthening priority setting, monitoring and evaluation capacity at different levels.
- ❖ Expanding of agricultural education through increased capacity for students' intake; increasing number of constituent colleges; Attracting and retaining bright brains in agricultural education and research; Encouraging more participation of rural students; Facilitating interest of pass-out students to be involved in farming and related enterprises; and Restructuring and modernizing graduate/postgraduate/doctoral programmes including curricula revision in various specializations.
- ❖ Promoting of academic excellence in critical/emerging areas at the postgraduate and doctoral levels apart from strengthening of PG research; Establishing Centres of Excellence on priority and focusing on niche areas of excellence; Initiating certificate, diploma and vocational training in open and distance mode of education; Initiating agricultural learning at the school level.

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Quality Check for Postgraduate Research

Gursharan Singh

The quality scientific manpower is an indicative of the progress of a country. To meet challenges of the 21st Century, all the developing nations including India should be investing for generation of required human resource with the requisite expertise in different areas of knowledge.

The ancient centres of Education at Takshila and Nalanda were well known for excellence in education. The Nalanda University was the oldest university-system of education in the world, imparting education in at least 18 arts, including agriculture.

Modern higher education in agriculture in the country was initiated with the establishment of the Imperial Agricultural Institute in 1905 at Pusa, Bihar, which was later shifted to New Delhi due to catastrophic earthquake in 1936. However, the agricultural education got the real impetus in the sixties following Land Grant System of the USA; and in 1960, the very first State Agricultural University (SAU) was established at Pantnagar, in the erstwhile Uttar Pradesh, now Uttarakhand.

At present, higher education scenario is not satisfactory in the country across the multiple dimensions. An important factor which impacts the quality and the quantum of postgraduate research is the scarcity of competent and dedicated manpower committed for research. The country requires qualified doctorates for research laboratories to teach and engage in research in the universities, apart from the trained human resource to work for research and development in all sectors of the industry.

India's higher education system is the third largest in the world, after China and the United States. According to a UNDP report, in

2008, India's overall outlay for R & D was 0.8 % out of its gross domestic product (GDP) in comparison with China's 1.2 % and USA's 2.7 %.

Our higher educational institutions suffer from large variations. As per Nasscom-Mackinsey Report (2005), not more than 15 % of graduates of general education and 25-30 % of technical education are fit for employment. Apart from this, access to higher education and equity are other areas of concern. In 2002, number of researchers in India was only 112 per million inhabitants compared to 633 in China and 4,374 in USA. The growth in number of doctorates has been only a modest 20% in India from 1991-2001 compared to 85% in China. Not only the number, but also the quality of the thesis in India is average or below average.

Generally, Ph. D. Students are required to do three things towards completing their doctoral work. First, conceptualise an idea or thought/hypothesis. Second undertake scientific experimentation to collect inferences. Third, present the results in context of contemporary and known knowledge in the field. In SAUs, hardly 1% of the thesis thus submitted get rejected and almost 100% of the candidates get their degrees in the very first attempt. On the contrary, in the US universities even under highly favourable conditions, only three-quarters of PhD students complete degree programme (Krull, 2010).

To address all the above issues to ensure quality postgraduate research, relevant points are discussed below along with the suggestions.

Prioritizing Areas for Postgraduate Research

While deciding the research areas of priority, it needs to be ensured that required infrastructure and expertise is available. In general, a scrutiny of theses/dissertations produced in a discipline / department would reveal that often different specialized researches are conducted under the supervision of the same advisor. Such a practice is mostly followed to give an easy access to the student for obtaining a degree. The major advisors/supervisors need to define long-term research goals for students' guidance in conformity with the thrust areas of the discipline, and preferably they should restrict their guidance in their own area of expertise / specialization. Website of each university should contain details of relevant fields of research where expertise/guidance could be offered. This will give prior information to students. The Punjab Agricultural University has defined the 'broad topics of research' for each faculty member wherein they will guide postgraduate students. This will ensure worthwhile research outputs; and at the same time it will help a teacher to update/strengthen his/her expertise. Out of all the patents filed by the PAU during the last three years, more than 50 % are from the PG researches and also about 37 % publications from PG research are of high quality (NAAS rating 6.0 and above).

Nurturing Undergraduate Students

It is a common observation that only after the student is admitted into a master's programme, he/she starts thinking about the area of research. Sometimes a student may later realise that he/she has chosen a wrong area of study, but then it is too late to shift to the other field. It is very important for the concerned teachers to know the interest/aptitude/potential of the students during graduation with an eye on those who could be potential researchers. In fact, a good undergraduate teaching programme is must for grooming prospective students towards research. Our present education system is largely unimaginative and monotonous with a stress on rote-learning and research problems are often handed down to students. There is an urgent and immediate need to initiate wide ranging reforms that encompass pedagogy of teaching, curriculum and evaluation, which are a prerequisite to nurture and inspire students for undertaking meaningful research.

Screening for Doctorate-level Programmes

The procedure of entrance examination being practised in most of the universities (including the SAUs) may be viewed as satisfactory, but the same yardstick for admission to Ph.D programme may not be appropriate since for doctorate level entry more weightage needs to be given on the aptitude and attitude of the students towards research rather than merely considering marks/ranks obtained in the master's degree. In fact, the entry level screening for the doctorate programme should be such that only those interested in research should be admitted. Some suggestions are as follows.

- Instead of formal interview or entrance examination, presentation of the 'Synopsis of the Research Problem' prepared by the candidate, before the selection committee, should be the main criterion for admission to a Ph.D programme. The candidate will be required to propose the name of the supervisor/guide (from the faculty of the concerned discipline) or outside co-supervisor/co-guide (in case of collaborative PG programmes), who will preferably be present at the time of the presentation for comments/support of the proposed research programme. Considering relevance of the research proposal, availability of the necessary infrastructure and the expertise, the committee should take the decision. Of course, other aspects of merit of the candidate, such as publications/ patents may also be considered. Adoption of this procedure will avoid the casual candidates.

- ❖ Provisions should also be made for online evaluation of candidates for Ph.D admission to attract foreign students also. Narrow boundaries of the subjects also need to be abolished and possibilities for lateral entry across disciplines should also be explored keeping in view the integrated approach towards a research problem. While admission to a doctorate programme, preferably select those candidates whose proposed research projects are extensions of their master's work.

Incentives to Make Research a First Priority

Lack of opportunities coupled with financial unattractiveness, has made research obviously a secondary choice. The situation is really gloomy when there is inappropriate or little reward after spending prime years of life in pursuits of academic ventures. When we expect that only the interested students shall opt for research as a career, there is also an urgent and immediate need to make financial packages attractive to pursue doctorate programme. Following are suggestions in this regard.

- ❖ Fellowship/scholarship should be sufficient to support independent living in a hostel or outside the campus, and there should be regular upgradation with rise in the cost of living. To add to their earnings, teaching assistantship to bright students should be made available. Engagement of the doctorate students (under guidance of the senior teachers) as part-time teachers will resolve shortage of faculty. There could be other part-time engagements for the students within an institution as well. The Punjab Agricultural University (PAU), Ludhiana, has already taken initiative in this direction by employing students in the library on hourly basis. The recently announced 'Prime Minister's Fellowship Scheme for Doctoral Research' whereby DST and CII have announced a scheme to provide double scholarships to Ph.D students; is the step in the right direction.

- Possibility to seek financial assistance from the industry under collaborative research projects should be explored/utilized. The PAU has some such collaborative programmes, e.g. Syngenta Crop Protection Fellowship; Monsanto Merit Fellowship and Bharati Field Fresh Fellowship. Sand-witch degree programmes can provide both the financial assistance and the required research training.
- To facilitate travelling of students to attend national/international conferences/workshops/training programmes, liberal travel grants should be earmarked.

Ensuring Expert Guidance/Capacity-Building

Undoubtedly, the quality/potential of the future researchers depends upon the training they had been given as doctorate students. Competent faculty of an institution is in fact the backbone of any educational programme. Faculty must keep on updating their knowledge/skills to guide students attuned with national and global challenges. Measures should be taken to ensure that the faculty is provided with the required infrastructure and other facilities to create a congenial working environment. Teachers need to be awarded for innovation in teaching and research methods. The mentoring of young faculty with established scientists is must. Unfortunately, there are more professors in the Indian Universities than associate professors or assistance professors. However, one way out could be movement of the faculty across the disciplines to share knowledge and expertise. Provisions should also be made for free flow of faculty between industry and academia. Though majority of the SAUs including the PAU have signed a number of MoUs with various national/international universities/research institutes and industry to give a practical shape to this idea, but care needs to be taken to make them operational in letter and spirit.

Participation in conferences/workshops should be made mandatory for teachers, at least twice a year. How could one expect world-class research guidance from a teacher who did not have a single opportunity to visit or work in a reputed university or institute abroad. Provisions for the faculty to avail sabbaticals to work in the institutions of their choice relating to the area of their research should be ensured. Such facilities are, however, available in the SAUs and many other universities of the country.

The faculty should not be unduly overloaded with teaching of courses; the teaching should not be at the cost of research. Given to the serious shortage of faculty across institutions/universities, the practice of engaging contractual faculty has started but this will obviously affect the quality of the teaching since the new entrants will lack both expertise and experience, and may not be able to evince needed interest in the students. Some suggestions are as follows.

- ❖ In all the SAUs, it is mandatory for Ph.D students to pass some minimum number of courses as partial requirement for the degree, and this keeps students busy for about initial one and half years. In fact, the concept of having course work in the programme was started so that a student must know what latest is happeningin a particular field, especially when only hard copies of the journals were medium of knowledge. In the present circumstances when facilities for e-communication are available to facilitate prompt knowledge sharing, the relevance of formal advanced (600-series) courses in a discipline are not that important, and course work for Ph.D can be eliminated or curtailed. Reduction in course load would have corresponding increase in research component for PhD students. However, to keep the student abreast about the advanced/latest development in the discipline, he/she should present a seminar before the faculty in each semester on the emerging scientific concerns, and should be graded accordingly. A student will have to give a minimum of 6 seminars to fulfil doctorate degree requirement.
- ❖ It often happens that different departments of a university/ institute offer courses with overlapping contents. To avoid duplicity and to reduce teaching load, such courses can be taught jointly by cross-listing them among relevant disciplines; this integrated approach of teaching will broaden student's vision of subject. On these lines, the PAU has implemented revised PG course curricula, wherein, more than 50 courses of different disciplines in the University have been cross-listed.
- ❖ e-delivery of lectures should be encouraged, particularly in courses which are common to all or to the majority of the students; this will reduce course load of teachers. For instance, a course entitled "Intellectual Property Management, Biodiversity and Biosafety", mandatory for all the postgraduate students of the PAU, is offered through e-delivery. For content e-delivery, services of retired dedicated faculty should be utilized. Caution needs to be exercised while engaging the contractual faculty. The door must not be shut tightly for recruitment of new faculty. Simply, not to recruit faculty in the garb of financial crisis, will not be a wise step. The society needs to be educated about the significance of education;

when people are ready to donate liberally for religious proposes, they can/should also be motivated to do the same to strengthen the exchequer of any educational institute/university.

Synopsis Writing of Research and Thesis/Dissertation

Synopsis of Research is probably the most important part of a PG research programme; this is like the foundation of a building. The student and the major advisor/supervisor are required to critically select area, or more precisely the topic of research keeping in view its rationale/relevance/demand to emerging national/global challenges utilizing cutting-edge technologies for execution of technical programme of work of the research problem. A critical review of the available literature is the prerequisite for defining 'knowledge gaps' and formulating Objectives of the Study. The PAU had taken lead among all the SAUs by writing a separate booklet entitled "Guidelines for Writing Synopsis of Research and Thesis/Dissertation by the Postgraduate Students" in 1998, which were subsequently revised in 2008. These guidelines are loaded on the local portal of the University website.

Monitoring Research Progress

Periodic monitoring of progress of various experiments must be made by the supervisor, and if needed changes can be made in consultation with the members of advisory committee. There should also be provision for comprehensive mid-term evaluation of the research progress, particularly of students pursuing doctorate research. A log-book should be maintained in each laboratory to facilitate monitoring of a student's work progress. Similar record with respect to field experiments can also be maintained. Monitoring of the research work of a student should be such that no possibilities of plagiarism are left. Moreover, the Department should be equipped to detect plagiarism and take timely action.

Evaluation/Assessment of Thesis/Dissertation

In India, and many other developing/under-developed countries, evaluation of thesis is seldom a serious business, which is the major reason of poor quality of PG research across various universities/ educational institutions. Some suggestions for the evaluation/ assessment of are as follows.

- The competent authority in a university or institute should maintain a periodically updated pool of experts, discipline/ specialization-wise. From this pool are selected at least two examiners for evaluation of thesis/dissertation; one preferably from abroad of a reputed institute. After receiving satisfactory comments, the student will be required to present his work before the entire faculty in the presence of external examiner(s), advisory committee and the Director Resident Instruction/Dean, Postgraduate Studies of the university, thus mandating the open defence of his/her work. In case student fails to defend, there should be second defence. If the student does not succeed even in the second, then an honourable exit should be ensured.
- Submission of Ph.D dissertation should be allowed only after publication / acceptance of two research papers in the refereed journals (at least one in a journal of international repute). It should also be made mandatory that he/she should have participated in minimum of two national/international conferences and should have presented paper in one of these. The revised academic regulations for writing Ph.D dissertation have recently been implemented in the PAU, whereby the dissertation will be a compilation of published/ accepted research articles from student's research, leaving little scope for delayed publication of research work.
- It is very important to check plagiarism in the submitted thesis/ dissertation by applying appropriate software for identifying plagiarism. It can be facilitated by using websites which are particularly tailored to check plagiarism. Probably the simplest way could be to put the title of the thesis/dissertation and do a search on Google to find out the contents by title. In addition to those which can be purchased, free softwares are available for checking plagiarism. The Jawaharlal Nehru University has started checking plagiarism in dissertations submitted by using software, and any match found beyond 30 % of the dissertation is not accepted for submission. Reinforcing such practices in all the universities of the country will go a long way to produce quality degrees and competent human resource.
- From June 2009, the UGC has notified "minimum standards and procedure for awarding M.Phil and Ph.D degrees". The notification is hailed as a step towards regulating research. But till date, it has not been adopted by majority of the universities across the nation. One of the conditions laid down by the UGC was that soft copies of all M.Phil and Ph.D theses submitted to the varsities would be sent to the UGC to be hosted on the Information and Library Network (Inflibnet) Centre, Ahmadabad, designated as

the repository of research work. But the progress in this is not yet satisfactory. On the other hand, the ICAR had been successful in implementing common academic regulations in different SAUs of the country as per recommendations of the National Core Group (NCG) constituted for suggesting ways and means to revamp postgraduate education in the agriculture sector.

Collaborative and Integrated Postgraduate Research

It is of paramount importance that required collaborations be signed (MoUs) with the national and international universities or institutions relevant to the area of research. The PAU has signed several such MoUs where students from the University can conduct research in the foreign universities and *vice versa*. All universities should encourage PG students, especially those pursuing doctorate programmes, to spend a semester or so in research labs of reputed national or international universities to be exposed to latest techniques. It is also very important to facilitate linking of researchers at all levels. A comprehensive National Project and Research portal is needed and should be established for connecting students and researchers at all levels, facilitating formation of virtual peer groups, disseminating information related to various projects and schemes, and providing information of various positions for doctorates etc. Integrated doctoral programmes with provision of exit points at master's level and with flexibility of inter-disciplinary movement will go a long way in exposing students to vital research links and networking of the same to have new ideas

Another way out could be that collaborative research should be encouraged in the joint/dual degree programmes, where a student can select a Co-guide in some other university/institute thus breaking inbreeding. Inter-institutional research projects can still provide another solution to resolve inbreeding. The international exposure of faculty of an institute or university will also go a long way to alleviate inbreeding by updating competency of the faculty. The policy suggested by the ICAR i.e. training of 20 % faculty nationally and 4 % internationally each year in the best of institutes, should be made mandatory.

Library Facilities, Access to Online Journals/ Literature

Spending 6 hours in the library may save 6 months of the labour in the lab or field. Apart from hard copies of all sorts of books, periodicals etc, a library needs to be equipped with free internet access with online databases and online access to journals, e-books etc. The PAU has ensured all these facilities in its central library. to be emulated by others.

Hostel for Students

If we are really interested to have the best output from the students' research, it is of paramount importance to provide adequate hostel facilities to all the interested PG students, ensuring availability of internet facilities in their hostel rooms along with requisite canteen, common room and mess provisions etc. The students may not mind giving increased charges when the standard of the hostel facilities is up to the mark.

Research Ethics

Sound foundation in research ethics is critical for higher degree students to establish the usefulness and trustworthiness of research. Vallance (2005) gave a holistic definition of research ethics as "Research ethics are the guiding principles, based on values that esteem people and the growth of social structures, that promote and safeguard the integrity of all persons involved in the research: participants; gatekeepers; stakeholders; researchers and research consumers, to promote the good of all without sacrificing the interests of any, so that the research outcomes represent a progress worthy of time and resources expended".

Misconduct or unethical behaviour includes, fabrication or falsification of data, plagiarism and practices unacceptable to research community regarding proposing, conducting or reporting of research. There are at least three aspects in which traditional understanding of research ethics are deficient. They are: ethics limited to data collection; ethics limited to institutional demands; and ethics not linked to personal accountability. The ethical publication of research findings include due accord to authors, not submitting the same article to multiple journals, willingness to share data when requested; responsibility to reprint retractions if research outcome is later found unsubstantiated.

The research community in universities/institutes/organisations need to act firmly when the research fraud and cheating are discovered. Those acting as 'whistle blowers' to report a fraud or misconduct, should be respected and protected while ensuring befitting censures for the perpetrators.

Role and Support of State and Central Governments

Education seems to be nobody's child as is evident from the low priority given to this sector. Though the commitment and attempts of the central government to establish many central universities and other educational institutes is laudable, but to ensure quality standards therein, is an uphill task. There is a fear that due to opening of the central universities, the existing universities would become dysfunctional because of the exodus of experienced faculty to the central universities where the retirement age is 65 years instead of 60 years, Further, whereas the state universities are starved of funds and could not expand its facilities, the central universities would receive a huge chunk of finances hard to utilize. Here lies the role of governments, both the state and central, to ensure requisite funds to develop/strengthen infrastructure and recruit competent faculty. The trend of employing contractual faculty is not going to pay dividends since education is a serious business and should be dealt accordingly; how can a fresher be a substitute for an experienced teacher from regular faculty. To recruit duly qualified and competent teachers should be the prime agenda for ensuring quality education.

The establishment of private universities with attractive physical facilities but alarmingly poor expertise is another area which demands a serious thought and consequent action from the government. Such universities critically lack element of research and are with the sole objective of fulfilling course requirements by employing contractual or retired faculty. Mushrooming of these private universities is eroding the very essence of higher education.

Creative Environment for Young Researchers

All universities or institutions of higher learning must aim at establishing and fostering a culture of creativity, possibly culminating into innovation. Creativity manifests itself in the work that requires not only mechanical skills to produce it, but intelligence and imagination as well. To foster such creativity in a university or research institute, Krull (2010) has given following seven preconditions to be met.

Competence: To provide best training for future generation of academicians and to enable researchers to develop their skills as freely as possible.

Courage: Not only researchers, but also institutional leadership and funders must be courageous and adventurous. You can only encourage people to enter new fields and leave beaten track if you are prepared to share risks. The readiness to take risks must be complemented by a high degree of error tolerance.

Communication: Thought-provoking discussions are essential for achieving progress in research, in particular, cross-disciplinary and trans-cultural exchanges, and also interactions with the world outside.

Innovativeness: Those researchers who are prepared to take a risk with unconventional approaches need to be identified and encouraged. Academic leaders as well as heads of foundations and other funding organizations must appreciate unconventional approaches and encourage risk-taking by providing incentives.

Persistence and perseverance: To forge new paths in a barely known territory often takes longer than two or three years, the usual lengths of project funding. Mistakes as well as changes of direction must be allowed. To put it in the words of Albert Einstein: **"Two things are indispensable for our research work: untiring persistence and the readiness to dispose of something in which we have invested a lot of time and hard work."**

Diversity: Monocultures in academia do not provide an adequate breeding ground for exceptional thoughts. New knowledge is usually formed at the boundaries of established fields, so the interfaces between these areas of expertise must be activated. To be successful, it is essential to provide ample opportunities for all researchers to interact intensively so that new paths can be developed and breakthroughs achieved.

Serendipity: It is impossible to plan the precise moment at which a radically new idea emerges or a major scientific discovery occurs. The philosopher Ludwig Wittgenstein once said: "Sometimes we do not know what we are looking for, until we finally found it." But there are numerous examples in the history of research which prove that it is possible to establish a particularly stimulating environment more conducive to scientific breakthroughs than others. Although there is no one-size-fits-all kind of recipe we can apply, it is certainly worthwhile to try, and try again.

The readiness to listen to independent voices inside and outside of one's own institutional network, to encourage risk-taking in "off beaten track" areas, and to foster a climate of mutual learning are prerequisites for successfully establishing a true culture of creativity. This is the culture in which talented Ph.D students can truly flourish, broaden their horizon, and turn into visionary stewards of their respective discipline, who as researchers can freely embark upon inter-, and trans-disciplinary projects that have the potential to transform view of the world. It is by no means easy to achieve these goals. But we have no reason to fall into despair, as Albert Einstein said: **"Amidst all the difficulties, there is room for opportunities".**

Teachers' Commitment

Whatsoever academic guidelines or regulations are framed, there can be no productive outcome if a teacher does not realise or play his part well. Perhaps it is not appropriate to call teaching a profession, it is rather a mission resulting from the passion or urge within. A teacher's property is not the money he/she earns but the status of the students in their future life, whom he had taught. Qualities of a good teacher include empathy i.e. a sense of belongingness with the students, and a positive thinking and to keep smiling even when the things get tougher. He should always be open to change and willing to listen to others' ideas, exhibiting both calmness and a sense of humour. He/She must realise the responsibility of being a Role Model who is to inculcate true attributes of a researcher into his/her students. A teacher has no moral right to accept students for research guidance until he has the ability.

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Technical Session 5

Perspectives of Stakeholders in Transforming Agricultural Education

Technical Session 5, Chair Dr. G.S. Khush

Lending and Learning: Lessons from the World Bank's Experience with Agricultural Education

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Introduction

It may come as a surprise to many that the World Bank is not the leading lender for agricultural education and training (AET) projects and programmes. But that does not mean that the World Bank lacks interest in AET. The Bank has been a major supporter of the Agricultural Knowledge and Information System (AKIS) which consists of three pillars - Agricultural Research, Extension, and Education (Figure 1). In 1998, seeing that lending for AET was not very robust, the AKIS group in the Rural Development Department of the World Bank hired Anthony Willett to undertake a review of lending for agricultural research, extension and education during the decade 1987-1997. The results were quite startling and showed that in the ten-year period, World Bank lending for agricultural research came to about $2.5 billion; lending for agricultural extension was another $2.2 billion and, for education, a tiny $156 million. A later study on lending for AKIS projects in Africa by Ryngstad *et al.* (2005) reflected the same trend. Many wondered how the investment in education could be so low. The World Bank is an organization that lends for a wide variety of development projects and programmes. Like most bankcustomers, in this case eligible countries from among the approximately 182 member states, any can come to the Bank with a development idea for which there is a need for additional or supplemental financing. The Bank asks for a concept, a plan, which makes a technical, social and economic case for the proposed activity, and if that concept is sound, it follows up with a series of appraisals that culminate in a jointly produced project blueprint. A loan or credit can be made to finance this activity.

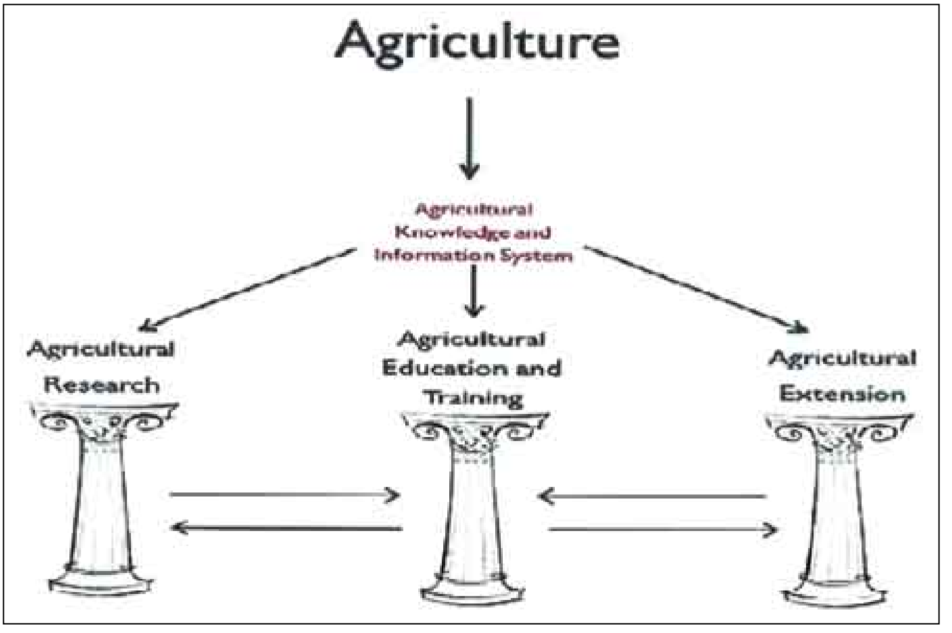

Figure 1. Agricultural Knowledge and Information System

We can say at the outset that over the years, the Bank has received few requests for support of Agricultural Education projects that fit the profile of what needs to be addressed in India lately.

Agricultural Education

The term is short and seemingly clear but behind the crisp descriptor is a complex model. So how should Agricultural Education be defined? It is the spectrum of academic, vocational-technical, and practical learning that provides the human resource needed to serve the agricultural sector and the rural space. This definition hints at a complex education and training matrix that covers a wide variety of audience in a number of learning environments (Figure 2).

The AET systems, depending on the particular country and its agriculture sector, vary in size and complexity. India has one of the world's largest AET systems.

Management of the Agricultural Education System

In virtually every World Bank member–country, responsibility for agricultural education and training is divided between ministries

Figure 2. Agricultural Education System

Source: USAID 2012

of education and agriculture and between agriculture and rural development. Universities and Vocational Education and Training Institutes are, after all, education institutions and fit neatly under the Education Ministry umbrella. Agricultural training for staff of the ministry of agriculture and for farmers and their families is largely the responsibility of the Ministry of Agriculture. Experience shows that different sectors whether in the public domain or in bi-lateral or multi-lateral agencies do not easily cooperate. Further, in the case of Agricultural Education, neither the education nor the agriculture agencies are staffed with people skilled with each other's specialization. Ministries of Education do not hire agricultural education specialists, nor do Ministries of Agriculture hire education specialists. This is a problem that has persisted for a long time world-wide and weakens the level of support for AET. After that quick profile of the AET system and its management structure, it is important to revisit the fact that the World Bank has, in the past, received only a few requests for AET projects.

The golden era of investment in AET

There was an era of greater interest and greater investment in AET.

Fear of widespread world hunger spurred investment in the sixties to eighties. During that time USAID emerged as the biggest investor with substantial additional support from multi-lateral and bi-lateral organizations (Box 1: India was a major beneficiary of the USAID investment programme that saw establishment of eight Agricultural Universities, modeled on the US Land Grant Universities. As will be recalled, world focus on agriculture waned towards the end of the eighties for a number of reasons. One was that the catastrophic world-wide shortage of food did not materialize and then there were other pressing development demands that included universal primary education, climate change, HIV-AIDS, malaria, and global

Box 1. Past investment in AET

USAID has been one of the leading investors in AET over the past half century, and its programme to establish Land Grant-type universities in Asia, Africa, and Latin America during the sixties remains the gold standard for AET institutional investment.

AET investment from 1950 to 2004 amounted to $1.631 billion (1999 $) (G. Alex, personal comm.). Over the same time period, research and extension investments totalled $5.988 billion and $2.951 billion respectively (in 1999 $). USAID, like other donors, reduced its level of investment in AET over the past two decades. During the same time period investment in agricultural research and extension also showed a decline but each of these categories outpaced investment in AET. This investment profile mirrors that of the World Bank in the 1987-1997 decade where the investment in agricultural research and extension amounted to close to $2 billion each and in agricultural education to a mere $ 156 million. It could be argued that USAID investments in research and extension contributed to education and training, but these investments were focused on specific research and extension goals, and not on AET system strengthening for networks of universities, colleges, vocational schools and training centers to prepare human resources for the overall agricultural sector and for work in rural development. Perhaps, some investments in research and extension supported capacity-building programmes that were weak because of the less than desirable quality of graduates being produced from all levels of the AET system

USAID April 2011

trade. Agriculture became lower profiled, and support and lending for agricultural projects dropped. Many development support organizations cut or did not replace retiring agricultural staff and the small number of AET specialists were also allowed to go. It seems un-necessary to conclude that this turn of events had an impact on AET project requests.

AET has had its critics

A large number of agricultural educators, agriculturalists, educators, and private sector observers highlighted weaknesses in the AET for the past 20-25 years, and advocated for change. A World Bank report: Cultivating Knowledge and Skills to Grow African Agriculture (2007) is particularly insightful in its review of African AET. From the critics, a short list of the most glaring weaknesses which, in the past, I have labeled the" seven deadly sins" can be assembled—Governance; Academic and stakeholder isolation; Political interference; Uncertain funding; Outdated curricula; Inappropriate pedagogy; and Lack of accountability

It is important to note that not all AET systems reflect all seven weaknesses. Some systems are effective and efficient while others run the gamut from fair to poor in terms of their achievement of their primary goal: the production of skilled human resources for the agriculture sector and the rural space. What must be kept in mind is that weaknesses in AET systems are not a new phenomenon but, regrettably, little progress has been made in bringing about sustained changes needed to alleviate them.

What's been done to improve AET?

What we know is that efforts have been made to tackle some of the items on the list of weaknesses: a new laboratory here; some teaching equipment there; curriculum revision; some staff or student scholarships; computers; a short twinning with an overseas institution; perhaps collaboration with the agricultural research department for a project; or funding of field visits for students. But, while these initiatives all have merit, do they get to the root of AET's fundamental weaknesses? Indeed one notable effort to bring about system-wide change was undertaken in India with the 1997 AHRD project. Other system-wide reform efforts have been undertaken in China and in Brazil. Newly created agricultural universities that are not in the public sector have developed innovative and effective educational models that meet the needs of modern agriculture. Among these is EARTH

University in Costa Rica (www.earth.ac.cr), which aims to produce "job creators rather than job seekers". These private universities are small but their programmes are innovative and progressive, and can serve to inspire those who would lead AET reform.

Concerns with the state of AET

Concerns about food shortages have heightened again because the world population forecast indicates continuing population growth that will reach 9 billion by 2025; climate variation cannot be ignored, and the world is witnessing extremes of drought and floods effecting breadbasket countries and regions; water is becoming a limiting factor in many countries; natural resources continue to be consumed at a non-sustainable rate; population shift from rural to urban continues and large urban areas presents special demands for constant fresh food supplies that are free from contaminants; improved standards of living in populous countries has increased demand for animal protein; input costs have risen reflecting rising prices for energy; there is a global competition for raw materials and for arable land; some staple crops are experiencing yield stagnation; and globalization of trade in agricultural goods and commodities presents both opportunities and challenges to producers, large and small. The agriculture sector has changed dramatically since the days of concentration on production. The sector has become more science-based, mechanized, commercialized, and market focused. AET has to adapt to these changes and the demands they make for skilled human resources.

There are additional concerns such as the failure of AET to attract the brightest secondary level students and the fact that, in many systems, older academic staff is retiring leaving gaps in the quality of teaching and learning capacity. There is little doubt that others involved with AET can add to the list of concerns. But the important thing is that one can imagine the implications of each item for the content and focus of AET and for those who exit from the AET system and are expected to work effectively in a modern agriculture sector and in the rural space.

However, there is an even a more urgent concern that should be a call to action in AET systems. That relates to skill packages or skill mixes that employers in general expect in young people who exit from degree, diploma and certificate education and training programmes.

What is the most important thing that a new AET graduate can bring to an employer? It is skills for the labour market, not just the agriculture sector market, but the market, in general. The complaint from employers in a number of countries is that graduates are not adequately skilled for the demands of the workplace. The World Bank has published three recent books that address this concern: Skills for the Labor Market in Indonesia – Trends in Demand, Gaps, and Supply (2011); Putting Higher Education to Work – Skills and Research for Growth in East Asia (2012); and Skills, Not Just Diplomas – Managing Education for Results in Eastern Europe and Central Asia (2012) with a common message: *higher education is critical for countries to maintain growth and register improvements in productivity because higher education provides the high-level skills and research to apply current technologies and to assimilate, adapt, and develop new technologies, two drivers of productivity. But higher education today does not sufficiently provide its graduates with the skills that firms need to increase their productivity. The quantity of higher education graduates is still too low for the labor market in some countries. More important than quantity, however, is quality. Across low-and middle-income East Asia, employers expect workers – particularly those with higher education – to possess the technical, behavioral, and thinking skills to increase their productivity and growth. They need science, technology, engineering, and math (STEM) skills. They also need the problem solving and creative skills to support a higher value-added manufacturing sector and the business, thinking and behavioral skills for a higher-productivity service sector. Employer perceptions and wage skill premiums point to gaps in all these groups of skills in newly hired professionals across the region.* (Summarized from Putting Higher Education to Work (2012))

A recent statement from a senior official in the Russian Federation puts the shortage of adequately prepared graduates in an economic perspective:

Today, business companies suffer from professional staff hunger. Every year, the Ministry of Education spends about 100 billion rubles on training professionals, while business has to spend about the same amount for retraining the graduates they employ. (Nikitin 2012 in Russia beyond the Headlines supplement in the New York Times January 2012) www.rbth.ru

World-wide attention to skills for the future

The Organization for Economic Cooperation and Development (OECD), concerned about the capacities of the future workforce, listed the following types of skills that would be required by graduates from the education and training systems in its member-countries.

- ***Basic skills and digital literacy:*** Reading, writing, numeracy, and the ability to use digital technology and access and interpret information in a knowledge-based society.
- ***Academic skills*** to pursue disciplines in advanced educational institutions such as languages, mathematics, history, law, and science.
- ***Technical skills*** required by specific occupations; these skills include academic and vocational skills and knowledge of certain tools or processes.
- ***Generic skills*** such as problem solving, critical and creative thinking, an ability to learn, and an ability to manage complexity.
- ***"Soft" skills*** such as the ability to work and interact in teams and heterogeneous groups; communications skills; motivation, volition, and initiative; the ability to read and manage one's own and others' emotions and behaviors during social interactions; multicultural openness for understanding and communicating across cultures; and receptiveness to innovation.
- ***Leadership skills:*** Building and leading teams, coaching and mentoring, lobbying and negotiating, and coordinating, with a clear understanding of ethical behavior; charisma.
- ***Managerial and entrepreneurial skills*** to put innovations into practice and enable organizations to adapt and respond in competitive environments. These skills are a mix of competencies related to leadership, communication, and self-confidence, aside from technical skills.
- ***Commercial aptitude*** and ***creativity*** for the generation of new ideas, linked to design and the transformation of ideas into new products and processes (OECD, 2010).

It is not difficult to see that the concern of the labour market, in general, is applicable to the agriculture sector labour market in many countries around the world. The quantity of graduates emerging from AET is, in many cases, too great for the labour market to absorb but a bigger issue is that when the agricultural labour market has vacancies the quality of graduates does not meet employers' needs.

It is worth recalling that twenty-five years ago the Report of the Joint Indo-US Impact Evaluation of the Indian Agricultural Universities in 1988, after praising the development of India's AET system cautioned:

However, given the state of flux in world agriculture, agricultural educational institutions world-wide need to be able to respond to a new and rapidly changing social, political, economic, cultural, ecological, and technological environment. The older purposes and objectives of such institutions are in question, calling not only for new purposes and missions, but for an examination of the very process by which missions are defined and implemented. The new world-wide challenge is to complement current orientations in agricultural production with an emphasis on productivity and sustainability as well as to move from a relatively stable to a constantly evolving mission.(USAID Project Impact Evaluation No. 68. 1988)

Importance of innovation in development activities

There has been universal recognition of the role of innovations in bringing about improvements in science and technology and their impact on health, communications, and agriculture (Box 2). The World Bank has been, and continues to be, involved with gaining a better understanding of how innovation works and how it contributes to agriculture sector development.

Agricultural Innovation

Agricultural innovation typically arises through dynamic interaction among the multitude of actors involved in growing, processing, packaging, distributing, and consuming or otherwise using agricultural products. These actors represent quite disparate perspectives and skills, such as meteorology, safety standards, molecular genetics, intellectual property, food chemistry, resource economics, logistics, slash-and-burn farming, land rights-the list is far too long to complete.

For innovations to emerge or to happen, interactions among these diverse stakeholders need to be open and to draw upon the most appropriate available knowledge. Aside from a strong capacity in research and development, the ability to innovate is often related to collective action, coordination, exchange of knowledge among diverse actors, incentives and resources available to form partnerships and develop businesses, and conditions that make it possible for farmers or entrepreneurs to use the innovations.

Agricultural Innovation Systems: An Investment Sourcebook (2012) Overview and User Guide p.3

To How can AET be more effective in meeting the human resource needs of the sector?

Most AET professionals will recognize some or all of the weaknesses of AET systems in their own or others' universities, ATVET institutes, and in diploma and certificate training centres. What will it take to correct these weaknesses?

The simple answer is that AET systems need to change but to bring about the needed change one should be clear about how the AET of the future should look. Table 1 summarizes where higher and system-wide AET is at present and where it needs to be in order to be relevant and effective.

The challenge of organizational change

AET professionals know that bringing about organizational or institutional change is difficult. Thousands of books and large numbers of conferences have been devoted to the process of change but it still remains one of our greatest challenges. The World Bank has a lot of experience with projects that attempted to bring about civil service reform, education systems reform, university reform, health service reform and financial systems reform. The results of these interventions are mixed for reasons that will be discussed in terms of AET reform.

Table 1. Current and potential future directions of agricultural education and training systems

Higher agricultural education now	Future directions
Weak, unenforced, or absent policies	Clear AET policies with responsibilities defined and enforced
Weak governance	Strong governance inclusive of stakeholders
Little autonomy	Autonomy that enables staff decision-making, financial control, and standards setting
Uncertain funding	Steady and regular funding guaranteed
Isolation	Academic, rural community and stakeholder connections established and maintained
Programs not accredited	Accreditation the norm

Contd...

Table 1 contd...

Curriculum now	**Future directions**
Outdated	Updated and current with stakeholders' needs
No stakeholder input	Stakeholder consultations; input solicited and incorporated in changes. Stakeholders participate in governance.
Teaching	Learning
Theory	Theory and practical application
No student attachments	Regular, organized, and supervised attachments
Inappropriate pedagogy	Effective pedagogy tailored to subject matter and learner needs
Little use of external teaching resources to augment in-house-capability to broaden knowledge and skill base	External resources used in team teaching to expand knowledge and skill pool
Little use of information communications technology (ICT)	Use of appropriate ICT the norm
Technical training now	**Future directions**
Heavily supply driven	Mostly demand driven
Managed by the public sector	Managed through public–private partnerships
Poorly qualified and remunerated instructors	Qualified and fairly remunerated instructors
Qualifications not certified by professional bodies	Certification ensured
Equipment in short supply and outdated	Equipment/practice areas obtained through public–private partnerships
Management of human resources now	**Future directions**
Weak human resources management leadership	Qualified human resources managers and trainers
Selection of trainees not based on need	All selection based on need and future tasks
Training needs assessments are not undertaken	Needs assessments are standard procedure

Contd...

Table 1 contd...

Little supervisor/manager involvement	Supervisors/managers consulted and involved
No evaluation of trainee performance on the job	On-the-job performance measured
Trainers not trained to instruct/teach	Qualified trainers standard

Source: Author, in Agricultural Innovation Systems: An Investment Sourcebook 2012

Organizational reform prompters that may lead to change

- The realization that the *status quo* is not good enough. In the case of AET, this realization may come from feedback from stakeholders, or from observation, or from inputs from visitors or staff-members, who have been to other AET organizations or conferences.
- The presence of a leader who is convinced that change is in the best interest of the organization and its stakeholders.
- A vision for the future of the organization.
- The ability to convince others inside and outside the organization that the goals of the vision are obtainable and worthy of support.
- The tenacity of the leader to see the change process through to the end.

Essential elements that support institutional reform

Martin Jischke, President, Iowa State University and President of the Global Consortium of Higher Education and Research for Agriculture (GCHERA), offered some key observations on the elements that support AET change.

- The need for reform is externally driven;
- Many trends are universal;
- Context is always local;
- Individual leaders make a difference
- Awareness (of the need for change) is quite uneven across the globe
- International partnerships are essential
- External resources are the key driver of reform

- ❖ Current patchwork of organizations is insufficient
- ❖ Reform can and must be accelerated

(Leadership for Higher Education in Agriculture 1999. GCHERA Inaugural Conference, Amsterdam)

Principles that drive educational change

A list of principles that guide the change process in higher education is offered by Rick Foster of the Kellogg Foundation, an organization that has been a major supporter of AET in the USA and abroad.

- ❖ In order to change a system, you must start everywhere at once.
- ❖ Change must be value based and vision driven.
- ❖ When people and institutions finally realize that change is imminent, they will look for new models to replicate and emulate.
- ❖ Diversity and inclusivity are essential for innovation and creativity.
- ❖ There must be a critical mass (but not necessarily a majority) for change to occur.
- ❖ Technology enables change to happen more quickly.
- ❖ Change must occur within the resource structure of the institution-not just from philanthropic funds.
- ❖ For institutional change to occur, policy must be impacted, capacity built, and budgets reallocated to new and more relevant programmes.
- ❖ Knowledge exists in every community, in higher education as well as in business, government, and the people we serve.
- ❖ There is strength and power in collaborations and partnerships that allow complementary solution-finding rather than competition for scarce resources.
- ❖ The role of public higher education is changing (Richard M. Foster, 1999).

Identifying key AET change priorities

It would be difficult to argue that reforming AET is an easy task, but successful attempts assure us that it can be done. What, then, are the most important steps that need to be taken to bring about real change in AET systems? Although every case in every country will differ, and although it is hoped that new ways will always be found to make AET more effective, the following list gives an indication of the range of options for reform and the issues that often prove to be the most important.

Develop a policy framework

A major change priority is to seek policies from government to guide AET, enable it to develop effective education and training strategies, and provide it with high visibility in sector and national development planning and implementation. This reform alone has wide implications for AET, as well as major implications for inter-ministerial cooperation, financing, and stakeholder involvement. Specific investments to develop a policy framework might include facilitation of interagency dialogue, technical assistance to help draft policies, consultations with affected parties at draft policy stage, and policy launching where all key stakeholders are represented.

Support wide-ranging, systemic reform

Once the policy framework is in place, AET system reforms are the next major priority. Such reforms enable universities and other institutions of higher education to clarify their roles in relation to the educational system, to their stakeholders, and to the wider needs of the agricultural sector. Then they can make the necessary adjustments to governance, administration, curricula, pedagogical methods, provision of in-service and life-long education for graduates and civil society, and partnerships and links with stakeholders, including the private sector.

In this “inside-out” approach to reform, the system itself (and especially the tertiary institutions) undertakes the reform process from within and reaches out to stakeholders to measure expectations and satisfaction with existing programmes. Gaps between the supply, content, and quality of education and training and demand in the labour market point the way to reform measures.. Investments in system reform, especially at the university level, must support internal dialogue, interaction between the educational institution and those who make policy and decisions, stakeholder consultations, analysis of gaps between stakeholders’ expectations and current academic programs, formulation of the reform strategy, a schedule for its implementation, and the related costs. External facilitators are required to manage the reflection process, carry out the needs assessment, formulate the reform strategy, and determine the final reform agenda.

Change what is taught and how it is taught

Very often it is a priority to invest in reforming curricula and teaching methods—in many instances, such changes are long overdue. Course-work will include practical as well as academic knowledge and skills. Traditional teaching methods will be replaced by a learning approach that enables students or trainees to discover and internalize knowledge and skills and thus equip the AET system with people who know how to communicate and share their knowledge with others. Potential employers of graduates from the AET system consistently report that they seek (and often do not find) problem solving skills, the ability to listen, the capacity to analyze situations, and familiarity with information technology (including computer applications), among other skills

In-service training: Continue investing in human resource

In-service training is a reform priority for continuing enrichment of human capital for the sector. Continuing training and learning (life-long learning) maximizes use of already acquired knowledge and skill, adds lessons of practical peer experience, and expands human capacity by introducing new and updated technical and social information and knowledge. Well-managed, high-quality, flexible in-service training and learning for public, private, and civil society clients expands a network of people in the innovation system with relevant information and knowledge. In many cases, they gain specific skills in communicating more effectively and supporting others in assessing the suitability and viability of agricultural innovations. AET systems, generally, have not fully developed their potential to offer in-service training and life-long learning programmes.

Tap the power of information and communications technology

Investments in academic staff capacity building and infrastructure that enable information and communications technology (ICT) to facilitate learning and research, improve delivery of subject matter, and support global and local networking and communicating are critical for effective interaction within an education system and the agricultural innovation system (AIS). The ICT revolution has vastly increased the flow of information and ideas throughout the rural space. It has also increased stakeholders' expectations of AET graduates, who should be familiar with a range of ICTs and use them to communicate technical and managerial information to others in the broad agricultural sector and the AIS. The *ICT for Agriculture Sourcebook* (www.ICTinagriculture.org, http://bit.ly/ICTinAG) shows how widely ICT is being used to provide advisory services, capture and disseminate market information, and facilitate research, learning, and communication.

By bringing clarity to new material and offering a refreshing approach to the teaching/learning environment, ICTs can enrich learning. Despite the evolution of traditional lecturing to interactive, student-centred learning, many AET systems still operate in a "chalk and talk" era. Some systems of higher agricultural education rely on dated lecturer's notes as the only teaching aid, and some vocational technical programmes cannot provide students with an opportunity to practice on equipment or use laboratories as they learn. Even when teachers and instructors are willing to use ICTs, budgets are insufficient to have necessary equipment, or unreliable supplies of electricity make use of the technology difficult. Investments in institutional or curriculum reform for tertiary agricultural education, agricultural TVET, or in-service training should include provisions for introducing and/or updating selection of ICTs and training staff to use them.

Meet recognized standards for quality

Investing in accreditation or certification provides universities and training institutes an incentive to raise their academic quality to recognized standards. Investments that develop close working relationships with preeminent educational institutions are another means of raising academic standards. For institutes of higher education especially, these alliances lead to collaborative learning programmes involving information sharing, staff and student exchanges, and joint research. The local institution, its staff, and its graduates gradually become much stronger contributors to sector development and the AIS. In India, the ICAR has led the movement for accreditation of agricultural universities with the goal of setting and maintaining quality of education.

Summing Up

AET is important not only to the agricultural sector but to both urban and rural areas. However, AET, for a variety of reasons that relate to governance, links to stakeholders, autonomy, financing, and teaching methods is weak. Yet, the critical role of AET is again being recognized as reliance on the agricultural sector to contribute to feeding the growing world population while finding ways to adapt to external pressures from a variety of sources. Change in AET is no longer a choice. There are a number of key elements that must be present if successful AET reform is to take place. A selection of the most vital is considered below:

Leadership

University reform needs leadership. AET needs a person or persons who have a vision for the direction and the contribution of quality human resources for the sector and for the rural space. The leader or leaders have to be able to articulate their vision to others both inside and outside the institution. These leaders have to have the time to see their vision implemented. Magrath (1999) suggested that:

Reform in any university anywhere in the world cannot occur unless there is a vision passionately believed in and furthered by leaders. If we want change or reform, it will not happen casually or simply by it's bubbling up within a university. There may be ferment for change within a university and a desire for adaptation. But change will not occur unless there are leaders willing to step up and step out and provide direction and articulate a vision that can unite men and women to work for needed change, building on the accomplishments of the university and its history, but pointing unequivocally to the future

An interesting aspect of AET reform leadership is related to the tenure of leaders in the system. How long does it take to bring about reform? There is no real formula that can forecast the time it takes to bring about desired change and to ensure that it is sustained. A number of studies around the world show that senior staff tenure ranges from four to six years. Is that enough time to make a difference?

Supporting team

Once the vision for change is articulated the leader or leaders need a supporting team to begin and sustain the necessary reform steps. This team should be representative of the stakeholder group.

Incentives to change

It is well known that organizational change creates winners and losers among academic and administrative staff so any change effort has to anticipate supporting measures for both categories

Institutionalization of change

Once changes have been agreed the challenge is to make them sustainable. This means that changes need to have the rules and regulations in place to make them official and recognized by AET management at all levels. Institutionalization of change includes the allocation of funds to ensure that the changes are supported.

Accountability

An AET organization that espouses change will recognize that change is not a one-time event but a process that has to be continuously revisited to test for the relevance and effectiveness of its programs

AET Institutions have to expand their educational reach

AET is operating in an era of dramatic changes in the agricultural sector; an era of evolving climatic impacts; an era of declining natural resources especially water and arable land; an era of urbanization that creates new demands for supply, quantity and quality of agricultural products; and an era of concern about food safety, pollution, and zoonotic diseases. There is a massive demand for both in-service and life-long education and training that AET systems can meet. Higher agricultural education institutions must strengthen links to other parts of the AET system for the agriculture sector, while dependent on research to create new knowledge, needs to adapt and apply this knowledge, develop improved technology for production, processing, and distribution, provide farmers, farm families, farming communities with opportunities for building skills and management capacity, and represent agriculture to civil society. This critical role cannot be effective if higher agricultural institutions remain focused on only part of their mandates.

Commitment to change

It is clear that to embark on a change process is a serious institutional decision that must be preceded by clear communication of the reform vision. The decision to reform must be agreed by all stakeholders and there needs to be continuous feedback as the process continues. Earlier in this paper there was reference to the India AHRD project that appeared to set the wheels of AET reform in motion in the late

1990s. The project completion report undertaken by independent evaluators indicated that:

In hindsight, the project was over-optimistic in assessment of capacity and readiness of the government and implementing agencies. Many of the assurances obtained at negotiation did not materialize within the agreed time-frame. The capacity of implementing agencies to identify their priorities and needs, and make workable annual plans for procurement, financial management and training, was over-estimated.

Governance

AET suffers from a major governance problem. The divided responsibility for AET between different sector ministries; lack of authority to hire and fire staff; unevenness of financing; failure to link with stakeholders; and a general lack of accountability for the effectiveness of graduates make it difficult for AET systems to be robust. The dissatisfaction voiced by stakeholders for the quality and effectiveness of AET systems creates a situation where stakeholders begin to look elsewhere for human resources to meet their workplace needs.

Learn from the success of other institutions

Leading an AET change initiative can be a lonely and stressful process. It is important, therefore, to review and analyze the success of other institutions that have successfully undertaken reforms. Fortunately, there are such examples from countries ranging from the USA, China, Brazil, Japan, and Egypt. Presentations by representatives of some of these changes will have been made at this Congress and a number of them have been detailed in Module 2 of the Agricultural Innovation Systems Investment Sourcebook (www.worldbank.org/afd/ais). Reformers can also benefit from looking at the programs of innovative new-style universities such as EARTH University, Costa Rica (www.earth.ac.cr) where a small university is preparing human resources for the complex agricultural sector of the future. Finally, if Indian AET reformers need to confirm their belief that change is needed in higher agricultural education they should carefully read the recent book by professors Tamboli and Nene that pinpoints problems with the present system and offers clear pathways to bring about desired improvements.

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Agricultural Education for Women: Needs and Challenges

Krishna Srinath and H.K. Dash

Education is an important component of human development, and higher level of human development is crucial for socio-economic development of any country. In developing countries like India, which suffer from many development ills such as low per capita income, high proportion of malnutrition and poverty, poor health and low productivity, improving access to quality education for boys and girls, men and women is considered a major strategy to create momentum towards higher and sustainable development. While talking of sustainable development, the role of agriculture becomes very critical. Lately worldwide, as also in India, revitalizing agriculture has become an important goal of R&D planning to achieve higher and sustainable growth, to address issues related to food and nutritional security, to meet changing food needs and demands of people, to strengthen farm-nonfarm linkage and to make agriculture attractive and remunerative.

We have evidences from across the world clearly establishing significant role of women in agriculture, persisting gender gaps in access to various resources, knowledge, services and opportunities and their consequences for women and agriculture. According to a study, had they enjoyed the same access to productive resources as men, women could have boosted yield by 20-30 %; raising overall agricultural output in the developing countries by 2.5-4.0%. This gain in production could lessen number of hungry people in the world by 12-17 %, besides increasing women's income (FAO, 2011). Now, not only is the global community awakened to the challenges facing women, but also is joining hands for collective action to address gender issues. Of several interventions, promoting agricultural education among women is considered an effective strategy to harness untapped potential of women and promoting gender mainstreaming in agriculture.

Agricultural Education and Women: Scenario in India

Over years, emphasis has been laid at the policy level on girls' education from time to time. Importantly, measures have been taken to provide more opportunities to girls and women in vocational training (including agriculture) and non-formal education. However, there has been no exclusive policy on agricultural education for girls and women in India. At present, agricultural education is a formal education being imparted largely through Agricultural Universities.

Every year, admission into various courses for UG, PG and Ph.D. in Agriculture, Animal Husbandry, Fisheries, Agricultural Engineering, and Home Science are held by universities that attract students from all-over India. What is heartening is that percentage of girls' enrollment in agricultural courses is increasing steadily, and in 2012, girls constituted 36% of the total students in agricultural universities. In many agricultural universities, girls' enrollment in certain courses, particularly agriculture, crossed 50% mark. Unfortunately, there are no worthy initiatives at the national and the state level to take agricultural education to rural women who are the key stakeholders, and who would perhaps be the prime agents for sustaining future agriculture in India.

Agricultural Education for Rural Women—Why?

About 833 million people constituting 68.84% of India's population live in rural areas. Of the total rural population 405.17million i.e. 48.6% are female (Govt of India, 2011). It is this population that mostly supports Indian agriculture. Much of the future scenario of agriculture would depend upon the attitude and the capacity of the rural population. If current labour dynamics in agirculture are any indication, more and more are likely to migrate from agriculture to non-agriculture sector. In this situation, can we pin our hopes on women, who are today looked upon as the saviours of agriculture? If at all women are to assume a more important role and serve as vibrant partners for agricultural growth, equipping them with scientific knowledge and modern technology should form the integral part of the broad agricultural strategy. Moreover, as rural women have to perform their triple roles — reproductive, productive and community management, their capacity to balance these roles is critical to achieve efficiency in the work place and at home. In this context, agricultural education has a very imortant role to play. And agricultural education for women would have a transformative role in agriculture and rural development on the following accounts.

- ❖ Reduce persisting gender gap in access to knowledge and resources;
- ❖ Act as a pull factor for technology flow by creating demand for and adoption of scientific and technological knowhow;
- ❖ Create new opportunities for educated women settled in rural areas;
- ❖ Promote scientific (better) knowledge-based home and resource-management practices;
- ❖ Help tackle health and nutrition related issues at family level through education of women; and
- ❖ Improve development effectiveness of programmes.

Agricultural Education for Women : The Two Perspectives

There are following two perspectives in which we can discuss agriculture education for women.

- ❖ Perspective-I: How to make Agricultural Education serve women's cause and address gender issues?
- ❖ Perspective-II: How to take Agriculture Education to rural women?

In India, we have a well-developed agricultural education system comprising agricultural universities and institutions that impart agricultural education. During the past decades, agricultural courses offered at the UG, PG and Ph.D levels in such institutions have created a strong and large pool of agricultural professionals. These professionals either as researchers or managers or extensionists or academicians have contributed to the development and dissemination of new knowledge, technologies and innvoations that have driven growth and develoment of agriculture all through these years. But, of late, questions are being raised about gender sensitivity of agricultural courses in view of the growing importance of gender issues in agriculture. Does the existing course curiculae in agriculture teach students about gender issues in agriculture? Do these courses offer sufficient orientation to students on gender perpectives in agriculture? Certainly not. Therefore there is an urgent need to reorient our agricultural education to make it gender-sensitive so that agri-professionals may be able to pay due attention to the issues affecting women while addressing issues in agriculture. This calls for changes in the system and its structure. The following measures may be useful both in short and long run.

- Gender sensitization of teaching professionals;
- Introducing gender courses for students both at UG and PG levels;
- Integrating gender perspective into different subjects;
- Making gender an inbuilt component in RAWE programme at UG level;
- Recognizing professionals for their contribution to gender and agriculture; and
- Mentoring with institutions for organizing specialized programmes.

The second perspective is about taking agricultural education to rural women. Though we have a well developed formal education system to educate students and professionals with the provision of awarding degrees and certificates, access of rural women to agricultural education is virtually absent in India. Though India has one of the largest extension systems in the world as a mechnism for disseminating knowledge and technology, reach of women in agriculture to scientific and modern knowhow is very limited. As a result, those women (and men), who are directly associated with agriculture and engaged in various activities directly influencing quantity and quality of agricultural production, are far short of agricultural knowledge base that is required for real transformation and sustainability of the sector. The exeperiences of past years have also shown that it is impossible to equip rural women with all knowledge and skill that is required for efficiently and effectively performing wide range of activities. In such a situation, developing policies and institutional innovations to promote and spread agricultural education among rural community, paricularly among women, would create a long-term impact on agriculture. One important challenge is to develop agri-courses with proper structure and content to meet the needs and match the capacity of rural women. Different methodologies such as open/distance learning mode with diploma and certificate courses may be thought of. While desinging the agricultural courses for rural women, the following points need to be considered.

- Courses should be designed to enable learners to understand the context and scenario and to overcome problems.
- Focus should be on different modules ranging from on crop production (specific crops), animal husbandry, fisheries etc. to other need-based areas such as home and natural resource management.

- As women have to manage their household chores along with productive roles, contents from Home Science should also form part of the courses.
- Content should be simple with inputs from Agricultural Science and Technology, encompassing social, cultural and gender aspects considering local conditions.
- Care should be taken to make courses women-friendly.

In order to create demand for these courses and make such courses as effective programmes for empowering women and increasing their adoption level of scientific knowledge and technology in agriculture, some critical policy changes, as suggested below, are required.

- Incentives should be announced to attract women to agricultural education.
- Certificate/diploma courses should be a mandatory eligibility criterion for different grass-root level positions under government departments.
- Differential positive treatment should be given to those certificate holders for microfinance /participation in govt programmes.
- A special fund should be created for promotion of agricultural education among rural women.

For succesful implementation, scope of convergence of education programme with agricultural extension system should be explored. A paradigm shift in our approach from vocational training to vocational education may be required with following provisions to make the concept workable.

Is environment conducive for promoting agricultural education among women?

There are many reasons that support the case of introducing agricutural education for women. High female literacy is one most important reason, and it is grwoing (Figure 1). According to the Census 2011 report, there are 21 states in India wherein female literacy is above 70% and seven states where female literacy is between 60 and 70% (Table 1). Similary there are many pockets/districts where female literacy is also high, surpassing national average.

Secondly, today there are a number of schemes being implemented by Ministries of Agriculture, Rural Development etc. having direct relevance to women, and where participation of women is essential

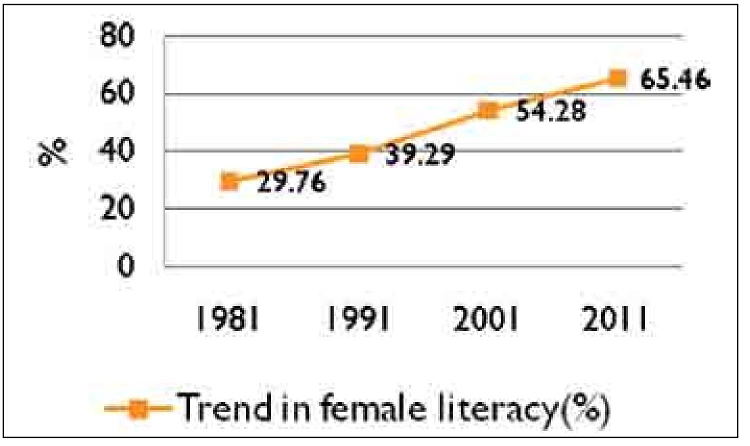

Figure 1. Trend in female literacy in India (%)

Source: Various Censuses

for better outcome. Therefore agriculture education would create multiplier effect through wider application of scientific knowledge in agricultural production, post production and home management.

Table 1. Female literacy rate of Indian states and UTs in 2011

Literacy rate %	States	Number
Less than 60	Rajasthan, Bihar, Jharkhand, Jammu and Kashmir, Uttar Pradesh, Arunachal Pradesh, Andhra Pradesh	7
60-70	Madhya Pradesh, Orissa, Chhatisgarh, Dadra & Nagar Haveli, Haryana, Assam, Karnataka	7
More than 70	Uttarakhand, Gujarat, West Bengal, Punjab, Manipur, Meghalaya, Tamil Nadu, Maharashtra, Sikkim, Nagaland, Delhi, Pondicherry, Chandigarh, Daman & Diu, Goa, A & N Islands, Tripura, Lakshadweep, Mizoram, Kerala, Himachal Pradesh	21

Source: National Census, 2011

Conclusion

In India, the scenario of agricultural education has changed dramatically over past few years with changes in course curiculae and increasing enrollment of girls in various agricultural courses; which indeed is an encouraging development. Participation of women in agricultural research, extension and education is also on the rise. But the rural women who are so important for development of agriculture lack the much needed access to agricultural knowledge and technology. If the transformation of agriculture is really something to happen in India, then empowering women through well-designed agricultural education programme seems a completely unavoidable and non-negotiable strategy.

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Women in Agricultural Research and Education: State and Constraints

Gita Kulshrestha and Nagendra K. Singh

There has been a substantial gain in the proportion of women scientists and teachers in the ICAR research institutes and agricultural universities over the last four decades after the establishment of the first agricultural university. Similarly, the number of female postgraduate students has also increased sharply in most agricultural universities. This is a clear reflection of changing status of women in the Indian society where emphasis on the education of girl child is leading to gender equity, economic independence and enhanced contribution by the one half of our population which was earlier contributing only through manual labour. However, this shift has exposed several structural constraints that need to be addressed for creating enabling environment for women to contribute more effectively to agricultural development by working together with men-folks.

To feed a projected world population of 9.2 billion in 2050, agriculture will need to double food production, despite a shrinking base of per capita arable land, a steady decline in crop yield gains, mounting stress on the ecosystem services, and the impact of the climate change. The strategic objective, therefore, is sustainable intensification of crop production (FAO, 2005). This calls for increasing crop productivity for ensuring food security and rural livelihood through sustainable farming practices such as integrated pest management and conservation agriculture, better management of biodiversity and a shift from subsistence farming to market-oriented production (USAID, 2012). The agriculture sector is underperforming in many developing countries including India, partly because men and women do not have equal access to resources and opportunities for being equally productive.

Why Pay Attention to Gender Issue in Agriculture?

Many seem to view gender issue merely as the number of women in a particular setting. This assumption needs to be corrected. Gender balance is actually a social construct that is part of the fabric of any society; gender analysis is done as a tool to look at the society in totality and make sure that the interests of all members—men, women and children—are addressed in a balanced and inclusive manner. Closing the gender gap in agriculture would generate significant gains in agriculture sector and for the entire society (World Bank, 2011). If women had the same access to productive resources as men, they could have increased yields on their farms by 20–30 %. This could have raised total agricultural output in the developing countries by 2.5–4 %, which in turn could have reduced number of hungry people in the world by 12–17 % (FAO, 2011). Rural women although efficient, produce less because they control less land (if any), use fewer inputs and have lesser access to important services such as extension advice. When women control additional income, they spend more of it than men on food, health, clothing and education of the children. This has positive implications for immediate well-being, long-run human capital formation and economic growth through improved health, nutrition and education.

The rationale for considering gender in agricultural research and education relates beyond agricultural productivity and food security to nutrition, poverty reduction and empowerment. In all of these cases, women play a critical but often under-recognized role, and face greater constraints than men. Recognizing this, sets the stage for identifying ways that the agricultural research and education system would help redress these problems and contribute to productivity and equity (Ruth Meinzen-Dick, 2010). If gender is not fully accounted for in agricultural research and development, it will be impossible to meet food needs of future populations. Changing agricultural research and education from a male-dominated to gender-equitable is not merely an issue of political correctness or ideology; it is a matter of inclusive and effective development that will benefit entire society.

Successful developmental interventions are by their very nature transformative. They create opportunities, commodities, relationships and services that ultimately change the way people do things. Creating a gender-equitable agricultural research and education system is such a transformative intervention. By understanding the constraints and the potential of women in agriculture, it will be possible to develop new ways to address their needs and enhance their contributions in improving agricultural productivity. Hence, there is need to examine whether women are factored into the work of research and educational institutions, and whether these institutions effectively focus on the women's needs to create an enabling environment. It is necessary to integrate gender into setting agricultural priorities; conducting teaching and research; designing, implementing, and adopting extension services; and evaluating their impacts.

State of Women in the National Agricultural Research and Education System

The Indian Council of Agricultural Research (ICAR), an autonomous organization under the Department of Agricultural Research and Education (DARE), Ministry of Agriculture, is the apex body for coordinating, guiding and managing research and education in agriculture including horticulture, fisheries and animal sciences in the entire country. In a traditionally male-dominated agricultural research system of the ICAR, there are total 4,074 scientists as on December 2012, of which only 540 are women (Table 1). The highest proportion of women scientists is in fisheries institutes (21%), followed by agriculture (14%) and dairy (14%) institutes, and is lowest in poultry (8%) and veterinary (8%) institute. Women gender ratio in ICAR has improved substantially during the past four decades from about 2 % in the late sixties to 13 % at present, but there is still a long way to go for an equitable ratio. Gender status of scientists in four deemed to be universities of the ICAR is presented in Table 2. The gender gap has, however, narrowed considerably in two eminent higher educational research institutes, CIFE (35%) and IARI (28%), as compared to NDRI (14%) and IVRI (8%). There is a need, therefore, to encourage women scientists to take up research in latter two dairy and animal sciences.

Table 1. Gender status of agricultural scientists in ICAR institutes in 2012

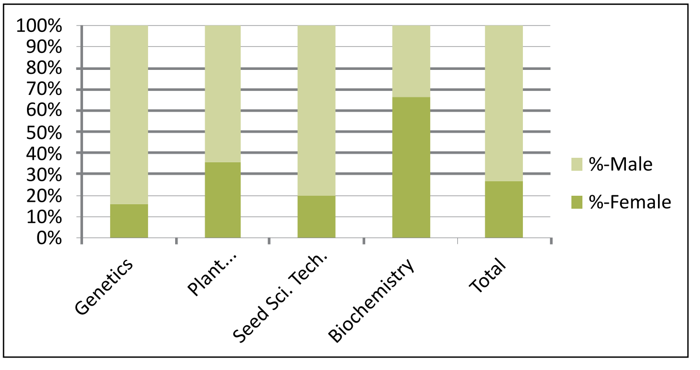
Research Institutes	Total	Male	Female	%-Female
Agricultural	3070	2646	424	13.8
Veterinary	684	631	53	7.7
Fishery	262	206	56	21.4
Dairy	35	30	5	14.3
Poultry	23	21	2	8.7
Total	**4074**	**3534**	**540**	**13.3**

Table 2. Gender status of scientists in ICAR's deemed to be universities in 2012

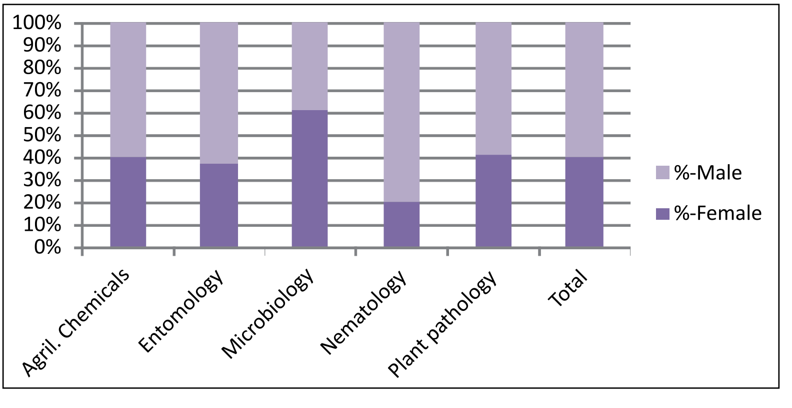
Institute	Total	Women	Men	%Women
IARI	256	72	184	28.1
NDRI	35	5	30	14.3
IVRI	684	53	631	7.7
CIFE	63	22	41	34.9
Total	1038	152	886	14.6

The IARI (Indian Agricultural Research Institute), a premier agricultural institute located at New Delhi, has 72 women scientists in the total strength of 256 scientists (Figure 1). At overall institute level, there are 28 % women scientists at the IARI, which is more than twice that of the ICAR as a whole.

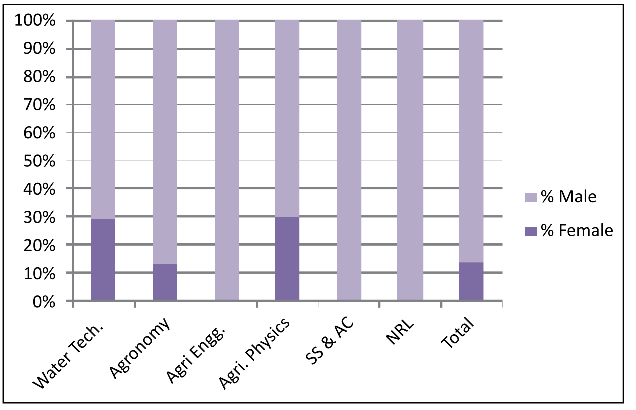
- **Crop Production**



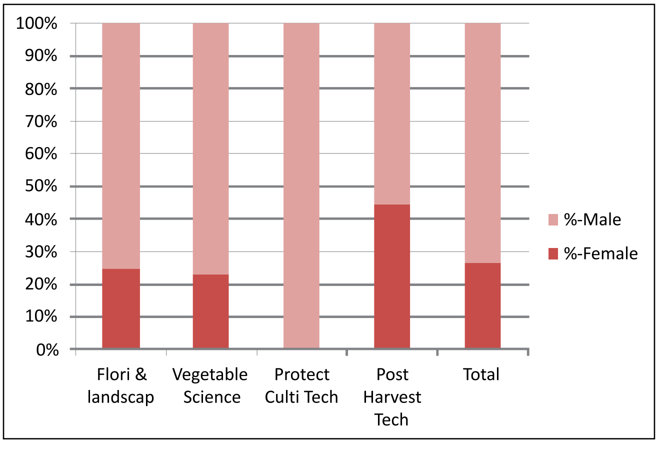
- **Plant Protection**



❖ Natural Resource



❖ Horticulture



❖ Social Sciences

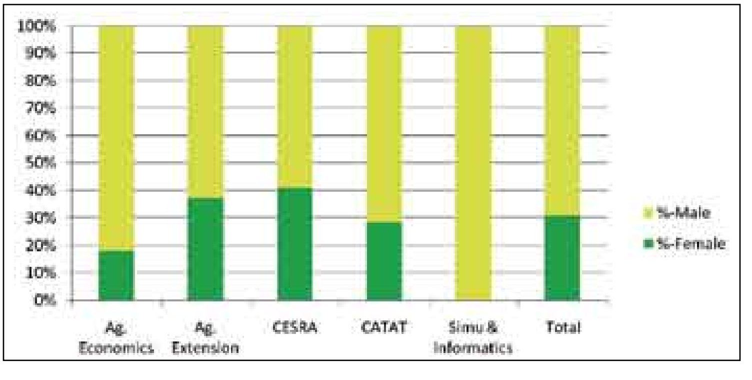


Figure 1. Gender status of scientists in various agricultural disciplines at IARI in December 2012

The trend of admission of female and male students for postgraduate education (M.Sc. and Ph.D.) in the PG School at the IARI during the past four academic sessions, beginning from 2009-10 to 2012-13 is presented in Figure 2. The girl students after completing their Ph.D. tend to preferentially join agricultural research service (ARS) and stay in agricultural research. Thus, higher percentage of women scientists in agricultural research at the IARI could be because of more girls (25%) showing interest and opting for higher agricultural education.

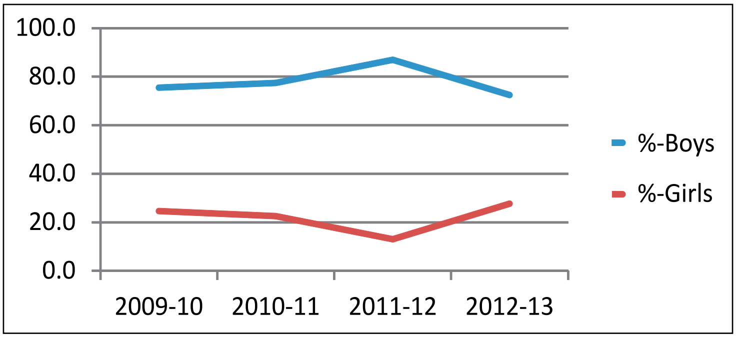


Figure 2. Trend of gender intake of PG students at IARI

There is no compiled gender data available at present for agricultural education at the undergraduate level in different state agricultural universities; however, there is a visible change in the proportion of female students as is evident from conversion of boys' hostels to girls' hostels and building of new girls' hostels in several agricultural universities.

State of Women in Agricultural Education and Research in Other Countries of South Asia

The proportion of women in agricultural R&D staff is quite variable in four South Asian countries, excluding India, according to an IFPRI report (Stads Gert-Jan, 2012). Although women represent about 40 % of the agricultural workforce in these countries, their role in the decision-making process is often limited. Female researchers, teachers and research managers offer unique perspectives and insight that can help address specific challenges faced by women in agriculture. As compared to the about 13 % women scientists presently engaged in R&D under the ICAR, the 2009 data collected by the IFPRI indicate that the proportion of the women scientists was 10% in Nepal, 12 %

in Pakistan and 16 % in Bangladesh. In sharp contrast, Sri Lanka has 48 % share of women in the agricultural R&D (Figure 3). However, even in Sri Lanka with very high level of women participation, only 11 % of the women R&D workers were Ph.D. degree holders as compared to 32 % of their male counterparts. A similar gender gap exists in other South Asian countries also. This limits their participation in the decision making process and underlines the importance of higher education for women.

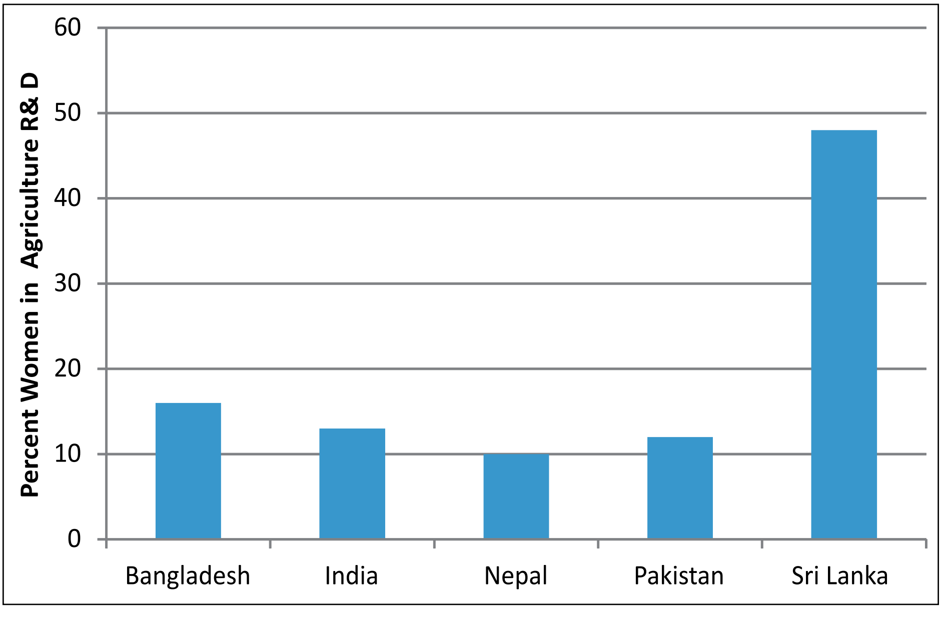


Figure 3. Proportion of women researchers in the R&D in five South Asian countries

ICAR Initiatives Focusing on Gender Issues

The ICAR established a National Research Centre (NRC) for Women in Agriculture in 1996 at Bhubaneswar, which has been upgraded to the Directorate of Research on Women in Agriculture (DRWA) in 2008. The mandate of the DRAW is to carry out basic, strategic and applied research to identify gender issues and test appropriateness of available farm-technologies/programmes/policies with women perspective; training and consultancy for promoting gender mainstreaming in research and extension for empowerment of farm women and capacity building of scientists, planners and policy makers to respond to the needs of the farm women.

The ICAR has provided gender focus of training in best practices for horticultural and other sustainable crop intensification and diversification initiatives in rural and in urban/peri-urban areas. It included in its national integrated pest management (IPM) programmes and policies focus on vulnerable groups, including women, in developing methods for conservation and enhancement of ecosystem services such as timely preparation of bio-pesticides, agri-clinic etc. The fact that women are responsible for family health makes them more responsive to information on pesticides and IPM techniques. In the area of bio-energy, ICAR has investigated implications of new bioenergy crops such as sugarcane, maize and jatropha for food security, the use of labour and time by men and women, and the division of income from crop production or employment. Small-scale biofuel crop production could provide income and a source of electricity that would reduce women's domestic burdens.

Constraints Faced by Women Researchers and Teachers

Despite the positive trend in reducing gender gap over the last four decades, women still face a number challenges. This is because appropriate structural changes have not been made to address the unique problems faced by the women in managing family and office work. The traditional joint family structure in India and many other societies has now broken down due to increased dependency on non-farm income for livelihood. The situation has further deteriorated as in many instances even husband and wife cannot live together because their jobs are at two different places. In this situation, the entire burden of bringing up the kids normally falls on the shoulders of the young mother. This happens either during the Ph.D. studies or early career of the women researchers and teachers. The requirement of professional family care services and flexible as well as part time working hours is the need of the day if women are to contribute effectively to agricultural research and education. Following are some of the urgent requirements that need attention.

Flexible working hours

Due to socially required role at home such as cooking, child-care, attending to elderly etc., women often require flexible working hours so that they can do justice to work at both places, and are better performers in research and teaching.

Working part time for extended period post maternity leave

Women are often unable to resume full-time work even after availing maternity leave of six months. If she is allowed to work part time on part payment, with such policy to recruit another part time person, from the savings, it will not only benefit employer but will also generate employment. In the present scenario many women are forced to leave their job or go on extended leave without pay, loosing continuity of their research and teaching work and the much needed financial support.

Availability of good quality creches near work place

In order to take care of the infant post maternity leave and for small children (1-5 years age) in emergency, women scientists' require good quality creches near their workplaces.

Security from sexual and emotional harassment at work place

In a traditionally male dominated organization, any derogatory remark or comment from fellow colleagues often make women scientists' feel emotionally harassed and this slowly results in under-performance. To check this and to provide security against any kind of sexual/emotional harassment of women, right policies with effective implementation system must be in place.

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Employment-Oriented Agricultural Education: Challenges and Strategies

Ram Pratap Singh

The establishment of Agricultural Universities was undoubtedly the most significant landmark in the history of Agricultural Development in India. It was the recognition of an urgent need to link agricultural education, research and extension education with agricultural programmes and to assign area responsibility to the State Agricultural Universities. Subsequently, the National Commission on Agriculture made elaborate recommendations and clearly identified goals to be achieved and the new vistas to be covered. Afterwards, the Indian Council of Agricultural Research had set up a Review Committee on Agricultural Universities to critically assess their growth and development. This Committee, headed by Dr M.S. Randhawa, the renowned administrator, scientist and author, assessed the working of the Agricultural Universities in the country, particularly the extent to which these were meeting needs of trained manpower at different levels.

Further development that has taken place in agriculture during the last five decades is the establishment of the several agricultural (Horticulture & Forestry, Veterinary and Animals Sciences, Animal and Fisheries Sciences etc.) universities, institutions and colleges in different states, which are responsible for agricultural education, research and extension education programmes. Fortunately, at present each major state has more than 3-4 such agricultural universities. It is the partnership in agriculture research and education between the ICAR and agricultural universities which is a major factor in achieving whatever success India has achieved in this field lately.

No doubt our teaching programmes have stood the test of time reasonably well during the Green Revolution era. It must, however, be recognized that there is a scope and need for strengthening and improving present system of agricultural education. We must make much greater provisions for in - service training and update courses to meet the requirements of the time.

Challenges

The institutional network for agricultural education and research includes integrating agricultural education with job-creation, increased pressure on natural resources, demand for specific human resource from client groups, sustainability perspective to agriculture, value addition to agricultural produce, shrinking resources with educational institutions, emerging global economic order and so on. The WTO also warrants need for quality improvement in higher education to make it globally competitive.

Many of the Agricultural Universities continue to suffer from structural weakness. To ensure minimum uniformity in the structure, organization and governance of the Agricultural Universities, the Indian Council of Agricultural Research had formulated a Model Act in 1966. Some of the Universities have adopted the Model Act as such but many other have made significant departures from it. The Review Committee, including Deans' Committees, from time to time involved to review functioning of the Agricultural Universities had aptly pointed out these deviations which compromised autonomy of the concerned Universities and impaired development of proper working conditions. It is, therefore, felt that all the Agricultural Universities should work together to remove lacunae existing in the Act in a systematic manner.

Agricultural Universities should enjoy full autonomy in their functioning and academic pursuits, and their rules and regulations should not be framed on the pattern of Government rules; because Government rules do not usually permit flexibility so necessary in administration of the academic institutions. It is a general feeling that unless the management of education and research is placed on independent but sound rules of governance, the progress would continue to be tardy and natural commitment, devotion and enthusiasm of scientists and academicians in their work cannot find full expression and may ebb out. The Indian Council of Agricultural Research needs to pay greater attention to promote scientific management of Agricultural Education; based on the sound research footings for excellence in Agricultural Education systems to create self-employment opportunities in rural areas through commercialization, industrialization and liberalization.

The financing of Agricultural Universities by the Indian Council of Agricultural Research and State Governments also needs improvement and strengthening to enable them to fulfill their obligations squarely. In this regard, rules and regulations governing allocation and utilization of grants need to be simplified and operated with speed and efficiency. The State Government may fix block grants for a period of five years, and give University sufficient freedom to regulate expenditure within the grant as it deems fit. The State Government may also provide sufficient foundation grant so as to overcome time lag in the release of funds by the State Govt. or the Indian Council of Agricultural Research. The National Commission on Agriculture has very rightly recommended that 10-20 % of the total State Plan outlay under agricultural development programmes should be earmarked for agricultural education and research for the State Agricultural Universities. The pattern of assistance from the Indian Council of Agricultural Research should be according to the recommendations made in the Indian Agricultural Universities Association during conventions, besides, visiting committees constituted by the ICAR from time to time. Agricultural Universities also need to establish closer contacts with appropriate National and International organizations for grants.

The agricultural education system in the country is further confronted with a number of challenges. There are problems in developing faculty competence and resource base for grooming agricultural graduates on the lines of current requirements in the job-markets on the one hand and sharp decline in public sector employment opportunities on the other. These are major threats in ensuring employability in the existing agricultural education system in the country. Employment Oriented Agricultural Issues include the following.

- Limited opportunities to widen faculty-mix, especially in the areas like business management, information and communication technology, environmental sciences etc. in SAUs, which limit quality of education and entrepreneurship development.
- Lack of sensitization in the system towards re-engineering agricultural education befitting to the needs of the time.
- Lack of advance knowledge as per the needs of employment opportunities available in different sectors and no institutional

intervention with the perspective stakeholders. Lack of flexible and need-based course-curricula in agricultural education systems.

- Duration of graduate programme and its distribution among teaching in basic subjects and practical session.
- Lack of confidence, entrepreneurship and competence for self-employment among agricultural graduates and postgraduates.
- Need for multi-disciplinary and integrated farming system based knowledge.
- Globalization of higher education services under the General Agreement on Trade in Services (GATS) of WTO, and likely entry of foreign universities in the country either as partners with local institutions or by establishing own institutions.
- Emergence of a number of frontier areas of learning and limited access/opportunities for learning in those areas.
- High rate of in-breeding of students and faculty.
- Decline in share of public sector employment and information gap in the perspectives of private sector opportunities.
- Lack of adequate inter-institutional linkages, leading to duplication of activities, and inadequate harnessing of benefits.
- Lack of career development opportunities for existing faculty members.
- Steady decline in financial assistance to the universities from central and state government, and proliferation of SAUs in sectoral areas of agriculture specially when flow of financial resources are shrinking.

It is a reality that expected professionalism for self-employment could not be brought into the agricultural educational system despite increasing duration for graduation by an extra year. There is a great *need to build professionalism in agricultural education* by suitably remodeling class room instructions, field and lab practicals, besides, gaining practical knowledge through agricultural works experience programmes involving students for learning in the fields by doing field work along with farmers and allowing opportunities for development of management knowledge, creativity and entrepreneurship through industrial mode of operation.

Suggested Strategies

Traditional emphasis on production of mere degree holders without concern for their relevance and utility to various stakeholders and sectors of economy for the service and employability will be of little significance. The dilemma in employment prospects of agricultural education and the solution to the problem is not confined to agricultural education system alone. There are a number of extraneous factors. The overall change in the economic environment and government policies have resulted in drastic changes in all the sectors of the economy. The implication of such changes in agriculture is inevitable. However, we cannot remain as silent spectators as far as the agriculture sector, especially, agricultural education is concerned. Reforms in the agricultural higher education are under active consideration of the ICAR. Some of the strategies to enhance employability of agricultural graduates are discussed as follows.

Systematic manpower need assessment

The foremost task is a systematic assessment of the quantitative and qualitative manpower requirement in agriculture sector at the national and regional levels. Such an assessment must focus on opportunities both within and outside the country. The possible consultancy services in other developing countries to launch systematic agricultural education in those countries by providing expert services, private sector potentials within the country in production, processing, distribution, input delivery, technological services, etc. will have to be systematically assessed. Self employment opportunities are to be identified and also ways and means to operationalize such options.

Regulation of admissions in on-going courses

Once the manpower need exercise is systematically made, the supply side of manpower is required to be matched with the manpower demand. If necessary intake capacity and the number of admissions in existing subjects/disciplines will have to be regulated based on the current and future employment opportunities.

Introduction of need-based programmes

With the change in the focus from quantitative production oriented agriculture to qualitative production and agricultural trade, a number of new areas of learning have become relevant and inevitable to ensure sustainability of agricultural education system. Such new courses may include newly emerging frontier areas of sciences, entrepreneurship building areas, agri-business and management related areas. Keeping the focus on job-market, the introduction of subjects and methods of teaching and learning aligned fully with employability should *form* the core of the strategy *for* new programmes. While making the blueprint for reengineering the course curricula, there is a great need to consider other sectors of economy, country's national commitment and international obligations.

The course curricula must find adequate importance on newly emerging global concerns like sustainability, food and nutritional security, livelihood security, bio-diversity conservation, natural resource management, new and renewable energy sources, environmental safety and new areas in agriculture like integrated farming system model, hi-tech horticulture, precision farming, green cultivation, modern irrigation techniques and so on.

Promotion of para-professional vocational courses in job-oriented areas

Introduction of para-professional/vocational courses in applied areas of agriculture for grass-root level services designed *for* secondary and higher secondary (10+2) level students may help limit undesirable intake in agricultural higher education.

The NABARD refinance scheme includes setting up of agri-clinics / agri-business centres by agricultural graduates. The basic objective behind this is to supplement the efforts of government by establishing Agri-clinics and provide gainful employment to agriculture graduates. Agribusiness centres are envisaged to provide input supply, farm equipments on hire basis and supply of other services.

Besides, there are a number of newly emerging micro enterprises like production of seeds of field and horticultural crops, tissue culture, mushroom, sericulture, apiculture, lac culture, vermi compost, bio-agents, fruit and vegetable processing' and preservation, cut-flower, rabbitary, piggery, dog farming, ornamental fisheries, etc. Strategic attempt in these areas may help promote self-employment programmes on one side and also find gainful employment by developing agricultural services as a viable option for generating employment avenues for trained agricultural technicians and graduates on the other side. The

NCERT has also already identified potential areas in agricultural and allied areas for para-professional vocational courses.

Launching P.G. diploma courses in potential areas of employment

The PG diploma in 'organic agriculture management' in collaboration with R.R. Morarka, GDC Rural Research Foundation, Jaipur, and also Diploma programme on 'Fashion Designing' in collaboration with Zee Interactive Learning Systems Ltd, New Delhi, were started on self-supporting basis. More of Such programmes can be planned; those having flexibility to run on intermittent time mode basis rather than on continuous mode, depending upon the needs and job availability (Annexure-1).

'All Courses Mode' to 'Selected Course Mode' in the SAUs

At a time when flow of funds from government sources for developing infrastructure and facilities is shrinking, all SAUs should not try to run all possible programmes. Rather, a selective approach to run potential courses in terms of infrastructural facilities and faculty competence can help run such courses more effectively.

Establishment of more Centres of Excellence in different departments of the SAUs

In terms of faculty competence, effective teaching, research and extension education integration, laboratory and field facilities, each university may identify certain potential areas and disciplines which can be developed into centres of excellence in the areas. Definitely, the advantages of such centres will be harnessed by the students also. The quality enhancement in teaching in such areas will push up employability of outgoing students, specialized in concerned areas.

Faculty upgradation/competence development

The existing faculty in the SAUs are mostly trained in discipline oriented teaching system. The course curricula were also drawn as warranted by time at the time of their education. With the emergence of WTO and AoA, trade in agriculture, agribusiness, agro-processing activities, international trade, managerial and communication skills, etc. have become more dominant. The information and communication technology has also changed drastically during the recent years. The education technologies and education methodologies including e-learning are also coming up in a big way. The accesses to internet and library software have brought out drastic changes in the process of learning leading to quality improvement in teaching - oriented teaching system is also a need of the time. Besides, orienting the teachers with such programmes of relevance organized by reputed institutions can help them to upgrade their competence. To impart teaching with latest education technology and methodology, *the faculty upgradation and competence is* a *need of the time.*

Induction of newly emerging and relevant supporting faculty

The current system of agricultural education has the scope for supporting courses from related disciplines. In most of the SAUs, the teaching of courses in areas of business management, computer application, information technology, etc. are taught by faculty members who are not competent to teach such courses. The induction of competent faculties in such areas will definitely help students to develop required confidence and competence in such areas.

Inter-institutional linkages

Effective linkages of SAU s with other teaching and research institutes of respective areas and also with institutes absorbing the trained manpower either in private or public sector including agro based industries, is presently a miss-link. Such linkages to the extent of faculty/resource person exchange programmes and through other means of collaboration and cooperation will facilitate to perceive the problems of demand and supply sources of trained manpower in the most befitting manner. The feedback of such attempts will help induct required changes in curricula for the effective employability in agricultural education.

Preparedness for overseas opportunities

An assessment of overseas opportunities of agricultural experts by a competent organization and suitably training persons at the organizations like National Academy of Agricultural Research

Management, MANAGE, etc. may help find job opportunities for unemployed educated persons. The international competitiveness in agricultural education being enjoyed by the country can also be projected to enhance employment capacity by providing job opportunities for agriculturally trained human resources in overseas countries.

Other options

It is a fact that the total solution of the problems cannot be explored from within the system. The reforms in agricultural education with remodeling of the components of agricultural education system may lead to evolve solutions partially. Both short-term and long term strategies will have to be evolved. More and more deliberations at national and regional level to make the gravity of the problem felt by all concerned may itself lead to identification of feasible solutions.

The State of Government of Haryana started a condensed degree programme in Agriculture for the Village Level Workers. This programme provided unique opportunity to improve their qualification and also turn them into types of development workers, since they already possess a deep practical bias. Besides, provision for higher agricultural education for another category of field workers, viz. the Agricultural Sub-Inspectors was made. The imparting of higher education to both these categories of basic field workers become instrumental and also contributed significantly in the growth rate of Agriculture in the State.

Annexure 1

Sl. No.	Component of the system	Strength	Weakness	Opportunity	Threats
1.	Institutional Setup	Diversified teaching programmes with UG programmes in 11 broad disciplines, masters degree in 95 specialized disciplines and Ph.D. in 80 disciplines	Lack of desired responsiveness to the changing scenario and temporal needs	GATS under WTO opens up scope within and outside the country	Entry of foreign universities under GATS and capturing the market of agricultural education
2.	End product (Students)	Supply of trained manpower in various areas of agriculture	Lack of competence, confidence and entrepreneurial ability	Self employment opportunities and private sector job market	Lack of employment options for minimum survival
3.	Faculty	Diversified in various disciplines	Lack required Up-gradation, competence and skill evelopment	Responsiveness to complex situation	Teacher-taught quality link (inefficient teacher makes poor students)
4.	Curricula	Sound theory oriented	Inflexible, mismatch between theory and practical leading to lack of risk bearing capacity and confidence	Entrepreneurship building	Increased unemployment & under employment problems

Contd...

Annexure 1 Contd...

Sl. No.	Component of the system	Strength	Weakness	Opportunity	Threats
5.	Resources and infrastructure	Availability of established labs and equipment research and Instructional farms, competent faculty and effective teaching, research and extension linkages with feedback mechanism.	Lack of adequate updating and modernization of resources	Potential to respond to the needs of time	Imbalances between Resource, components for ensuring sustainability
6.	Institutional linkages	ICAR at apex level for ensuring Inter-institutional linkages and mobilizing financial support through national and international agencies	Inadequate and in effective linkages between institutions and SAUs system and also with other institutions	Better use of resources and developing competence and onfidence in the output	If linkages are made with poor institutes, things may worsen rather than improving.
7.	Youth involvement in Agricultural Transformation	A huge number of unemployed youth need to be motivated after imparting skill oriented training for different potential enterprises for employment in different Agriculture and allied sectors and their by raging income for livelihood	Lack of motivation and change of aptitude for accepting agricultural activities as a potential business for their productive employment	A bright scope for self employment opportunities and additional employment in small scale Agricultural Industries	Willingness towards any kind of job anywhere for their sustainable income and not attracted in the transformation of agriculture

Youth Perspective: To Attract and Retain Youth in Agriculture

M.P. Yadav

The following measures are suggested by the Panel for making agricultural education attractive to the youth from rural and urban constituencies so as to get best brains for taking admission in agriculture education at the graduate and post-graduate levels, along with strategies to retain them in education and research.

1. Introduction of agriculture at the level of primary and secondary education

At present, in most of the States in the country, agriculture is not taught at primary or secondary education levels. Since about 70% of our rural population, directly or indirectly, is dependent on agriculture, it would be prudent to include agriculture as a subject right from primary and secondary school levels.

2. Awareness about agriculture education

By and large people are not aware about the importance, significance, potential and scope of agriculture education, covering crop agriculture, horticulture, livestock, poultry, fisheries and related entrepreneurship through secondary agriculture for on-and-off farm employment and income generation through value addition of primary produce. As such there is an urgent need to create awareness among public and youth about various facets of agriculture and agricultural education through electronic and print media.

3. Retaining of meritorious UG and PG scholars in research and teaching

Teaching and research are complementary to each other and excellence in either is not conceivable without the support of the other. This has been clearly proven in the case of agricultural education in India, where merit in the ICAR piloted admissions for master's and doctoral programmes, students from the deemed universities, IARI, IVRI, NDRI and CIFE, dominate in NET and ARS examinations conducted by the ASRB. These institutions are the first choice of the students for getting admission to PG education at master's and doctoral level. However, in veterinary sciences the graduates prefer to join field services where pay scales are comparable besides other attractions of private practice, free accommodation etc. Once they remain in this atmosphere, they often loose interest in pursuing higher education and research. A provision of Junior Residentship or Teaching/Research Associateship to the pass out of B. VSc. & AH and Senior Residentship/Senior Research Associateship may be made available to the top meritorious students, so that they involve in teaching/or research. This arrangement will serve two purposes. The meritorious students will be retained in teaching and research, and will shoulder some responsibility for research to fill the vacuum created as a result of vacant positions of faculty, which is presently about 40% in the national agricultural research system.

4. Skill development

Several interventions are needed for adequate skill development among the agricultural graduates and post graduates, commensurate with the requirement of public and private sectors and meeting challenges of competitive trade of agricultural produce in the present scenario of climate change, global warming, WTO, and degraded and shrinking natural resources. Programmes such as experiential learning, industry attachment of students, and earn while learn will be useful in this direction. It should be mandatory to have 50% credit hrs for practicals by dividing each course separately into theory and practical. The student should pass separately both theory as well as practical courses.

5. Training of faculty

For skill development, the faculty should be exposed to further training in leading laboratories/institutions/universities in India and abroad for specified period on the expenses of Government/ Industry, as the case may be. Exposure to centres of excellence in their discipline should be the main criteria for attaching them for in-service training. The recruitment procedure of the faculty and promotion policy also need innovation and reorientation for upgradation of their professional skills, and competence and suitable models need to be developed in this regard.

6. Credibility of educational institutions

A graduate must feel proud of his/her almameter not only in terms of academic and research excellency but also in its transparent and effective governance and respect for quality. The universities should have functional autonomy with adequate financial support from the central and state governments. To achieve their objectives, zero political interference in the academic institutions is the first prerequisite. The ICAR Model Act should be adopted fully by all e agricultural universities in the country. There is a need to facilitate movement of students as well as faculty between academic and research institutions to avoid inbreeding. Similarly, for the appointment of Vice-Chancellor, merit should be the sole criterion.

Students Perspective

K. Pradhan

An Elocution contest on the theme was conducted by the Academy in six zones covering all the State agricultural universities in that zone. Twelve students who were the Winners and Runners-up at the zonal levels, listed below, further participated at the National Elocution Contest held during the Congress.

1. Ms Neha Rajawat, College of Agriculture, Indore, RVSKVV, Gwalior
2. Ms Devani Bansee M., Junagarh Agricultural University, Junagarh
3. Ms Aparna Radhakrishnan, NDRI, Karnal
4. Ms Jayalakshmi R., Kerala Agricultural University, Trissur
5. Ms Sabiha Perween, Bihar Agriculture University, Sabour
6. Ms Shewta Gupta, GBPUA&T, Pantnagar
7. Mr Abhinav Krishna, MPKV, Rahuri
8. Mr Avay Kumar, Birsa Agril. University, Ranchi
9. Mr Pranav Kumar, GBPUA&T, Pantnagar
10. Mr Puspendra Ku. Patel, IGKVV, Raipur
11. Mr S.M. Saminathan, TNAU, Coimbatore
12. Mr S.P. Subash, PAU, Ludhiana

The following students bagged the first three prizes:

- First prize : Ms. Neha Rajawat, RVSKVV, Gwalior
- Second prize: Ms. Aparna Radhakrishnan, NDRI, Karnal
- Third Prize jointly: Ms. Shweta Gupta, GBPUAT, Pantnagar and Mr. S.P. Subash, PAU, Ludhiana

First prize winner,
Ms. Neha Rajawat

Most of the participants were of the opinion that though agricultural education has revolutionized agricultural scenario in the country, it still is far from facing challenges of food and nutritional security and sustainability. To achieve the target, reorientation and refinement in teaching, research and extension through policy change is absolutely necessary. We must remember that "there is only one thing that can bring the country down is our dependence on foreign countries for food".

Agricultural education is the substratum for food production, processing, marketing and distribution of consumer goods, which must be quick and cost-effective. It also should be farmers and consumers friendly. The change in environment and ecosystem further demands a paradigm shift in our approach to improve education in agriculture.

Thus, the policy on educational system must be redefined and appropriate curricula for Diploma, Graduate and Post graduate levels on various disciplines should be developed leading to quality education. For this, the ICAR should play an active role to support agricultural universities in creating better academic environment, research system, development of entrepreneurship, distance education for farmers and small entrepreneurs and quick communication systems.

India needs a bold new vision and feasible action plan on agricultural education and research.

Agricultural Education and Rural Banking Sector

S.K. Chatterjee

Ever since independence, several government measures initiated have brought agriculture to the pedestal where it is at present. The advent of Green Revolution in the mid-sixties of the last century, the forces unleashed by bank nationalization in 1969, the great impetus given to agricultural research, education and training, several measures to usher in comprehensive rural development, measures to bring in inclusive growth and a host of other measures actually have changed the face of Indian agriculture. Overall from a food-deficient nation, we have transformed into a food-exporting country.

Concerted steps will have to be taken to step up the growth rate in the agriculture sector to at least 4% per annum so that overall GDP can grow at a healthy rate of 8% plus per annum. One of the major stakeholders to give a thrust to agriculture sector is the banking infrastructure in the country. Investment in agriculture owes mostly to private initiatives and banks play a major role. Ever since nationalization in 1969, the banks have played a stellar role in augmenting rural and agriculture credit, helping in rural extension, contributing to proper price realization by encouraging cold storages and in effective and relevant measures to lend credit against pledge of agricultural commodities etc.

The Reserve Bank of India and National Bank for Agriculture and Rural Development (NABARD) from 1982 have played a major role in stepping up agriculture and rural credit, construction of agricultural and rural infrastructure, capacity -building of rural community (especially farmers) generating rural livelihood and employment through several outreach measures like Self Help Groups (SHGs), 100% financial inclusion drive, etc. Post-1969 and with active role of the Reserve Bank of India and the NABARD, banks have penetrated into the rural areas. The quantum of rural credit especially over the last 8/9 years has shown an increase from Rs 292,437 crore in 2008-09 to Rs. 509,040 crore in 2011-12. For 2012-13, the target of agriculture credit has been set at Rs. 575,000 crore. Similarly, the branch network has also shown significant growth. From the total of 8,262 commercial bank branches in 1969, number has risen to 82,408 in 2009, of which 31,699 branches (i.e., 38%) are in the rural sector. A massive and exclusive rural credit network comprises 31 State Co-operative Banks (SCBs), 370 District Central Co-operative Banks (DCCBs), 95, 633 Primary Agricultural Co-operative Societies (PACS), 20 State Co-operative Agricultural and Rural Development Bank (SCARDBs), 697 Primary Co-operative and Rural Development Banks (PCARDBs) and 82 Regional Rural Banks (RRBs) in the country.

However, with the above "inflation" of banking presence, average for every 6 villages is of only 1 PACS. We have 6.40 lakh villages in the country but only 32,000 bank branches to cater them. Less than 20% of the Indian population has a bank account. The government has unleashed a major "Financial Inclusion" drive, that will lead to increased use of banks and "Business Correspondents" (BC) to fan out to rural population. Further, banks, especially in the public sector would need to create/fill -up more jobs as large number of employees will retire in the next five years.

The synergetic development of agriculture and banking system should further be strengthened particularly for adoption of new technologies, enhanced and timely availability of inputs and increased employability of agricultural graduates in the banking sector. Agricultural universities / colleges can play an important role in strengthening the synergy.

There is an interesting phenomenon in the Indian agriculture and the rural banking. The early sixties of the last century saw the advent of many Agri-Universities in the country. The Green Revolution of 1965-66 almost coincided with the extension of Banking Regulation Act 1949 to Cooperatives in 1966. This was quickly followed by Social Control of Banks in 1968, making bank nationalization in 1969, and advent of Lead Bank Scheme in 1972. All these events had tremendous influence in boosting farm sector. This also signaled the need for evolving a coordinated approach by agri-universities and banks in ushering in a prosperous rural economy.

Perhaps the best signal that agri-universities and institutions need to provide quality manpower to the banking sector comes from the stipulation in the Section 54 of Reserve Bank of India Act that the "Bank may maintain expert staff to study various aspects of rural credit and development..." The importance of this stipulation is path-breaking and a continuous reminder that banks require qualified and dedicated manpower to further the cause of agriculture and rural development. Agri-education institutions have thus their jobs cut out for the sake of agriculture and rural development through bank initiatives. Agricultural Universities and learning institutions must device their course curricula keeping the above in view.

It will be worthwhile if a joint body of agri-educationists and agri and rural development banking experts decides syllabi for graduate and undergraduate courses. Emphasis may have to be given to issues pertaining to credit, development theory, micro-finance, functions and working of the NABARD and RBI's role in agriculture and rural credit. Ever since nationalization of banks, they have played a significant role in agriculture and rural development extension services.

Field studies, of farm experiments and other demonstration activities are an integral part of agri-education. The role played by banks/ RBI/NABARD in these areas needs to be studied. Similarly, bank probationary officers need to be attached to agri-universities/ research stations/KVKs for some time to hone their skills in agri-banking. Needless to say a fine balance has to be struck between "Qualification" and "Capability'. The students pursuing courses in universities and the Officers in the banks engaged in agri-banking will have to go beyond their respective "current experiences" and look for imbibing more practical and field orientation in their attitudes and activities.

While graduates and post graduate students can be absorbed by banks to further their rural development and agriculture lending responsibilities, there is an urgent need to develop a cadre of "bare-foot" rural professionals, who will work in rural areas to render extension and "inclusive banking" support to the DRDAs, banks, KVKs, NGOs etc. These professionals could be "plus two" vernacular background students whose livelihood requirements are generally restricted to their own native districts. A three months' course on the basic agriculture/horticulture/rural credit/banking/development issues could be designed by agricultural universities.

To cater to the specific demands of the banking sector, a one year P.G. Programme in Rural Banking can be designed and launched by Agri-Universities. A model broad syllabus for the same may include;

1. Rural India
2. Basic Economics & Development Theory
3. Research Methodology & Quantitative Techniques
4. Basic Accounts
5. Information Technology
6. Marketing of Financial Services & Products
7. Appraisal of Agricultural Projects
8. Micro Finance
9. Management & Communication Skills
10. Financing of Small, Medium & Micro Enterprises
11. Human Resource Management
12. Financial Management
13. Functions and Working of RBI & NABARD - Principles of Development through Credit - Rural Financial Institutions.
14. Banking Law and Practice
15. Attachment to Rural Financial Institutions
16. Village Stay

The subject mix offered by various universities requires a further reflection. They need to be aligned at least to some extent to the needs of the banking sector, especially in the areas of crop loan financing, infrastructure financing (cold storage/godowns/ market yards etc.), rural credit, banking, micro-financing etc. The students should be given some freedom to choose different combination of subjects so that they will have no difficulty in joining a banking career at a later date.

The Agriculture learning institutions and the banking sector can jointly ensure that the efforts are well intentioned and effectively implemented.

View Points of Seed Industry for Agriculture Education

S.K. Rao

To achieve food production requirements, in future, major efforts are required for enhancement of seed replacement rate of various crops through increased production and distribution of quality seeds. There is a need to integrate the National Agriculture Research Organizations involved in crop improvement programmes for the development of products as well as seed development agencies at the National and State level, including private seed industry to build up a viable seed system to bring quantitative changes in agricultural production. There is a direct relationship of seed replacement rate with enhancement in productivity. The development of globally competent human resources for seed industry is thus a high priority, including increased research and development investments in the seed sector resulting in wide range of products and services to farmers.

Current agricultural education policy and curricula do not address emerging issues, especially agribusiness to the extent, required of skills in the seed industry for agricultural business, marketing, value-addition, new areas of seed, research and development, international trade, export and related disciplines and needs of the illiterate and unskilled landless marginal and small farmers of outreach areas of the country.

Seed companies in India, are growing at a compounded annual growth rate of more than 15%. The seed industry in India is likely to reach Rs 20,000 crore by 2020 from the current level of Rs 15,000 crore shifting from conventional seeds to high quality seeds by seed companies. Looking to the structure of the seed industry, hybrid seed market of cotton comes to 20% followed by rice 18%, wheat and vegetable 12%. Fourteen seed corporations and three National level seed corporations i.e. SFCI, NSC, HIL are engaged in seed production and distribution marketing of high volume low value public breed notified varieties. More than 400 private seed organizers and about 300 small seed companies as well as thousands of seed dealers networks of seed companies require human resources in dynamic seed business and meet managerial skills to address key issues at various levels of the educational system in Agricultural universities (NSAI 2012).

Issues and challenges

Globally competitive skilled human resource is a key to address the new challenges due to fast changing technologies, Intellectual Property Rights (IPR) regimes and trade related issues. Well trained scientists will develop cutting edge technologies to get higher investment returns to the farmers. There is a need to develop a new class of human resources with new skills and knowledge of quality seed-chain management to propel agricultural growth. Linking the manpower produced by Agricultural Education System with the trends of employment needs of various stakeholders of the economy and clients (students and farmers) is essential. Education in seeds generally does not address the emerging issues for the regulations, agriculture business, marketing, value addition, new areas of agriculture international trade exports and related disciplines.

Opportunities in different interrelated components of seed business underpin the need for organizing need-based education in the seed sector. Agricultural graduates trained in seed research and science, seed production, processing and marketing are needed (Figure 1).

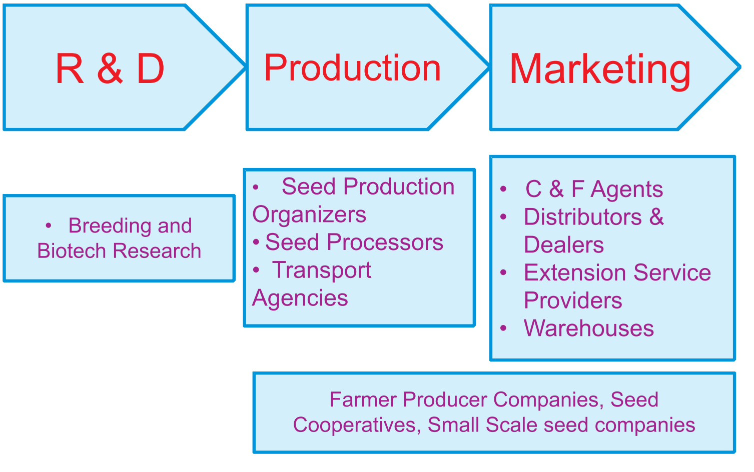

Figure 1. Opportunities for seed business

In fact, there should be joint departments of Seed Research, Production and Business, as done in several Land Grant Universities in USA several years ago. Building on a strong base of fundamentals of Agriculture, managerial issues of individual components of quality seed value-chain should duly be covered in seed degree programmes (Figure 2).

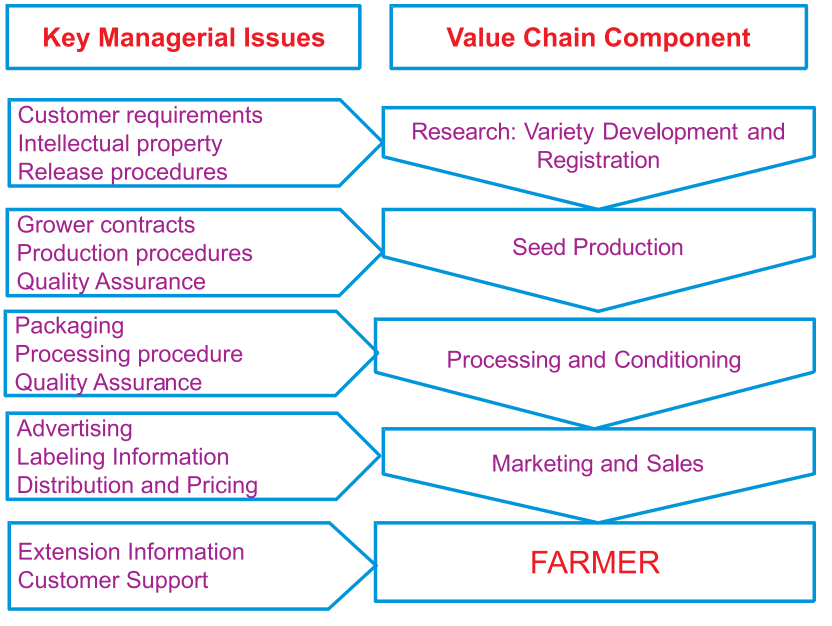

Figure 2. The requirement of manpower in the value chain component in the seed business

Source: Mac Robert, JF (2009)

In order to attract the rural youth for seed business education through awareness programmes among the outgoing students of 10+2 agriculture stream and State must provide scholarship for all students admitted in undergraduate programme. This is possible mainly through creating best infrastructural facilities, good faculty development programmes in educational technology, method of conducting examinations and evaluations, intake of best students, supported by globally competitive course curriculum of seed business. There is a need to produce the graduates with new set of competencies i.e. interpersonal competencies, better communication, research competencies, business and economic competencies, etc. Graduates should be technologically competent and equipped with soft skills and business skills, and able to work in the rural areas to bring the desired growth in agriculture. The field instructional units as well as the research laboratories must be better equipped to provide the skills during the graduation period. In addition to above, capacity building programmes of all the stakeholders must be designed by developing appropriate need based courses to meet the demands of diversification of agriculture and seed industry.

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e-Governance for Improving Communication Skills, Dissemination of Technology and Monitoring and Evaluation of Agricultural Education System

C.J. Dangaria and N.K. Gontia

To meet challenges and improve quality of education, it becomes necessary to use innovative technologies and internet, computer and communication facilities; and e-governance is one of the major innovations helping institutions to mobilize work and progress with limited resources. The e-governance includes development of specific softwares for application of better decision support at the headquarters and systematic approach to educate officials of sub headquarters/ sub divisions/sub centres through information technology. It is a state-of-the art implementation of internet and intranet to disseminate information, information exchange and knowledge sharing among officials, staff, farmers and other interested groups of people. The scope of e-governance in agriculture is very broad, including information on pesticides, fertilizers and seeds, soil health, farm machinery, training and Good Agricultural Practices (GAPs), weather forecast, prices, arrivals, procurement points, besides providing interaction platform, electronic certification for exports and imports, marketing infrastructure, monitoring implementation / evaluation of schemes and programmes, fishery inputs, irrigation infrastructure, drought relief and management, weather forecasts and outlook, and livestock management.

The Department of Agriculture and Cooperation (DAC), Ministry of Agriculture, has authorized a project called DACNET Dissemination System. The project is a state-of-the art implementation of internet and intranet to support dissemination of information, information exchange, and knowledge sharing among governmental offices. Applications of GIS is in precision farming approaches and can be helpful to small-farm agriculture. The various applications includes GIS-based mapping and modelling of soil erosion, land classification and suitability evaluation, remote sensing and GIS for soil-resource management, internet service system of agro-soil environmental information, BHOOMI, e-seva, e-Choupal, AKSHAYA (Kerala), Setu (Maharashtra), Lokmitra (Himachal Pradesh), i-Shakti (Andhra Pradesh), FINO, Gyandoot (Madhya Pradesh), Tata Kisan Sansars (TKS), IFFCO Kisan Sanchar Coop Ltd., Suwidha (Punjab) projects on Soil Health Card and Soil Fertility taken in different states of India.

The e-governance is implemented in Junagadh Agricultural University (JAU), Junagadh, for academic, research, education and administration works. e-Krishi Kiran is an Online Agricultural Extension System initiated by the Government of Gujarat (http://shc.gujarat.gov.in) for providing inter and intra linkages to scientists, farmers, officials, NGOs and public. Soil Health Card is a successful experience in Gujarat. The information is classified in the following four groups.

1. General Information

(i) Soil health card number

(ii) Farmer's name

(iii) Name of the village / taluka / district

2. Land Information

(i) Account number

(ii) Survey number

(iii) Survey number-wise land area

(iv) Soil type.

3. Soil analysis information

(i) pH value

(ii) Electric conductivity

(iii) Organic carbon

(iv) Available phosphorus

(v) Available potash.

4. Crop-wise fertilizer recommendations

(i) Season
(ii) Crop name
(iii) General recommendations of dose for chemical fertilizers (N, P, K) made for each crop by the Department of Agriculture
(iv) Recommendations of dose for chemical fertilizer (N, P, K) made for each crop on the basis of soil analysis report of each field
(v) Recommendation of FYM for each crop.

Details of Soil Health Card and Soil Fertility Projects operational in different states could be obtained from:

(a) Gujarat - AGRISNET Project (e-Krishi Kiran of Anand Agricultural University) http://agri.gujarat.gov.in/krushi_mahotsav_2006/soil_health_card.htm#; http://www.shc.gujarat.gov.in/
(b) West Bengal - AGRISNET Project (DAC Sponsored); http://wbagrisnet.gov.in/;
(c) Karnataka - BHOOPALA Software, developed by NIC in the Raichur District, Karnataka;
(d) Maharashtra – Software developed by NIC (Pune) and being used during the last 10 years;
(e) Haryana (http://www.rkvyharyana.com/ost/SSHC.aspx)
(f) Tamil Nadu (http://agritech.tnau.ac.in/agriculture/agri_soil_soilhealthcard.html)
(g) Andhra Pradesh (http://www.apagrisnet.gov.in/s_index.jsp)
(h) Tripura - ICAR Research Complex for NEH Region, (tsu.trp.nic.in/tripuraicar) - A NABARD funded Project
(i) IISS, Bhopal
(j) Software Standardisation efforts by NIC

A project under RKVY is on **Smart Farming for Increasing Agricultural Production in Sodic Soils of Coastal Area of Saurashtra** using remote sensing and internet for Remote Data Monitoring, Management, Control and Farm Solutions through interface of Sensors (such as Soil EC Sensor, Soil Temperature Sensor, Soil Moisture Sensor) and Internet. The Farm Management Portal provides real-time data from sensors (soil moisture, temperature, weather station, water and electric meters) located in remote farms, and provides irrigation scheduling recommendations, which a farmer can use to manage/control irrigation system from remote (Figure 1). Web-based Portal allows farmer to conduct his/her business from a distance using a desktop/a laptop or a web-enabled Phone (iPhone) from anywhere at anytime (24x7). Data from sensors and meter reading devices from remote farms are saved in a central database, and specific crop models and decision support algorithms are applied, and irrigation recommendations are presented along with alerts, notifications with ability to turn on/off irrigation systems, as well as allow fertilization and disease management also remotely. Besides, farmer has the ability to view his/her farm via a real-time video streaming data from a PTZ Web Cam, Anonymous 2013).

The e-governance in the JAU is implemented through intranet facilities. JAU Online Links is a programme developed with classic ASP language with MS Access as database management (Figure 2). This programme is developed and maintained by the university staff only. The JAU Online links includes Online Bill; Online PF; Online Tour; Online Software and Online JAU Circulars.

Figure 1. Smart farming project at JAU Mahuva

e-Governance in finance includes online account system (Bill), online bill programme developed with classic ASP language with MS Access as database that maintains and processes bill transactions of various schemes' budget heads running in JAU. This programme provides easy bill data entry for pay and allowances and contingency bill and display status of submitted bill. System generates various accounting reports. Admin Reports such as Budget Head Statement, Scheme Type wise summary, monthly expenditure / Income, Scheme type wise expenditure (Summary and chart). Tour programme is specially designed and developed for tour programme entry and approval of all the JAU officers and employees.

The JAU has adopted Google Apps facilities rendered through an MoU with Google for the benefit of all UG/PG students and faculty of the University. Facilities provided by Google Apps are Gmail – 25GB Capacity Per user, Calendar – Advance Sharing for Better Teamwork, Gtalk – 3rd Line of Communication (Text, Voice & Video), Google Docs, Google Sites, Google Video, Google Groups etc.

Challenges in wide-scale adoption in e-governance are trust, resistance to change, digital divide, cost, privacy and security, huge population and different languages. Measures for successful implementation of e-governance enhance citizen awareness, upgrading skills, common standards, technology evaluation, experience sharing, security, reliable infrastructures etc.

Measures for successful implementation of e-Governance

Enhancing awareness: Awareness about the potential of ICT should be made among the scientists/teachers/staff, students and farmers.

Upgrading skills: Upgrade IT skills of employees. Employees should be effectively trained before introducing desired changes in work process in government departments.

Common standards: All the state agricultural universities and ICAR should adopt common standards to ensure creation and optimum utilization of government databases for nation-wide education, research and farmers-related services.

Technology evaluation: Common evaluation methodology should be evolved for hardware and software selection to derive maximum benefit from investment.

Experience sharing: The sharing of experience on projects should be promoted between the state universities and the ICAR to avoid reinventing wheel.

Security: Transactional security should be given priority to ensure that internet use is safe, seamless and crisis-free.

Reliable infrastructures: Resources should be allocated to build a reliable ICT infrastructure to avoid breakdown of services. Cementing public-private partnerships to supplement ICAR/State government efforts should be considered.

There is a need to develop software for education and research management and monitoring in universities. The research management software should include details of the project, its present status, physical and financial progress; targets and achievements etc. Monitoring and evaluation of projects kills lot of time of scientists and higher authority; a clear picture of project development and progress available on the internet will save time and energy of all end-users and authority. Therefore, implementation of e-governance is a need of the hour for improving communication skills, dissemination of technology and monitoring and evaluation in agricultural education system.

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Technical Session 6

Strategies and Policies for Transforming Agricultural Education to Reshape India's Future

Technical Session 6, Chair Dr. M.C. Saxena

Achieving Excellence in Indian Agricultural Education: Experience from the World

Uma Lele

In the sixties through the assistance provided by the United States Agency for International Development (USAID), the Rockefeller and Ford Foundations and the World Bank, a premier agricultural research and education system was established in India. By 1975, in a decade since the balance of payments and a food crisis of the mid-sixties, the Indian agricultural educational system, patterned after the US Land Grant Universities, contributed enormously to agricultural science capacity in ushering in the Green Revolution (Lele and Goldsmith, 1989). External assistance combined with India's strong political commitment to build a world-class system of education and research, which was then driven by a desire to achieve food self-sufficiency and reduce dependence on external food and financial-aid, turned the country of recurrent droughts and famines dramatically into a food-surplus country. Indo-US relations deteriorated in the seventies, thus ending links to the US agricultural university collaborations. While the interactions were restored later, research, scientific and educational collaborations between them never reached the earlier peak. In contrast to India, Brazil maintained a steady collaboration for training and research with the US Land Grant Universities. And China invested a great deal in university education domestically and abroad after it opened itself to the world in the late seventies.

It is now widely recognized that in India while agricultural challenges during the post-Green Revolution have increased and become complex, the country's agricultural education has suffered from prolonged neglect, isolation and inbreeding (Tamboli and Nene, 2011). Stopping training abroad of the Indian scientists in the seventies contributed to eroding norms and standards for the conduct of research and education, which freshly minted returning graduates used to bring into the newly established Indian Agricultural Universities. The decline in the Indian agricultural educational system is in sharp contrast to other emerging countries, like Brazil and China.

Reforms in the Indian agricultural educational system have been also been piece -meal, addressing only some of the many fundamental challenges facing the system, rather than being part of an overall agricultural educational strategy. Agricultural research has received more attention through Committees headed by Dr M.S. Swaminathan and Dr Mashelkar, and agricultural extension has received attention through introduction of the Training and Visit system, followed by the establishment of Agricultural Technology Management Agency (ATMA) and the Krishi Vigyan Kendras (KVKs). Even though the reforms adopted in research and extension were not as far reaching as those recommended by the various committees, their implementation was half-hearted and in some cases the solutions were inappropriate as in the case of the T and V system, the reforms helped identify the necessary constraints which needed to be alleviated.

Why Include Research and Extension In Reshaping Agricultural Education?

Agricultural research, extension and value-chains define demand side of the agricultural education system. Their contemporary requirements need to be clearly understood to tailor human capital attuned to rapidly changed needs of the agriculture sector. And in a well-working agricultural educational system, strong interactions exist routinely among agricultural research, extension and education to ensure effective services are provided to the farming communities and other clients.

Agriculture and Agricultural Education

Agriculture has often been perceived by policy-makers as a declining sector. They assume that it can meet societal needs without nurturing its needs continuously. Decline in real food prices for nearly three decades contributed to a sense of complacency, not just in India, but globally. The sharp rise in food prices and increased volatility since 2007 are wake-up calls that agriculture sector needs more attention of policy-makers.

After years of under-capitalization of the sector, neither global nor Indian efforts are commensurate with the challenges in agricultural sector in a highly changed context. The undercapitalization is manifested in India's total factor productivity; the TFP growth lags behind other major developing countries (Figure 1).

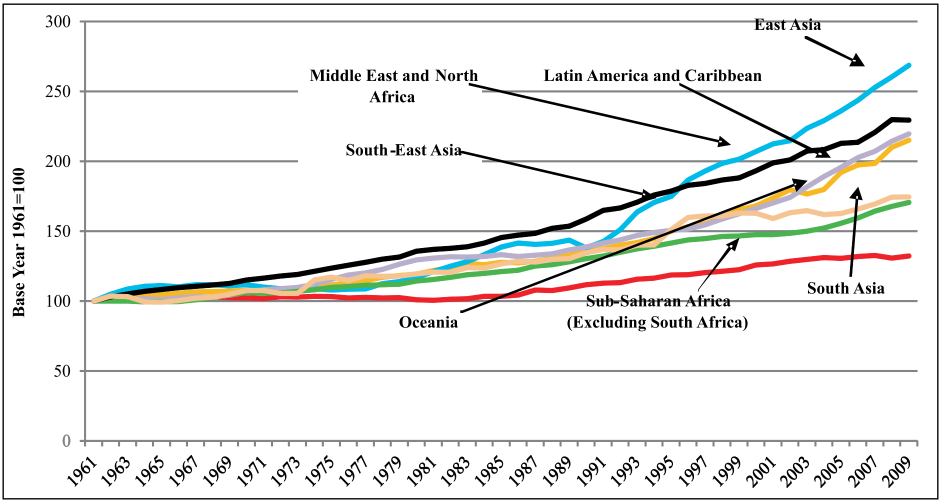

Figure 1. Agricultural TFP Indexes Growths, by Region (1961-2009): Agricultural Factor Productivity Growth is Critical for Overall Economic Growth but is lagging in South Asia and Sub-Saharan Africa

Source: Fuglie, Keith. 2012.

Brazil and China experiencing more rapid agricultural productivity growth than India have invested more in "technology capital", i.e., in agricultural research, education and extension, (Evenson and Fuglie, 2010). Growth in productivity requires much more than directs physical capital in agriculture. It calls for investments in the primary and secondary education, roads, power, and community and market institutions. India has now fallen behind other major East and South East Asian countries by most measures of physical and social capital, including women's education, rural access to energy, transport, internet and markets leading to a lagging process of structural transformation relative to countries like China and Indonesia. This is despite the fact that China and Indonesia had started with similar or worse initial conditions than those in India in 1960 (Lele *et al.*, 2011).

Changes in the World Affecting Indian Agriculture

The changes in the global environment add to complexity of challenges faced by Indian agriculture. These changes include the following.

- The accelerated speed of globalization leading to highly inter-connected markets at the global level, ranging from agriculture and energy to financial and exchange rate markets. Together they influence international food and energy prices.
- Rapid technological change - in Information technology and biotechnology, in which others are surging ahead.
- Climate change is already projected to severely affect severely the South-Asian region.
- Population of India will exceed China's by 2023, and will exert considerable pressure on natural resources and increase risks and uncertainty.

The educational system must develop human capital necessary to help Indian agriculture facing these broad set of challenges, not incorporated in the agricultural strategies, while addressing issues of food security and elevating living standards of the masses.

To address such new challenges, the focus in the more progressive countries has shifted from a top down unidirectional approach to research and education to flexible horizontal problem-solving approaches involving multiple stakeholders and learning-by-doing. Universities and research systems are adapting to these changes as will become evident from the cases of Europe, the US and Japan.

Internal Changes in India Affecting Agriculture

There have been changes in India too. Those for the better include: India's accelerated economic growth for nearly two decades, leading to growing self-confidence and more fiscal revenues. Yet the increased fiscal deficits since the global recession hit in 2008are calling for retrenchment in government spending with increased need to use resources already allocated to agricultural research, extension and education more efficiently.

India has more trained people now, a dynamic private sector, including an impressive IT (Information Technology) industry, which is insufficiently harnessed in the business of public sector management, a strong civil society, the rising middle class, an active media and judiciary, each demanding better socio-economic performance.

But some changes in India are ominous. A large underclass of uneducated, unskilled and undernourished population threatens to turn the demographic dividend into a demographic liability. The pervasive decline in the overall quality of governance compounds challenge of reshaping India's agricultural education for increased accountability, than when educational reforms are considered in isolation.

India needs "Disruptive Innovations"

In a system riddled with vested interests dramatically changed paradigms for agricultural education globally offer a new way to increasingly focus on innovation rather than technologies alone. Changed paradigms for agricultural education and research focusing on innovation include the following.

- Problem-solving Inter-disciplinary education and research (rather than elitist, "knowledge for its own sake").
- Life-long learning (cradle to grave learning, including Internet-based education rather than just classroom teaching, which ends with formal degree education).
- Pluralistic institutional structures : i.e. not just public but private sector, farmers' organizations, consumer- and client-focused organizations, processors and exporters all contributing to knowledge as well as learning.
- Strengthening of global and local collaborations in scientific and educational endeavours to accelerate learning.
- New funding mechanisms which are often competitive rather than block funding based.
- New sources of funding beyond agriculture to include: Environment, Health to address broader scope of challenges facing food and agriculture; demand for improved accountability in public sector management which includes:
    - Evidence of efficiency and effectiveness of public institutions.
    - Accountability mechanisms, including professional peer based standards, norms, government imposed performance requirements, client, civil society and media-driven standards.

Disruptive innovation has now become a global norm through the contributions of the likes of Bill Gates, Steve Jobs and many others including an army of micro-innovators of "apps" that form panoply of innovations. They have dramatically changed the way we do business, acquire information, communicate, learn and spend our leisure time listening to music or watch movies. They have democratized information and some have struck a major blow to intellectual property regimes, thereby fundamentally changing our mindsets. Reshaping "agricultural" education needs to achieve such changes to make equitable and sustainable economic growth a reality. It means understanding how others are striving for—

- Cutting edge but relevant research
- Training to produce high-quality skilled staff
- Doing performance assessments
- Pursuing meritocracy
- Conducting impact assessments
- Introducing increased accountability and
- Entering into effective Public-Private-Civil Society Partnerships, including in managing such thorny issues as IPRs (Intellectual Property Rights).

Global Innovation Approaches India-Specific Challenges

The global innovation approaches must be seen in the context of India-specific challenges in agricultural education. These include the following.

- **India's complex public agricultural education system** is matched in complexity only by China's 51 Universities including 44 state agricultural universities, 5 deemed-to-be universities and 2 central agricultural universities.
- **Vast and multi-sectorial scope of agricultural research, education and extension system**, requiring cooperation among the Departments of Agriculture, Council of Scientific and Industrial Research (CSIR), Departments of Science and Technology, Fertilizers and Chemicals, Commerce, over 80 All -India Coordinated Research Projects, in soils, water, crops, horticulture, livestock, fisheries, home science, agricultural engineering, education, etc.
- **Agriculture (like water, land and forestry) being a "State Subject"** constitutionally in India in contrast to China has led to a seemingly highly decentralized system of "state responsibility". It seems to have all the disadvantages of a large country (diseconomies of scale) without advantages, described by some as 28 states acting as independent countries.

How do large countries such as China, Brazil, the US, Japan each with quite different political systems, reform and perform? How do they use Public-Private-Civil Society Partnerships to achieve constructive solutions to controversial issues?

If the allocation of public sector research resources between the central and state units is any guide, Brazil and China seem to undertake more research through centralized institutions to achieve national objectives. They appear to exercise more central direction and control to public sector agricultural research than does India. Their research systems also seem to enjoy more autonomy and less political interference. State-level educational institutions in India on the other hand seem to receive a larger share of R &D budget than either in Brazil or China, according to ASTI (Agricultural Science and Technology Indicators) data, but seem to be conducting less research and more teaching. What limited research they undertake seems to come from central resources provided by the Indian Council of Agricultural Research and other grants. This will require more thorough reporting, monitoring and analysis of quality and impacts.

The several tasks ahead that need attention are as follows.

1. First and foremost, it is to develop a precise consensus on India's current problems/challenges.
2. To examine if an adequate National Strategy for Reform of Agricultural Education exists—ranging from primary, secondary to tertiary, and if the strategy does not exist, to determine, how to develop one.
3. To clearly establish the locus of leadership for the design and implementation of reforms. e.g. for stronger Inter-Ministerial Cooperation (ICAR and NAAS [National Academy of Agricultural Sciences], Ministry of Education, Agriculture, DBT [Department of Biotechnology], Information and Communications, Environment and Forests?
4. To explore how to establish active regular continuous cooperation with the external actors including the USDA, Brazil, China, Japan and Netherlands, besides the CGIAR, FAO and GFAR.
5. To Establish "LABEX (Laboratory of Excellence) like" programmes for scientific exchanges.
6. To seek support of International Agencies in a catalytic way e.g. World Bank, FAO, Gates, IFPRI (International Food Policy Research Institute).
7. To establish international mentorship programmes for training, collaborative research.

8. To identify needs for curriculum improvement and its implementation in a multi-stakeholder-public-private-civil society mode.
9. To revamp and implement Performance Assessment Systems.
10. To devise improved incentive systems for teachers and students.
11. To address organizational issues on the appropriate roles of centralized agencies (establishment of standards and norms, accreditation, definition of responsibility and accountability for performance) and decentralization, including fiscal issues, such as level of operational budgets.
12. To find ways to introduce routine Independent Monitoring and Evaluation.
13. To establish Centers of Excellence in the SAUs on a Competitive Basis.

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Agricultural R&D in India, Brazil, and China: Analysis of Recent Financial and Human Resources Trends

Nienke Beintema and Kathleen Flaherty

High investments in agricultural research and development (R&D) are essential for enhancing agricultural productivity. Over the past five decades, these investments have contributed in economic growth, agricultural development and poverty reduction in developing regions (Fuglie 2012; World Bank 2007, IAASTD, 2008).

A number of emerging countries, particularly Brazil, China and India, have become major forces in global economic, social and environmental affairs. All three have experienced substantial economic growth in the recent years (Table 1). Combined with their size in terms of economy and trade, they have an intensifying impact on the development and food security of other developing countries (Fan and Brzeska, 2010). Brazil and China have particularly experienced robust growth in agricultural productivity since seventies (Fuglie, 2012; Beintema *et al.*, 2012). All the three countries have made progress in lowering the proportion of their population living in poverty; although the degree of success was of mixed nature (Fan and Brzeska, 2010).

Public Agricultural R&D Spending

Improving agricultural productivity has been a high priority in Brazil, China, and India, which resulted in increased government contribution to public agricultural R&D. India's R&D spending increased close to one-half during 2000-08 and totaled 2.1 billion PPP dollars in 2008 (in constant 2005 prices), and increased a

Table 1. Country overview, 2011

Indicator	Brazil	China	India	World
Population, total (million)	197	1,344	1,241	6,974
Population % of world	3	19	18	100
GDP (billion 2005 PPP dollars)	2,021	9,971	3,977	70,230
% share in global total	3	14	6	100
GDP growth (annual percent)	2.7	9.3	6.9	2.7
GDP per capital (2005 PPP dollars)	10,279	7,418	3,203	10,071
Agricultural GDP (billion 2005 PPP dollars)	110	1.001	685	na
Agricultural GDP growth (annual percent)	3.9	4.3	2.8	na

Source: World Bank (2012).

further 40 % during 2009-2010. China's spending increased even more impressively since 2000. Spending levels almost doubled during 2000–2008 and increased further by 50 % (or an additional $2 billion PPP dollars in 2005 prices) during 2009–2010 (Figure 1). Interestingly, spending growth appeared to level off during 2011 (as of January 2013, data for 2012 were still unavailable). Brazil traditionally has one of the most well-established, well-funded research systems in the developing world, but its spending levels fluctuated over the past two decades. The Brazilian government increased its commitment to agricultural R&D, resulting in an estimated increase of 20 % in spending during 2008–2011.

Strong government commitment to agricultural research in Brazil and China were combined with policy and institutional reforms, such as improved incentives for farmers, macroeconomic stability, relatively strong extension and rural education systems, and improved rural infrastructure and market access (Chen, Flaherty and Zhang 2012; GHI 2011). This boosted agricultural productivity of both above the rest of the developing world during the eighties, and both have maintained rapid growth ever since (Figure 2). Both countries experienced sustained higher agricultural growth - measured as total factor productivity (TFP). By 2009 (relative to 1981 levels), cumulative TFP growth increased by 142 % in Brazil and by 119 % in China. Policy and institutional reforms affecting agriculture have been less pronounced in India (Fuglie and Schimmelpfennig, 2010),

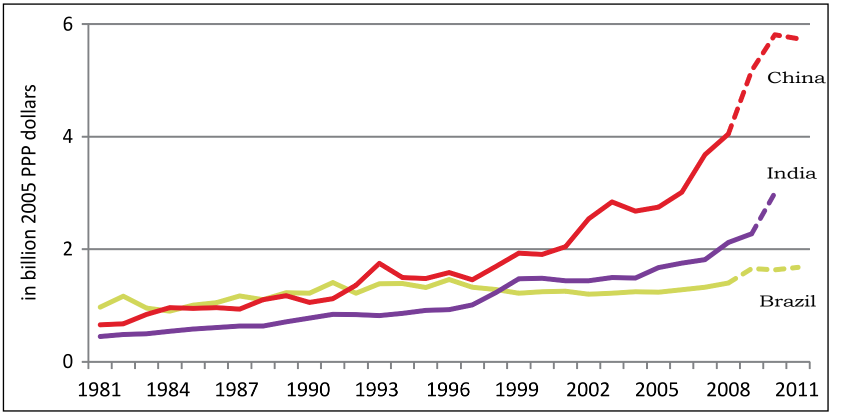

Figure 1. Public agricultural R&D spending trends in Brazil, China, and India, 1981-2011

Sources: ASTI (2012), Embrapa (2012), Government of India (various years), NBS and MOST (various years).

Notes: Dotted lines indicate preliminary estimates; 2009–2011 estimates for Brazil are based on financial data from Embrapa (2012) and the assumption that spending growth at other Brazilian agricultural R&D agencies was half that of Embrapa's; estimates for India are based on financial data from the Indian Council of Agricultural Research (ICAR) and the state agricultural universities (SAUs), and the assumption that spending growth at the other agencies was half that of ICAR and the SAUs. The 2009–2011 estimates for China are based on the assumption of the overall agricultural R&D spending grew at the same rate as direct research costs of government spending data (the only data that were available).

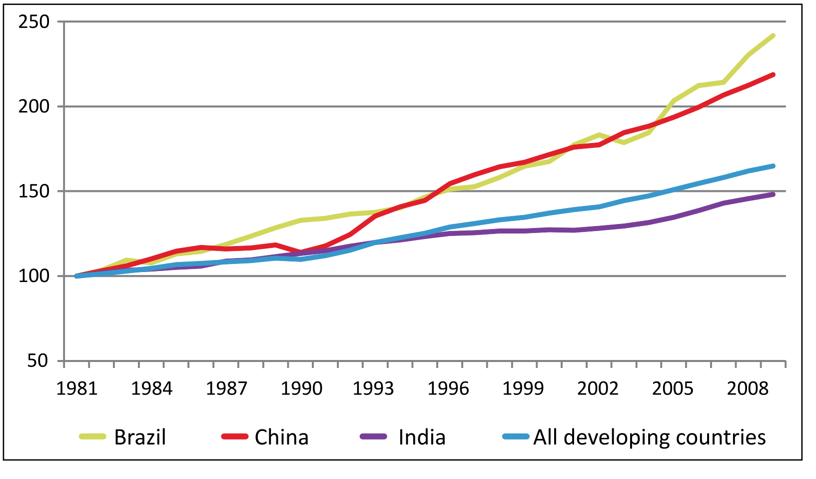

Figure 2. Accelerated agricultural productivity growth in India, Brazil, and China, 1981-2009

Source: Fuglie, 2012.

India's productivity growth of 48 % has been considerably lower than the other two as well as of the average of 65 % for developing countries as a whole.

Another way of evaluating a country's agricultural R&D commitment - and of placing it within an international context—is to calculate its agricultural research spending relative to agricultural gross domestic product (AgGDP). This indicator is commonly known as the research "intensity ratio." Brazil's status as one of the most well-established and well-funded research systems in the developing world is reflected when relative levels of agricultural R&D spending are measured in terms of the dollars spent per $100 of agricultural AgGDP and per population employed in agriculture. In 2008, Brazil invested $1.52 for every $100 of agricultural output on average, which was considerably higher than the $0.50 and $0.40 for China and India, respectively (Figure 3). Despite the growth in public agricultural R&D spending in India since the turn of the millennium, its intensity ratio remained fairly constant, as the result of complementary growth in AgGDP. A similar trend was observed in China, where the intensity ratio in 2008 was about one-

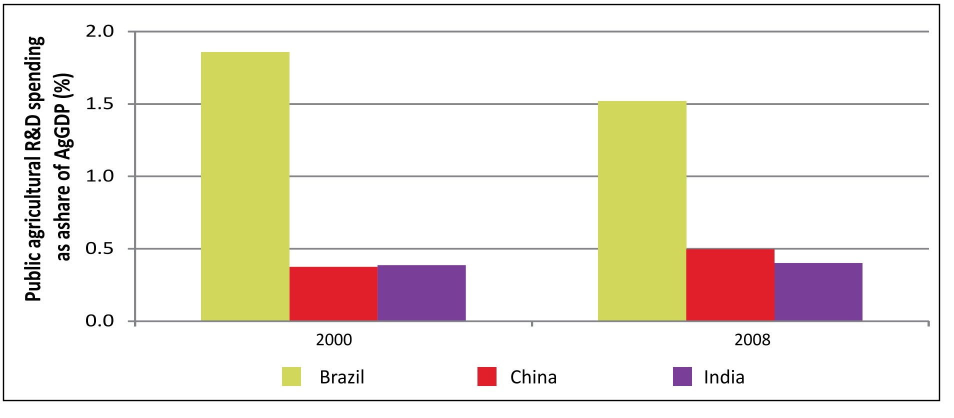

Figure 3. Intensity ratios, 2000 and 2008

Sources: See Figure 1. For agricultural GDP, see World Bank (2012)

third higher than the corresponding ratio in 2000 while spending almost doubled.

This discrepancy reflects one of the limitations of using intensity ratios. For example, a decrease in research intensity may not mean a lower level of investment, but rather an increase in agricultural output - as in Brazil during the 2000-08 period. Intensity ratios are not always appropriate as they do not take into account policy and institutional environment within which agricultural research occurs or the broader size and structure of a country's agriculture sector and economy. For example, while China and India have had lower research intensity ratios than many countries in Africa, their research systems are equipped better to address farmers' scientific and technological challenges due to larger absolute size and greater research capacities. Due to their limitations, intensity ratios should neither be used as the sole measure of public agricultural R&D spending levels. Other factors, such investment growth, human resource capacity, and infrastructure, should be considered as well (Beintema *et al.*, 2012).

Spending Trends in a Global Context

In part as a result of the strong spending growth in China, India, global public agricultural R&D spending increased from 26.1 billion in 2000 to 31.7 billion PPP dollars (in 2005 prices) in 2008 (Table 2). China's share in this 5.6 billion dollar growth was 38 % and India's corresponding share was 11%. During this period, public spending grew in the United States and Japan, as well as in some other large, more-advanced middle-income countries, Brazil, Argentina, Iran, Nigeria and Russia.

In 2008, expenditures were roughly split evenly between high-income countries and low- and middle-income countries; a sharp contrast with 1981 when high-income countries accounted for about two-thirds of total global spending (Figure 4). This decline resulted largely from relatively higher spending growth in China and India during the eighties and nineties China's share increased in the global total from 4% in 1981 to 13 %; and India's share from 3 to 7%. Because of this increase, Brazil, China, and India combined accounted for about one half of the total spending in public agricultural R&D of the low- and middle-income countries. Given the large size of its population employed in agriculture sector and large number of undernourished people, increased investment levels will have a positive impact, as increased agricultural innovation will lead to increased availability of food at lower price (Pardey, Alston, Chan-Kang 2012). Furthermore, the agricultural innovations developed by China and India will potentially have substantial impact on the economic development and food security of other developing countries (Pardey, Alston, and Chan-Kang 2012, Fan and Brzeska, 2010).

Table 2. Growth in public agricultural R&D spending by major country and income groups, 2000-2008

Country/income group	Total spending		2000-08 spending growth	
	2000	2008	Absolute	Global share
	(*billion 2005 PPP dollars*)			(%)
Brazil	1.2	1.4	0.2	3
China	1.9	4.0	2.1	38
India	1.5	2.1	0.6	11
Japan	2.9	3.1	0.2	4
United States	4.3	4.8	0.5	10
Low income (31)	0.7	0.9	0.1	3
Middle income (102)	10.2	14.7	4.5	79
High income (46)	15.1	16.2	1.0	18
Total (179)	26.1	31.7	5.7	100

Sources: ASTI (2012), Embrapa (2012), Government of India (various years), NBS and MOST (various years); USDA-ERS (2012), OECD (2012), Eurostat (2012) and various country-level secondary sources (see www.asti.cgiar.org/globaloverview *and Beintema et al., 2012).*

Notes: Number of countries is given within brackets.

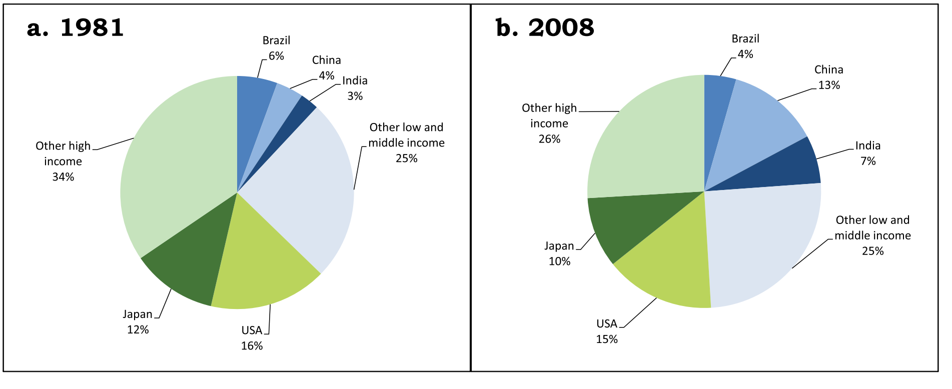

Figure 4. Public agricultural R&D spending trends in India, Brazil, China, and other middle-income countries, 1981-2011

Source: See Table 2.

Human Resource Capacity

Human resource capacity refers to quantity and quality of scientific and technical personnel employed in the national research systems. It is difficult to arrive at estimates of human resource capacity in agricultural R&D across the three countries because of different definitions of what constitutes an "agricultural researcher." In China, agricultural researchers include a large number of BSc holders, while in India and Brazil BSc-holders are mostly classified as a research support staff. In 2008/09, China's public agricultural R&D sector employed more than 43,000 researchers, measured in full-time equivalents (FTEs); considerably more than in Brazil and in India (Figure 5). However, excluding BSc-holders, China's researcher pool dropped to close to 18,000, which is still higher than India's 11,217 FTE researchers and Brazil's estimated 5,376 researchers in 2009 and 2006, respectively.

Institutional composition of public agricultural R&D

In all three countries, the higher-education sector, in terms of human resource capacity, increased in importance (Figure 6). In India the sector's share is one of the highest in the developing world, which

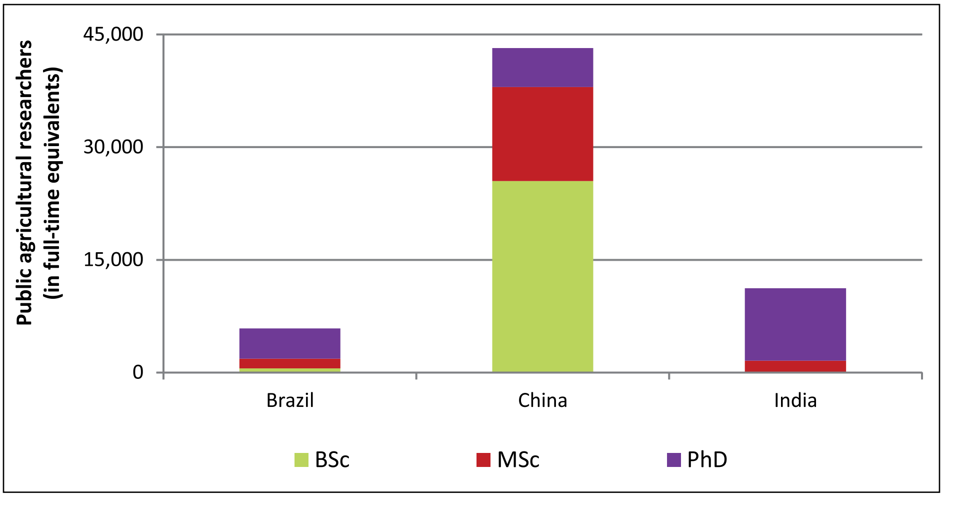

Figure 5. Public agricultural researchers in Brazil, India, and China, c. 2008

Sources: Beintema, Avila, and Fachini (2010); Chen, Flaherty, and Zhang (2012); Pal, Rahija, and Beintema (2012).

Notes: Brazil data for 2006, China for 2008, and India for 2009. Degree distribution for China and India are based on government agencies only.

reflects the country's organization of public agricultural research following the United States' land grant system. The higher-education share has also increased substantially in China since 2001 and accounted for close to 40 % in 2008. Although the higher education sector increased in importance in Brazil as well, its share of 16 % remained relatively low.

Brazil. Agricultural R&D in Brazil is conducted at the federal and the state level. The Brazilian Agricultural Research Corporation (Embrapa), a semiautonomous agency, plays a primary role in federal research, and accounted for 41 % of the total public agricultural research capacity (in FTEs) in Brazil in 2006 (Beintema, Avila, and Fachini, 2010).

State level research comprised 38 %of the total public agricultural FTE researchers in 2006. However, because the state research agencies receive much lower levels of funding than Embrapa, their share in the country's total public spending, at 21 %, was considerably lower. Agricultural research agencies are located in 17 out of the country's 26 states. The São Paulo Agency for Agribusiness Technology (APTA) accounts for half of total state spending and is the largest state system with some of the most long-established research institutes.

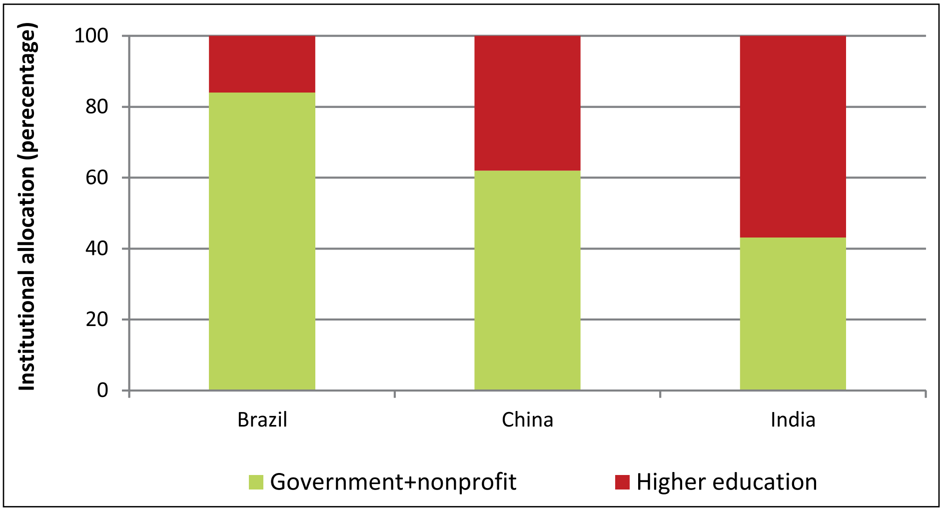

Figure 6. Institutional distribution, Brazil, China, and India, c. 2008

Sources: Beintema, Avila, and Fachini (2010); Chen, Flaherty, and Zhang (2012); Pal, Rahija, and Beintema (2012).

Notes: Brazil data for 2006, China for 2008, and India for 2009. Distribution is based on number of FTE researchers.

The other state systems are much smaller and focus on applied research and extension.

A number of other federal government and nonprofit agencies are engaged in agricultural research, accounting for 4 %of the country's total research capacity. More than 100 university faculties and schools are involved in agricultural research in the country, its share being estimated at 16 % in 2006.

China. Public agricultural research institutes operate at the national, provincial, and prefectural levels in China, with a high degree of decentralization. The Chinese Academy of Agricultural Sciences (CAAS) is the main agricultural research agency and reports to the Ministry of Agriculture (MOA). The Chinese Academy of Sciences (CAS), administered by the Ministry of Science and Technology (MOST), also undertakes agricultural research and oversees several relevant research institutes.

Capacity at the provincial and prefectural institutes combined accounted for 62 % of the government total (Chen, Flaherty, and Zhang, 2012). There are fewer national research agencies (59 compared with 454 provincial and 592 prefectural), although they tend to be larger in size.

Agricultural research capacity in the higher education sector in China has increased since 2000, accounting for 38 % of the country's total in 2007. This sector includes agriculture-specific universities as well as multidisciplinary universities involved in agricultural research.

India. Agricultural R&D in India is conducted predominantly by the Indian Council of Agricultural Research (ICAR) and the State Agricultural Universities (SAUs). The ICAR accounted for 34 % of the total FTE researchers in 2009 (Pal, Rahija, and Beintema 2012).

The SAUs accounted for more than one half of public agricultural FTE researchers in 2009. Some of the largest universities include Acharya NG Ranga Agricultural University, Tamil Nadu Agricultural University, and Punjab Agricultural University, each employing over 500 FTE researchers.

Other government and higher-education agencies are also involved in agricultural research in India, including the agencies of the Indian Council of Forestry Research and Education (ICFRE). However, these groups only accounted for 10% of total agricultural research capacity in 2009.

In contrast to the steady positive trend in agricultural R&D investment, the number of FTE researchers fell by 17 % during 2000-09. This decline occurred throughout the system, but was most severe within the SAUs; the latter can be attributed mainly to slow recruitments.

Private Sector Involvement in Agricultural Research

China. As a result of a series of reforms in the nineties that encouraged commercialization, input market liberalization, and supporting intellectual property rights, private investment in China expanded considerably. From 3 % of total (i.e., public and private) agricultural research spending in 1995, the private sector share grew to 16 % in 2006 (Pray and Fuglie 2001; Hu *et al.,* 2011). In 2006, private investment was estimated at $565 million (in 2005 PPP dollars). Investment may in fact be even higher as these data do not include research in the pesticide industry (Hu *et al.*, 2011). Like in India, the size and growth of R&D investment in food-processing industry is substantial. Food processing R&D surpasses levels in each of the other areas of private agricultural research spending. If included, with a total of $385 million in 2006, it would comprise 40 % of all private agricultural R&D investment (Hu *et al.,* 2011).

The composition of the sources of private investment has shifted over time, from foreign to domestic. State participation in the private sector has also decreased since 1990s. However, even fully privately owned companies receive a small share of government funding. In fact, this direct R&D investment by the government to private companies has contributed to overall growth of private sector research. The growth has been offset, however, by public sector research, which continued to concentrate on technology development, thus not leaving profitable research to the private sector (Hu *et al.,* 2011).

India. Private-sector involvement in the country has also grown considerably in the past few decades. Total spending by the sector increased almost ten-fold from $57 million in 1984-85 to $553 million in 2008-09 (in 2005 PPP dollars). The private sector accounts now for close to one quarter of India's total (i.e., public plus private) agricultural R&D investments. Indian firms make-up for two-thirds of the total, with the remaining owned by multinational companies. Seed and biotechnology research accounted for about half of all investment, followed by pesticide research (20 %). These figures exclude R&D on agricultural machinery and food processing. This type of research is not usually considered to be in the scope of agricultural research for the purpose of international comparison (as the category is also excluded from agricultural GDP). Agricultural R&D investments in these two manufacturing sub-sectors have also grown exponentially and accounted for an additional $203 million in research investment in 2008-09 (Pray and Nagarajan 2012).

Liberalization of the seed market and elimination of tariff barriers greatly contributed to this growth in private investment. Both national and multinational companies responded to reforms by increasing investment in joint ventures. Compared to public sector, private companies have produced significantly more vegetable hybrids, pesticide formulations, patents, and plant variety protection certificates than the public sector agencies (Pray and Nagarajan 2012).

Brazil. Unfortunately, recent data on the private sector agricultural R&D in Brazil are not available. In the 1990s, while the number of private agribusiness firms increased, very few were involved in agricultural research. Most of the technologies provided originated from foreign sources. In 1996, private sector investment was estimated to be less than 4 % of the country's total agricultural R&D spending that year (Beintema, Avila, and Pardey 2001). Considering trends in China and India, private sector investment in agricultural R&D most likely has grown substantially since 1996.

Conclusion

Public agricultural R&D investment in Brazil, China, and India combined has increased since early 1980s, and accounted for about one half of the total spending by all low- and middle-income countries in 2008. Furthermore, the private sector has also stepped up its involvement in agricultural R&D (as well as in related sectors such as food processing). Particularly in China, increased investment and institutional reforms have resulted in a high productivity growth. These increased investments will have a positive effect on the livelihood of large number of poor people, who through the development of new agricultural innovations will have access to more and cheaper food (Pardey, Alston, and Chan-Kang 2012). Continued increased focus on agricultural R&D will allow China as well as India to continue lowering proportion of population living in poverty. In the case of India, productivity levels could be accelerated by coupling country's increased investments in agricultural R&D with similar policy and institutional reforms that have had such positive impacts in Brazil and China.

Developments in agricultural R&D in Brazil, China, and India will have global implications, not only in terms of transfer of technologies and south-south collaboration, but also for agricultural trade, natural resource management and environment. The main public agricultural R&D agencies in Brazil, India, and China can play a leading role in transfer of agricultural technologies and knowledge—historically done by high-income countries and international research centres—to other developing countries; many of which have low agricultural productivity levels and high rates of poverty.

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Educating Future Agricultural Scientists and Academicians in India

Rattan Lal

India has a total area of 329 million hectares (Mha) and a land area of 297 Mha; 2.4% of the world's land area. Its 1.22 billion people (17.4% of the world's population) live in 5,100 towns and 380 urban agglomerations. Agricultural production since 1960s has increased significantly, especially with the onset of the Green Revolution. However, there is no scope for complacency, because future challenges are even greater. Food production may have to be increased considerably as the population may be 1.69-1.8 billion by 2050 and 1.85 to 2.18 billion by 2100.

Despite the increasing trends in productivity of crops in India between 1970 and 2011, the yields of major crops are lower than the attainable potential, and considerably below the maximum yields obtained in other countries. Thus, agriculture in India has a long road ahead to realize its full potential, and education plays a crucial role in realization of the potential.

High Impact Agricultural University's Attributes

A university is an institution of scholars and facilities organized for developing new knowledge, teaching and outreach. A university must challenge faculty and students to be original, creative and innovative. It is the standard of the undergraduate and the graduate education which makes a university a first-rate one. Inter- or a cross-disciplinary programme is an important attribute of a first-rate university. A scientist, who has rarely conducted research outside his/her field of specialization, cannot assess the importance of an observation, which may be of an interdisciplinary nature and of a greater significance. Thus, in addition to agriculture, learning mathematics, physics, chemistry, biology, genetics, sociology, economics, theology and other basic sciences is a must for research and education in agriculture. Students must be taught importance of basic and applied research. The former is a reservoir of knowledge to be drawn later, and the latter is the information to be immediately made use of. A university must also prepare its students to differentiate between knowledge and wisdom. Knowledge is accumulated through lectures, laboratories, research experiments, brain-storming sessions, etc. Wisdom is a common-sense to apply that knowledge appropriately. Wisdom involves reasoning out answers from known facts. Teaching wisdom is a big challenge. Students must understand the difference between "a test" and "an experiment". A test ends when the hypothesis is verified; and an experiment ends when new truth divulges out. Access to good library facilities is essential to synthesize known facts; identify known unknowns and hypothesize unknowns. In an era of rapid advances, as much as 90% of the scientific literature available today may not have existed even a decade ago. Therefore, graduate students must be trained in reviewing literature, in synthesizing knowledge, and in identifying researchable issues.

In the context of South Asia, in general, and India, in particular, agricultural science and technology must alleviate drudgery and obviate risks of farming operations, introduce labour-saving devices, develop appropriate tools for women farmers, and elevate status of farming, and of those connected with the farming profession.

Despite the commendable achievements of the "Green Revolution", students must be taught that a new revolution begins with each class. If we are not sure whether to plough or not, puddle and flood the rice paddy or not, grow crops containing BT gene (e.g., cotton, brinjal) or not, use dung for cooking or as a soil amendment or not, design tools exclusively suited for women-farmers or not, then the revolution has not yet begun.

Yet, agricultural science, like any other, must not become arrogant and all-knowing. It must be environment-friendly and in-grained in high moral and ethical standards. Students must know that agricultural scientists will always be humble to discover the vast unknown, including reading of theology, philosophy and spiritualism, which must be intricately linked with the scientific knowledge (Lal, 2013). Above all, agricultural scientists must not be detached from the society that pays them. They must care for the well-being of the community and strengthen warmth in human relationships. Indeed, agricultural scientists must also work with popular press and create headlines, and even flirt, up to a limit, with sensationalism. Agricultural scientists must go back to nature for a reality check because agriculture must be compatible with nature and ecosystem health. While being creative thinkers, agricultural scientists must be incredulous, inquiring and inquisitive about ecosystems and environment.

Most state agricultural universities are focused on applied agricultural research and testing programmes (varietal testing, dates and rate studies). It is understood that many site-specific problems of practical nature need a rapid response. However, agriculture is a science, an industry and also an important business. Thus, it must be profitable to practitioners, the ecosystem, in which it is practiced, and the planet Earth. Thus, state agricultural universities (SAUs) must participate fully in fundamental and basic research. Some applied problems of agriculture in India await answer by laws of basic science. Thus, there is a need to develop a good balance between the two.

Respectability to Agricultural Profession

Public image of agricultural scientists and professionals must be improved. At present, SAUs are not the first choice of the best and the brightest students, and farming is not the choice of the young and aspiring entrepreneurs. This scenario needs to be changed.

Respectability and recognition of the agricultural science by the SAUs and institutions of the Indian Council of Agricultural Research (ICAR) can be enhanced by the following ten tenets.

1. **Originality** in thinking and identification of problem(s) are needed to be a scientist rather than just a follower. It is always important to use brain, especially, when budgets are low. Thus, researchers must be thinkers rather than equipment users;
2. **Objectivity** is necessary to being impersonal, impartial and detached in interpreting results and looking at data without wearing tinted glasses;
3. **Accuracy** in making observations is essential by being a skeptic in supporting evidence and facts, and avoiding speculations;
4. **Conservatism** in implications and scaling up pays dividends,
5. **Reductionism** by minimizing generalizations from site-specific testing is important;

6. **Moral neutrality** by not involving questions of right and wrong is an essential pre-requisite;
7. **Accountability** is critical because agricultural educators and researchers must never forget that no one is indispensible, everyone is answerable to public and pay back to farming community that supports them. To be accountable, a faculty member cannot do what he/she wants with little or no obligation;
8. **Relevance** to the needs of the society, developing a demand-driven research and academic programme and regarding the farmer as the boss are crucial;
9. **Output-based** mission-oriented and problem-solving approach is indispensible; and
10. **Team building** and collegiality are required through cooperation of many minds because no scientist is an island.

Integrity in scientific research and academic institutions is crucial to originality and objectivity. It includes research misconduct such as plagiarism and faking data (Kaiser, 2002). Integrity must be imbedded in the curriculum. In search of excellence in teaching, evaluation of teaching by students is another important aspect of improving agricultural education in India. A system which takes students' achievements into account in various ways comprises a different way of doing business.

Similar to other sciences, agricultural science is not merely an intellectual conviction, it is a **way of life**. Thus, agricultural curricula must prepare students to feel it deeply, believe in it, and experience it even during their dreams. The way of life is not confined to strict office hours; it is to be experienced with every breath inhaled and exhaled. Researcher and teachers must be taught work ethics and be prepared for dedication towards responsibility and commitment. Their job neither has 8 to 5-punch clock nor 5-day-work week. Similar to riding a bicycle, to avoid a serious fall or rust out, agricultural scientists must pedal continuously. Walking at the same speed as others perpetuates stagnation and mediocrity. One must run to be ahead, and maintain the tempo in perpetuity.

Agricultural Education in India

India has been a land of knowledge and wisdom for millennia. However, access to knowledge was limited to a select stratum of society. Being a secular state and its constitution guaranteeing access to education for all, the challenge lies in meeting needs of the vast variety of its citizens. India comprises more than 2,000 ethnic groups, which speak 22 scheduled and 200 overall languages and some 2,600 dialects. Towards an earnest effort to making education accessible to all its citizens, the country has created a vast and a modern education system, which is the largest education system in the world. It comprises 378 universities, 864 colleges, 0.5 million faculty, and 14 million enrollment. Agricultural colleges and universities are important component of this vast system.

Formal agricultural education began with the establishment of an agricultural school in 1877 at Saidpet in the then Madras province (now Tamil Nadu). Organized agricultural education started during the first decade of the 20th century through the establishment of four colleges in 1905 (Kanpur, Lyallpur, Coimbatore and Nagpur) and two in 1907 (Pune and Sabour-Bihar). The degree programme started in early 1920s, and had a total of 17 agricultural colleges at the time of independence in 1947. At present, there are 71 agricultural colleges with 5,452 candidates enrolled in each university annually (ICAR, 2007). The University Education Commission, established in 1949 and chaired by Dr S. Radhakrishnan, recommended establishment of rural universities on the patterns of the Land-Grant Institutions (LGIs) in the USA. (*See* also **Adapting the Land-Grant System into SAUs**). Agricultural education has grown tremendously since 1960s. However, funding levels have not kept pace with the growth (Challa *et al.,* 2011). Scarcity of funds have hindered development of modern facilities and infrastructure. Yet, there is a strong need to create a cadre of well-trained professionals to serve agricultural community. Rao *et al.* (1997) made three specific recommendations—(1) the number of diploma holders at the lower end of the professional ladder must be increased (2) agricultural education must be broad-based, and (3) participation of the private sector must be increased.

Factors Affecting Quality of Agricultural Education

The education system of the SAUs has a vast potential for improvement. The system faces constraints of decreasing funds, declining faculty number and proliferation and bifurcation for political rather than scientific/technical reasons. The system is plagued with inbreeding and lack of reward system and incentivisation.

Even more serious problems than those listed above are the following.

- **Unaccountability**,
- **Irrelevant curricula** to changing realities (e.g., globalization, intellectual property rights, linkages with industry),
- **Insensitivity** to market-oriented demands and needs of private investors,
- **Inflexibility** in the choices of courses,
- **Obsolete** teaching methods,
- **Lack of competition** among peers for public and private funds,
- **No peer or student evaluation** of teaching, and
- **Inbreeding** with little faculty and students recruitment from outside the state.

The teaching methods are **exam-centric** rather than **learning-centric**. The emphasis is on teachers completing syllabi rather than students learning the concepts and skills. In a **learning-centric approach**, the focus is on the self-study, group-study, assignment, case-studies, and hands-on projects.

In addition, there are problems with motivation, low morale and lack of incentives. The system is held back because of:

(i) Poor reward system which is based on seniority rather than on performance and productivity, **(ii) Low social acceptance** and lack of professional recognition, **(iii) Ineffective** and **poor governance**, **(iv) Political interference**, **(v) Lack of transparency**, **(vi) Provincialism**, and **(vii) Favoritism**.

The Land Grant System in the USA

A land-grant college or university is an institution that has been designated by its state legislature or U.S. Congress to receive the benefits of the Morrill Act. A series of acts were enacted to create LGIs (Table 1). The Morrill Act, signed by President Abraham Lincoln on 2 July 1862, funded educational institutions by granting federally controlled land to the states for them to develop or sell to raise funds to establish and endow "land-grant colleges." The mission of the LGIs has been "to teach agriculture science, military tactics and mechanical arts as well as classical studies so members of the working classes could obtain a liberal practical education that had a direct relevance to their daily lives as a response to industrial revolution and changing social class, and to engage youth in experimental learning though 4-H programme". Iowa was the first state to accept the law on 11 September 1862 and start a State Agricultural College (now Iowa State University). The Hatch Act of 1887 appropriated federal grant funds to each state for establishing an Agricultural Experiment Station in connection with the LGI in the state. However, federal funds must be matched by the state. The Smith-Lever Act of 1914 created a "Cooperative Extension Service" associated with each LGI to disseminate information gleaned from the Agricultural Experiment Station. The Act also authorized federal support for the Extension Service, but similar to the Hatch Act, it also required states to provide matching funds.

The Morrill Act of 1890 was signed to extend access to higher education by providing additional endowments for all LGIs, but prohibiting distribution of money to states that made a distinction of race in admissions. A total of 70 colleges and universities were evolved under this Act, and are known as the 1890 LGIs.

Table 1. Evolution of the Land Grant System in the USA

Year	Act	Initiated by
1862	Morrill Act	Rep. Justin Smith Morrill (VT)
1887	Hatch Act	Sen. William Hatch (MO)
1890	Second Morrill Act	Evans-Allen Act (1977)
1914	Smith-Lever Act	Sen. Hoke Smith (GA) Rep. A.F. Lever (SC)
1946	Fulbright Act	Sen. J. William Fulbright
1994	Tribal Colleges Endowment Fund	Congress authorized support to certain Native American colleges as LGIs

States that provided a separate LGI for blacks in each of the then segregated states were eligible to receive funds. Rather than Hatch or Smith-Lever Funds, 1890 LGIs receive support through Evans-Allens programme. The Fulbright Act of 1946 (Public Law 584) was aimed at enabling Americans to study and teach abroad.

Similar to 1890 LGIs, the 1994 LGIs created 29 American tribal colleges. These colleges provide access to education for all native tribes in the USA. Along the patterns of LGIs, other initiatives include the Sea-Grant colleges (1980), Space-Grant colleges (1988), and Urban/Sun-Grant colleges (2003).

The United States Department of Agriculture (USDA) has played a crucial role in LGIs. It administers federal grant funds, and coordinates land-grant activities at the national level. The Extension Service of the USDA administers the Smith-Lever funding in liaison with the Cooperative Extension Service.

Most LGIs have been transformed into large public universities that offer at present a full spectrum of educational opportunities. Consequently, millions of students, both domestic and international, are able to study every academic discipline and explore fields of inquiry beyond the scope envisioned in the original mission of LGIs.

Major strengths of LGIs are: openness, accessibility, competitiveness, review-based grant funding, teaching evaluation by student and peer and service to people.

The system believes that a college degree is not a sign that its holder is a finished product but an indication that a person is prepared for life. The LGI system is strengthened by a healthy competition for grant funds. Competition is a painful process but essential for achieving excellence. It promotes wisdom in knowing what to do next, and accentuates virtue in doing it. Evaluation of teaching by peers and students is another important component of the LGIs. Student achievements and job placements of alumni are also pertinent to improving education standards of the LGIs.

Alleviating Constraints of Agricultural Education in India

The need of improving agricultural research, extension and education in India is widely recognized (Mellor, 2011; Ayappan, 2012; ICAR, 2011; Lele *et al.,* 2012). Among the common recommendations of improving the education system at the SAUs include the following.

- ❖ **Developing** a mechanism to upgrade curricula on a regular basis through periodic (3-5 year) reviews,
- ❖ **Strengthening** link between teaching, research and extension,
- ❖ **Reducing** time lapse between research, education and extension,
- ❖ **Enhancing** entrepreneurship through developing linkages with agro-business, international trade, etc.,
- ❖ **Making** curricula rural-realistic and farmer-centric,
- ❖ **Incorporating** both basic sciences and human dimensions in the curricula, and
- ❖ **Involving** private sector in the education process.

Funding basic agricultural research is a major challenge, even in the U.S. and other developed countries (Danforth, 2006). Yet, basic research (e.g., in biology, pedology, hydrology, biogeochemistry, genetics, climatology, pest management, post harvest technology) is essential for increasing land productivity and for preserving natural resources. Globally, private investments in food and agricultural research increased from US $14 billion in 1994 to about $19 billion in 2007 (Fuglie *et al.*, 2012).

In India, however, there has been a decline in crop yield in some regions or slowdown in the rate of growth of total production since mid 1990s. Global challenges of the 21st century require a strong and symbiotic combination of science and innovation; thus, variable and diverse funding sources are important to improve science (Elder, 2012). There exists a strong need for strengthening linkages between SAUs and the private sector to promote investment in research and development. And developing linkages with industry must be duly incorporated in the curricula.

Towards Improving the Curricula: "STREAM-Lining ICAR"

The agricultural enterprise of the 21st century, and especially in the era of globalization, is a complex undertaking. It is affecting and is affected by a multitude of interacting factors (Figure 1). As a business, the agricultural enterprise is influenced by complex interactions among a series of stakeholders from farmers and scientists to retailers, grocers and risk managers. In turn, the enterprise must be so managed to be restorative, eco-ethical and knowledge-based so that it is conscious of its impact on the environment and C/H_2O/N/energy footprint and the related regulatory issues. Both research and education must play a pivotal role in promoting this crucial enterprise. The research must be **innovative** (I), **cutting edge** (C), **anticipatory** (A), and **rewarding** (R) – **ICAR**. Research and education funds must be provided on a competitive grant basis. Healthy competition among peers is essential for developing a high-class programme. Similarly, education must be **strategic** (S), **transferring skills** (T), **resource (human) enhancing** (R), **effective in teaching** (E), **agricultural-profile raising** (A) and **managerial-skill promoting** (M) – **STREAM**. Thus, agricultural curricula must be developed on the principle of **"STREAM-Lining ICAR".**

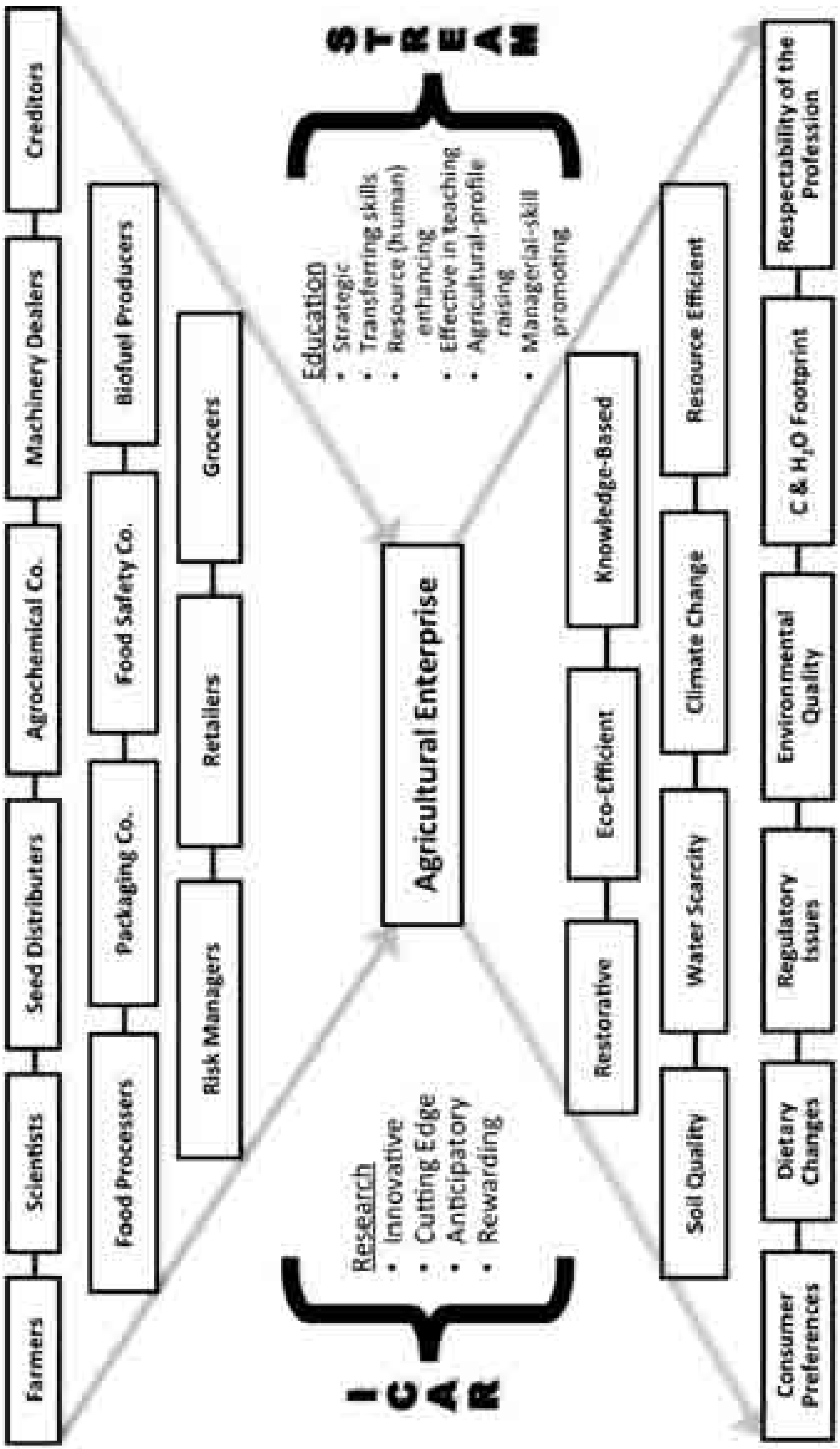

Figure 1. Complex realities of agricultural enterprise require innovations in research and education

The education systems in the SAUs must be broad-based, flexible and accessible to all. It must teach knowledge, skills and entrepreneurship. The competency development in agricultural education (Ghadei *et al.,* 2011) is important to prepare graduates for complexities outlined in Figure 1. This is especially important because agriculture is a cause and a solution towards major global challenges of the 21st century (NAAS, 2011). Thus, demand-oriented curriculum to improve relevance of SAUs, requires reforms, investments in staff training (including overseas training) and educational infrastructures, and increase in the quality and diversity (beyond the state borders) of staff and faculty (Maguire, 2012). Rather than partitioning and prolificating (i.e., separating veterinary and animal sciences from agriculture and separating soil/agricultural chemistry from soil/ agricultural physics), it is important to promote and strengthen inter-disciplinarity. Agricultural research and education must be a cross-disciplinary programme based on the concepts and methods taken from diverse disciplines (Vale *et al.,* 2012). The importance of the post-harvest technology cannot be over-emphasized in view of the several million tonnes of wheat rotting every year when stored in open (Parsai, 2012), while 200 millions are starving (Bhardwaj, 2012, a, b, c; Das, 2012). People begging for food in front of a rotting pyramid of wheat is indicative of a system gone wrong but that no one seems to bother.

Adapting the Land-Grant System in SAUs

The modern agricultural education in India had started during the later part of the 19th century (Tamboli and Nene, 2011). Development of an education programme in India had started in 1877, but it accelerated after independence (Table 2). In 1949, Dr S. Radhakrishnan, Chair of the University Education Commission, recommended creation of rural universities on the patterns of the LGIs. Thus, the first joint Indo-American Team chaired by Dr K.R. Damle was established in 1955 on the advice of Dr Frank Parker and Dr I.H.W. Hannah. The second joint Indo-American Team was chaired by Dr M.S. Randhawa in 1959, and the Agricultural University Committee was chaired by Dr Ralph W. Cummings Sr in 1960. The second committee chaired by Dr M.S. Randhawa recommended that each agricultural university must: (i) be autonomous, (ii) have agriculture, veterinary, animal husbandry, home science, technological and science colleges located on the same campus, (iii) offer composite courses, and (iv) integrate education, research and extension.

Table 2. Historical Evolution of Agricultural Education in India

Year	Established	Leaders
1877	Saidpet, Madras	
1905	Kanpur, Lyallpur, Ciombatare, Nagpur	
1907	Pune, Sabour (Bihar)	
1920s	Degree program started at 6 colleges	
1947	17 agricultural colleges	
1949	Established "rural universities"	Dr S. Radhakrishanan
1955-56	1st Joint Indo-American Team	Dr K. R. Damle (Chair)
1959	2nd Joint Indo-American Team	Dr M.S. Randhawa (Chair)
1960	Agricultural University Committee	Dr Ralph W. Cummings, Sr
2007	71 agricultural colleges	

These recommendations are precisely along the principles of the LGIs. Therefore several LGIs were involved in establishing SAUs in India (Table 3).

Table 3. Indo-U.S. collaboration in establishment of SAUs with support from LGIs (Read, 1974)

U.S. University	SAU	Year
1. University of Illinois	G.B. Pant University of Agriculture & Technology, Pant Nagar, Uttar Pradesh (now Uttarakhand)	1960
2. The Ohio State University	Punjab Agricultural University, Ludhiana (Haryana & Himachal Pradesh), Punjab	1962
3. University of Missouri	Orissa University of Agriculture & Technology, Bhubneshwar, Orissa	1962
4. Kansas State University	Andhra Pradesh Agricultural University, Hyderabad, Andhra Pradesh	1964
5. University of Tennessee	University of Agricultural Sciences, Bangalore, Karnataka	1964
6. Pennsylvania State University,	Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra	1968

India is endowed with an abundance of natural resources. Properly managed (biophysically, socially, ethically and politically) soil and water resources of the Indo-Gangetic Plains (from Amritsar to Calcutta) can surpass productivity of Cerrados of Brazil, Corn Belt of the U.S., and the HHH Plains of China. Herein, lies the challenge of SAUs and ICAR, because a scarcity of all basic needs persists in every walk of life. For example, Mousinram, near Cherrapunji in the north-western region, receives world's highest rainfall (~1.25m/yr). However, it also frequently suffers from a shortage of water during non-rainy season. The country as a whole faces problem of flood-drought syndrome. The great rivers of India (Ganges, Yamuna and Brahmaputra) have contributed through flood-drought syndrome, to the miseries of their worshippers. There is no justification why the population of resource-rich river systems must be perpetually subject to poverty and misery year after year. Sustainable management of natural resources must be a key course taught at all SAUs within the ICAR system.

Motivation of students to be interested in studying agriculture must begin in the primary and secondary schools. For example, the U.S. is undertaking a programme entitled "Next Generation Science Standards" or NGSS (Coffey and Alberts, 2013). The objective of the NGSS is to establish new common standards in science education for students from age of 5-18 years in the U.S. It encourages student participation in key science and engineering practices through asking questions, defining problems, developing and adapting models etc. Similarly, SAUs and ICAR should reach out to young students in primary and secondary schools and motivate them to learn agriculture.

Indian agriculture is challenged by a serious trilemma (Table 4). The challenging trilemma is driven by the increase in population at the rate of 30/minute, which will make India the most populous country of the world by 2020. Escalating demands of increasing and growing affluent population are impacting adversely natural resources. Accelerated soil erosion is estimated at 38-152g soil/ha/minute, water withdrawal for irrigation depleting aquifers is 1.5 million m^3/minute. There are 8.25 new vehicles produced every minute, and CO_2-C emission is estimated at 1,075 tonnes/minute. Despite impressive and revolutionary gains in agricultural production, the death from hunger in India is estimated at 5/minute.

Table 4. Trilemma of India - Dynamics per Minute

Dynamic	Per Minute
Population increase	30
Environmental impact	
Soil erosion	38-152g soil/ha
Water withdrawal	1.5 million m^3
Net virtual water import	0.07 million m^3
Vehicles produced	8.25
CO_2-C emission	1075 t
NPK consumption	32
Tons of wheat grain rotting	40
Brick making from top soil	0.08-0.10 ha
Food Insecurity	
Death from hunger	5
Female deaths	3.8

The world is familiar with Gandhi's seven sins of humanity:

- Wealth without work,
- Pleasure without conscience,
- Knowledge without character,
- Commerce without morality,
- Politics without principle,
- Religion without sacrifice, and
- Science without humanity.

If Gandhi were alive today and faced with the trilemma outlined along with millions of tonnes of grain rotting annually while more than 200 million are starving, he may have expanded the list of sins by including the following.

- Technology without wisdom,
- Humanity without conscience, and
- Education without relevance

Above all, integrity, as an ethical issue (refer to Section IV), must go beyond a casual discussion. Integrity programmes must be part of the standard for accreditation.

In view of the vast importance of agriculture, this subject occupies an astonishingly marginal place in the thinking of growing middle-class and the elite segment of Indian population. In addition to mentoring graduate students in becoming excellent researchers, efforts must also be made in mentoring them as future educators. Faculty discussions on curricula are often limited to who teaches/ covers what rather than to planning what students must know prior to entering job market (Goldsmith, 2002).

There are seven Is of improving curricula at Indian SAUs:

1. Institutions,
2. Infrastructure,
3. Incentives,
4. Innovations,
5. Information technology,
6. Inputs, and
7. Indigenization

While adoption of the basic principles of the LGI is pertinent, it is important that the LGI system is fine-tuned to meet specific needs of a highly diverse society, complex physiography, and a broad range of biomes and ecosystems. In consideration of specific needs to educating agricultural scientists and academicians in India, suggested improvements in the LGI system include the following.

- Providing equal credit for research, extension and teaching,
- Promoting involvement of younger faculty in international programmes,
- Globalizing curricula, and
- Learning lessons also from failures rather than worshipping only successes.

The importance of indigenization through adaptation is highlighted by the following dialogue between an Indian Chief and Benjamin Franklin.

"But you, who are wise, must know that different nations have different conceptions of things; and you will not therefore take amiss, if our ideas of this kind of education happen not to be the same with yours. We have had some experiences of it; several of our young people were formerly brought up at the colleges of the northern provinces; they were instructed in all your sciences; but when they came back to us they were bad runners, ignorant of every means of living in the woods, unable to bear either cold or hunger, knew neither how to build a cabin, take a deer, nor kill an enemy, spoke our language imperfectly, were therefore neither fit for hunters, warriors, nor counselors; they were totally good for nothing" (CIC 1968).

X. Conclusions

There is a strong need to improve research, extension and education in the SAUs and other agricultural institutions in India. The system must be relevant, competitive, peer-reviewed, demand-driven and world-class based on originality, innovativeness, and integrity. Adoption of the basic concepts of Land-Grant Institutions (openness, accessibility, competitive, subject to review and service to people) is appropriate, but must be fine-tuned to specific needs of India. Funding must be based on competitive grant proposals. Faculty (in research, education, and extension) must be rewarded on the basis of merit and productivity rather than seniority. In addition to support from public funds, research and education must also be supported by private investments. Thus, there must be close linkages with industry and agro-business. Entrepreneurship and managerial skills must be integral to agricultural curricula.

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Role of Educational Institutions in Transforming Agricultural Knowledge Systems for Development

Ajit Maru and D. Rama Rao

Introduction

It is widely perceived that conventional agricultural education is now not meeting the emerging needs of agricultural development. This is more so in the economically developing world which now more than ever needs new agricultural knowledge to meet new challenges such as participating effectively in globally competitive markets and adapting rapidly to climate change, reduced access to natural resources, narrower agricultural biodiversity and new pests and diseases from afar that spread rapidly.

Most of the time the common belief, as discussed in several fora including the Global Conference on Agricultural Research for Development (GCARD 1 and 2; see http://www.egfar.org/gcard) is that the failures are in the education systems' abilities to attract students, retain them during the course and produce competent graduates. The reasons attributed to this failure are lack of adequate investment and curricula that do not meet aspirations of the students and the needs of their employers.

The malaise is a lot deeper. This paper discusses the wider role of educational institutions in transforming agricultural knowledge systems for development, especially in developing countries of the South, while considering the Indian case in detail, so that they lead and are central to the shift for agriculture and agribusiness to become key economic and social components of emerging knowledge based societies.

Key Trends of Educational Institutions in Transforming Agricultural Knowledge Systems for Development

There are six key trends that drive educational institutions to fulfill their role in transforming agricultural knowledge systems for development in the foreseeable future. These are exemplified by the transformations erstwhile agricultural educational institutions in the North, including Wageningen University in Europe and several universities in the United States are undergoing. These Universities initiated radical changes in the previous decade and at present have become hubs for innovation not only in agriculture but also in broader disciplines related to life sciences and environment. They are contributing significantly in transforming agricultural knowledge systems to be much broader by including complex food systems and environment as components of agriculture to meet not only the needs of their own regions but also of the world. In several cases, their new visions and actions have become brand names for their specialization and fame that attract quality faculty and students, besides private investment.

Role beyond increasing agricultural production and productivity

The first key trend is in providing new knowledge and skills and in contribution in innovation and technology generation, beyond conventional agriculture. Wageningen University has considered healthy food and environment together. Agricultural educational institutions in the South also should reconsider the needs of their societies in the changing context in a similar fashion and include a larger agenda of agricultural knowledge and innovation in development rather than the current approach of development through agriculture only. This would mean these Institutions foray, team up and integrate with other Institutions, both public and private, and in several cases outside their parent country, that contribute to development beyond agricultural production and productivity. This would also mean that these Institutions while keeping focus on the needs of agricultural and agribusiness actors and stakeholders also address formal educational and informal learning needs of actors in the entire chain of development. This is similar to shifts that premier educational institutions in other academic disciplines are undergoing as they include new approaches and curricula to address requirements of science, technology, medicine, business, humanities and art.

Blurring of conventional disciplines and emergence of new academic areas

The second trend is of blurring of conventional disciplines as new trans-disciplines, biotechnology, nanotechnology, information and communications (ICTs), space technologies and materials sciences are emerging and becoming central to developing new technologies and innovations included in agriculture, agribusiness, food chains and environment. The key issue is not the category the institutions are classified as but how they deliver needs of development through academic excellence as measured through innovations they are contributing to the society.

Investments defined by stakeholders

The third trend is about the investments society consider to make in these Institutions and, because of this, how it is involved in making decisions about the Institutions.

The type of infrastructure and faculty needed and the cost of its maintenance in the new context forces that these Institutions be large and, therefore, need to cater to larger communities. There cannot be a multitude of institutions, as the society cannot afford and sustain them cost-wise and in pursuing academic excellence over a range of disciplines and academic areas. Thus, smaller Institutions are being forced to consolidate and merge with other Institutions, both public and private, to increase size, infrastructure, faculty, other capacities, and more importantly share investments and costs. For example, Biotechnology research in human health and medicine at a primary level does not differ much from that in agriculture and other areas of applications and greater synergy can be attained when it is viewed as such rather than as being biotechnology for human medicine or for agriculture. It is only at the applied level that differences emerge. Considering huge investments needed for state-of-the-art infrastructure and intellectual and technical capacities to pursue excellence in each of the trans-disciplines, it becomes apparent that consolidating large, multi and trans-disciplinary Institutions than a multitude of small Institutions is a more logical and rational way forward. These consolidated larger Institutions, as is happening in China and has happened in the North, need also to include private sector, which incubate technologies and innovations spun-off from the Institutions without burdening Institutions with the cost and effort of technology dissemination and the communities, who further innovate in using these technologies and innovations for their development and benefit. These Institutions are hubs for innovation, and therefore, new inclusion of actors and stakeholders in all aspects of managing these Institutions becomes imperative for societies to invest in them. This trend makes Institutions change their governance.

Supporting educational needs of large catchments of students and learners

The fourth key trend, and critical for the South to consider, is in the ability of agricultural educational Institutions to support a much larger catchment of students and learners, many a times beyond their immediate communities and even countries. In the South, due to reasons of inadequate investments and lack of faculty, Institutions tend to remain small in size, faculty, number of students and knowledge areas and disciplines. They do not enlarge to provide knowledge and skills at a wider scale, informally and through off-campus means. There have been suggestions that they venture into distance, open and off-campus modes but their small sizes, lack of capacity and expertise as also academic coverage limit their venturing to widen their catchment. This puts rapid growth of entire knowledge systems for development, critical for developing countries at this juncture, at a disadvantage. For example, farmers and small agribusiness and agriculture-related entrepreneurs such as in processing, packaging and logistics are denied access to new knowledge and skills so necessary to shift into more knowledge-intensive enterprises when these Institutions cannot offer distance, open and off-campus learning opportunities. But, this trend also brings competiveness and Institutions need to adapt to it bringing new challenges to their leadership and management.

Use of ICTs for on- and off- campus education and learning

The fifth key trend is to leverage advances in Information and Communications Technologies (ICTs) use in education and learning, especially for lowering overall costs and improving quality of learning experience both on- and off- campus. The now ubiquitous availability of new ICTs such as smart cell phones and Internet connected tablet computers even in rural areas is a major paradigm shift. Yet, many of these Institutions, especially in the South, have found it difficult to leverage ICTs in their educational activities. These Institutions are finding it difficult to invest in the necessary infrastructure, software, hardware, skills, connectivity and content and use ICTs to cater to learners, who are not or cannot attend on-campus and access potential learning opportunities. This failure to use ICTs, primarily because of lack of policy support and investment from the State, preempts the wider role of education institutions in enabling rapid development of knowledge based agriculture and related activities especially by the youth and women engaged in agricultural vocations. The State now has an additional cross-sectorial role across its agriculture and rural development and telecommunications sectors and for which it may not have the necessary experience and wherewithal to execute.

Political commitment for new roles and academic excellence

Finally, an important consideration in the context of the above trends is political and social commitment by communities, societies and countries that are in the catchment of these Institutions to provide necessary investment, support, leadership and policies for transformation of these Institutions to take up new roles in transforming agricultural knowledge systems that benefit their own development and pursue academic excellence. These, especially political commitment, are many a time in short supply for educational Institutions of the South.

Transforming Agricultural Knowledge Systems for Development — India

The main challenges India faces in transforming agricultural knowledge systems for development are indicated as follows.

Capacity Cliff

India faces what may be termed to paraphrase a now famous term a "Capacity Cliff" for developing its agriculture scientifically. There is a mounting shortfall in filling current and future demands of trained manpower in agriculture. The existing education system is producing around 24,000 graduates per year, and 2/3rd is in crop science. The projection indicates that by 2020 the requirement would be about 54,000, resulting in a demand-supply gap of 30,000. The shortfall is high across board and is higher in rapidly growing sectors, horticulture, dairy and fisheries, (Rama Rao *et al.*; 2011, Menon *et al.,* 2012). Even the graduates the present Universities produce seek alternative employment in banking, insurance and other areas rather than in directly related to agriculture. There is also attrition out of agricultural professional employment, especially in the case of women, when posted in rural areas for field duties. The reasons are varied from poor service conditions, career prospects to social and family pressures.

The Indian public sector agricultural research system even with a very large agricultural education system has faced a reduction of 17 % in its human capacities in the past decade (Pal *et al.,* 2012); the reduction is in numbers and disciplines. In addition, it is also perceived, as discussed in a recent ICAR retreat that the quality in terms of field experience has also suffered. In a subject like agriculture where it takes almost decade or more to build competence, this in the medium and long term indicates a future catastrophe in the making for agricultural institutions, especially Universities. This is especially so as shortfalls in post-graduation severely affects agricultural research, education and extension systems. This is so critical that many Universities and Research Institutions in the country at present do not have adequate trained and experienced manpower in plant breeding, plant pathology and veterinary sciences.

Inadequate and falling investments

India reduced investments in its agricultural education system in the eighties and in the early part of nineties. Along with reduced funding accompanied with poor leadership and injudicious political interference in all aspects of administrative and academic fabrics, these Institutions lost most of their academic excellence. The situation that India faces in developing its trained agricultural manpower and skills is a stark choice between whether to pursue growth in number of Institutions or consolidate them and provide them the necessary wherewithal to pursue academic excellence and quality especially in the emerging areas. It is apparent that quantity without quality will not serve the purpose of development; but enabling consolidation with appropriate investment and infrastructure in the Institutions can provide the necessary growth in number of students along with the academic excellence. A policy and strategy shift once is necessary now to bring considerable change in Indian agricultural education system to contribute further through academic excellence and innovation for India's development in future.

Revamping agricultural knowledge system for development

For India, the key impact expected from its knowledge system is on development, especially agricultural. India has a large extension system in which, in addition to state machinery, there are more than 100 ICAR Institutes, about 65 agricultural universities and nearly 650 KVKs to transfer technologies and advisory services to farmers. In addition, the State and Central Governments have ICT-based advisory services for farmers through radio, television, phone and the Internet/World Wide Web. There are also some private TV channels. The private sector and the Civil Society also provide advisory services to farmers. However, most advices at present are episodic, event-driven and generic-problem based, and a very little contribution is through innovation and value-addition by farmers and by the millions of small and medium agribusiness and agriculture related entrepreneurs, who are processors, transporters and market intermediaries. The extension systems do not cater to farmers, producers and market intermediaries for customized solutions with a basket of more options needed for market-driven needs with the growing demands of the consumers regarding farm and food products. Apparently, a disconnect exists between the development needs and what educational institutions provide. Further, today's extension for a more knowledge-driven agriculture requires that a continuous dialogue be maintained between structured scientific and technical organizations and agricultural communities for rapid innovation and its spread. This does not happen with systems that are based on antiquated training and visit (T&V) based approaches, which are slow in their responsiveness to transform. This results in low impact rates of new technologies and lack of farmer and producer-led innovations; as also innovations in value -addition chains are very slow and many a time non-existent. Educational institutions now need to consider how they can enable more effective information use through learning in agricultural communities beyond the campus. There is an urgent need for research in new extension policies and strategies as also methods by using new information and communications tools and techniques with the full and core involvement of educational institutions in India.

Transforming Educational Institutions for a Central Role in Agricultural Knowledge Systems

Transforming Educational Institutions to further build and strengthen agricultural knowledge systems in India requires the following.

Re-envisioning and including new academic areas

The origins of the modern Indian agricultural Universities system was in the Land Grants Universities of the United States of America that were initially supplanted in the early sixties and seventies but whose original concepts and principles were diluted and fully vacated by late eighties. This resulted in their losing financial and consequentially academic freedom. Now, there is an urgent need to re-envision role of educational institutions post land grants Universities phase in transforming agricultural knowledge systems for development. The inclusion of more basic and adaptive trans-disciplinary research, inclusion of private sector and enabling innovation for development and agricultural value addition are key areas to be considered in re-visioning Institutions.

Connecting to development needs

Indian agricultural universities continue to teach disciplines and areas that have little connection with the transformation of agriculture and rural development in the country. While the country's agriculture rapidly shifts towards more market participation and value-addition, agricultural universities curricula and syllabi continue with conventional education focused on staple crops such as wheat and rice with little emphasis on horticulture, livestock production such as dairying and poultry and fisheries or even in environmentally friendly agriculture. Even in specializations such as Veterinary Sciences, the curricula focus on ambulatory care of individual animals rather than on preventive medicine, food animal practice, epidemiology and herd health, biosafety and public health. There are very few colleges that offer courses in agribusiness and entrepreneurship. Very few Institutions are equipped to offer advanced training and scholarship in new trans-disciplines such as biotechnology and bioinformatics, nanotechnology, ICT, space science and material science as related to agriculture and environment. Without these disciplines it is difficult, if not impossible, to attract the youth of today into agriculture science and teaching as a career. The academic agenda and curricula of Indian agricultural institutions need to be changed urgently.

Consolidation of institutions

An important issue is the mushrooming of agricultural Universities and colleges in India. This is in reverse of a trend being noticed elsewhere in the countries at similar development stage as India such as China and Brazil. While the demand for trained agricultural graduates needed by India cannot be denied, the current strategy, in view of reduced investments and falling human capacities of experienced teachers and academic leaders, compounded by admission of a fewer post-graduate and doctorate students, of multiplying Universities rather than consolidating them is inexplicable, other than when viewed in the context of political expediency to open new Institutes. However, the impact of this mushrooming is adversely affecting quality of education and learning so necessary for rapid development to a more knowledge-based agriculture. India needs an urgent review of its agricultural education policy and strategy within the need to rationalize and consolidate its entire National Agricultural and Innovation System.

Financial investment

It is estimated that 65 Universities and deemed Universities, each will need between 100 million and 500 million USD in the next 5-7 years depending on the size to transform to a new vision and rebuild their infrastructure and capacity to include new academic areas, and reach an acceptable standard of academic standards comparable to Universities in the United States and Europe. The Government and the public sector cannot at the moment make the investments that would be adequate to revamp and transform all agricultural education Institutions in the country. A new strategy is needed to improve the academic quality of these Institutions. This strategy will include the need to consolidate and strengthen a few Institutions so that funds available are utilized efficiently and effectively to bring better quality agricultural education and knowledge system. There is an opinion that due to entrenched vested interests, it would even be more cost effective to start a fresh with new Institutions rather than attempt to transform existing Institutions.

Autonomy and responsiveness to stakeholders

The current Government financing of these Institutions are seriously influencing their autonomy. These institutions at the moment have in reality no direct responsibility to their stakeholders other than the Government. Without the necessary autonomy in all aspects of academic management, from envisioning to setting academic agenda and curricula and lack of responsiveness to stakeholders, attaining academic excellence by the Institutions is difficult if not impossible. New ways of financing, even when it is largely from the Government, to ensure autonomy and responsibility to stakeholders in these Institutions is now needed. The Land Grants Model was one approach initially attempted but later abandoned for various reasons, mainly political and for the Government to gain control of the Institutions that were influencing development in rural areas. Now, Funding these Institutions through new approaches such as competitive grants evaluated by representative stakeholder organizations such as farmer cooperatives and Chambers of Commerce and the Civil Society may be one of the ways to ensure responsiveness and academic excellence. Co-optioning of the private sector, which has started to invest more in agricultural research and innovation in the country, to fund capacity development, research, technology generation and innovation can also be avenue way for part of funding required to transform agricultural knowledge system. However, it is apparent that Governments in developing countries which have large populations engaged in agriculture such as India cannot absolve themselves from funding agricultural education and learning and for bringing change for academic excellence and transforming agricultural knowledge systems. If they do not do so, a socio-economic, and consequentially a political catastrophe awaits them.

Quality Assurance, Monitoring and Evaluation and Change in Reward and Accountability Systems for Faculty

As an immediate intervention, in addition to financial investments, educational institutions, which include the ICAR Institutes, the State Agricultural Universities and colleges affiliated to general

Universities, engaged in teaching agriculture and environment related subjects, need Institutional changes urgently, which includes changes in statutes and governance towards academic independence and excellence and to enlarge scope of providing education and learning especially through distance, open and off campus formal education and informal learning for agricultural communities along with formal, on campus students. An independent University Grants Commission like structure for agricultural Institutions with power to assure academic quality through effective monitoring and evaluation at individual Institution and the system collectively is a must. This may entail changes in Central-State relations as regards agriculture, which is a state subject. But, for a country which has almost 65 % of its population dependent on agriculture and allied livelihoods and who need to rapidly shift to a more knowledge based economy, the gains from this can be immense.

For Indian educational Institutions to contribute to development the need for change in accountability and reward systems of public sector agricultural development, extension, research and education systems is also urgent. Continuing education and regular upgradation of academic skills need to become a norm rather than a formality. Under the University Grants Commission guidelines that also the ICAR and the State Agricultural Universities follow, there is formal provision of teachers to attend training courses for promotion, and this has also been applied to scientists but these trainings are too short, and span over time. There is a little impact of these trainings, largely is short-term on improving quality of teachers and scientists. In fact, while primary and secondary school teachers need to undergo training, there is no such requirement for professors in Universities! Nor is training and skills enhancement compulsory for scientists and research managers. The resultant quality in teaching and providing learning is poor.

Reward and accountability systems for agricultural teachers and scientists in India recognize them largely for scientific publications in journals and for books. The reward systems do not acknowledge contributions such as content for new digital media and contribution to learning outside the campus. This is a major barrier in generating digital content that can be used by web and cell phone based services to share new knowledge in a more widespread manner and in offering distance, open and off campus learning. Training and skills enhancement, work processes that promote team-work so necessary for generating new digital content, infrastructure such as digital repositories of text, images, audio and video clips and interoperable, re-useable information objects have not yet be developed by the ICAR, which should by its position, be its core function to fulfill its mandate. The development of these repositories using international standards and a prominent coordinating role of the ICAR would contribute significantly to strengthening content development for agricultural education and learning and in transforming India's agricultural knowledge system.

India's Role in Transforming Agricultural Knowledge System Globally and International Agricultural Capacity Development

India cannot escape its obligation as a responsible member of the global community and need to participate in efforts to build agricultural capacities globally. India has one of the largest national agricultural research and innovation system and its experience and skills in building this system and its capacities remain valid for many countries especially in Sub-Saharan Africa and Central Asia to emulate in their current stage of development. India can do this by actively participating in global and regional initiatives such as the Tropical Agricultural Platform led by the FAO and GCHERA, collaborate with AGRINATURA and RUFORUM for African agriculture and enter into bilateral arrangement with other reputed Universities in different countries. India can also open its educational facilities to foreign students and encourage foreign and expatriate faculty. India can also offer short and medium term trainings in specialized areas. It can also contribute to sharing of agricultural content for education globally.

India needs to learn how educational Institutions are transforming and re-envisioning their role and contributions to societies in other countries. It needs expertise to develop new curricula and educational content needed for its future development. It needs managerial expertise in academics. It also needs to know the use of new ICTs in enabling off-campus, distance and open learning. Opening its Institutions to foreign faculty can in many ways contribute to this as was done successfully in the sixties when India opened its agricultural education and invited foreign teachers and experts to contribute to developing the State Agricultural Universities. India also needs to re-attract its large diaspora with expertise in agriculture and related areas to contribute and share their and Indian experiences in agricultural education and in transforming the role of educational Institutions in transforming agricultural knowledge systems.

Conclusion

There are several key trends that are impacting educational institutions in their transforming agricultural knowledge systems. These include re-envisioning the role of these Institutions to make their roles broader beyond increasing agricultural production and productivity, introducing new trans-disciplines in their academic agendas, consolidating them for greater efficiencies and academic excellence prior to investing in them, changing leadership, curricula, widening the catchment by offering education in new academic areas and providing off-campus, distance, and open learning using new ICTS and considering them as hubs for agriculture and agribusiness innovation.

The Indian agricultural education system and along with it the agricultural knowledge system is at crossroads. It needs urgent transformation institutionally, in revisiting their vision, consolidation, investment, capacity generation and quality assurance and widening its scope to offer formal, on campus and off campus distance, open and informal learning and innovation to agricultural communities so that India can bring about a more knowledge-based agriculture in as short a period of time effectively and efficiently.

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Modernizing Higher Agricultural Education in India to Meet Challenges of 21st Century

P.M. Tamboli and Y.L. Nene

It is somewhat doubtful whether in the ancient time, formal education was imparted in agriculture, although it is believed that agriculture was formally taught at Taxila, and possibly Nalanda. Through millennia farm education, gained through empirical research, was imparted by farmers of a village and nearby areas to each succeeding generation. In the early years of the 20th century, the British introduced formal education in agriculture, which was modeled on a European knowledge base. The education was primarily imparted to revenue workers and landlords and not to the farmers. By 1947, India had 17 colleges of agriculture with annual enrollment of about 1,500 students, including colleges at Coimbatore, Pune, Nagpur, Kanpur, and Pusa.

Higher Agricultural Education in Post-Independence Period

After independence, the Indian University Education Commission was appointed, and was headed by Dr S. Radhakrishnan. In 1949, the Commission urged that the country needed a continuous flow of scientific workers as well as leaders in all fields, including agriculture. In 1954, first Indo-American joint team was appointed; the Indian team was headed by Dr K.R. Damle. In 1955, the first authorization was provided for five university contracts with United States Agency for International Development (USAID) to strengthen agricultural universities in India. The second Indo-American joint team appointed in 1959 made supplementary recommendations, which were a prelude to setting up agricultural universities on a modified basis of Land Grant pattern universities in the US. Dean HW Hannah of the University of

Illinois prepared a blueprint of an agricultural university and circulated to all state governments. On the basis of this and recommendations of Dr Ralph Cummings committee, the first agricultural university was established in 1960 at Pantnagar. Few more such universities were established and a Model Act was passed.

Current status of agricultural research

To increase productivity per unit of land, there is a need to develop a location-specific technology package by a multidisciplinary team. This package of best practices should be economically viable and environmentally sound.

While addressing the 79th Annual General Meeting of the ICAR, the Union Agriculture Minister said, *"That the pace of innovation in agriculture universities and research institutes of India is not satisfactory; therefore, remedial steps must be taken by the council. It must also put in place skilled and competent resources. There is need to revise course curriculum of agricultural education to make it more relevant."* In 2005, the Minister of Agriculture appointed ICAR Reorganization Committee (headed by Dr R.A. Mashelkar) to suggest reorganization and procedural changes in the ICAR. Among recommendations made by this Committee in its report "Accelerating ICAR's journey towards excellence", one was that India's Prime Minister should head ICAR. Another Committee, in the same year, "Task Group (headed by Dr M.S.Swaminathan) on revamping and refocusing of national agricultural research", was constituted by India's Planning Commission. The Report admitted that bureaucracy was a problem, and added that political and administrative tinkering with staff selection process should lead to recruitment of subordinate scientists. The Group recommended setting up a National Board for Strategic Research in Agriculture that would act as an umbrella organization and coordinate government agencies that fund research in overlapping areas of plant and animal sciences.

However, these recommendations have not been fully implemented. The ICAR needs major restructuring to be able to meet the needs of the 21st century. Various reports and published papers (The World Bank, 1983) have pointed out that in India, the research relevant to farmers' needs is not usually done, and more importantly the contacts between research team and farmers is almost nonexistent due to fragmented responsibilities of extension between state governments and universities.

Status of agricultural extension

A recent study done by FAO "The State of Agricultural Extension and Research Reforms in India – Strategic Priorities and Policy Options (Babu *et al.,* 2012) has done a detailed analysis and a case study of extension/research system in India and have given specific recommendation to improve performance of research and extension. One of the important recommendations is to develop a strategy for human resource capacity and management at all levels, especially at the higher education level.

India has moved away from the earlier old extension services, Gram Sevaks, and T&V system. A new structure of Krishi Vigyan Kendra (Farm Science Center) (KVK), Agricultural Technology Management Agency (ATMA) is in place. However, adequate human resources are lacking to make this system to function effectively.

Status of higher agricultural education (The State Agricultural Universities)

There are more than forty-five SAUs, one Central Agricultural University, and five deemed (to be) universities. However, the SAUs are facing serious problems. Some of the major constraints are discussed below along with some suggestions.

Difficulty in attracting talented students: In general, agricultural education is not a preferred option for students. Based on the merit list of the all-India entrance competitive exams, talented students go for medicine, engineering, law, business, etc.; only those who do not get admission anywhere, end up in Agriculture. Of course, there are exceptions. Some effectual action needs to be taken to attract students.

Funding crunch: Agriculture being a state subject, the statutory responsibility for agriculture is in the domain of state governments. The budget grant is sufficient to meet salary component of the university to the tune of 87%, and the operational fund is only to the extent of 10%. Hence the SAUs are starved of funds to maintain buildings, laboratories, and infrastructure. Ideally the ratios should be 60:40. This situation needs to be rectified.

To address funding crunch, universities should be allowed and encouraged through policy directives to attract private funding into agriculture education; the universities should be encouraged to be self-sustained over period of time; the Vice-chancellors should be consulted at the time of budget formulation with the Planning Commission; and the state departments of agriculture should provide adequate operation funds.

Large number of vacancies: The number of vacancies is very high, some 43% of approved positions are filled and no significant recruitment has taken place in recent years. A large number of faculties are retiring in 2-3 years time, and they are not very active. This results in heavy work-load on the remaining, which results in poor performance in teaching, and no time for research or extension. To address staffing shortage it is suggested that SAUs should undertake recruitment against vacant positions on a priority basis and state departments of agriculture should support this action on priority basis. In the mean time the SAUs should be allowed to hire experienced and retired teachers from within the country, and a rolling-faculty scheme may be launched to enable teachers to travel to any place and teach a course.

Inbreeding: There is high "inbreeding" in the staff recruitment. Recent figures show that 51% of the faculty has degrees from the alma mater. Also the staff turnover is low, which reduces opportunity to introduce new blood in the faculty. Currently it is estimated that 46% faculty has been in the position for over 15 years.

Lack of autonomy to Vice-chancellors: The Vice-chancellors do not enjoy academic freedom. They need state government's permission/ clearance to appoint and promote faculty. They are not consulted about budget needs. More importantly, there is a considerable political interference. There is no accountability mechanism to assess relation between the SAUs and the state government.

Poor State-Center relationship: Since agriculture is a state subject, ICAR plays only a facilitating role by providing development grant. In view of the changing context, the agricultural education and research may be appended to the Concurrent List of the Constitution, leaving agriculture per se with the states. The Government of India may also consider constituting a national regularity authority for agricultural education to ensure equity assurance and accreditation.

Weakness in teaching-learning process: The other problems confronting SAUs include: (i) traditional method of teaching material and aids with age old lecture notes; (ii) lack of good textbooks, combining theory and case studies in Indian context; (iii) inability of most of the faculty to inspire and motivate students and promote interactive classes; and (iv) ineffective communication skills of faculty. All the weaknesses in teaching-learning process can be addressed by retraining faculty and introducing modern methods/technology in teaching.

Lack of Internet connectivity: All SAUs do provide computers, but the connectivity on many campuses is unsatisfactory. The students do not have access to books and international and national journals.

Faculty development: There are very limited opportunities for the faculty to attend international and national seminars and workshops. Also they do not get opportunities to take sabbaticals to improve and update their knowledge.

Lack of networking and public-private partnership in education: With the advent of the World Bank funded National Agricultural Technological Project (NATP), partnerships in research in a consortium mode was nurtured in the National Agricultural Research System. Most of the SAUs do have partnership with private sector and non-governmental organizations. However, in academic programmes, there is a different picture. Most of the universities handle their own curriculum agenda, without involving outside agencies, and also without signing MOUs between the universities. Some efforts were made by some universities in having exchange programmes with universities from abroad but the costs involved and logistics are higher. Such exchange programmes do exist in PG programmes. Exchange of faculty from across the universities is another issue. Within the university some colleges do have sharing of faculty expertise for courses at UG and PG level but sharing of faculty between the universities has been a far cry.

Private sector involvement: Most of the universities have either reactive or inactive Placement Cells which at the most provide information to the students. The private sector has its own professional requirement of skills. They require professional skills, domain skills, management skills, and other soft skills such as communication skills, presentation skills, etc. Most of the graduates possess academic intensive skills but do lack skills required for jobs in the private sector. Imparting such skills to the students has not been emphasized by the Deans Committees in the curriculum and by way of organizing academics in the universities. Inviting industry to discussions on the curriculum has not been encouraged by the university academia.

With secure jobs in organized sector (Government) declining, there is an urgent need for the universities to encourage entrepreneurship in graduates. Interestingly, the percentage of graduates who are self-employed is much higher in veterinary sciences than in agricultural sciences. The agricultural education system is designed to meet manpower needs of the government, and hence there is hardly any motivation for self-employment. A survey indicated that more than 80 % of students preferred jobs in the public sector.

In order to show how a state university can be effective, we are giving below a comparison between SAUs in India and Land Grant Universities in USA, where the system is working very well. There is full integration of three functions of teaching, research, and extension.

State Agricultural Universities (India: SAUs) vs. Land-Grant Universities (USA: LGUs)

SAUs	**LGUs**
1. Integration of Research, Teaching, and Extension	
Three functions not integrated	Three functions fully integrated
Faculty finds little time for research; extension work with the state and not university faculty (little formal exchange)	Faculty often has split responsibilities; Teaching 75, Research 25 or other ratios. The Dean supervises all functions
2. Funding Arrangements	
The State provides 100% funding for teaching and research and ICAR provides development fund	For academic program: State provides 50% and tuition contributes 50%; for research 50%, Federal 15%, and grants 35%; for extension 53%, Federal 12%, Counties 20%, grants 15%
Universities starved for operational and maintenance funds	Adequate funding for salaries and operation
3. Programme Planning: Academic, Research, and Extension	
Academic: Dean with faculty and Academic Council	**Academic:** Campus, college, and Deans Committees
Research: Director with Research Council	**Research:** Producers' group, extension workers, State and funding agencies, and then approved Program Planning and Development Committee

Extension: Director with Extension Council, State officials, and farmers' representatives	**Extension:** Formulated by County Advisory Committee, State Advisory Committee, and National Advisory Committee
Functioning: Not effective due to poor linkages	
4. Faculty Evaluation	
Faculty submits annual performance reports to Dean for review	Annual faculty review and evaluation; CVs updated every 3 to 5 years
Promotion not related to review or evaluation by students	Dean reviews faculty progress with department head and recommends advancement for salary and position
Promotion on time bound frame	Students' evaluation of the teacher is given weight

Role of external donors: Donor assistance in the agricultural sector in the past 65 years was substantial. United States has been a major donor, starting from PL 480 assistance in establishing six SAUs. The Rockefeller Foundation, Ford Foundation, and Fulbright invested substantial amounts in training large number of agricultural scientists (Tamboli and Nene, 2011). However during the last two decades, this support has dried out, partly due to bad economy in the USA.

Agricultural Human Resource Development (*India*) project was more directly involved in improving SAUs. In general, foreign assisted projects did provide valuable input, but they were not sustainable. Moreover, there has been no follow up after the end of that project. It is recommended that lessons learned from the previous projects be taken into consideration in designing and implementing this new project.

Recommendations

Improving the quality and relevance of agricultural education requires a fundamental change of approach in governance and control, financial sustainability, accountability, autonomy, transparency and meritocracy.

By Central and State Governments

a. At the Central level, the Ministry of Agriculture and the ICAR in coordination with State authorities should take leadership role in improving overall governance of the SAUs by ensuring adherence to the provisions of the Model Act.

b. A central regulatory authority should be established, which would accredit universities for maintaining high standards in agriculture teaching, research, and extension, and monitor system delivery and quality.

c. Review, develop, and adhere to clear responsibilities and relationships for the central, state, governing bodies, and vice-chancellors.

d. Ensure appointment/nomination of qualified members to governing boards and as vice-chancellors.

e. Central Government/ICAR may consider providing block grants to SAUs to improve teaching, research facilities, and for starting new departments.

f. Streamline functioning of the ICAR: As recommended by various committees appointed by the Ministry of Agriculture and by the planning commission, there is an urgency to take bold steps to strengthen ICAR towards higher agricultural education. Just as other central research organizations such as CSIR and Space and Atomic Energy Agencies, the Prime Minister of India should head the ICAR.

g. Provide adequate funds: Most of the state universities are starved for funds, especially operating funds. Currently the ratio between staff and operational budget is approximately 90:10. The desirable ratio is around 60:40. The state should ensure output based sustainable and uninterrupted financial support and allow universities to diversify and generate their own income source and attract private funding; the universities should be encouraged to be self-sufficient over a period of time.

h. Grant autonomy and authority to SAUs to make crucial management decisions - academic, student admission and staff appointment, and promotion; establish clear criteria for interventions and avoid political interference. Currently Vice-chancellors are treated like subordinates to senior bureaucrats and politicians. Since the decision-making power of Vice-chancellors is curtailed, students, faculty, and workers turn hostile to them. To achieve excellence, universities should enjoy full administrative and academic autonomy. This would attract distinguished persons of integrity to position of Vice-chancellors and would ensure smooth functioning for advancing university teaching, research and extension services. Selection of each Vice-chancellor should be by a committee of eminent scientists who are also known for their impeccable integrity. The Vice-chancellor should be involved in planning commission's exercise, so they have opportunity to ensure regular flow of adequate funds for the activities planned.

i. At the central level, initiate a learning forum to bring together concerned state and institutional leaders to discuss changing skills required, challenges faced by SAUs, strategies for effective governance, deliverables and its quality through sharing of knowledge, experience, good practices, and study visits.

j. Appoint an International Review Committee to place Indian higher education at a par with the world-class universities. The terms of reference of such committees should be to recommend specific and detailed action plan to modernize higher agricultural education in India. There should be prior assurance from the Central and State governments and also ICAR that the recommendations of this committee will be implemented.

At the Institutional level

a. Boards of Governors should ensure good governance by prudent approaches and accept their collective and individual responsibilities. They should ensure and respect institution's autonomy and accountability.

b. Establish an institution-level committee including external experts to monitor and evaluate performance of teaching, research, and extension activities. The institute should also monitor students learning skills and employment outcomes of its recent graduates. Strengthen links with industry and farm community.

c. Periodically review and provide flexible (need based) education and practical skills.

d. Monitor outputs and improve efficiency and cost-effectiveness of financial and other resources.

e. Provide adequate faculty staff: Vacancies are high; some 43% of the approved positions are filled and no significant recruitment has taken place in recent years. Large numbers of faculty members are retiring in 2–3 years. It is recommended that SAUs should undertake recruitment against vacant positions on a priority basis; SAUs should be allowed to hire experienced and retired faculty from within the country. There is an urgent need to have short- and long-term master plan for human resource development for SAUs.

f. Encourage faculty development programme: The faculty should be given plenty of opportunities to attend national and international seminars and workshops; and to take sabbatical leave to improve and update their knowledge and be well-informed about the global development in their respective fields. The number of research papers published in peer reviewed journals should be a criterion for promotion, and not just seniority.
g. Upgrading of teaching and research methods: Teaching using blackboard and lecture notes should be discouraged; instead extensive use of latest computer-based and audio-visual methods should be employed and interactive teaching-learning process should be encouraged. Teaching students to think innovatively with originality should be promoted. Computer connectivity is very limited on many campuses. The students and faculty do not have Internet access for national and international journals. This needs to be rectified.
h. The Vice-chancellors should also devolve decision-making powers to academic, research, and other University level councils.
i. The universities should develop immediate and mid-term road maps and action plans for reforms and modernization and seek necessary approvals and support for implementation. The SAUs should also address resistance to change and achieve broad support from internal (within institution) and external sources.

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Reforming Higher Agricultural Education in India: The Way Forward

N.K. Tyagi

The higher education in a knowledge economy is essentially the currency with which we trade in the modern world. Therefore, it is no surprise that the entire society, be they academicians, policy-makers or common man, are showing concerns about higher education. A permanent commission for managing higher education has been planned, and realizing the importance of agriculture to Indian economy, the Government of India is now trying to correct imbalance in investment in agriculture. Therefore transformation of higher agricultural education and research, which has the responsibility of enabling the society to benefit from technology development or spreading awareness of what agricultural science and technology have to offer to the society, is important.

Society's Growth Path and Higher Education

Primary objectives of higher education are: studying existing knowledge and explaining its relevance in the evolving context; integrating knowledge from different branches to resolve problems faced by the society; and developing new knowledge through thought process, research and discourse. As the society evolves, scope, content and techniques of education change. The growth path for progressing from agrarian economy to super-industrial and service society is well defined. In the agrarian economy, development is largely based on the exploitation and use of natural resources and readily available labour. If the land and water are good and climate is favourable, the country can support its population at the pre-industrial level of life-style. At the second stage of growth, it is the technology and the trained manpower with higher wages that play a major role. Countries that developed or acquired efficient technologies were able to progress well. Japan, South Korea and European countries (Switzerland and Sweden), which were not very rich in natural resources, progressed fast due to access to efficient technology. China has been able to develop/ acquire technologies and could use them in the last two decades, and the result is a great revealer. The third stage of development is innovation-driven. The super-industrial economies like Netherlands, USA and Japan thrive on high value, low volume technology. India is at the second stage of development, and can hope to become advanced country, largely through innovative agriculture.

Status of Agricultural Education in India

Our post independence agricultural education system was modeled after the *land grant system*. This system has operated in the USA for more than 125 years and in India, it has completed half century. Whereas agricultural education performed reasonably well in the past, the impetus and vigour of 1960-90 seems to have dissipated. The renowned INFOSYS man Narayana Murthy in his famous book "A Better India – A Better World" (2009) quotes McKinskey, to say that only 10 % of the Art and 25 % of Engineering graduates, coming out of colleges in India, were employable The crucial factor for success- *the excellence* has not been paid due attention. Fragmentation of agricultural universities and mushrooming of agriculture colleges has impacted quality of education. A partial assessment of the education quality in different universities on the basis of students' performance of these institutions was made by the Agricultural Scientists' Recruitment Board (ASRB, 2007, 2008, 2009 and 2010); the performance was highly skewed. For example, 74 % of the successful candidates in the Agricultural Research Service (ARS) were from only 10 state agricultural universities; with a single university contributing to 20 % of the successful ARS entry-level scientists. Several universities drew blank for 3 consecutive years. Review of the data of the Agricultural Scientists Recruitment Board's National Eligibility Test for screening suitable candidates for appointments to the posts of lectures/assistant professors for past several years showed that though the number of candidates undertaking test remained consistent at 10,000, the number of successful candidates jumped from less than 1,000 to more than 2,500 when cut-off percentage was lowered from 50 to 45 % for the general category and from 45 to 40 % for the reserve category (Figure 1). It implies that two-thirds of the successful NET candidates scored less than 50 %. In many universities, there has been a

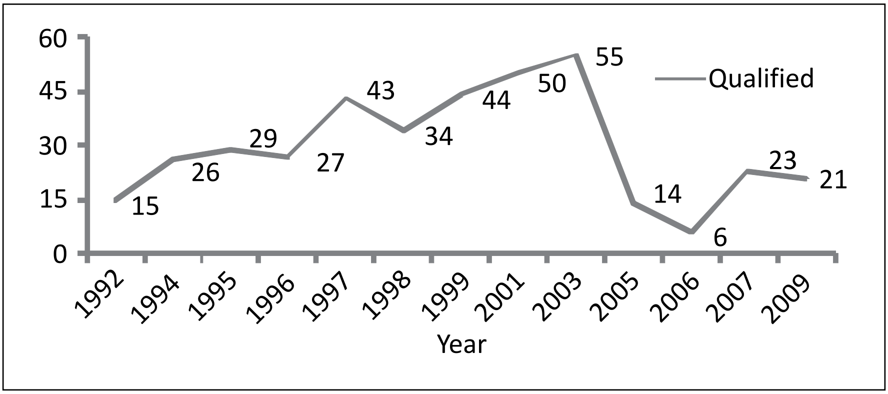

Figure 1. Percentage of successful candidates in NET Examination (1992-2009)

Source: ASRB Annual Reports (2007-2010)

continuous decline in standards at the PhD level. While interviewing candidates for ARS, it was discovered that a large number of them did not know the hypothesis they were trying to prove or disapprove. Research for them meant having a number of treatments like fertilizer doses and some replications and a crop to grow. If they could somehow generate two seasons' data, the computer did rest of the job. They failed to give logics for the kind of results that they obtained. It was also discovered that same experiment, with very minor changes could yield another doctoral thesis without making any new advancement. This is not a very reassuring situation for the higher education. A country of India's size and diversity has to have its own advanced education and research system in place to meet the needs of not only of today but of tomorrow. This capability can come only through institutions well equipped with man and material.

Teaching scenario

In the past, academic institutions of higher learning were not supposed to get involved in the nitty gritty of development in the society because pursuing higher education was considered an end in itself. The land grant system made a departure from this principle. The three essential components of the land grant system were: colleges for instruction, experimental station and cooperative extension service. It essentially implied integration of teaching, research and extension. The success of the system thus can depend on the right mix of these three responsibilities and the recognition, which each responsibility received from the system. Over a period of time, values attached to these responsibilities changed; research started getting more recognition as compared to teaching, and in due course teaching was relegated to secondary position. It was argued that excellence in research was a prerequisite for effective teaching. Whereas research leads to generation of a new knowledge and is helpful in establishing workability of the technological solutions, the correlation between the research and the effectiveness in teaching was in the range of 0.13 across multiple studies (Feldman 1987). The positive sign on the correlation coefficient only affirmed that research activity by a professor did not harm students, but statistically it did not support deeper relationship between the research and the teaching. Another conflict came with extension. Separate extension departments in agricultural colleges, to some extent defeated land grant spirit, but were successful in being supported by the political system and thus in receiving funds. No such support was available for teaching. According to Wilson (1979) involvement in daily events led to loss of scholarly detachment and neutrality.

Gradually teaching became less attractive as compared to research and was not considered a scholarly function in the universities, though primary purpose of establishing universities was education. By definition, scholarship is a creative intellectual work that is validated by the peers and communicated. The commonly accepted forms of scholarship are: i) discovery of a new knowledge, ii) development of new technology, methods, materials or uses, iii) integration of knowledge leading to new understanding and iv) artistry that creates new insights and understanding (Weiser, 1994). Often, there are problems with the application of scholarship norms to teaching because scholarship is often equated with publications, and peers evaluate performance without reference to the description of the position. Be it selections for senior positions or entry in academies, they are mostly based on the performance in research. The work of faculty in a university has academic and several other mandates, and not all the activities can be covered under the scholarship. The teaching could come under scholarship only if it integrated knowledge leading to new understanding. Somewhere down the line, the balance between the various functions of the university teachers has been lost, and teachers are no longer able to integrate knowledge creating new interpretations and innovations in teaching.

Way Forward

The greater involvement in the affairs of the clientele, particularly when both public and private sectors supporting higher education demand practical solutions for problems, is a fact of life. A new term *engagement* has been coined for involvement with a wider meaning assigned to it, and the clientele includes not only farmers, but also students, faculty, industry and business (Kellogg Commission Reports 1999-2000). The Commission recommended that the institutions of higher education should get more engaged with community they serve and create an environment in which flourishes both learning and scholarship. The big issue is how to promote learning and scholarship together with increasing involvement in lesser academic pursuits. Institutions would not automatically transform to truly engaged and learning organizations. It is a herculean task and there are many challenges in this process.

The first big challenge is the rapid change that is taking place in the learning environment in the form of explosion of information and communication technologies. Availability of hardware and software is not a big problem, but the ability of the faculty to continuously absorb and assimilate new developments is not easy. Learning is in itself a science which requires development of new techniques, and the agricultural universities should look beyond the NARS. Creating learning environment in higher education institutions by broadening access through a variety of teaching and learning opportunities can be the first step.

In terms of education standards, there are clear-cut gradations across the agricultural universities, but those in authority find it difficult to accept it. Developing closer association, not for annual meetings but effective partnerships between the developed and the developing universities may be the next step. Revolution in IT would make this partnership possible. Further, at present the universities have no linkage with pre-university colleges. Each regional university should establish association with the pre university colleges falling in its catchment area to promote quality education in the colleges.

In the past, farmers were considered sole clients of an agricultural university. This was tenable when primary agriculture was being practised. This is now changing with secondary and tertiary agriculture which is more dependent on industry and business. The growing importance of intellectual property rights and patents regime demands that agricultural education and research institutions and the industry should come together and develop the kind of relationship that has been established between Engineering institutions and the industry. This will broaden horizon of agricultural graduates beyond fields and farms.

To be successful, one has to compete with the best. The notion that some disciplines could be left to less bright people, is no more valid in present scenario. Many argue that positions meant for difficult areas or in KVKs can be filled with people having lower achievements. This appears to be wrong. More intelligent personnel are required to perform in unfavourable conditions. So excellence in all disciplines has to be the core motto.

There is also a problem with our evaluation system which puts more weightage on the research than on the teaching. Good researchers cannot be produced from poor teachers. Therefore, we have to devise suitable evaluation system in which performing teachers get same recognition as is given to good researchers. I am not talking of career promotions, which have somehow been universalized and everyone can hope to reach the same level. I am talking of the differential peer recognitions that the two categories enjoy. It is this difference in valuing contributions that in many cases is leading to substandard PhD dissertations.

Like colleges of engineering, the number of agricultural colleges is also growing. In some cases these colleges have got affiliated to agricultural universities/general universities. These colleges at present may not be receiving grant from the government, but have got recognition and may be running mostly undergraduate courses. We have to improve the bachelor as well as the post graduate level of education. The IITs became a global brand because of their superior B.Tech programme. Agriculture cannot perform with substandard products that many of the newly established colleges are churning out. The Central government is planning to establish a permanent commission for higher general and technical education. Agriculture being a state subject may miss this opportunity of eliminating some of the ills that have crept in unless it is brought in the concurrent list.

We will get excellence in agricultural education, if the society starts according it a high place in their value system. As agriculture becomes high-tech and moves beyond primary production, it will also attain some glamour and is likely to become more attractive to the society in the approaching times.

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Knowledge Sharing, Linkages and Partnerships in Agricultural Education and Development for Shaping Future of Indian Agriculture

C. Ramasamy

"The known is finite; the unknown infinite; intellectually we stand on an island in the midst of an illimitable ocean of inexplicability. Our business in every generation is to reclaim a little more land"

T.H. Huxley 1887

Knowledge is an indispensable asset for creating and sustaining competitive advantage. As an activity, knowledge comprises information, skills and expertise, which can be exchanged among members of a society, among organizations and across the countries. Knowledge sharing helps an organisation and a nation in making innovations, enhanced performance, achieving competitive advantage, sharing of experiences and lessons learned and integration and continuous improvement of an organization and subsequently of a nation. Knowledge sharing leads to socialization, internalization, combination and externalization. Infrastructure and technology are required for effective knowledge-sharing. In an increasingly competitive environment, individuals, organizations and nations are often subjected to repetitive works. It would be inefficient to let people 'reinvent the wheel' every time. Therefore organizations have tried to set-up knowledge repositories that contain best practices and other knowledge that could be of interest for others practitioners and organisations. Different ways of sharing information and knowledge include sharing articles and reports; organizing colloquia, workshops, and book reviews; creating knowledge platforms; networking of institutions; use of digital and electronic media, opening up data base, etc. Technology plays a crucial transformational role and is a key part of changing the corporate culture to knowledge sharing one. In many ways it is technology that has made knowledge sharing a reality – in the past it was impossible to share knowledge or work collaboratively with co-workers around the globe. Today it is a reality. Not only can one find the information and knowledge one needs quickly and effectively but one can post his/her knowledge on the system for access by others in the organisation - be they at the next desk or on the other side of the world. But more than just this, groupware technology such as Lotus Notes/Domino working over the Internet, one's organisational Intranet or Extranet allows one to work collaboratively with anyone anywhere in the world to achieve his/her objectives (Gurteen,1999).

Knowledge Platform and Net Working

Ideas do move the world but are static on their own. Knowledge platform is a place where ideas, and the remarkable people who move them, meet. Online platforms and initiatives contain tools that will make institutional objectives and businesses remarkable. Knowledge platform is often a global network of researchers and development experts who identify and address major knowledge gaps in theory and practice. With broader consultation and continuous research, knowledge platforms provide practitioners and policymakers with better tools to foster economic growth and implement development projects and programs. Information is a valuable resource and individuals and organisations can look for ways of generating extra value from this resource. Knowledge networking can aid to combine individuals' knowledge and skills in the pursuit of personal and organizational objectives. It is a productive activity wherein knowledge is evolved, developed and shared. It facilitates to resolve the unknown and develops new knowledge. Knowledge management plays an important role in promoting innovation, productivity, in a cooperative team (Dieng, 2000).

There has been a global shift from traditionally manufacturing based economies to economies that are largely knowledge based today. This shift has put forth a pressing need to develop a platform capable of transporting different forms of information to all the members of the society. In this new era of knowledge, India, which is a vast pool of knowledge workers, is competing in the global economic playfield. A large share of our national income comes from agriculture and is now in a post-green revolution era and a larger pie of developmental efforts is being directed for those who are in the rural areas. Developing the capacity of agro-based rural communities through cyber extension with the use of ICT will create opportunities of growth and prosperity and give a chance to Indian agricultural markets for creating a more efficient information and knowledge network.

In recent years, Government of India is proactive in promoting knowledge network. Government has approved the project on Establishment of National Knowledge Network in March, 2010 with an outlay of Rs. 5990 crores over a period of 10 years. National Informatics Centre (NIC) is the implementing agency. The objective of the National Knowledge Network (NKN) is to interconnect all institutions of higher learning and research with a high speed data communication network to facilitate knowledge sharing and collaborative research. Under NKN, it is proposed that the core and associated links to around 1500 institutions shall be established in 2-3 years' time. The application areas envisaged under the NKN cover agriculture, education, health, e-governance and Grid Computing. ICAR's Directorate of Knowledge Management in Agriculture (DKMA) and Indian Agricultural Statistical Research Institute (IASRI), and Intellectual Property Rights and Trade Mark (IPR &TM) are creating knowledge networks in the respective fields for easy transfer of information and knowledge.

Knowledge Platforms in Indian Agriculture

A number of knowledge platforms are emerging in India, both in private and public sector and under Public and Private Partnership (PPP) mode. A brief account of some of them is presented below:

i. Smart Knowledge Agriculture Corridor (SKAC)

India Center Foundation has launched the SKAC. With focus on 5Ps, which are Policy, Processing, Packaging, Preservation, and Power, this corridor based on unique PPP model will provide an effective, technical and commercial high-end platform to Indian agriculture and educate various sections involved in Indian agriculture by creating a direct interface between various participants. Substantial quantum of the perishables goes to waste due to lack of adequate infrastructure. The proposed SKAC will cover 13 Indian States. Knowledge dissemination is important as right and updated knowledge and technology must be imparted to the farmers. The knowledge itself needs to be backed by infrastructure, processes and systems. With SKAC, conservation agriculture and reorientation of research on natural resource management will be promoted along with varietal improvement, plant protection, agronomic packages and livestock integration and management and prepare for precision agriculture (SKAC, 2013).

ii. Agropedia

Agropedia is a unique Web 3.0 platform in the agricultural domain. Agropedia seeks to address lacunae in Indian agricultural knowledge and applications, specifically the lack of content, organized information, and the extension of services, which are serious challenges. Along with the certified content in the library section, it also allows space for interaction, knowledge co-creation and social networking making the site dynamic and learning participatory, integrating traditional wisdom with modern knowledge and social interactions. So, for any type of agricultural content, one will find a special dedicated spot on Agropedia, be it package of practices (text/voice), dos and don'ts, crop calendar, library, newsroom, and events. Any user who registers to the site is encouraged to either add, rate or comment on any content in all major Indian languages. All this is what makes Agropedia different from other sites (ICRISAT, 2013).

iii. Directorate of Knowledge Management in Agriculture (DKMA)

DKMA of ICAR as a knowledge platform is committed to promote ICT driven technology and information dissemination system for quick, effectual and cost-effective delivery of messages to all the stakeholders in agriculture. Keeping pace with the current knowledge diffusion trends, Directorate is delivering and showcasing ICAR technologies, policies and other activities through print, electronic and web mode. Directorate is the nodal center for design, maintenance and updating of ICAR website along with facilitation of network connectivity across ICAR institutes and KVKs. Besides, DKMA provides public relation and publicity support to the council and its constituents across the country. Thrust areas of the platform are:

- ❖ Dissemination and sharing of agricultural knowledge and information through value added information products in print, electronic and web mode.
- ❖ Development of e-resources on agricultural knowledge and information for global exposure.

- Facilitation for strengthening e-connectivity among ICAR institutes State Agricultural Universities and KVKs.
- Capacity building for agricultural knowledge management and communication[1] (ICAR, 2013).

iv. Agricultural websites

There are more than 25 websites dedicated to agriculture and allied areas including rural development. Some of the important websites are:

www.indiaagristat.com; www.apeda.com; http://fert.nic.in; http://agricoop.nic.in; and www.indiacommodities.com

All these websites provide a comprehensive source for Indian agricultural related information which is regularly updated. It provides authentic information on sectors like agricultural education, agricultural export, agriculture census, agricultural insurance, animal husbandry, agricultural marketing and prices, horticulture production, agricultural wages and all other relevant agricultural statistics of India. It also provides the agriculture related news. The portals disseminate useful information about improved technology to the farming community and service providers in the rural areas. It aims to create a platform for different levels in the rural agricultural landscape - farmers, cooperatives and professional bodies, farm machinery vendors, fertilizer and chemical companies, insurance regulators and agronomists, consultants, and farm advisors. In addition, all 64 State Agricultural Universities (SAUs) maintain their own websites with latest information covering various aspects relaying to agricultural and related sectors which are very useful to the students, farmers, food processors and many other stakeholders for day-to-day decision making and scientific applications (www.agropedia.htm, 2010).

v. Agricultural Knowledge Systems (AKS)/ Knowledge Network Projects

A number of institutions both public and private have developed knowledge systems covering various requirements relating to agriculture. Some of them are: e-linkage to KVKs through VSAT network

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[1]The key achievements include: publication of authoritative and benchmark publications; facilitating online access to 2000 journals from a single subscription in more than 123 libraries; providing ICAR website with links to weather based agro–advisories; development of National Agricultural Research Database; operationalization of e-connectivity of Krishi Vigyan Kendras.

operated by ERNET India; I-Kisan of Nagarjuna Fertilisers; Information Villages project of MSSRF; aAqua programme of KVK, Pune; E-Chaupal of ITC; Kerala Government's AKSHAYA project and an online trading portal, Vyapar at Madurai. These and many other systems cater to the 'knowledge' and 'do-how' demanded by different categories of farmers viz., livestock farmers, fishery farmers and crop farmers, field workers, students, policy makers and agricultural traders.

ICAR has, under National Agricultural Innovation Project (NAIP), initiated several activities for improving agricultural information and knowledge. They are: development of 10 crop knowledge models; price knowledge management portal; ASRB online examination system; re-usable learning objects; CeRA (Consortium for e-Resources in Agriculture); national information system on agricultural education network in India (NISAGENET); ICAR decision support system, and export system.

The network projects cover agricultural marketing, seed, co-operation, horticulture, fertilizers, plant protection, fisheries, weather, research, education, etc. A set of networks are: AGRISNET, ARISNET, Weather NET, Seed NET, Co-op NET, HORTINET, FERTNET, VISTSARNET, PPIN, FISHNET, etc. TNAU AGRINET PORTAL is an outstanding example of how a university's knowledge delivery has to be. It covers agricultural education, research and extension and price and weather forecasting (various websites; Choubey, 2009)

Knowledge Platform for Agricultural Education

Are traditional ways of learning and educational approaches adequate to manage and channelize the knowledge and learning materials? There is a critical need for leveraging developments in technology to improve the delivery of education. Technology facilitates to provide experiences for students that are more flexible, both in time and geography. Cloud computing, virtualization and open education resources are the consequences of computer and information technology. Globally many educational institutions are **developing strategies and programs** that focus on scalable and sustainable technology applications directed towards imparting all levels of education. They include: development of applications to enable and support flexible, modular and concept-based approaches for deeper learning and alternative learning pathways; creation of interactive content, tools and services to promote learning experiences that leverage the affordances of open and online educational resources and designing and implementation of Learning Delivery Environments that include configurable, contemporary applications as well as flexible learning spaces to address growing student and faculty expectations and applications.

For example, Massachusetts Institute of Technology (MIT) has a number of current technology centered initiatives such as **MITConnect, MIT Core Concept Catalog (MC3)**, **Adaptable Interactive Learning Environments (AILE), StarCellBio**, **Crosslinks,** and **ARTEMIS** with the objectives such as developing capacities for next generation educational platforms and asset of tools and services to enable teachers and learners to navigate open education resources; designating and delivering robust teaching and learning environments and so on. Thus educational delivery is fast getting transformed (MIT, 2012).Recently, an open courseware platform for agricultural education namely **'AgEd Open Courseware'** which is supported by U.S., India, and Africa for building IT-Enabled Agriculture Education Platform has been launched by ICRISAT, IT Companies, University of Florida, ICAR and IFAD for agricultural students, faculty members, extension agents, and smallholder farmers in both developing and developed nations. The platform hosts research infused agricultural curriculum which will help learners get dynamic curriculum instead of stagnant one (ICRISAT, 2012).

Another higher education platform for agriculture namely "International Platform for Asian Agricultural Education" has been launched by comprising six universities including three Japanese, two Thai universities and one German university. The platform targets the Master's course students. Lectures, seminars and practices would be provided by the faculties of cooperative universities. This would lead to quality education and the students can grow global mind for local issues. The topics treated in the platform would be agriculture, forestry, and environment in Asia, international development, and technical communication. The teachers can visit different universities and give lectures to the multi-university students. Multi-media and video conference systems would be also introduced. The project conducts various activities according to the four subprograms: (1) university collaboration, (2) curriculum development, (3) educational infrastructure and (4) system reform. These pioneering initiatives have shown the way for agricultural educational institutions in India to come together and create agricultural educational platforms leveraging developments in computer, connectivity and related technologies by synergizing the knowledge and financial resource of cooperating institutions.

These are some of the models worth emulating by SAUs and other institutions for shaping future of Indian agriculture.

ICAR and State Agricultural Universities

As India realizes its potential in the area of international food and agribusiness, the future of Indian agriculture will be complex, innovation driven and market driven. In recent years, ICAR as an apex organization, has initiated many activities to modernize agricultural education in India. One such initiative is the application of computer and IT technologies for effective delivery of agricultural education. The Fourth Deans Committee has recommended courses such as Introduction to Computer Applications, Cyber extension, Bioinformatics and other courses which need higher levels of computer applications and digital technology. ICAR is supporting all State Agricultural Universities (SAUs) with financial assistance to strengthen computer labs, internet connectivity and IT facilities. The NAIP is supporting the development of E-learning materials for B.Sc. (Agriculture), B.Sc. (Horticulture), and B.V.Sc degree programs. TNAU, TANUVAS, UAS (B), NDRI and other institutions are involved in developing the E-learning materials. These learning materials are expected to be hosted in special servers as open courseware for use students across the country.

With the development in ICT, E-learning, the new paradigm of learning and teaching, has become integral part of education programs in every field of development. With the development in agricultural science and technology, the need for transforming agricultural education to cope up with progress in S&T has also been realized throughout the world. Quality education in agriculture is need of the hour given formidable challenges we face in Indian agriculture. But practice of E-learning in developed countries particularly in field like business education is much ahead in comparison to E-learning in the field of agriculture. People can learn any subject anytime and anywhere with the use of E-learning which is enabled by ICT.With E-learning, the possibilities for getting knowledge and information out to the learner at her/his own pace opened a whole new world for knowledge transfer (Carabaneanu *et al.*, 2006). With the advances in internet technology, web based E-learning systems are gaining popularity. Being online, internet technology and web based learning form key pillars of E-learning. One limitation of this system is that teachers may not know a student's strengths and limitations in learning. But their goal should be to empower their students to become self-aware of these differences (Zimmerman et.al. 2002).

TNAU pioneered in promoting E-learning for agricultural courses and has uploaded learning materials for more than seven hundred courses for various degree programs offered by the University and are available as open courseware. Besides, core lectures are video-graphed and are available through Wi-Fi system in the campus. Part of the student evaluation is done through online examination system thus preparing students for the 21 st century. TNAU develops CDs containing lecture materials and distribute the same to all the campuses of the University for UG and PG programs (TNAU Portal/E-learning, 2012)

E-learning site developed by IASRI is meant for teaching and learning in the area of agricultural education. This is designed and developed at Indian Agricultural Statistics Research Institute (IASRI), New Delhi. This includes the courses taught under the PG School, Indian Agricultural Research Institute (IARI), New Delhi. Currently two disciplines have been included in the site namely Agricultural Statistics and Computer Applications. The courses have been distributed into different topics and each topic includes goals and summary, glossary, multimedia enabled presentations, lesson content, quiz and assignment (IASRI, 2012)

In order to integrate ICT learning into the agricultural curriculum, Agricultural Innovation Partnership (AIP) project has created E-learning centers to deliver ICT enabled courses to students at partner Indian agricultural universities leveraging on the technological expertise of US partner universities.AIP supported by USAID, India and led by Six US Universities with Cornell University as consortium leader has trained teachers of Agricultural Faculty of Banaras Hindu University, Sardar Vallabhai University of Agriculture and Technology and Assam Agricultural University on E-learning systems. The three Indian Universities are in the process of implementing E-learning in their respective campuses. Other SAUs are beginning to adopt this model but to go along way before accomplishing this (Sathguru-AIP, 2012).

AIP plans to establish an easily accessible repository for home grown and global knowledge in the area of agriculture and food sciences. Besides promoting E-learning, AIP intends to build capacity among the faculty and students for effective and efficient usage of the E-learning center. Another objective of AIP is to enhance the delivery of agricultural information to farmers through improved web and mobile based solutions synergizing the resources of public and private sector. Other key innovations are:

- The project provides access to curriculum cum course, reading materials and presentations seamlessly facilitating enhanced learning for the students

- ❖ Facilitates creation of uniform agricultural knowledge and interactions among the community (faculty, students and farmers) through a single platform approach.
- ❖ Supports highly compatible open source, course-based learning management system (LMS) in agricultural education
- ❖ First to deploy state of the art synchronization technologies in production in agricultural education in India
- ❖ Pioneers in building capacities for Indian faculty through training at US universities for media production

Informal Education: Supporting KVKs

Agricultural education not only encompasses formal but also informal education such as transmission of knowledge to farmers and other stakeholders besides students. On the delivery of knowledge to the farmers, KVKs are needed to be empowered with tools and technologies to improve their service delivery and self-improvement skills. Hence a mobile-based delivery platform and a Facebook-like knowledge-networking platform needed to be envisaged. It seems that among all the trends, voice based services delivered through cell phones are the most popular.. Future platforms may address lacunae in Indian agricultural knowledge development and application namely lack of most appropriate content, organized information, and efficient extension services. There is clear need for an open access research repository for agricultural documents. In the coming years people will see India as more developed in the agricultural sector. Appliances act as a local server, and through intranet connection, more than one system can connect to it and access information. It is useful for places with limited connectivity. It is important that those knowledge platforms make use of the existing vast extension network of KVKs in the country and allows the extension officers to send SMSs and voice based agro-advisories in local dialect to the farmer's mobile phone. One can also look for a platform for experts at KVK to share information and experiences. KVK experts join the community and write information on the wall, similar to Facebook.

Distance Education

Distance education (DE) is very effective, accessible, low cost educational platform opportunity for those, out of conventional educational system. A number of initiatives using distance education mode have been made in India to deliver agricultural knowledge and modern farming practices but yet to go a long way to realise solid results. However, DE to be effective in agriculture, more practical and field based approach is needed. There are several micro and macro issues before distance education system in agriculture in India.DE in agriculture is characterized by relatively less interactive teaching / learning programmes. The instructional programmes are mainly dominated by printed literature and postal correspondence but the system must have more of multimedia and cyber technologies. Subject matter and instructional programmes must have to be increasingly IT based. Obviously, the hands-on experience is extremely less and extensive use programmed audio and video lessons showing practical aspects will partly compensate the lack insufficiency in hands-on-experience. In DE programme, computer aided instructional material needs to be developed in a larger way. Countrywide classroom of UGC and IGNOU on national TV network has become very effective over last several years. But the time slot is very inadequate and devoid of prime time opportunities. In fact for distance education full time TV Channel with 24 hour telecast is necessary. A large network of teleconferencing and internet networking facilities for learners at cooperative / study centres is necessary. Qualified human resources, inadequate funds, doubts about quality of instructional programmes, poor incentives to hired faculty, miniscule interaction with students and quality of guidance and high dropout rate still remain. Use of computer and IT technologies will address these inherent problems effectively.

Linkages among Agricultural Educational Institutions

Linkages across educational institutions will bring many benefits. Innovative methods of learning practiced and custom-built programmes in one institution can be adapted to other institutions in cost effective ways. It will lead to national and foreign faculty, students and administrators to gain useful experiences. Linkages help to create new generation of students to follow best practices proven elsewhere. This collaboration can be achieved in several ways: faculty or student exchange, exchange of learning materials, research participation and involvement, and shared conference planning. The collaborations and linkages expand a University's academic and custom built programs to have more of a global perspective; internationalize the curriculum, pedagogy and extra-curriculum activities and catalyze indigenous students to gain international experiences; provides leadership in developing strategies to enable the University recruit the most capable international students into its undergraduate and postgraduate programs; leads to international exchange of students and scholars; and develops agreements with institutions of higher learning internationally as well as with the corporate world in areas of strategic benefits.

Some of the recent initiatives by firms, government, industry associations, and IITs in India have created innovative linkages in the IT field. They are: i) Infosys's own training facility and its interface with the universities and colleges wherein Infosys influences the curriculum; ii) NASSCOM working with Ministry of HRD, GOI, to create highly specialized professionals with skill sets in emerging and to promote "on-the-horizon" technologies that are not yet main streamed; iii) Ministry of HRD with support from NASSCOM and the IT industry launching of five new IIITs (Indian Institutes of Information Technology) on the Public-Private Partnership mode and iv) Encouraged by the success of its Assessment and Certification Program (NAC) for the BPO sector, NASSCOM introducing a similar testing and accreditation offering, NAC-Tech, for the IT.

SAUs have independently taken up collaboration with foreign universities over the time. It has largely come through international donors such as Ford Foundation, Rockefeller Foundation, USAID, CIDA, SIDA, and many other donors from Europe, Japan, Australia and other countries. ALO project of USAID brought in collaboration among three SAUs from India and six US LGUs. The linkage between Cornell University and TNAU has been a long standing one. The 'International Agriculture and Rural Development' (IARD) course offered by Cornell University jointly with Indian Agricultural Universities is a classic example that many universities must follow. The objectives of the IARD course are: i) Provide strategic and operational perspectives on emerging challenges and opportunities in agriculture and ii) Develop an awareness of the global nature of the international economy with multidisciplinary nature of issues. International visit of students is the part of the program. The institutions involved in IARD program are TNAU Coimbatore, UAS Dharwad, ANGRAU Hyderabad, GBPUAT Pantnagar and Universities in Thailand. Students from these universities have enrolled in this program for the past one decade. Currently universities BHU, SVUA&T, and AAU are also participating in the program. So far 66 students from TNAU underwent this course and about 10 per cent of them are pursuing higher education in developed countries as a result of this experience. The feedback from these students is: They had acquired International experience in agriculture; exposed to frontier areas of science and state of the art laboratories; experienced with innovative learning processes such as special lectures, field visits, group activities, blackboard interaction, video conferencing, etc.; and have been Instilled with self-confidence for higher academic pursuits. This course sensitized Indian and US students and policy makers on how to foment change in agricultural policy and technology to improve productivity, promote competitiveness and aid integration into a global economy (Ramasamy and Suresh, 2011).

Cornell University and TNAU ventured to launch dual degree program at Master's level during 2007 and is successfully carried on till now. So far 30 students from TNAU acquired dual degrees from the two universities. The degrees offered are: MPS-Food Science at Cornell University & M. Tech (Food Processing and Marketing) at TNAU and MPS-Plant Breeding and Genetics & M.Tech (Biotechnology and Business Management) at TNAU. The project has been funded by Sir Ratan Tata Trust and USDA-ISE from Cornell side. There are much other collaborations between SAUs and foreign universities from time to time mainly focusing on research and relatively less on education. Agricultural Human Resource Development Programme was implemented in the form of soft loan support to the State Governments by the World Bank during the period from 1997 to 2002. Only three universities TNAU, ANGRAU and HAU were benefitted wherein support was extended to faculty training in foreign universities, faculty exchange and infrastructural development (Ramasamy and Suresh, 2011).

Different agricultural universities in India among themselves developed linkages in the form of participation in evaluation of students' performance, Masters and Ph.D theses' evaluation and evaluating examination papers at UG level. Deans from other universities are nominated to the Academic Councils of other universities. Further, Indian Agricultural Universities Association (IAUA) organizes annual and regional meetings conducted regularly. This forum provides opportunities for exchange of experiences and making policy proposals regarding agricultural research, education and extension. Policy makers from ICAR invariably participate and get sensitized on the requirements and performances of SAUs. But policies recommended at this forum are not given due importance by the State governments who provide the major funding to the SAUs. Even though, creation of new and innovative linkages among Indian agricultural educational institutions are discussed and debated, time and again, nothing solid happened on this front.

Faculty and Students Exchange

Faculty exchange is recommended at different levels among SAUs. ICAR is favoring this proposal. Similarly students exchange remains only in the paper. In a recent survey made under AIP in BHU and SVPUA&T, both faculty members and students reported that there is no exchange program in place (AIP, Baseline Survey, 2012).The major constraint is lack of financial support. Most of the SAUs are undergoing financial distress and, rarely, they allot funds for faculty and student exchanges. ICAR is also silent on this aspect. Appallingly, there is no well-defined policy on exchanges. Sabbatical leave policy is in place in many universities and either university is not providing funding or faculty members not forth coming to participate. The policy of career advancement in accordance with UGC provisions does not offer any incentives for the faculty members to opt for using sabbatical provision. Further 'sons of soil' policy is implicitly adopted by many State governments which also discourage All-India recruitment of faculty. While something is happening on faculty side, students exchange is practically zero. Even pursuing Ph.D outside their own state is not happening leading to in-breeding of scientists resulting in faculty with poor research and teaching capabilities. It is high time that a clear cut policy is framed and financial provision made by ICAR and special incentives created for people to participate in exchange programs.

PPP in Agricultural Education and Extension

Public Private Partnership (PPP) broadly refers to a long term, contractual partnership between the public and private sector agencies, specially targeted towards financing, designing, implementation and operating infrastructure facilities, and services that were traditionally provided by the public sector. Presently, PPP is adapted to the fields of agriculture, education, health, poverty alleviation, food and nutrition, R&D in all fields, etc. Corporate Social Responsibility (CSR) is increasingly accepted by the private sector which more actively gets involved in nation building covering sectors which are so far antithetical in the realms of private sector. PPP leverages on the strengths of each other; ensures efficiencies and maximize returns to the stake holder. Public expenditure on education (Rs 850 billion in XI plan) has increased but the percentage share of GDP spent on higher education has not improved over years. Planning Commission has identified a resource gap of Rs. 2.2 trillion. PPP could be an effective mechanism for attracting private sector investment into the Higher Education (HE) system without diluting the regulatory oversight of the government and other regulators. PPP will ease the budget constraint and expand the investment. PPP in agricultural education is a new concept in India and as such an appropriate environment has to be created so as to attract reputed private players. Existing concepts such as CSR, volunteerism and offering tax rebate for donors will attract investment in agricultural education (Chengappa, 2011).

The agricultural education, which was largely designed for public sector agricultural extension in this country, has to transform itself in a dramatic manner as 21st century Indian agriculture is enormously different. It is characterized by high-value low-volume approach, possessing cash crop base potential, market led, export oriented private sector driven strategy, technology backstopping by both public and private R&D and higher level of integration with global agriculture in terms of technology and markets (Bisaliah, 2011).

One notable case of PPP in education is collaboration between S. M.C. College of Dairy Science, Anand Agricultural University and Vidya Dairy (a private one) wherein Experiential Learning Course for B.Tech (Dairy Technology) students of SMC College is offered by Vidya dairy. The courses provide hands-on-experience to the students. To develop and offer these courses, University provided 20 acres of land to build dairy unit and students' hostel; NDDB, Anand, provided necessary financial and technical support; KDCMPU Ltd. (Amul Dairy), Anand, provides raw milk and market for sale of liquid milk.

Maharashtra and Tamilnadu are pioneering in encouraging private investment in agricultural education. Maharashtra has affiliated about 100 private Agricultural Colleges to the Agricultural Universities in the State. Four private Agricultural Colleges and about 10 agricultural diploma offering private institutes have been affiliated to Tamilnadu Agricultural University (TNAU). Many more are in the pipeline in these States. Here, the quality assurance is mandate of the universities. TNAU places their Ph.D candidates in leading private companies such as Jain Irrigation Ltd., so that students work with the research facilities of the company and offer solutions to their problems. ICAR is not recognizing the supporting agricultural related new courses such as B.Tech in horticulture, food processing, energy and environmental engineering, bioinformatics, Agricultural information technology and B.S in agribusiness management in their accreditation process and also affiliation of private agricultural colleges. This policy must change.

Variety of public private partnership exists in the field of general education, the most common being the government aided schools/ college system but limited in agricultural education. ICAR has allotted KVKs to trusts/NGOs who are imparting training and conducting short courses in agriculture and allied fields.

Many private agricultural colleges mostly affiliated to general Universities are functioning in States like Uttar Pradesh and Maharashtra but are to be closely monitored by the universities for better outcomes.

Private investment can supplement the activities of Indian Agricultural Universities (IAUs). It is necessary to combine public sector's service motive and accountability with flexibility and efficiency and commercial culture of private sector. Private sector's knowledge, skills and innovations can be exploited to run the institutions. Technical skills, farm business skills, organizing skills, output marketing skills of both the sectors can be blended in delivery of agricultural education. Other forms of contribution could be provision of scholarships to the students, guest lectures from industry, and internship for the students, sharing infrastructure such as labs, instruments, and fields for trials, setting up science/research/incubation parks, assigning field problems to students 'research and help faculty capacity building. Government can think of private farm universities as that of general universities. Providing scholarships/fellowships to students as had done by Jindal Trust and Tata trust and institution of chairs and supporting centres of excellences will bridge the gap between private and public sectors.

Generally there is resistance on the part of ICAR and agricultural universities to go in a big way to work with private sector firms and organizations. PPPs in agricultural education and research are challenged fundamentally by different incentives; hindered by persistent negative perceptions of each other; impeded by the limited availability of information on successful working models of partnership and suffer from lack of appropriate industry-academia linkages. High cost of agricultural education projects, relatively lower returns *vis a vis* other streams of education-Engineering, Medicine, and Management and current regulatory landscape make it difficult to attract players for agricultural education projects. Since partnerships between public (by which we mean not for profit) and private (by which we mean for profit) organizations will invariably raise issues of conflicts of interest (COI) and the recognition and management of these COIs is critical to the existence of these partnerships.

Can PPP Play an Effective Role in Invigorating Agricultural R&D?

Public–Private Partnerships (PPPs) in agricultural R&D are increasingly viewed as an effective means of conducting advanced research. The three expected benefits with respect to PPPs are : (1) whether public–private partnerships contribute to reducing the costs of research, (2) whether they promote innovative research, and (3) whether they enhance the impact of research on smallholders and other marginalized groups (Spielman *et al.*, 2007).

Why are PPPs vitally important? Public investment in productivity-enhancing agricultural R&D has been declining in most of the world outside China. Private investments and capability, on the other hand, continue to grow. While the public sector provides strength in crop improvement, private organizations contribute expertise in plant sciences, genomics, bioinformatics, and the marketing and delivery of products and services. PPP in agricultural R&D is increasingly emerging as an effective means of conducting research in frontline areas of science and technology, commercializing new technologies, and deploying new products for the benefit of small-scale farmers, food-insecure consumers and other marginalized groups (Sarat Pawar, July 31, 2010). This synergetic effect enables returns on investment by taking advantage of the private sector's technical expertise, and the public sector's knowledge of local needs and networks (Syngenta Foundation, 2012).

Respective roles

Though the public sector has played a dominant role in the whole process, private sector's contribution in the development of hybrid seeds in cotton, sunflower, maize, sorghum, pearl millet and vegetables is well known. Besides new seeds, its role in the development of pesticides, fertilizers, weedicides, farm machinery and agro-processing technologies deserve special mention. The public sector's output with high public good character has addressed the food security and livelihood issues of millions of small farmers and poor sections of population. On the other hand, the private sector research output helped the development of agri-business in the country.

The recent trend is that private sector has been in the forefront in bringing out the products of biotechnology and transferring them to the farmers[2]. In spite of this kind of few specific achievements in recent times, Indian NARS remained stagnated as reflected from the lack of agricultural productivity growth and deceleration in TFP. ICAR has initiated the process of development of Public Private Partnership (PPP) in agricultural research[3]. ICAR – SAU system, though shared germplasm to a limited extent with private sector, is not fully open to share the knowledge and products with the private sector. So also private sector remained closed to share knowledge. The reality is that private sector made farming more economically viable through the spread of hybrid seeds and other modern inputs. CGIAR had a much broader vision of collaborating with private sector[4] (Ramasamy, 2012).

Approach and strategies

***Material exchange*:** There exists lot of potential for sharing of seeds, planting materials and biotech products. The access to materials such as germplasm by the private sector is constrained by bureaucratic hurdles and inefficiency in transfer of materials. The implementation of PVP&BR Act and Biodiversity Act has put additional restrictions in exchange of germplasm. There is an urgent need to smoothen these impediments through better interpretation of new regulatory provisions to make PPP in agricultural R&D more efficient. FAO has already approved the Standard Material Transfer Agreement (SMTA) for sharing the germplasm with a benefit sharing mechanism and this system can be followed to facilitate PPP.

***Allocation of research responsibilities*:** Public sector must allocate more resources to pursue the basic and strategic research in identified institutes, and university departments utilizing advances in S & T which will provide a strong platform to achieve breakthroughs in

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[2]Spread of Bt. cotton is the solid example of this trend. Monsanto's sharing of Bt genes with Mahyco in order to develop the Bt. cotton and Mahyco's further sharing of Bt. genes with many other Indian seed companies has revolutionized the cotton production in the country within a short span of five years.

[3]ICAR has organized ICAR-Industry Meet during July, 2010 at Delhi and had a wide range of discussions on strengthening PPP in commercializing public sector technologies and promoting agricultural research. Since early 1990s, government is following an open door policy for MNCs to market their products in India. Imports of seeds and planting materials were liberalized.

[4]With its location in India, ICRISAT had opened its doors for their products (varieties, parental lines and germplasm), and crop management knowledge to both private sector and Indian public system alike.

technology and to foray into frontier technologies. For specific areas of upstream research, PPP will be more ideal as exemplified by the DBT – Mahyco partnership on plant genomics. ICAR has approved several such projects under National Agricultural Innovation Project (NAIP)[5]. There is general consensus that the public sector can work on genetic variability, development of in-breds, CMS lines and semi-finished or intermediate products and selection of markers which can be shared with private R&D to develop new products which will sharply reduce time involved between basic/strategic research and products ready for commercialization. The Tropical Asian Maize Network (TAMNET) whose members include public and private from Asia, established in 1993, manages locational evaluation and annual field trials conducted throughout the region and resulting data across countries are synthesized and shared among countries

***Creating consortium*:** ICAR Institutes and SAUs can create consortium in which the private seed companies can become members and access the technologies available with these institutions[6]. Similar arrangement can be made for sharing parental lines developed in public sector for hybrid seed production by the private sector on a benefit sharing basis. In this case, the particular crop variety may be exclusively licensed to a company but the Institute / University will have the right to multiply and market the agreed product concurrently to benefit the small farmers.

***Sharing infrastructure and contracting research*:** Since public sector does not have market / dealer network as that of private sector, public sector can enter into agreement with private sector to promote Institute's or University's products. A reasonable profit sharing arrangement is not out of reach of both the parties. Both public and private can encourage contract research mutually[7]. ICAR/

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[5]NAIP is supported by the World Bank in the form of loan to Government of India for the purpose of strengthening agricultural R&D. Under NAIP, ICAR / SAUs and other leading research organizations such as IITs and general universities who will do the research and forward the results for agribusiness applications to the private sector thus are encouraging PPP in agricultural R&D.

[6]Private sector may deposit a nominal amount to become the member of the consortium. In Tamilnadu Agricultural University (TNAU), this arrangement works well for improved varieties of paddy and small machinery and equipment, plant protection and food processing technologies released by the University.

[7]For example, ICRISAT has biotech facilities and offer DNA testing, sequencing and analysis services to all groups of researchers by charging a fee. Similarly National Bureau Plant Genetic Resources (NBPGR) of ICAR offers customized protocols for event specific testing.

SAUs must open up its infrastructure to private sector at reasonable service charges. The public system must have business incubators wherein the small and medium level entrepreneurs can come and use the public facilities and develop their products. As agricultural and biotechnological research is capital intensive and requires huge funding, PPP mode can effectively use existing infrastructure and exchange materials such as genes carrying defined traits[8].

***Vertical and horizontal integration*:** The private firms pay fees for field testing of agro-chemical products (developed by private companies) to the public institutions such as SAUs. In many cases, there is undue delay in testing the products. In the future, once a product (chemical, seed, machinery, etc.) or a technology is to be released by the private firm, the ICAR / SAU system must facilitate in terms of testing it with very nominal fees and time efficiency. Further networking of institutions for select research projects will be one of the arrangements to share information, knowledge, IPR, HRD and financial resources.

***PPP research with human face*:** One of the criticisms is the lack of interest by the private sector in the case of orphan crops such as minor millets. This is one area where PPP can work on research projects with human face as it addresses the problems of small and rain fed area farmers. The PPP in agricultural research must be designed keeping in mind that the research outputs are accessible and relevant to the needs of the resource - poor end users. Further, international agricultural research shall have to be adequately integrated with regional and national partners covering public and private (GCARD, 2010). In developing countries, the share of private in total agricultural research investment is only 6.3 per cent as against 55.2 in developed countries (http:asti.cgiar.org). PPP in biotech research is exemplified by number of programs now on-going in Africa. Developing biotech bananas in Uganda with increased vitamin A, vitamin E and iron content is one such project. Successful research of this kind could dramatically improve the diets of millions of people[9].

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[8]The joint efforts of Mahyco – TNAU – UAS (Dharwad) in developing the Bt. Brinjal will be an eye opener to other institutions and private firms to adopt this model.

[9]Under Bio Cassava Plus project, public and private sector research is focused on enhancing levels of zinc, iron, protein and vitamins, as well as post-harvest durability. It will benefit 250 million people of sub-Saharan Africa. Africa Bio Fortified Sorghum project is a public private consortium developing a more nutritious and easily digestible sorghum. The African Agricultural Technology

IPR management**:** One of the PPP issues in agricultural biotechnology research is IPR management and there is vast scope to arrive at a mutually agreeable arrangement by considering the nature of research work, investment made and risk taken by each partner in a given project. Private sector feels the difficulties in accessing the germplasm available with National Bureau of Plant Genetics Resources (NBPGR) in India. Germplasm resources of public and private sector must be treated as a national wealth which must be usable for research purposes without much of hassles. The seed associations can play an important role in acquiring the needed materials available with public sector[10]. This kind of approach is very much replicable at the national level[11]. In Indian NARS, biotech companies are approaching ICAR institutes and select SAUs by assigning marker selection job by meeting the cost. One of the proposals is the creation of a consortium of markers at the national level by standardizing the markers[12]. It helps to achieve fast tract breeding which is the common objective of both sectors activities. Negotiated IPR arrangement will buttress the convergence of public and private units in specific areas.

Improving the governance**:** In the context of growing globalization, both public R&D institutions and private companies experience market demand from foreign countries for their research products such as seeds, agricultural machinery, agro-chemicals and services. The inter-ministerial approvals cause enormous delays in supply to the foreign markets. A single window clearance system for export of products and

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Fund (AATF) has worked with some of its private sector partners to negotiate licensing agreement of proprietary technologies that allow royalty free access and sharing of these technologies in order to improve farmer access. The project covers main staple foods such as maize and rice. The sustainable tree crops program (STCP) has been established on PPP mode. STCP launched in 2000 by the West and Central African cocoa stakeholders, World Cocoa Foundation, and USAID and managed by International Institute of Tropical Agriculture (IITA). The introduction of innovations in production, marketing and instructional management has led farmers to increasing their cocoa yields on average 15 to 40 percent.

[10]For example, AVRDC was funded by a group of companies for identification of a marker(s) to the extent of US $180 thousand dollars. Marker(s) were given back in two years with a condition, markers become open source.

[11]In the ICAR – Industry Meet held during July, 2010 at Delhi, a policy decision was made to hold such meetings annually to strengthen the linkages between public and private sector R&D.

[12]Monsanto has published 3000 markers but which are to be tested in Indian conditions. For example, J K Seeds, Hyderabad is testing some of these markers. IARI, New Delhi developed kits for a set of companies on demand.

services will improve the competitiveness of Indian agricultural R&D. In order to improve the access to information, public research system must develop a good data base which are accessible by the private companies (as a registered member) resulting in better understanding of research results, products and services of public sector.[13]

***Partnership in biotech and agricultural machinery industry*:** In the Indian context, the private sector has been more successful in development and marketing of biotech products such as Bt. cotton. In order to support small farmers, both the public & private sectors possess complementary assets needed for biotechnology to be applied to its full potential. Thus, in line with ADB's Private Sector Development Strategy (ADB, 2000), PPP programs are encouraged by the DBT, GOI in promoting biotech industry. The public sector research, particularly, ICAR-SAU system, has developed concepts, models, methods, designs and prototypes in the area of agricultural tools, implements and machinery (small scale). Further public research institutions also take up field testing of machinery and agronomic research for the use of machinery, implements and tools for various operations covering different crops and locations. Private sector has to upscale and commercialize these technologies which public system cannot handle and also do not have the mandate to do that.

Policy Recommendations and Needed Actions

- Agricultural research and educational institutions may continue the traditional methods of sharing information and knowledge. However, more focus should be on creating knowledge platforms, networking of institutions, and use of digital and electronic media, and opening up data base for sharing knowledge. Each institution must develop its website and special portals to provide research results, scientific findings, technology information, learning materials, data base, etc. which are open access.
- National Informatics Centre (NIC) is already implementing National Knowledge Network (NKN) since 2010 with GOI's support. The NKN should interconnect all institutions of higher learning and research in agriculture with a high speed data communication network to facilitate knowledge sharing and collaborative research.

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[13]According to private sector, often full information such as early maturity, grain quality etc. are not available for public sector hybrids leading to redoing some of the testing thereby adding to the cost of seeds.

- ICAR, SAUs and leading private companies engaged in agricultural development can promote global network connecting agricultural researchers, students and industries in a common platform to know and use research output, technologies and students connected to the researchers. The model to be followed is the research portal 'www.researchconnector.net' launched by Microsoft Research India jointly with ACM India. The portal provides the students a platform to connect with computer science faculty and researchers across the country. Agropedia promoted by seven institutions supported by ICAR is aright step in this direction. However, its impact can be assessed for further improvement and to replicate the model elsewhere if shows positive results.
- Special high end platforms are required for different purposes. For example huge amount of perishables go waste. A platform to support the supply chain for perishables will have good impact on empowering producers and consumers. One such example is Smart Knowledge Agriculture Corridor (SKAC) launched by India Center Foundation.
- Directorate of Knowledge Management in Agriculture (DKMA) of ICAR is a good example of knowledge platform for promoting agricultural education and development. One problem with this kind of institutional repository is underutilisation of such platforms. The repository must have exclusive sections for education, research, marketing agencies and agricultural produces. All the contents should be multilingual in a diversified country like India.
- Currently more than 25 leading websites are in place covering agricultural statistics, marketing, crop, livestock, poultry and fishery production technologies, weather data, export, commodity markets, etc. There are also network projects. The websites and networks suffer from lack of frequent updating, lack of user-friendliness, poor awareness about the sites, constricted access, missing focus, etc. For agriculture, commodity wise websites covering production and entire supply chain must be created and made open for use.
- **Future agricultural education programs (AEPs)** should not only focus on scalable and sustainable technology applications but should must be accommodative towards imparting all levels of education. They include: development of applications to enable and support flexible, modular and concept-based approaches for deeper learning and alternative learning pathways; creation of interactive content, tools and services to promote learning experiences that leverage the affordances of open and online educational resources.

- In offering agricultural education, Indian agricultural educational institutions may follow the approach of Massachusetts Institute of Technology. MIT has a number of current technology centered initiatives with the objectives such as developing capacities for next generation educational platforms and asset of tools and services to enable teachers and learners to navigate open education resources; designating and delivering robust teaching and learning environments and so on.
- The AEPs which address agricultural producers must have open courseware platforms so as it provide knowledge to all sections of the farmers. Since there are regional variations in agriculture, the agricultural universities, ICAR and CGIAR centres and input and processing companies located in the region can develop an open courseware platform for agricultural education relevant for that region.
- A higher education platform for Indian agricultural education may be thought of by select leading agricultural universities. The platform can target BOTH Bachelor's s and Master's course students. Lectures, seminars and practices would be provided by the faculties of cooperative universities. This would lead to quality education and the students can grow global mind for local issues. The teachers can visit different universities and give lectures to the multi-university students. Multi-media and video conference systems would be also introduced.
- All SAUs, Deemed Universities and other agricultural educational institutions have to be proactive and leverage developments in ICT and digital technology. E-learning may be introduced in all agricultural educational institutions as a new paradigm wherein students will have opportunities to learn round the clock. TNAU has been leader in E-learning. This model is easily adoptable by other universities The E-learning materials prepared under NAIP by select SAUs are not made available. ICAR has to speed up this process.
- Though various initiatives have been made, still a number of challenges exist in fully exploiting ICT and digital technologies. Some of the measures which can be contemplated are:
  - Designing and customizing open source technology for content delivery cutting down initial set up and maintenance costs
  - Training the team of faculty members and students (training of trainers) to ensure widespread adoption

- Assessing GAP of existing E-learning platforms in agricultural educational institutions and deployment of intuitive and customized user friendly learning interfaces of the learning management system
- Integrating and utilizing the best web resources from other leading institutions to kick start the program
- Providing faculty capacity building on cost effective and efficient technologies deployed for content creation and dissemination.
- Key challenges faced while implementing the project/ programme/initiative in the use of ICT and knowledge management system in SAUs and ICAR educational centers can be tackled as under:
- Ensure user readiness with requisite basic infrastructure - uninterrupted power supply, bandwidth, connectivity, maintenance and mitigation of UPS deployment, bandwidth upgrading, setting-up maintenance desks, bug tracking systems for online support
- Provide friendly access to delivery platforms by user communities; setting up computer cafes at campuses, campus wide Wi-Fi initiatives, encouraging students and faculty to own personal computing devices
- Improve computer skills among faculty through hands-on training for faculty on computer and digital information management basics
- Increase awareness of formal E-learning modules among targeted groups in agricultural educational institutions; sensitize targeted users by way of training sessions of E-learning platforms.
- Align learning objectives and content quality; set lesson plans with specific learning objectives that students can expect out of the course and setting quality standards for building content
- Other measures which agricultural educational institutions may contemplate:
- Training of educators: coping with rapidly changing education technologies
- Blended learning curriculum and supportive teaching tools to promote student engagement

- ♦ Progressive learning environment through connected classrooms enriching the experience of education
- ♦ Stemming education and tech assisted tools for student comprehension
- ♦ Alternative assessment strategies and innovative approaches in evaluation
- ♦ Keep looking for innovative learning practices in the 21st century technology challenges and digital insights

- ❖ On the delivery of knowledge to the farmers, KVKs are needed to be empowered with tools and technologies to improve their service delivery and self-improvement skills. Hence a mobile-based delivery platform and a Facebook-like knowledge-networking platform needed to be envisaged in the form of vKVK and KVK-Net.
- ❖ Distance education has to become techno-based and cyber based to cater to largeinformation needs efficiently. Qualified human resources, inadequate funds, doubts about quality of instructional programmes, poor incentives to hired faculty, poor interaction with students and quality of guidance and high dropout rate still remain. Use of computer and IT technologies will address these inherent problems effectively.
- ❖ The linkages across agricultural universities in India are weak. The existing ones are not effective. Similarly not all SAUs are having collaboration with foreign universities. ICAR must bring in liberal policies to encourage foreign linkages. TNAU-Cornell University dual degree program is a model worthy to emulate by other SAUs.
- ❖ Infosys: Own training facility; interface with the universities andcolleges wherein they influence the curriculum. Leading seed, fertilizer, sugar and milk processing companies can consider somewhat similar model as that of Infosys.
- ❖ Very little has been achieved in faculty and students exchanges. Many SAUs have conservative outlook in faculty and students exchange. They must acquire liberal approach to encourage student and faculty exchange. Financial crunch in SAUs is one of the major constraints reported in the promotion inter university exchanges.
- ❖ PPP could be an effective mechanism for attracting private sector investment into the Higher Education (HE) system without diluting the regulatory oversight of the government and other regulators. PPP will ease the budget constraint and expand the investment.
- ❖ PPP in agricultural R&D can be made successful by developing mutual confidence with clarly defined responsibilities and accountability of the partners.

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Valedictory Session

The Way Forward

Prof. Abhijit Sen (Member Planning Commission) was the Chief Guest. The Chair/Co-Chair of each Session presented the salient recommendations.

Prof. R.B. Singh, Chair of the Valedictory Session, read out the **Bhubaneswar Declaration** (page 1 to 3) and highlights of the **Roadmap to Transform Agricultural Education to Reshape India's Future** (Executive Summary given as Annexure I, Page 711 to 715) which, alongwith the recommendations of each Session, were unanimously adopted by the Congress.

Contributions of the local organizers of the Congress, Dr. D.P. Ray, Convener, Dr. K. Pradhan, Co-convener and their teams were appreciated. Prof. N.K. Singh, Secretary of the Academy proposed a vote of thanks.

Valedictory Address

Abhijit Sen

I am delighted to participate in this extremely important and timely Congress and to meet the thought leaders in the field of agricultural education from different parts of the world. I am grateful to the National Academy of Agricultural Sciences for inviting me to participate and to deliver the Valedictory Address. I congratulate the winners of the Students Elocution Contest, especially the First Prize Winner, Ms. Neha Rajawat who just made a brilliant presentation in this concluding session. My congratulations are also due to other awardees recognized at this Congress.

Based on the deliberations and presentations that I could attend, judging from the recommendations emerging from the various sessions, and keeping in mind the resolve expressed in the Bhubaneswar Declaration and the Roadmap presented in the Valedictory Session, I must say that this Congress has suggested sound pathways for transforming our agricultural education for reshaping India's future.

Agricultural production in the country has steadily been increasing and getting more insulated from the weather vagaries in the recent years, achieving record food production despite the overall rainfall being sub-optimal in three of the past five years. There is a turnaround in the agricultural growth rate, which may creep towards 4% during the next five years. The production and productivity gains must be largely attributed to the improved technologies and products developed by the scientific community. Therefore, we need not be too despondent about the state of art. Instead, we must rejoice our achievements, but realize that our struggle to free the country from hunger and poverty continues unabated and the scientists and development people must work together for solving the complex problems in agriculture.

Quality research, education and extension must be a part of the accelerated growth to keep it sustained. Our agricultural R&D must strengthen country's agricultural resilience to climate change, prevention of post-harvest losses, value addition and product quality, and empowerment of women in agriculture. It is encouraging to note that the public sector investment in agriculture during the 11th Plan had gone up by 47%. Unfortunately the states have not responded adequately. We must strive to invest about 1% of agricultural GDP in AREE4D. While the investments must further grow, agricultural scientists must be more interactive with allied disciplines, departments, Ministries and international systems. This will help rationalize the development process also in keeping in mind the needs of future generations and the global realities. It is gratifying that World Bank and other concerned international organizations are giving increased attention to agricultural development and agriculture-led alleviation of hunger and poverty in agriculture-dependent or agriculturally important countries, like India.

It is unfortunate that most of the budget allocated to the SAUs and several agricultural research institutes is spent on salaries and little is left for operational purposes. Therefore, there is a need to improve the quality of investment and the available funds must buy the maximum into the development process and for creation of public goods. The ICAR must play a leading role in developing the leadership which may enrich effective partnership among various stakeholders to optimize desired outcomes. The Council and other concerned agencies must implement the recommendations of this Congress.

Annexure I

Executive Summary

A Roadmap to Transform Agricultural Education to Reshape India's Future[1]

India's agriculture now faces new challenges. In addition to hunger and poverty being endemic and stubbornly high, India now has to rapidly become competitive in global markets. It has to not only contribute to India's growth but support its shift to a climate smart bio-based more knowledge-intensive green economy. India needs to rapidly innovate in its agriculture. India's agriculture has resiliently to improve its productivity by more than 4 per cent annually from the shrinking available arable land and water resources to meet its burgeoning food and nutritional needs and maintain food sovereignty to impact upon poverty, especially in rural areas. Thus agriculture has to be economically viable, globally competitive, socially equitable and environmentally sustainable.

The foundations of India's satisfactory growth in agricultural production from the mid-1960 are in its agricultural research, extension and education system. But, lately the education-research-extension synergy has loosened. By only partially adopting Land Grant University pattern of USA and not adapting it to Indian needs, and by ignoring basic sciences, humanities, languages, communication etc., the agricultural education system has somewhat alienated itself from mainstream higher education. Towards enriching the human capital and harnessing the demographic dividend, agricultural education in India has to provide the vital human capacities for research, extension and education as also for agriculture-related enterprises. The Indian higher agricultural education system also has a vital role

[1]Reproduceced from the NAAS publication entitled "A Roadmap to Transform Agricultural Education to Reshape India's Future", 2014.

as a backbone for research and extension which is more localized at State level.

Along with the need for more robust research and extension that in the past has contributed significantly to meet India's agricultural challenge and make it food sufficient, India's agricultural education also now needs to be simultaneously stimulated and improved to continue to contribute to act as a bulwark in meeting India's new challenges in agriculture, comprehensive food and nutritional security, rapid economic growth and geopolitical standing. It has to enable India participate in global markets through export of agricultural commodities and technology, support domestic and international agribusiness and develop new bio-based and knowledge-based enterprises including those for rural and agro-industrial services. In particular, judicious implementation of the recent Right to Food Bill, which stipulates food self-sufficiency based on home grown food, demands high quality human resources along the value-chain.

This Roadmap stems from the Declaration of XI Agricultural Science Congress held on February 7-9, 2013, at Bhubaneswar. The Congress had reiterated that agricultural education and agricultural research, education and extension for development (AREE4D) should be an integral component of the national agricultural policy to ensure adequate, consistent and predictable investments in agriculture, especially education, research and extension in creating a world-class agricultural university system attuned to face challenges and opportunities over short and long term.

India has more than 100 years of history in providing formal higher agricultural education. Indian higher agricultural education was restructured on the Land Grant University pattern of the USA and strengthened in the 1960s and has been fostered to grow since then. The widespread perception, borne by evidences and agreed at the Congress, underpins that Indian higher agricultural education in recent years is witnessing an erosion in its standards and ability to meet rapidly changing development needs of the country. The main reasons for the decline are reported as:

- ❖ Lack of financial and functional autonomy from Government;
- ❖ Declining investment and irregular funding with most Universities' revenue being utilized for establishment rather than in actual education and research;
- ❖ Inappropriate and obsolete tuition fee model;

- Poor governance and management; poor resource planning;
- Weakening of meritocracy; declining quality of students and faculty; lack of incentive mechanism for performance;
- Stagnant curricula, weak teaching-learning processes;
- Poor quality and weak implementation of accreditation norms;
- Widening disconnect among education, research and extension;
- Splitting of State Agricultural Universities without considering available capacities and resources;
- Depleted faculty strength and inadequate annual student enrolment;
- Inadequate hands-on skill/experience for the multiple disciplines within the profession;
- Neglect of women; especially rural women in agricultural education and skill development
- Lack of manpower in the frontier areas of science and technology;
- Poor contribution to agricultural and rural development policy and strategy formulation;
- Inbreeding where students are limited to one region and faculty who have graduated and done their post graduation from the same University where they teach;
- Inadequate and weak linkages with industry, corporate and private sector and their poor participation in agricultural education; and
- Isolation from international exposure.

The Roadmap provides direction to the path the country must now take to transform agricultural education to meet the challenges and opportunities of the fast-changing socio-economic, ecological and environmental scenarios. It aims to achieve the following objectives:

- Enhance knowledge and human resource capital, including rural women, in the field of food and agriculture, and agribusiness to enable Indian agriculture to be globally competitive in agricultural productivity and quality of its produce;
- Contribute and enable meeting challenges to agriculture, especially food and agriculture production and productivity, to eradicate hunger and undernutrition, to alleviate poverty, and to promote inclusive growth;
- Usher in a sustainable agriculture by increasing the productivity of arable land, soil, water, energy and labor, by conserving

biodiversity, and by arresting and reversing environmental degradation;

- Effectively utilize science, technology and innovation in agriculture by further linking education, research and extension to agricultural development and national progress;
- Strengthen international collaboration and through excellence contribute to global scientific and technological progress; and
- Provide direction to policy makers and planners to ensure quality investment in agricultural education to reshape India's future.

The above objectives based on perceptions of AREE4D managers, agricultural experts and University faculty are rather generic, but lay out the pathways for the various stakeholders to take effective actions. There clearly is a need for an in-depth analysis and review of agricultural education in the country that will verify the perceptions listed above and ascertain the perspectives of all stakeholders for this Roadmap's detailed implementation.

The Roadmap has a timeframe of 10 to 12 years. Its implementation should be done in two overlapping phases and synchronized with India's Five Year Plans and annual economic planning processes and leveraging the simultaneous investments being made in agricultural research, education and extension at the Central and State levels. There is a need for close synchronization between the Union and States as agriculture is a States' subject.

The Phase 1 principal actions within 5-6 years should focus on:

1. Improving governance of Indian Agricultural Education System especially at the University and college levels through mandatory accreditation and linking incentives with performance;
2. Increasing, improving and appropriately targeting investments in higher agricultural education, as also in higher secondary education, vocational training and community learning;
3. Revising curricula at UG/PG levels to meet the new needs now required for agriculture and entrepreneurship and for attracting and retaining youth in agriculture; and
4. Improving capacity in human resources, infrastructure, and connectivity with the communities it ultimately serves, particularly researchers, extensionists and farmers, and if need be, through consolidation of existing institutions and capacities, with due consideration of women in agriculture.

The principal Phase 2 actions within 7-12 years that will continue those started in the Phase 1 are in:

6. Broad-basing the scope of agricultural education, with due emphasis on basic and managerial sciences, so that the young professionals acquire scientific temperament and receive societal recognition and remuneration;
7. Ensuring continuing growth and improvements in quality of education and learning in the entire agricultural education system in a sustainable manner and with autonomy and flexibility;
8. Linking agricultural education institutions to the emerging bio-based green economy and enterprise; and
9. Providing "home" to new and emerging scientific ideas and concepts, and achieving academic and scientific excellence that is recognized globally and relevant locally.

President NAAS Prof. R.B. Singh presenting NAAS memento to Dr. D.P. Ray, Convener

President NAAS Prof. R.B. Singh presenting NAAS memento to Dr. K. Pradhan, Co-Convener

Opening of the Exhibition by Hon'ble Minister Sj. Debi Prasad Mishra

Prof. Abhijit Sen giving certificate to winners of Poster Presentation

A glimpse of cultural richness of Odhisha

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