INCENTIVES & REWARDS TO INNOVATION IN A RAPIDLY CHANGING GLOBAL ENVIRONMENT

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Filley-Garey Lecture

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Outline of Presentation

- Part 1--4th Industrial Revolution and its implications?
- Part 2--India's Policy of Doubling Farmer Incomes Under Climate Change
    - India's recent agricultural performance and Implications for DFI
    - Comparing India with East and South East Asia
    - Need for a transformational change --holistic ADAPTIVE, LEARNING approach-- to agricultural management, strategy formulation and implementation involving key stakeholders at multiple levels wrestling over a long period.
- Part 3--Deploying 4th Industrial Revolution to Agricultural and Overall Challenges

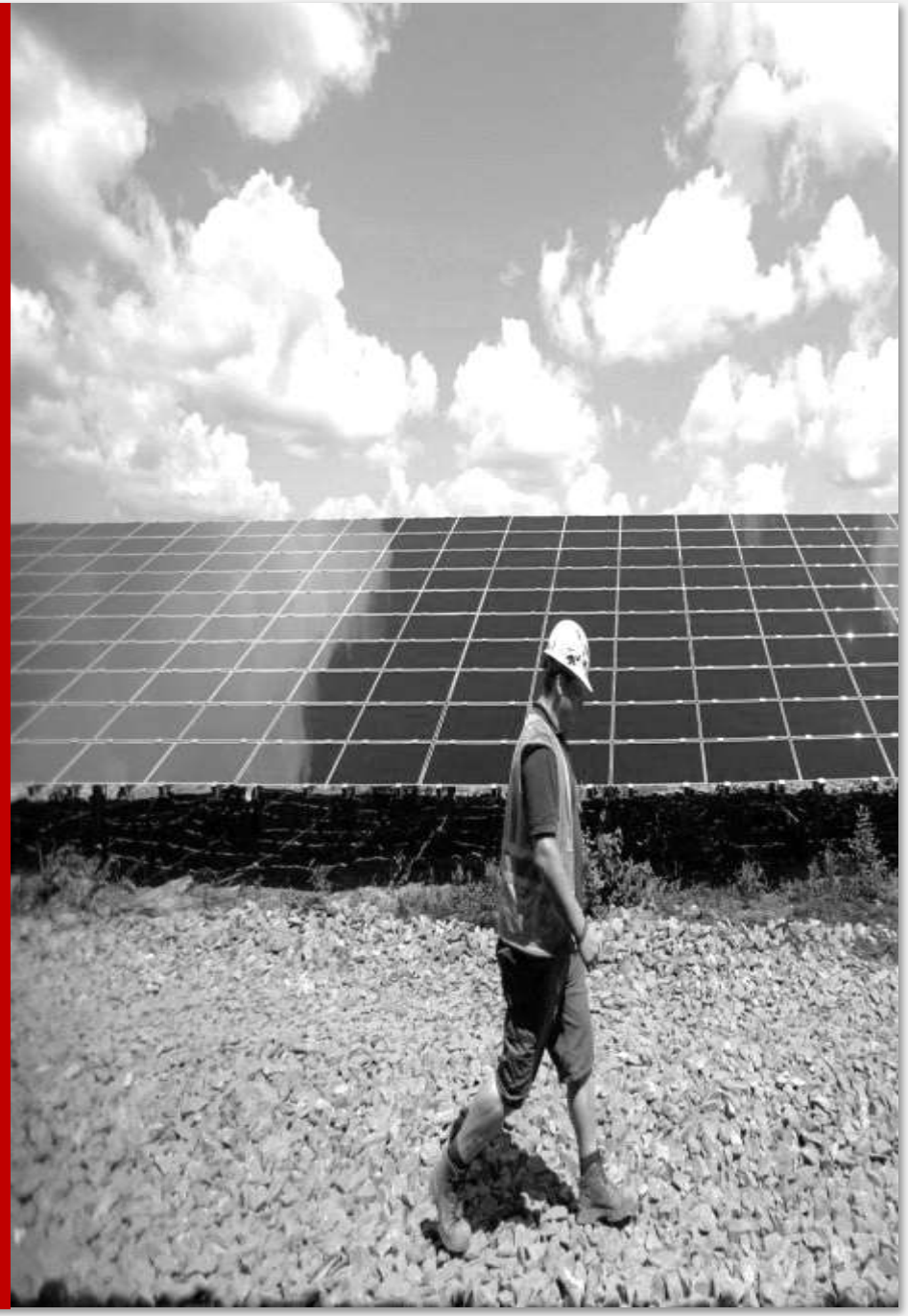
Part 1

4th Industrial Revolution and its implications?

What is Innovation?

- Innovation system as 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" (World Bank, 2008).*

"Agricultural innovation is the process whereby individuals or organizations bring ***existing*** *or new products, processes and forms of organization into* ***social and*** *economic use to increase effectiveness, competitiveness,* ***resilience to shocks or environmental sustainability, thereby contributing to achieve food and nutrition security, economic development and sustainable natural resource management****" (FAO, 2012).*



Scale, scope, and complexity of the 4th Industrial Revolution

- Fourth Industrial Revolution: Time of extraordinary change in every individual, business, industry and government being impacted by breakthroughs in computing power, connectivity, artificial intelligence (AI), biotechnology and other innovative technologies, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, materials science, energy storage, and quantum computing

- A fusion of technologies blurring the lines between the physical, digital, and biological spheres.

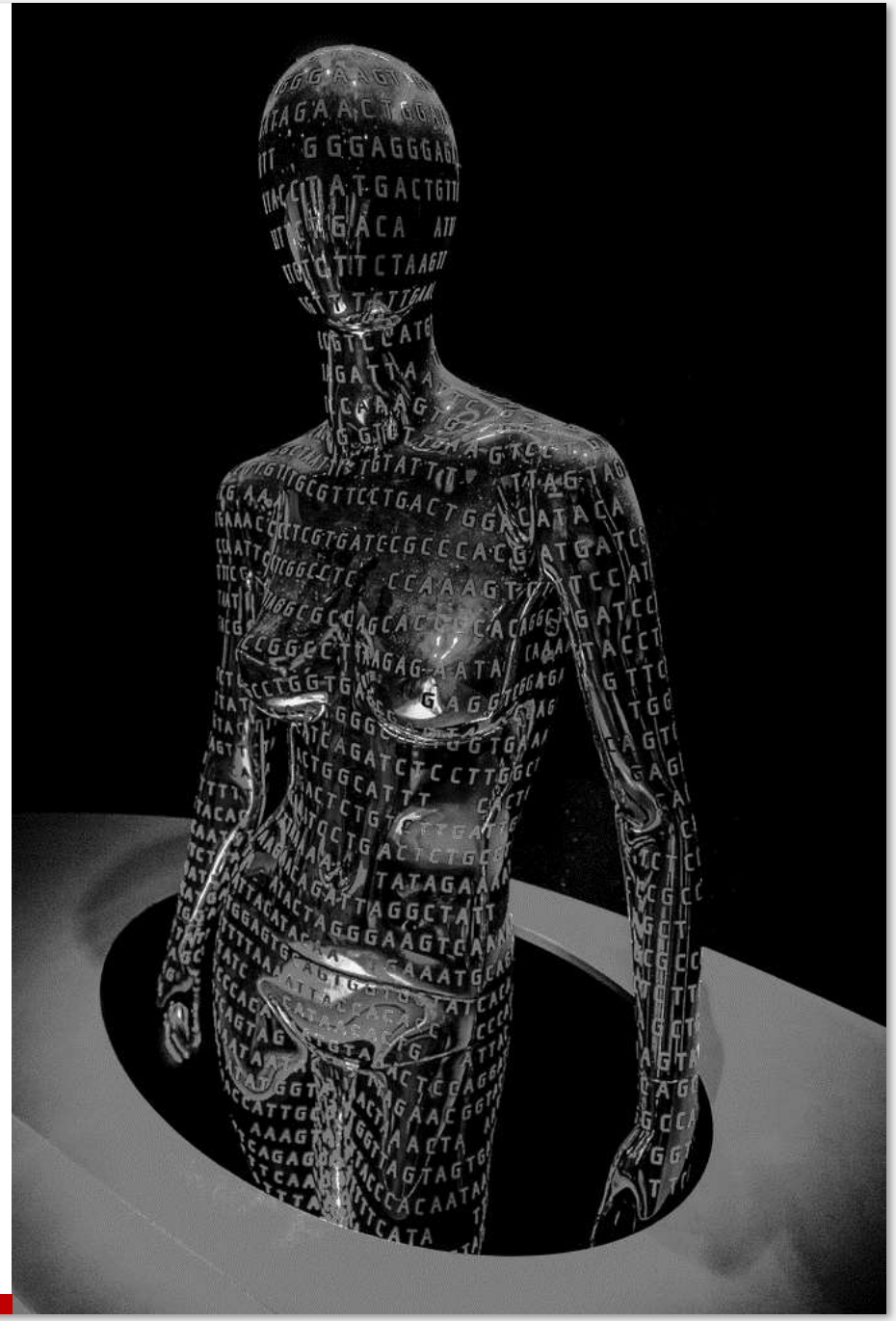
- 4th Revolution has no boundaries and high velocity.

Just in case some of you do not remember!

- First Industrial Revolution: water and steam power to mechanize production.
- Second Industrial Revolution: used electric power to create mass production.
- Third Industrial Revolution: electronics and information technology to automate production

Rapid Pace of change

- By 2020, more people with mobile phones than electricity or running water in their homes or villages.
- Cars as intelligent robots on wheels.
- Factories are automating manufacturing, displacing tens of thousands of workers.
- Call centers are turning to AI-powered catboats to manage customer interactions.
- We have already outsourced a lot of work to algorithms – managing financial portfolios, qualifying loan applications, reading MRIs, recommending products and optimizing travel routes.
- The human genome has become as readable and editable as a text document, transforming precision medicine.



Opportunities

- New products and services
- that increase
  - (1) inclusiveness, e.g. by increasing access to information,
  - (2) efficiency and
  - (3) improve our personal lives. (e.g., Ordering a cab, booking a flight, buying a product, making a payment, listening to music, watching a film, or playing a game—any of these can now be done remotely).

- **Technological innovation** leads to supply-side miracles, with long-term gains in efficiency and productivity, e.g. Amazon.
- Declining transportation and communication costs, more effective logistics and global supply chains and declining trade costs leading to open new markets and drive economic growth.
- Increased worker safety

But Challenges…. Structural Unemployment, Increased Inequality, Social Unrest

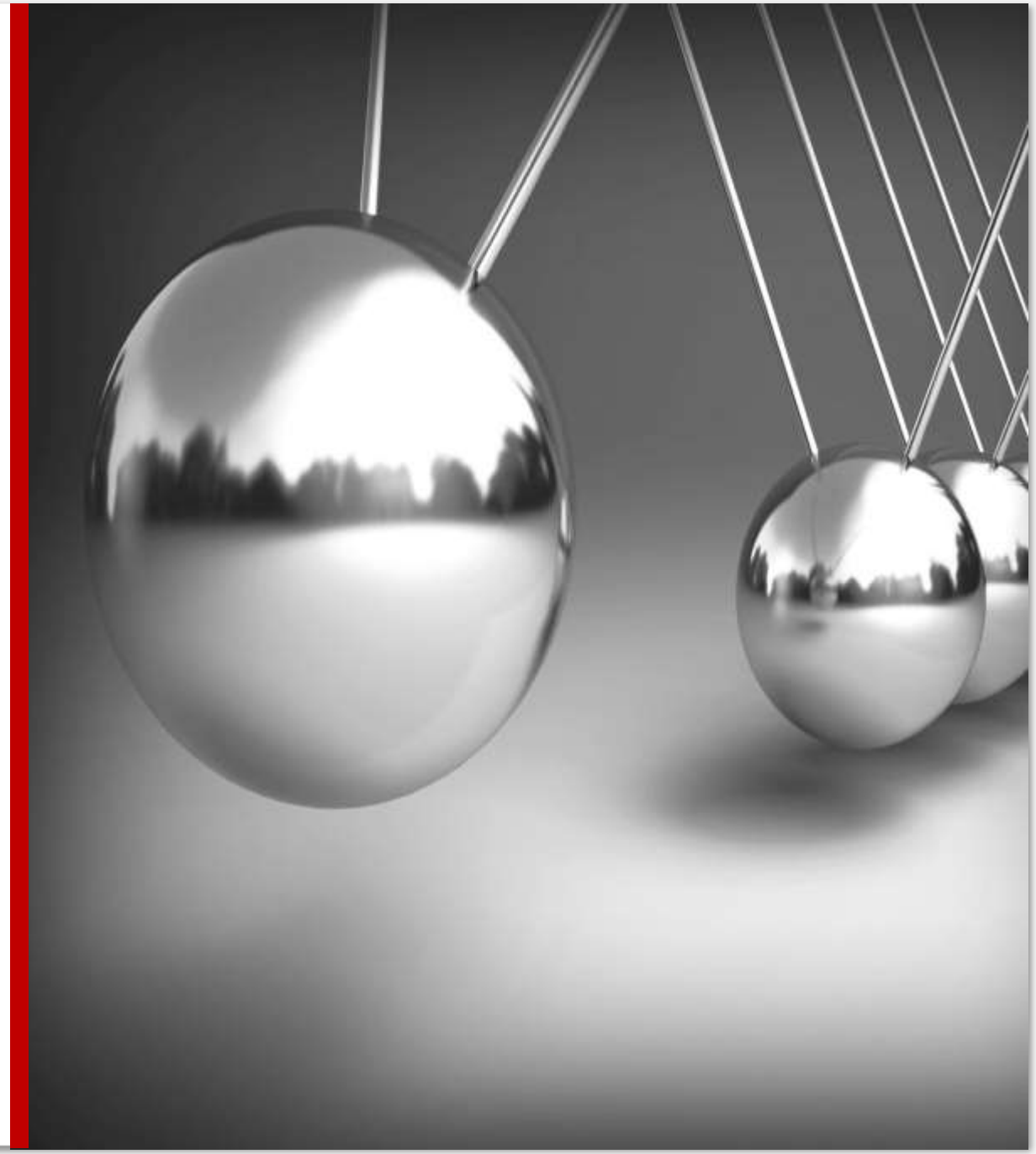
- Link between average productivity growth and income has changed
- Valuation have not turned into MORE productive jobs for all
  - Global Supply chains disrupting labor markets.
  - Automation substituting for labor across the entire economy, the net displacement of workers by machines exacerbating the gap between returns to capital and returns to labor.
  - Social concerns of lack of inclusion—
  - Hollowing out of the middle class
  - Terrorist networks
  - BREXIT and US Elections, rise of populism
  - French Election could end EU?
  - Governance and conflict are growing challenges.

Impacts on government

- Governments increasingly under pressure to change their current approach to public engagement and policymaking,
    - New sources of competition and
    - Redistribution and decentralization of power that new technologies make possible;
    - **Consumer interests vs. innovation—e.g. GM Technologies**
    - Increased surveillance
    - Freeing of private information to businesses
    - Terrorism
- Public Policy--
- **Legislative and regulatory challenges of an unprecedented degree**

IMPACTS

- **On Supply Side-**-Disruption from agile, innovative competitors who,(thanks to access to global digital platforms for research, development, marketing, sales, and distribution), can oust well-established incumbents faster than ever by improving the quality, speed, or price at which value is delivered.
- **On consumer behavior**----from the design, market, and deliver products and services.
- **On customer expectations**, on product enhancement, on collaborative innovation, and on organizational forms
- **Overall**, the Fourth Industrial Revolution is forcing companies to reexamine the way they do business
- Big Data Improving Manufacturing Processes



Effects innovations have on societies and environment as a whole

- Increased Demand for skills-
  - 500,000 engineers but 50,000 engineers trained
- Need for policy and governance frameworks for adopting new technologies in ways that have a positive and inclusive impact
- Set of priorities, ranging from autonomous vehicles and precision medicine to the Internet of things and block chain.
- All the priorities are interconnected;
- Role of businesses, civil society, universities

Are Democratic Institutions Up to the Task?

- Political paralysis?
- Make Existing workers smarter/more productive
- Manufacturing is not coming back?
- Need for new institutional design—state needs to become an arm of investments—e.g. public investments in infrastructure, skills
- Art of living
- Role back of Globalization?

Part 2

India's Policy of Doubling Farmer Incomes Under Climate Change

Viewing Asian Agricultural Transformation from the Perspective of the 4th Revolution

- Doubling Farmer Incomes Under Climate Change While Achieving Structural Transformation
- 880 Million Engaged in Agriculture Just in Five countries
- 720 Million Engaged in Non-Agriculture in 2013

Indian Prime Minister's Policy Proclamation to Double Farmers' Income by 2022

(during a 'Kisan Rally' in Bareilly, U.P. on Feb 28, 2016)

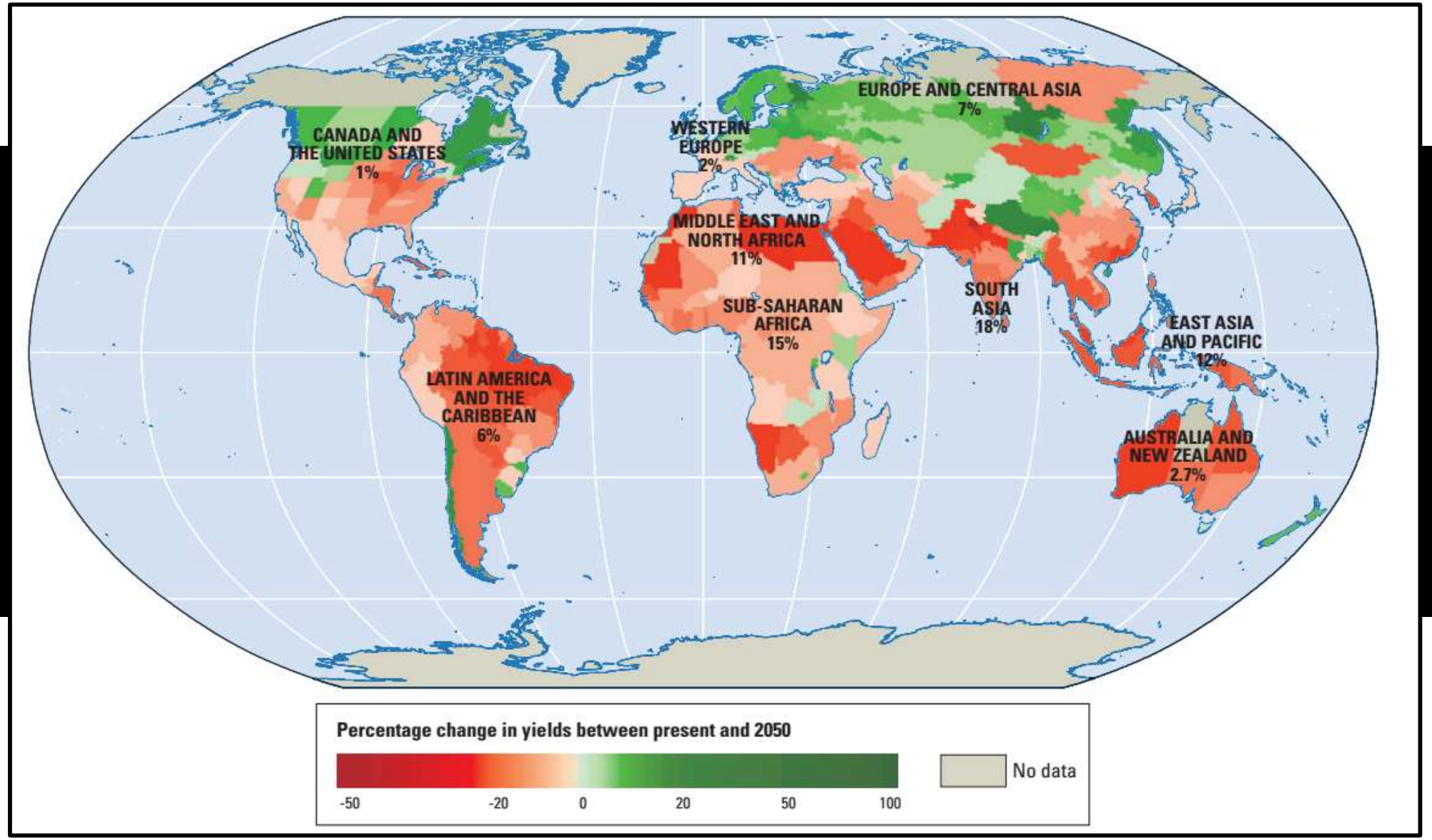
Debate: Is It Possible or a "Miracle of All Miracles"?

Determinants of Farmer Income

- **Farm Income** = f [Output x prices – cost of production]
  - **Annual Output per Farm Household** determined by: (1) yields per unit of land per crop; (2) double or triple cropping per unit of land; (3) shift from low to higher value crops; and (4) income from livestock and fisheries.
  - **Farm Size** = f [Share of population in agriculture, land distribution, land laws, customary practices, access to hire in or out more land and other factors of production].
  - **Prices** determined either by Government Minimum Announced Procurement prices (MSPs) for scheduled crops or Market Prices for crops, livestock, and fisheries, for which there are no declared scheduled prices and market access.
  - **Cost of Production** determined by Input Costs (including Input Subsidies).
- **Non-Farm Income** = f [(Non-Farm Employment and wages) + (Entrepreneurial income from trade) + (Transfer Payments/Social Safety nets such as Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) – Debt)]
- **Dynamics of Change**—from technical change, market access, land consolidation, labor migration, non-farm income.

Projected Impacts of Climate Change on Agricultural Yields by 2050

(given current agricultural practices and crop varieties)



Climate Change Calls for Business "Unusual" to Reduce Impacts on Poverty

Impacts of CC on Agriculture

Extreme Climate Variability beyond Average Attributable to Natural Causes

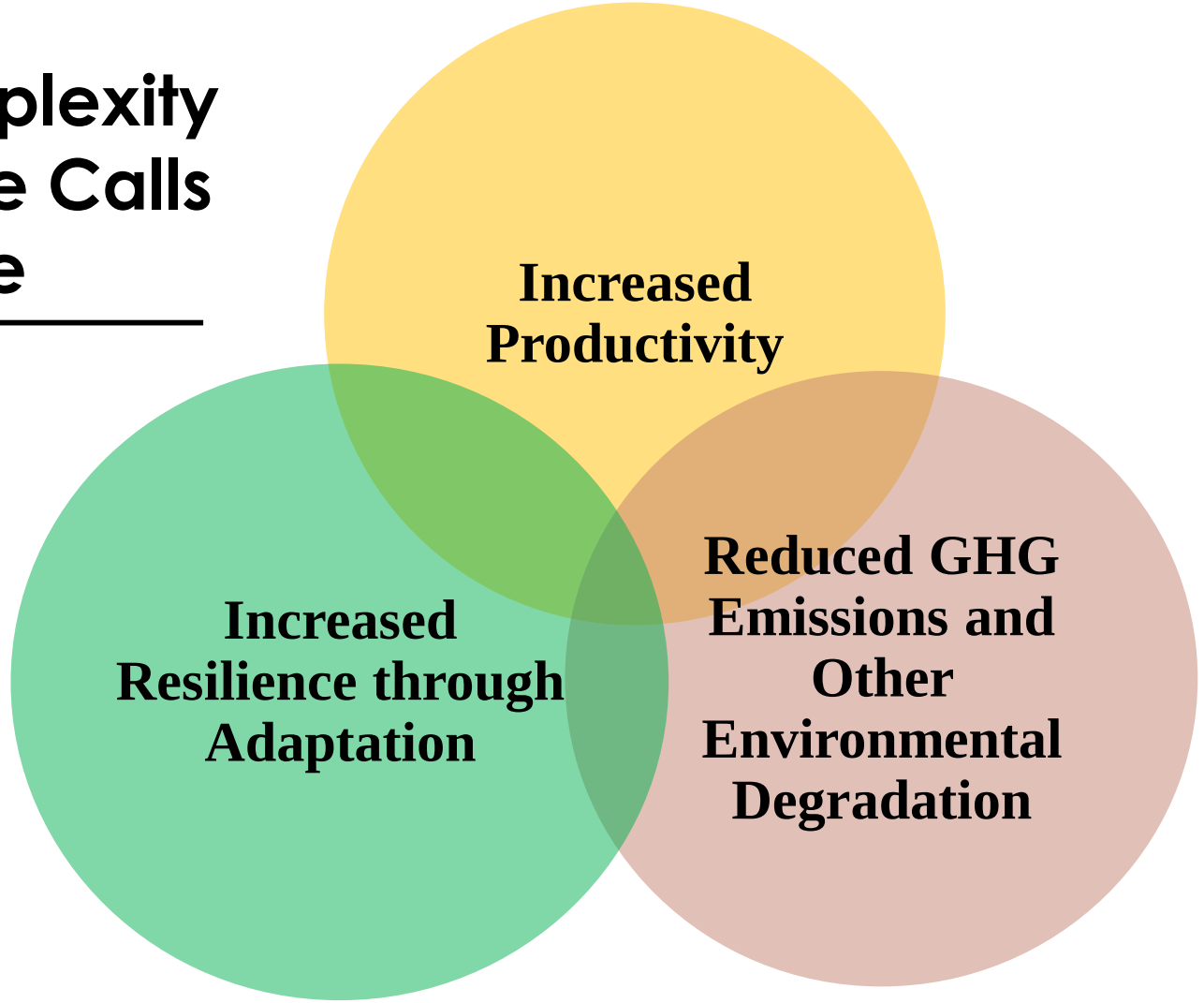
1. Rising temperatures
2. Increasing temperature variability
3. Changes in levels of precipitation
4. Melting of Glaciers
5. Rising Sea levels, salinization of fresh water
6. Droughts and floods/water stress
7. Loss of coastal areas
8. Areas out of farming Desertification
9. Increased Pastes and Diseases
10. Forest fires
11. Lower Yields, fish stocks and animals
12. Increased food insecurity
13. Environmental refugees

Impacts of Agriculture on Climate Change

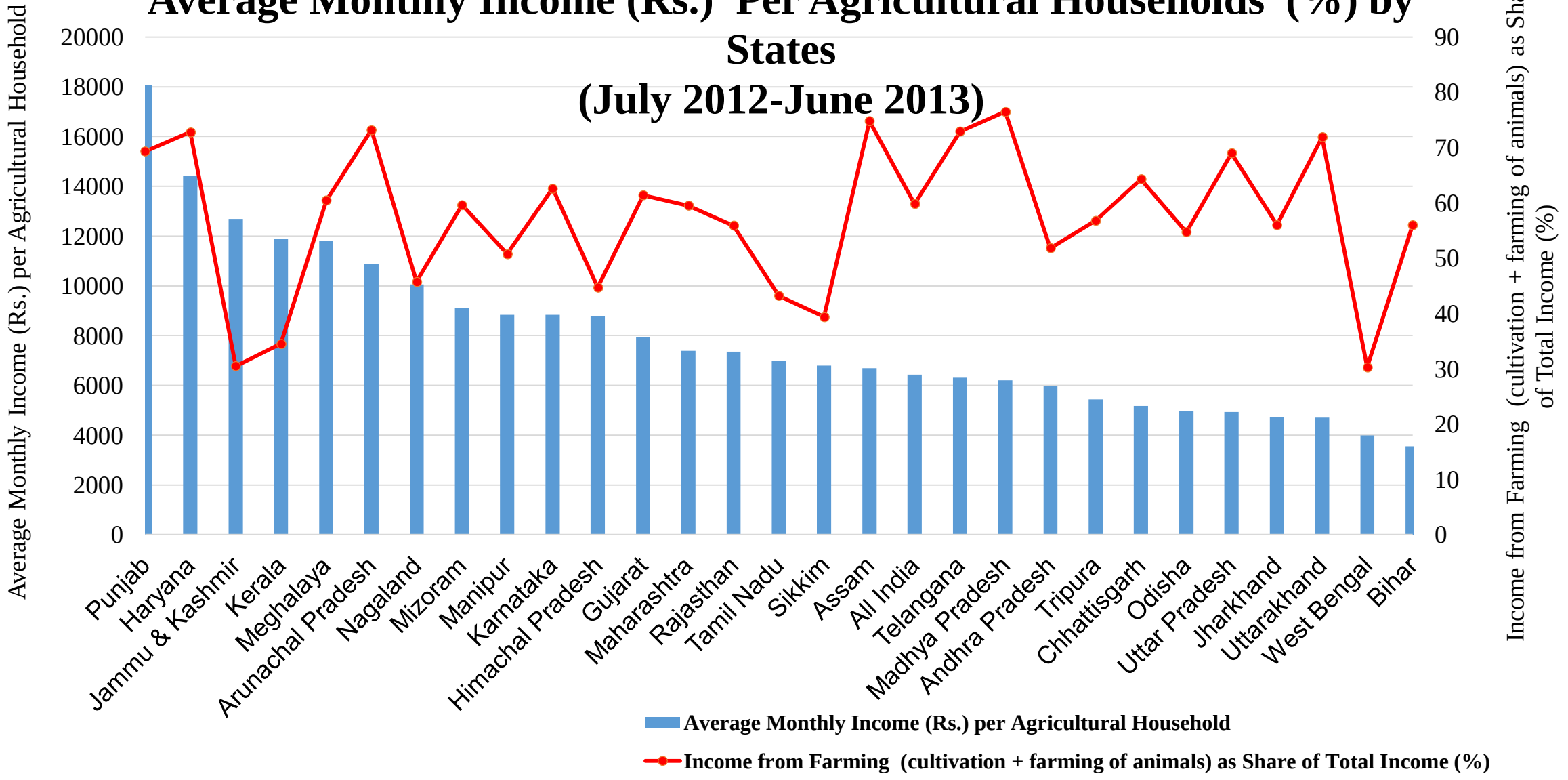
- Annual anthropogenic GHG emissions (CO2, Methane and Nitrous Oxide)
- Land Use Changes
  - Deforestation and forest degradation

- Agriculture
  - Rice----------Methane Production
  - Livestock-----Methane Production
  - Fertilizer use

Climate Change Adds Complexity to Doubling Farmers' Income Calls for Climate Smart Agriculture

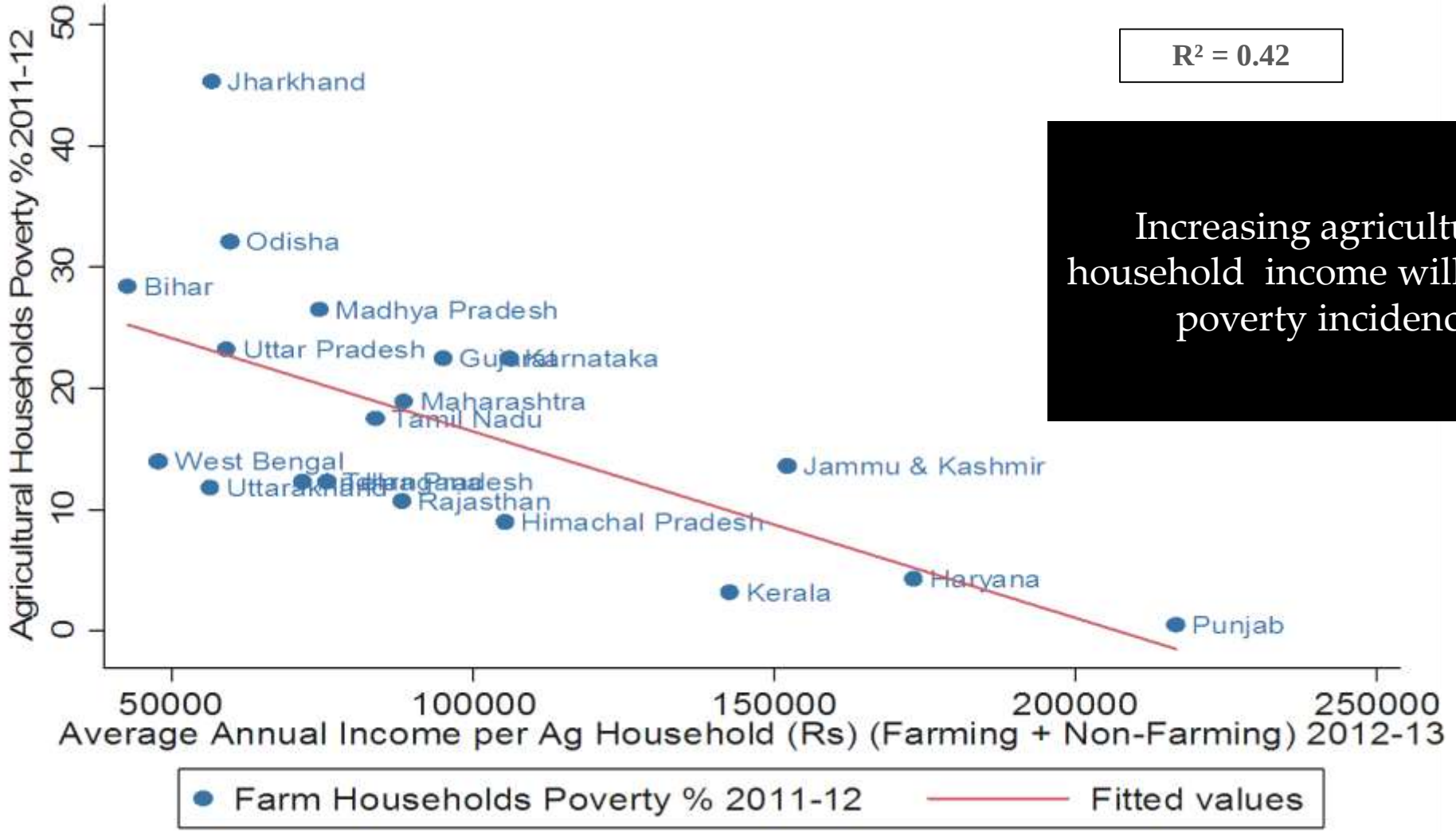


Share of Farming Income (cultivation + farming of animals) in Average Monthly Income (Rs.) Per Agricultural Households (%) by States (July 2012-June 2013)



Source: Based on data from National Sample Survey Organisation (2014): Key Indicators of Situation of Agricultural Households in India, Ministry of Statistics and Programme Implementation, NSSO.

Agricultural Poverty Incidence Is Inversely Related to Average Annual Income per Agricultural Household (Rs)



$R^2 = 0.42$

Increasing agricultural household income will reduce poverty incidence

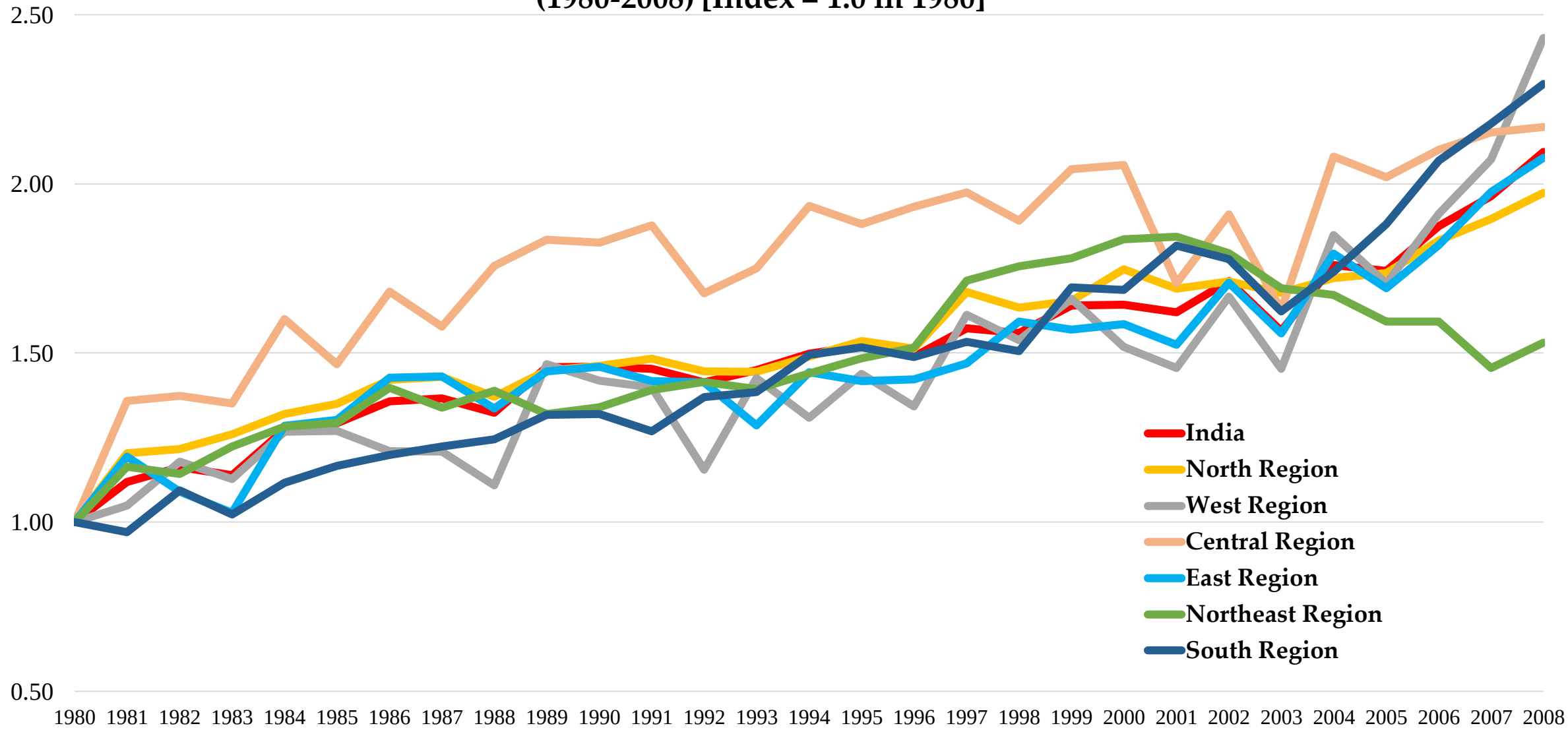
Recent Sources of Growth in Indian Agriculture

1. Yields per ha have grown slowly
2. Intensification of agriculture has come from

    a. Irrigation
    b. Some Shift to higher value crops—output growth away from the northern "grain belt" and toward high-value agriculture in traditionally less-productive regions. E.g. geographical and intensity shifts in Central Region.
    c. But nationally most of the increase in farmer income has been due to price increases since 2004
    d. Yet farm Real Income has stagnated despite subsidies and transfer incomes
    e. Inter-state income differences are considerable and also incidence of poverty with no evidence of convergence?
    f. Difference between farm and non-farm income has increased substantially particularly since 2004

Source: Ramesh Chand 2016, World Bank 2014, Nicholas Rada 2016

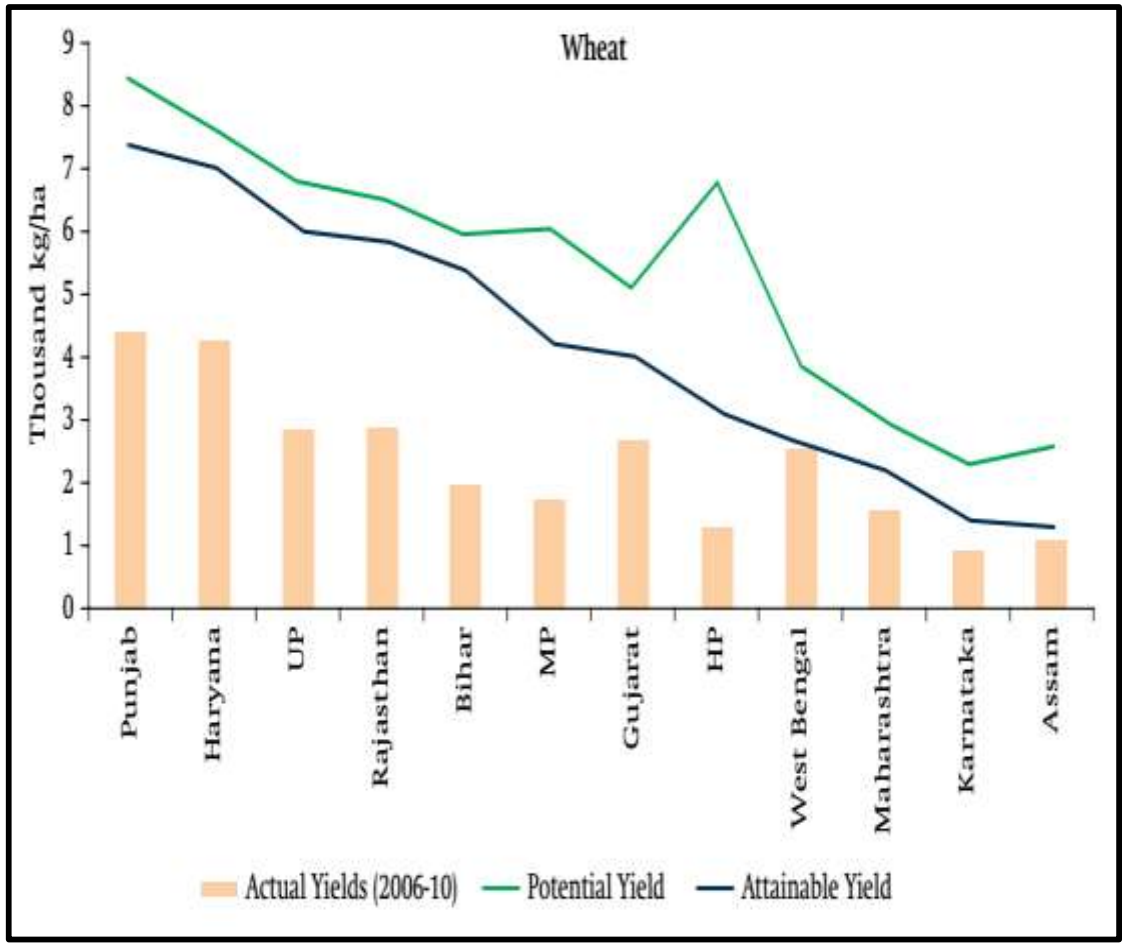
Gaps among India's National and Regional Total Factor Productivity Growth (1980-2008) [Index = 1.0 in 1980]



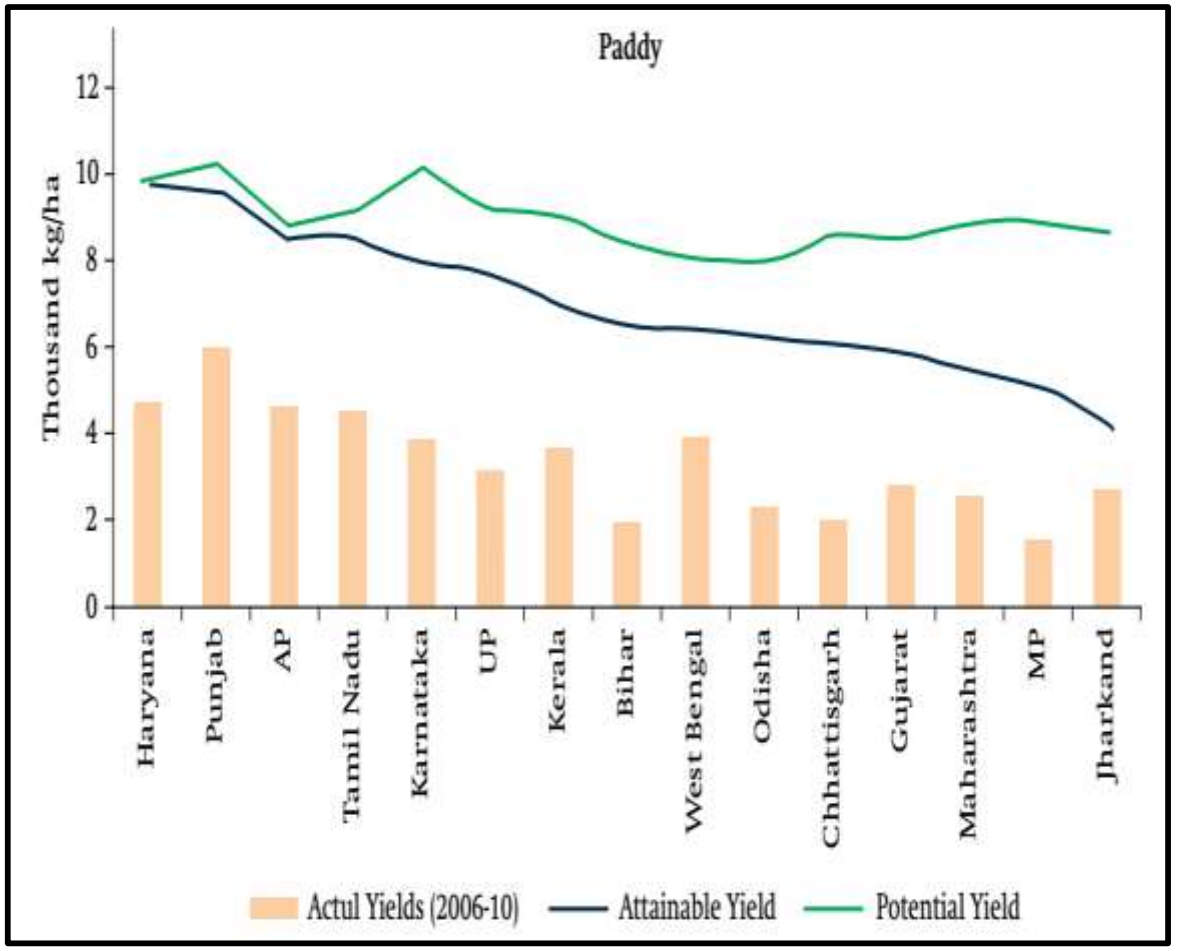
Source: Rada, N. (2016). "India's Post-Green-Revolution Agricultural Performance: What is Driving Growth?" Agricultural Economics (47) 3: 341-350.

Simulated potential yields (assuming no constraints to inputs), attainable yields (given the current level of irrigation), and actual yields (average of 2006–10)]

Current Yield Gaps for Wheat by State

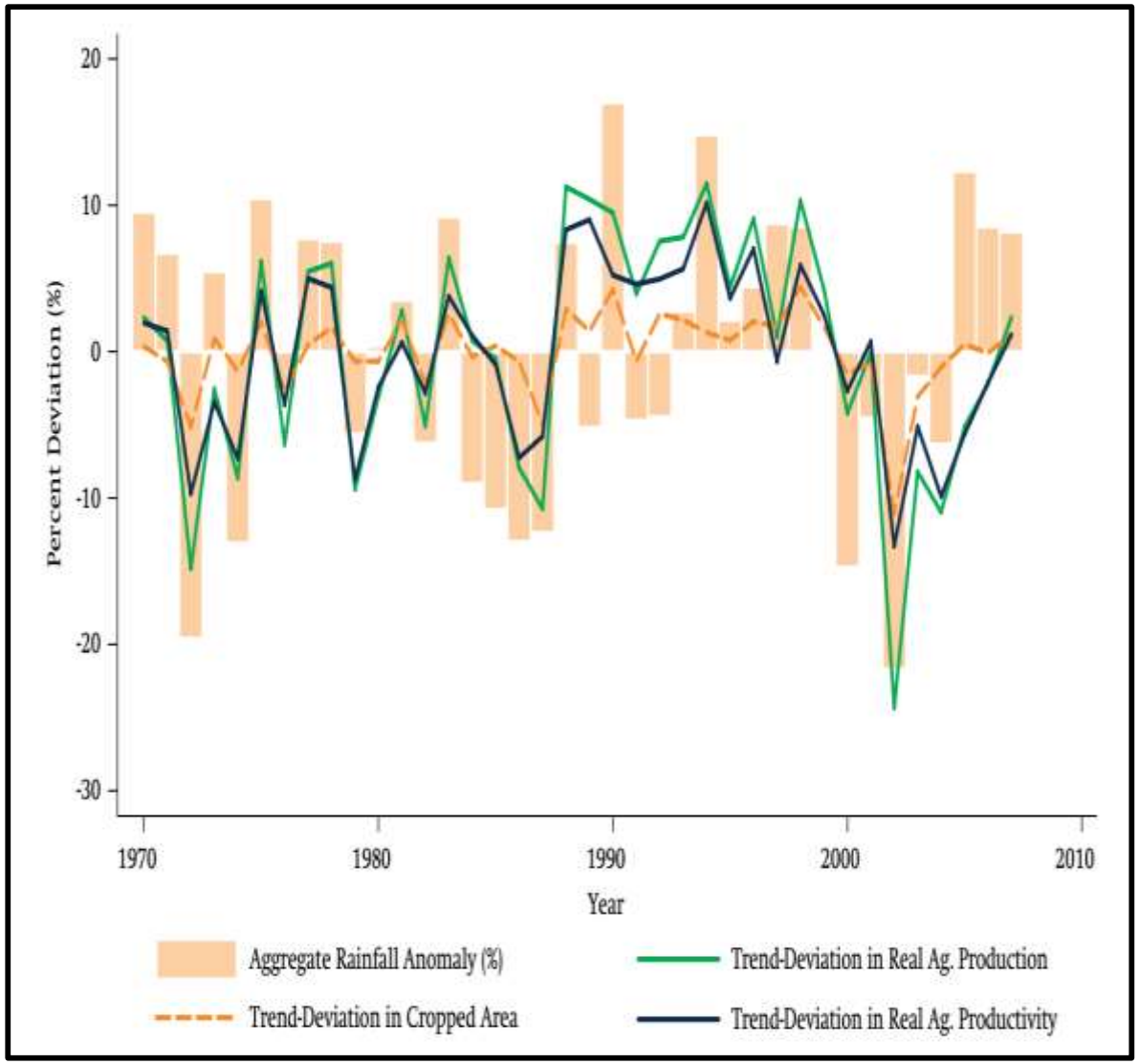


Current Yield Gaps for Paddy/Rice by State

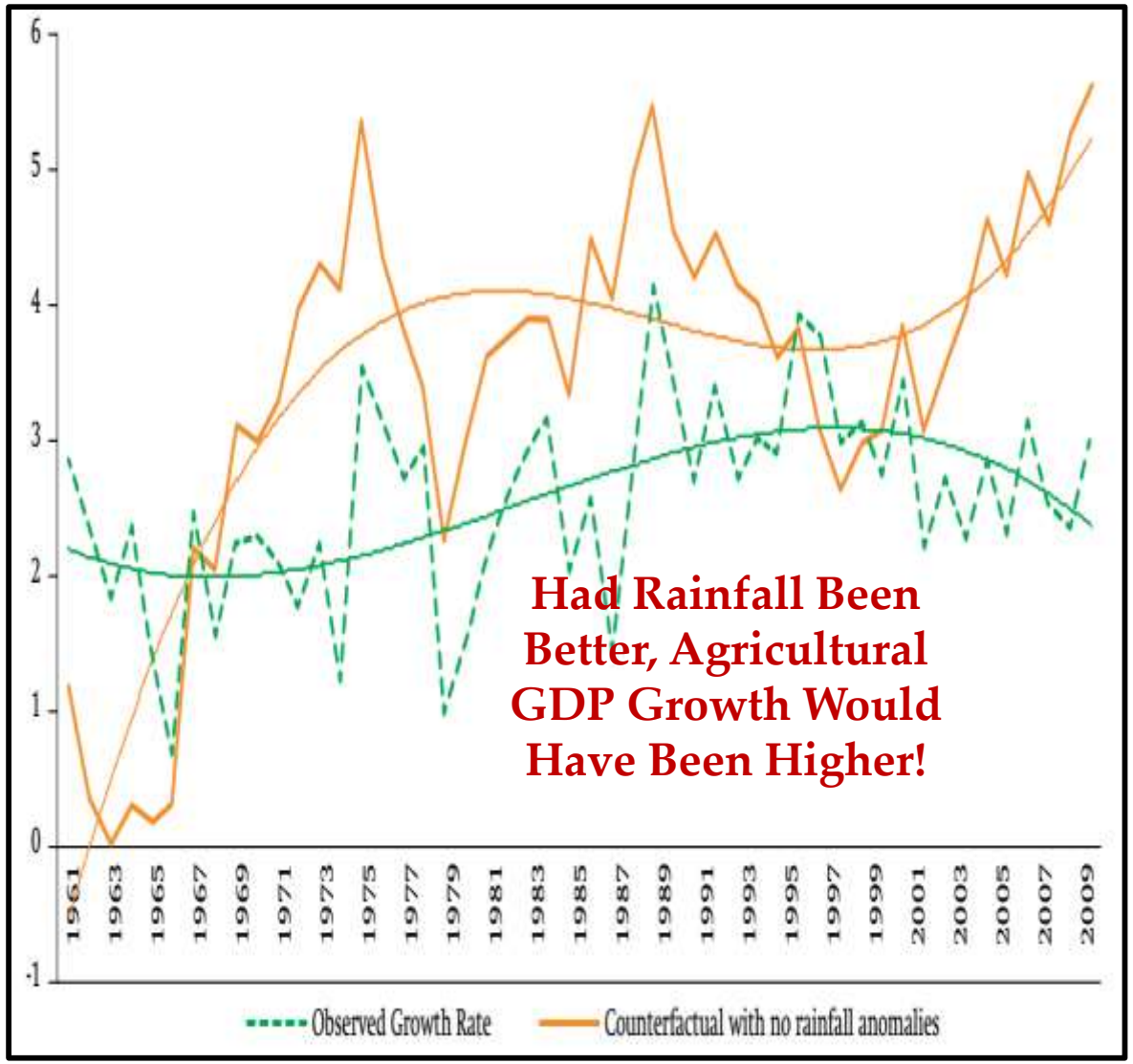


Source: WBG (2014). Republic of India Accelerating Agricultural Productivity Growth.

India: Strong Correlation between Agricultural Productivity and Rainfall

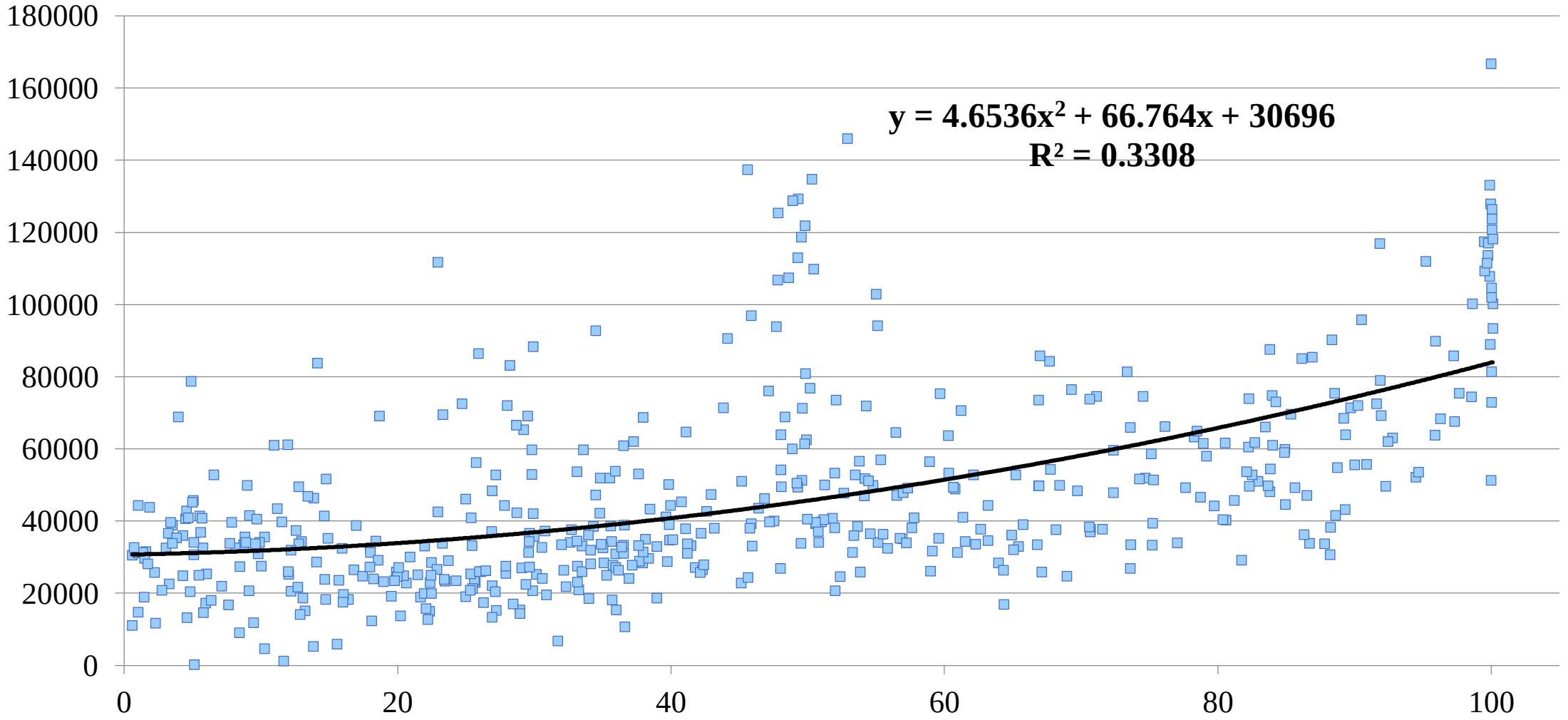


Ten-Year Average Agricultural GDP Growth Rates (actual and counterfactual scenarios)



Source: Kshirsagar and Gautam 2013.

Aggregate Crop Productivity is Boosted by Irrigation
But Irrigation Efficiency Varies a Great Deal
And Growing Challenge of Excessive Groundwater Exploitation



Data provided by Ramesh Chand and Chand (2016): Doubling Farmer's Income: Strategy and Prospects. Presidential Address

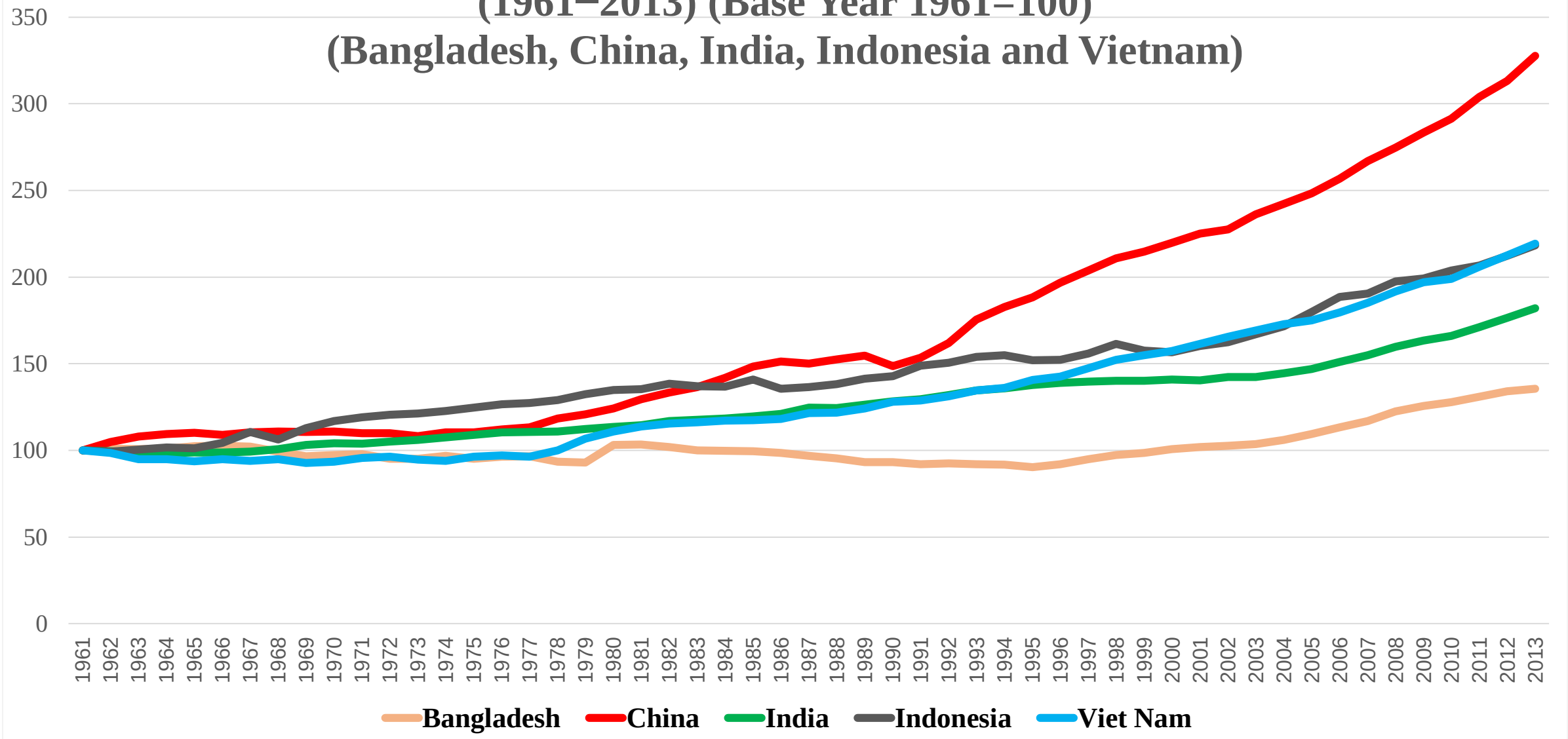
Experience of East and South East Asian Countries

- East and South-East Asia: where
  - ✧ Faster TFP Growth
  - ✧ More Rapid Reduction in Rural Poverty
  - ✧ Greater Intensification of Agriculture
  - ✧ More Increase in Farm Income
  - ✧ More Favorable Internal Terms of Trade
  - ✧ Sharper Drop in Share of Population in Agriculture
  - ✧ BUT Increased Rural Urban Inequalities!
  - ✧ Increased Stress on Resources?

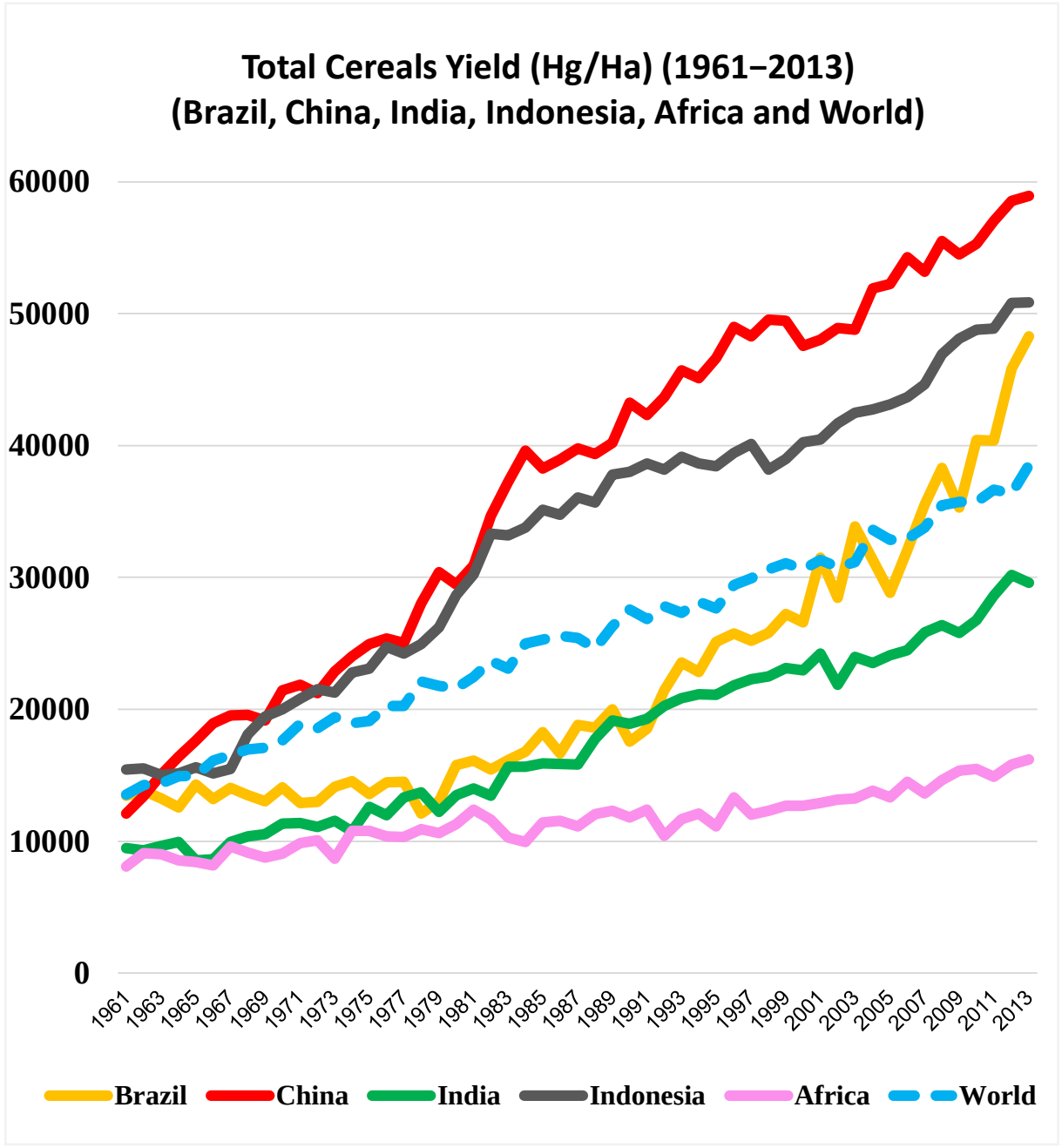
- Climate Change calls for a holistic transformative approach to agriculture
- Current Indian Approach--- too little and too fragmented
- India Needs Transport, power, R and D, education, security of tenure, access to agricultural finance,

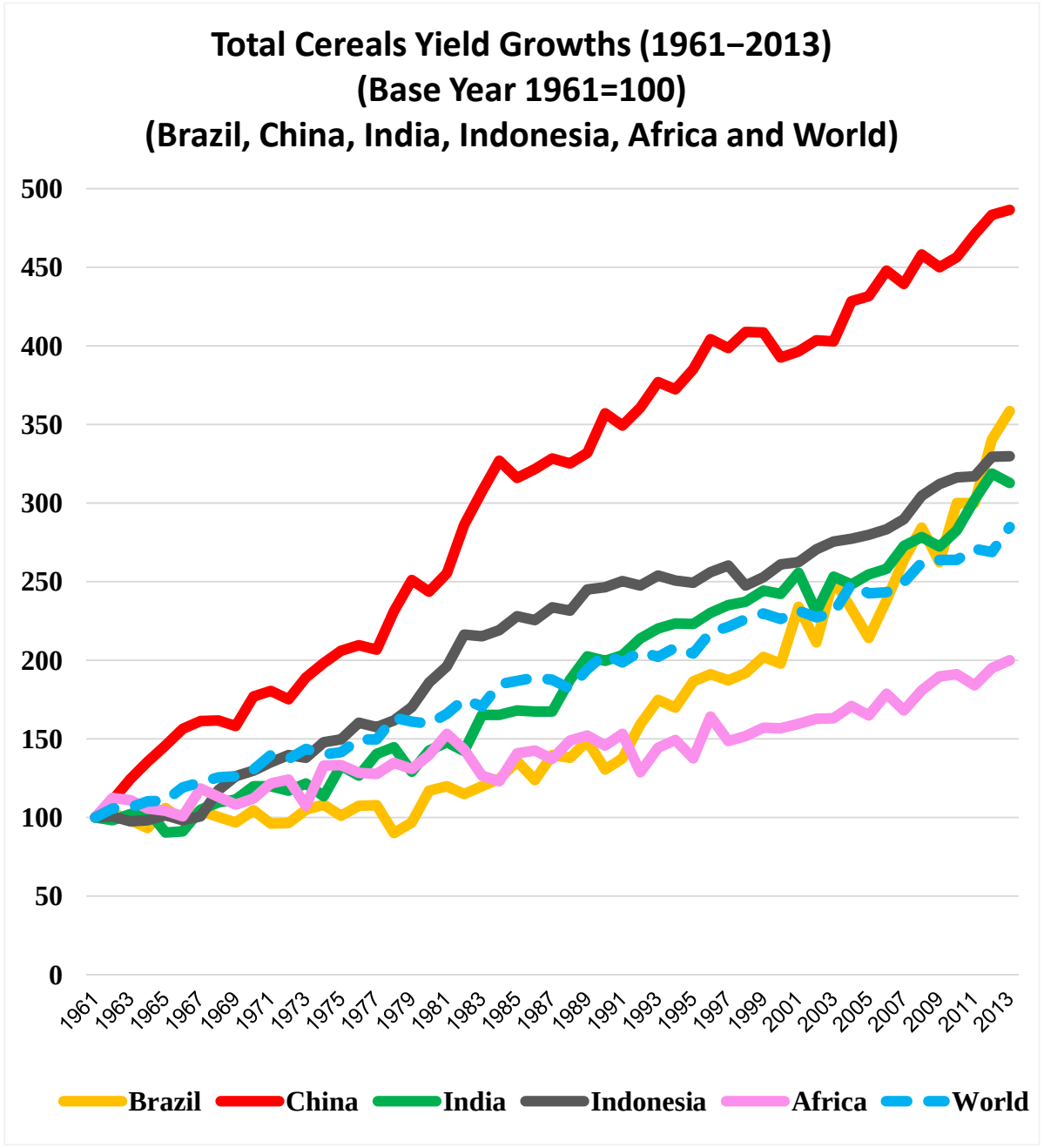
- Huge under-investment in agriculture and rural sector relative to countries but NO SILVER BULLETS!

Agricultural Total Factor Productivity (TFP) Index Growth (1961–2013) (Base Year 1961=100) (Bangladesh, China, India, Indonesia and Vietnam)

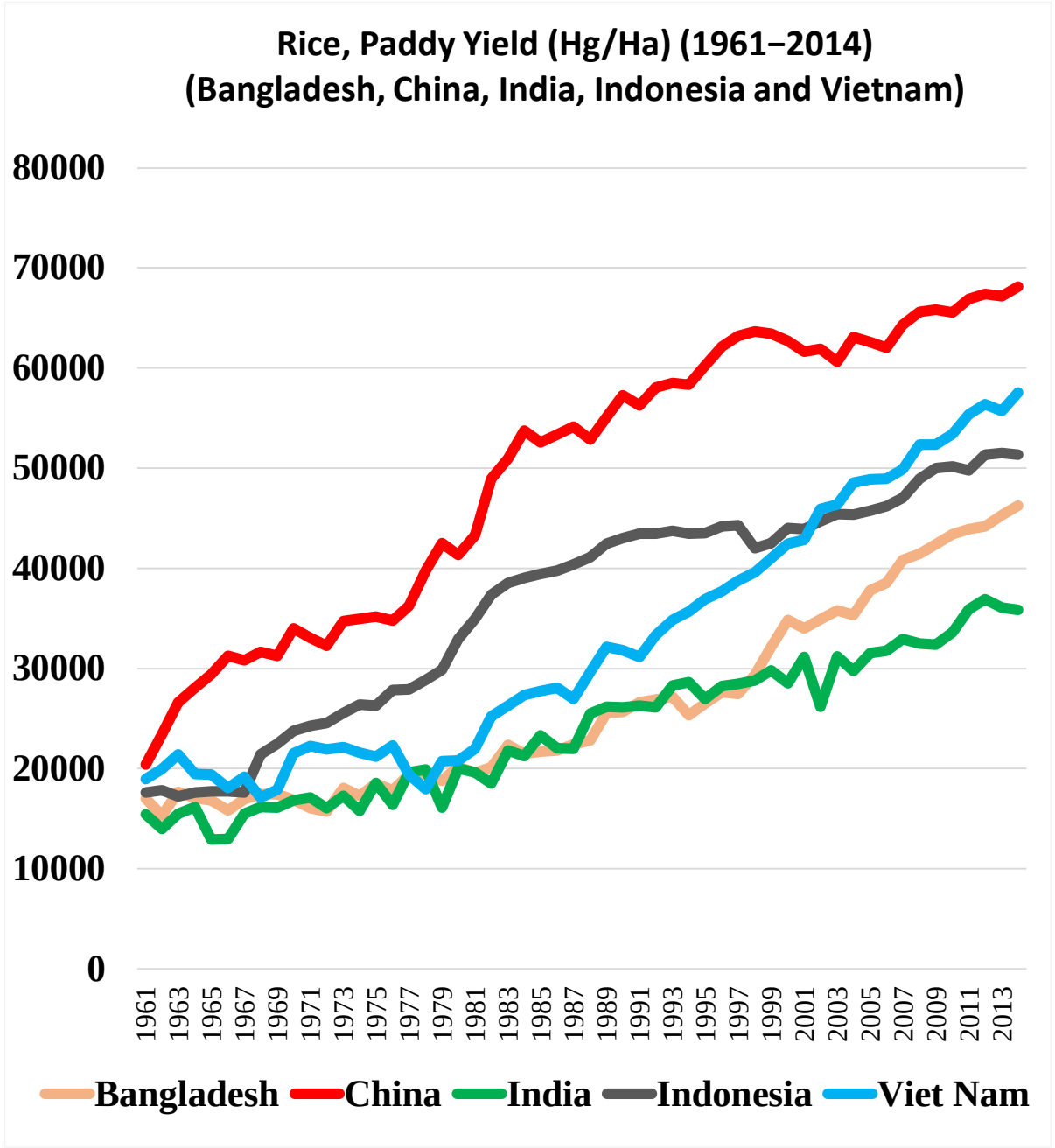


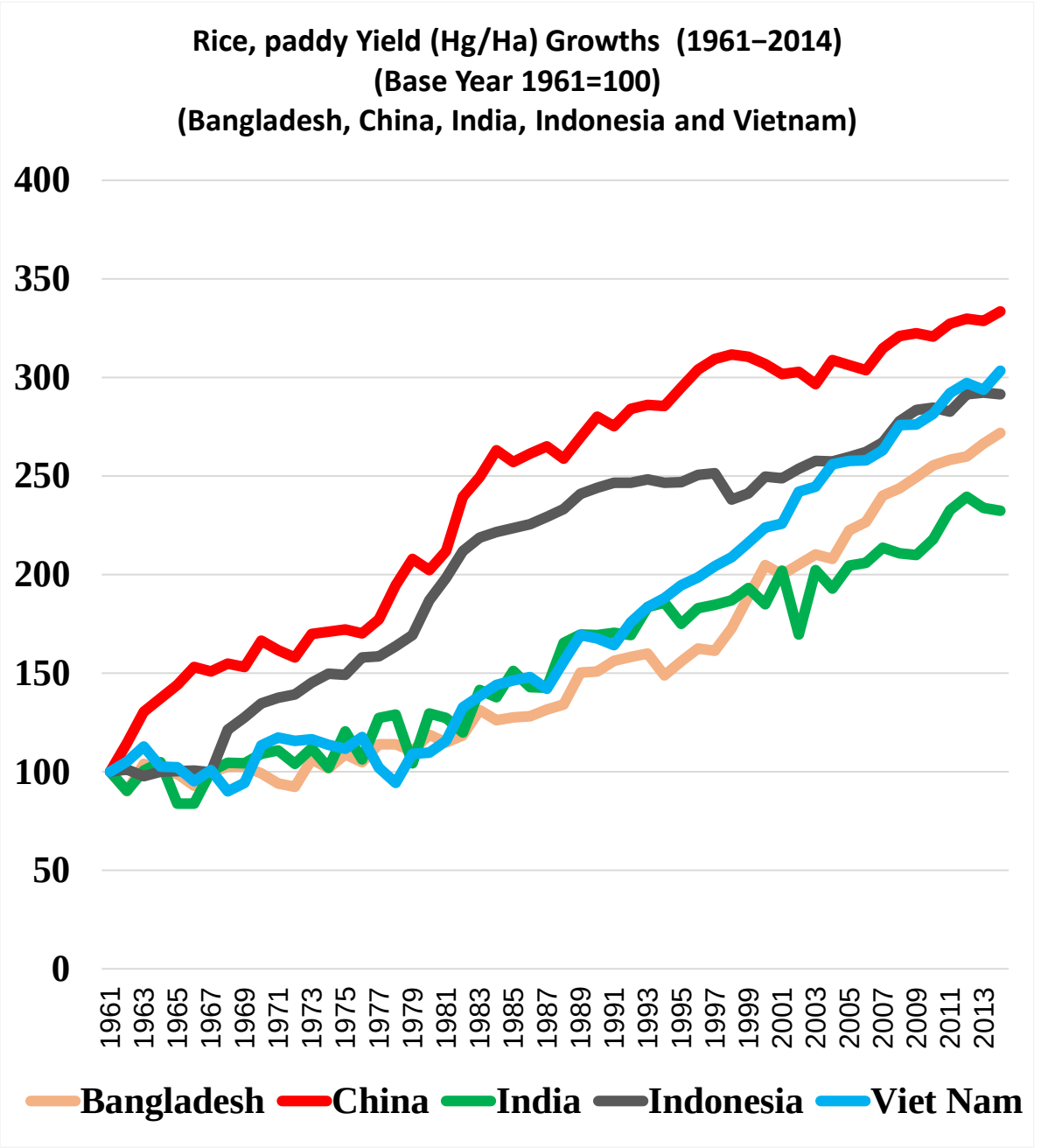
Source: Based on data available at https://www.ers.usda.gov/data-products/international-agricultural-productivity/





Source: Based on FAOSTAT data



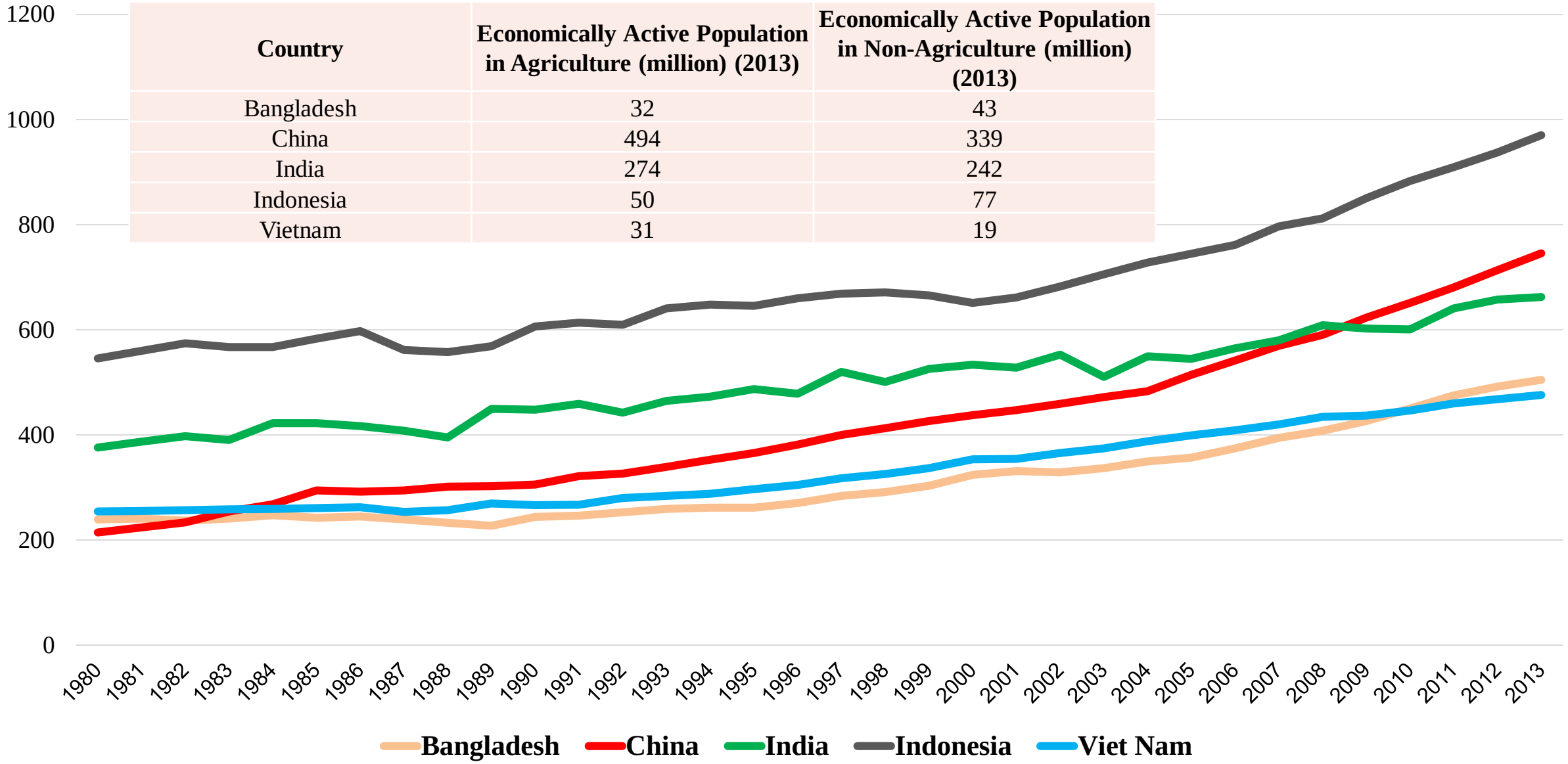


Source: Based on FAOSTAT data

Value Added per Worker

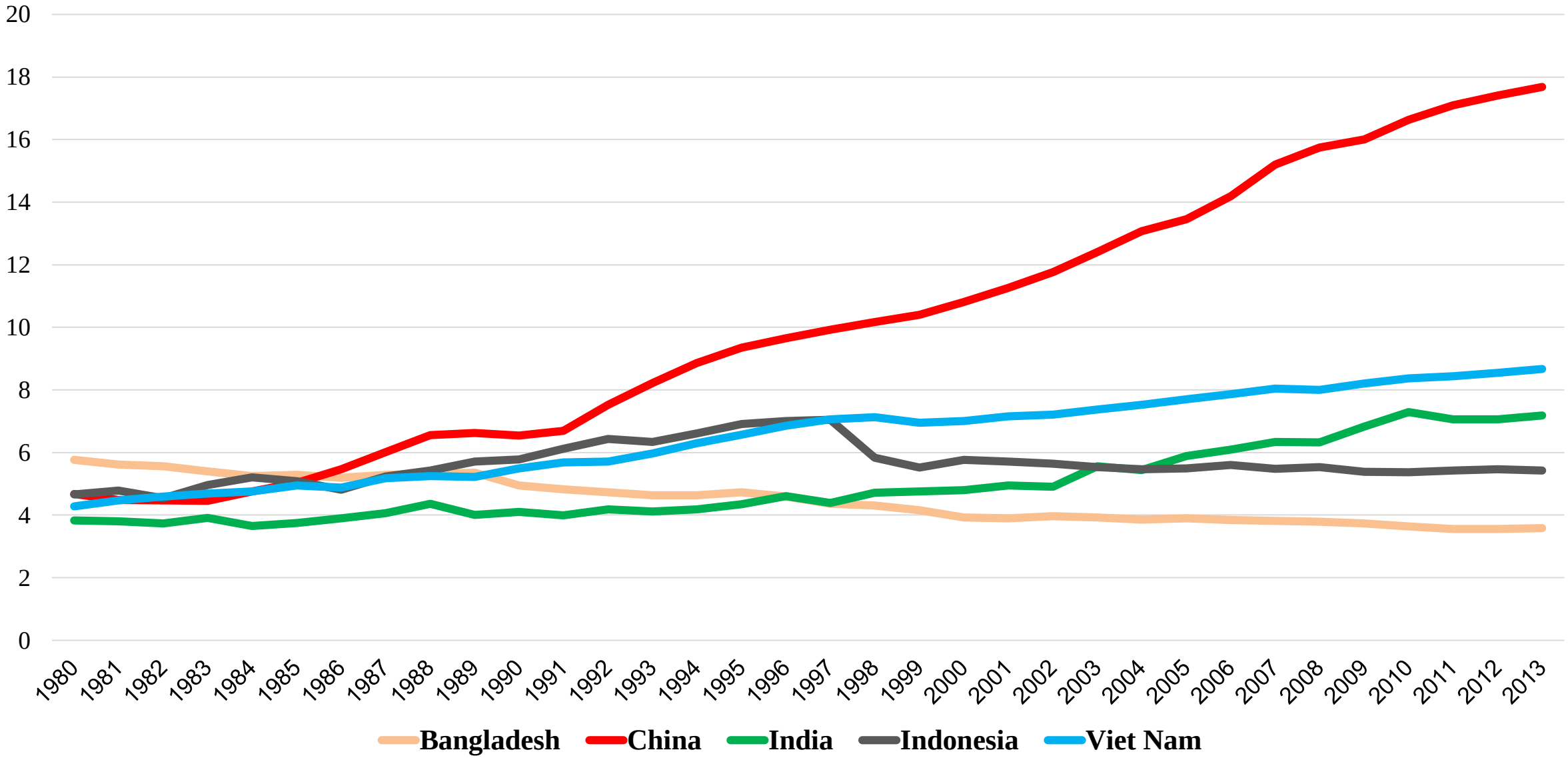
Agricultural Value Added per Worker [Based on FAO Estimates of Economically Active Population] (1980–2013) (Bangladesh, China, India, Indonesia and Vietnam)

Country	Economically Active Population in Agriculture (million) (2013)	Economically Active Population in Non-Agriculture (million) (2013)
Bangladesh	32	43
China	494	339
India	274	242
Indonesia	50	77
Vietnam	31	19



Source: Based on FAOSTAT data and WDI, World DataBank, World Bank

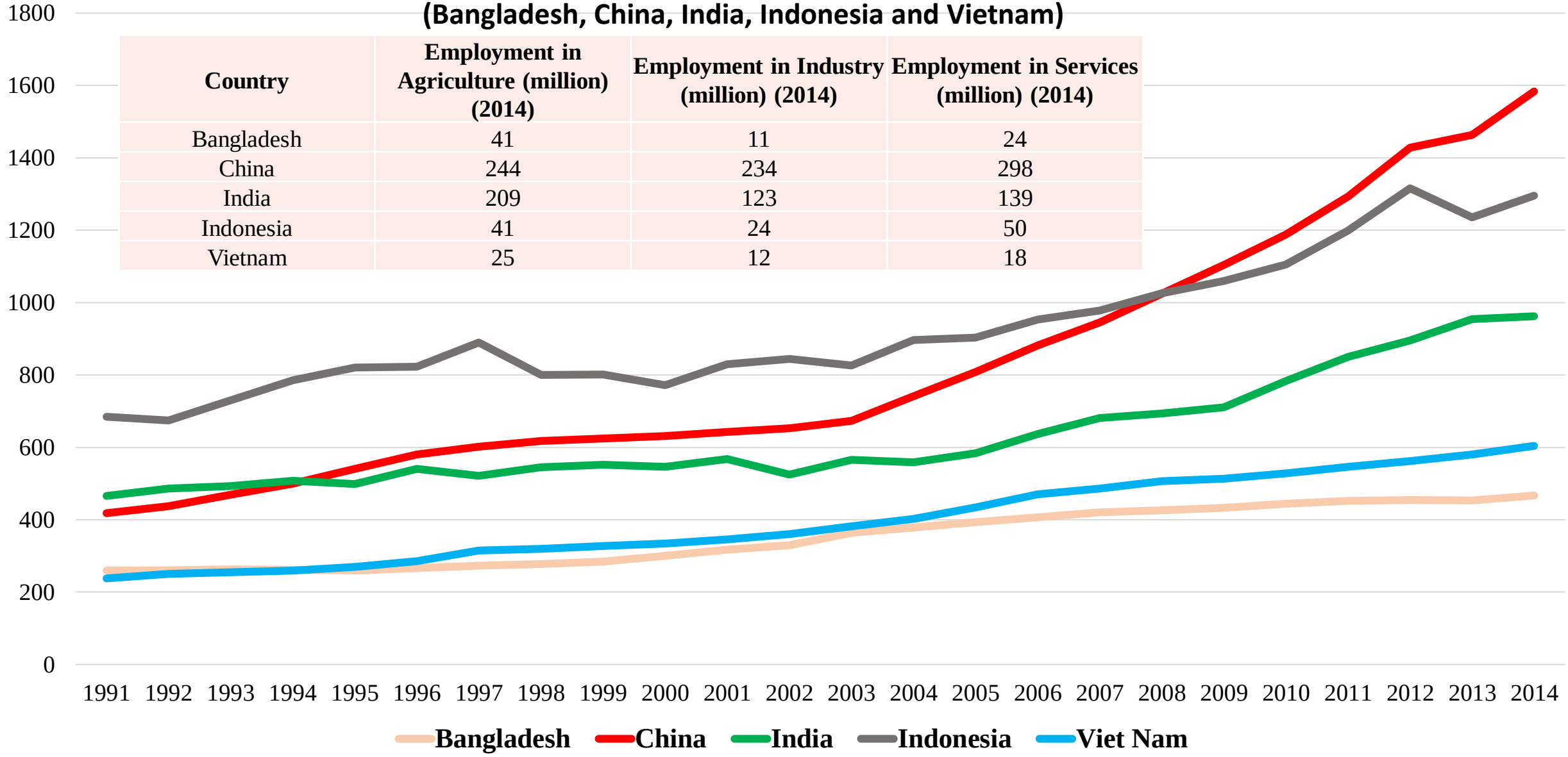
Ratio of Value Added per Worker (Non-Agriculture / Agriculture) [Based on FAO Estimates of Economically Active Population] (1980–2013) (Bangladesh, China, India, Indonesia and Vietnam)



Source: Based on FAOSTAT data and WDI, World DataBank, World Bank

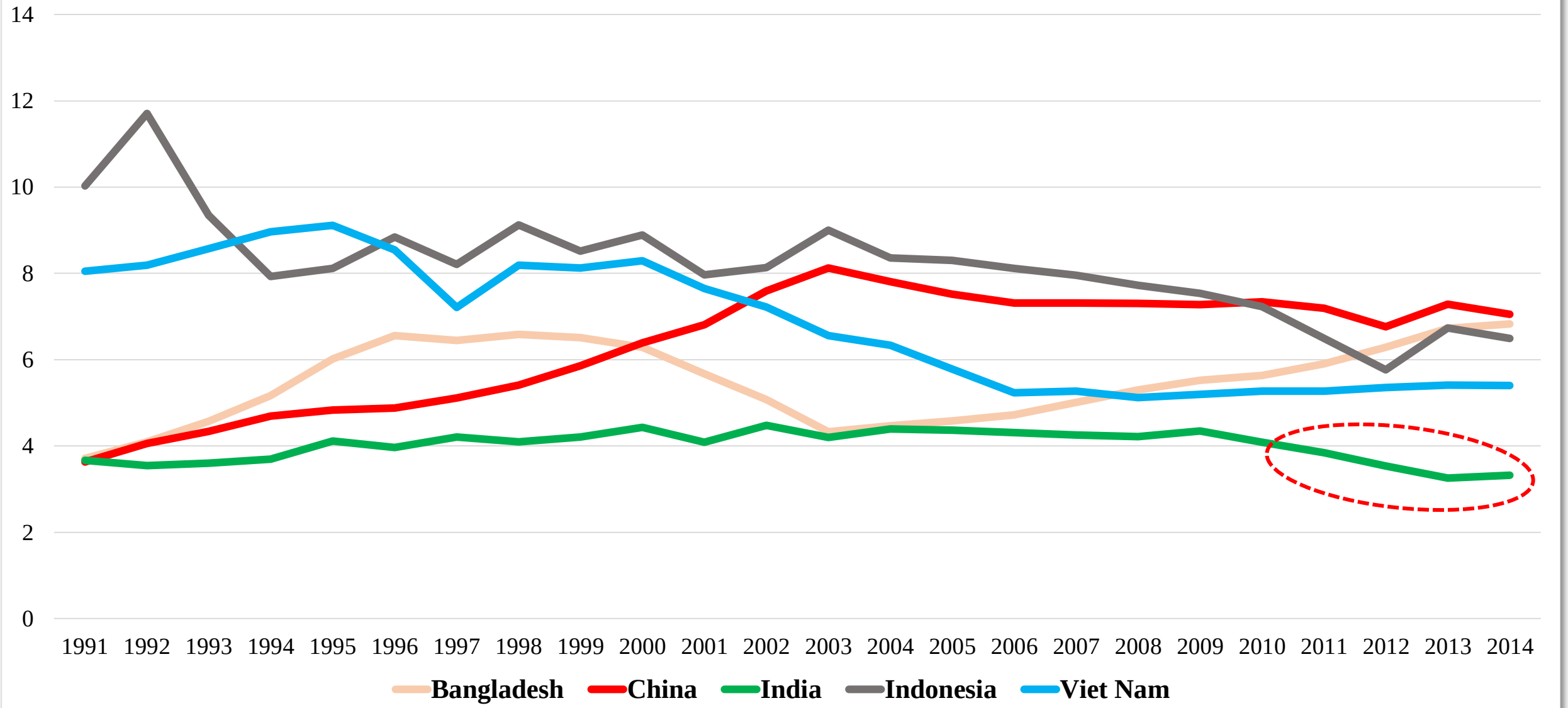
Agricultural Value Added per Worker
[Based on ILO Estimates of Global Employment Trends (1991-2014)]
(Bangladesh, China, India, Indonesia and Vietnam)

Country	Employment in Agriculture (million) (2014)	Employment in Industry (million) (2014)	Employment in Services (million) (2014)
Bangladesh	41	11	24
China	244	234	298
India	209	123	139
Indonesia	41	24	50
Vietnam	25	12	18



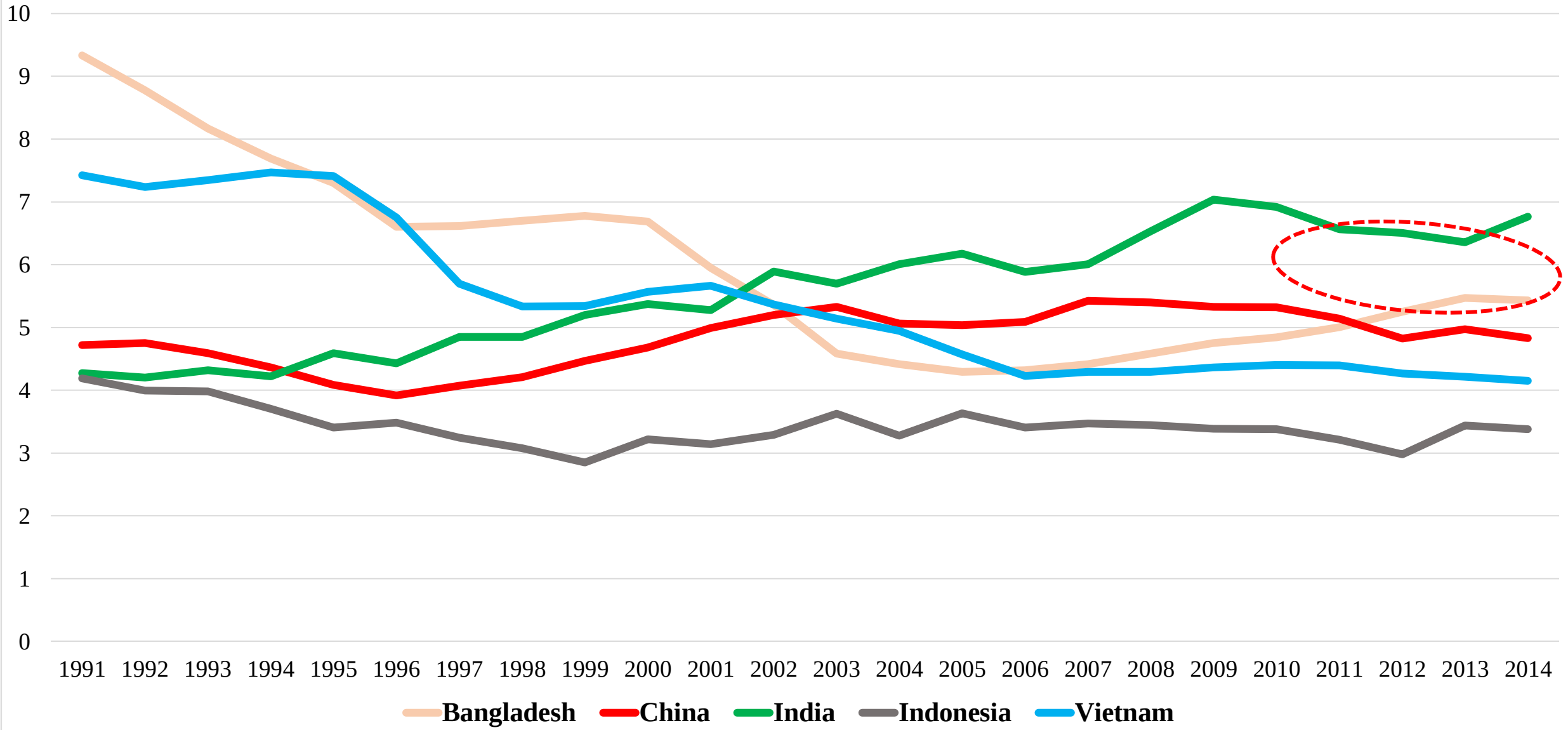
Source: Based on Global Employment Trends, ILO and WDI, World DataBank, World Bank

Ratio of Value Added per Worker (Industry / Agriculture) [Based on ILO Estimates of Global Employment Trends (1991–2014)] (Bangladesh, China, India, Indonesia and Vietnam)

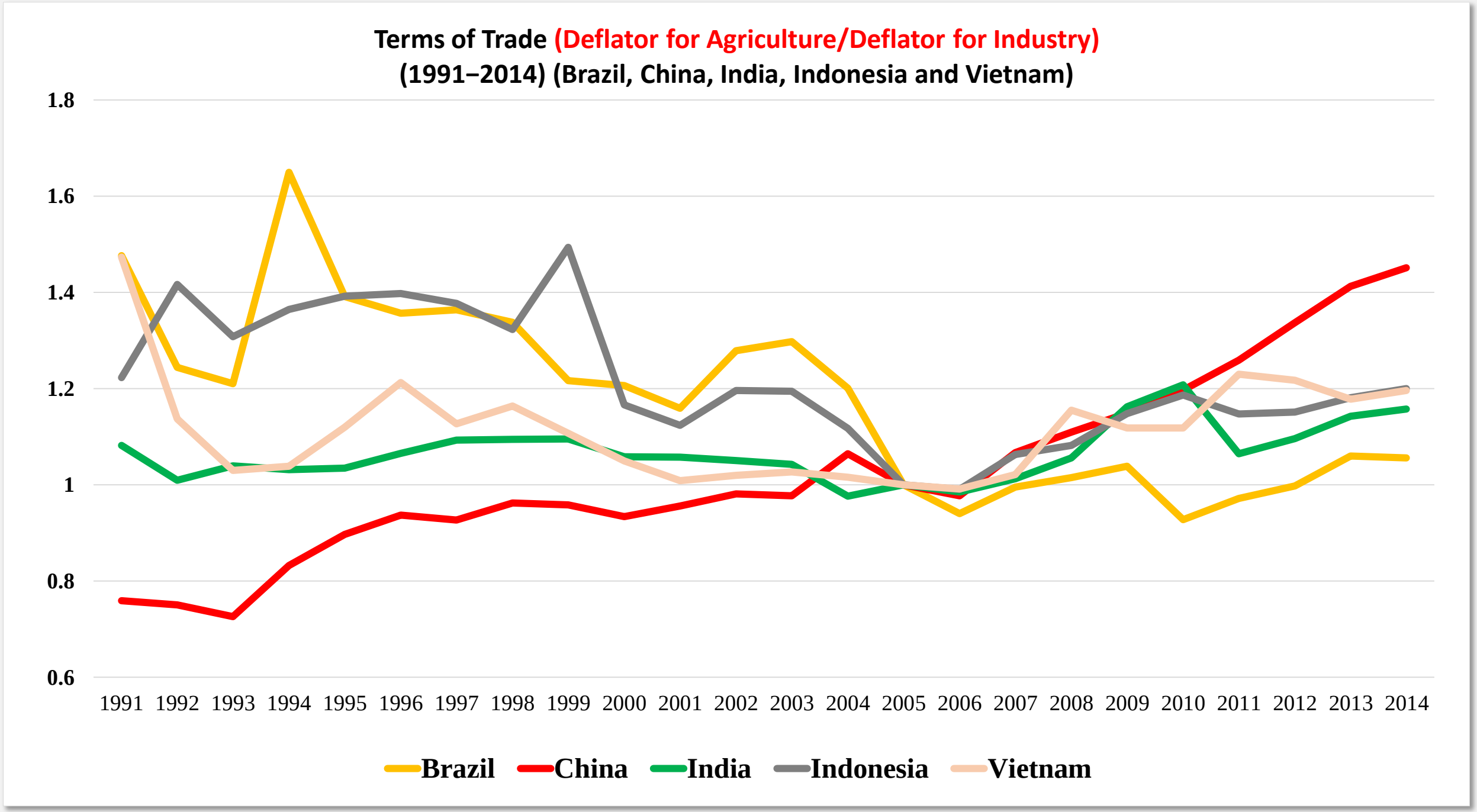


Source: Based on Global Employment Trends, ILO and WDI, World DataBank, World Bank

Ratio of Value Added per Worker (Service / Agriculture) [Based on ILO Estimates of Global Employment Trends (1991–2014)] (Bangladesh, China, India, Indonesia and Vietnam)



Source: Based on Global Employment Trends, ILO and WDI, World DataBank, World Bank



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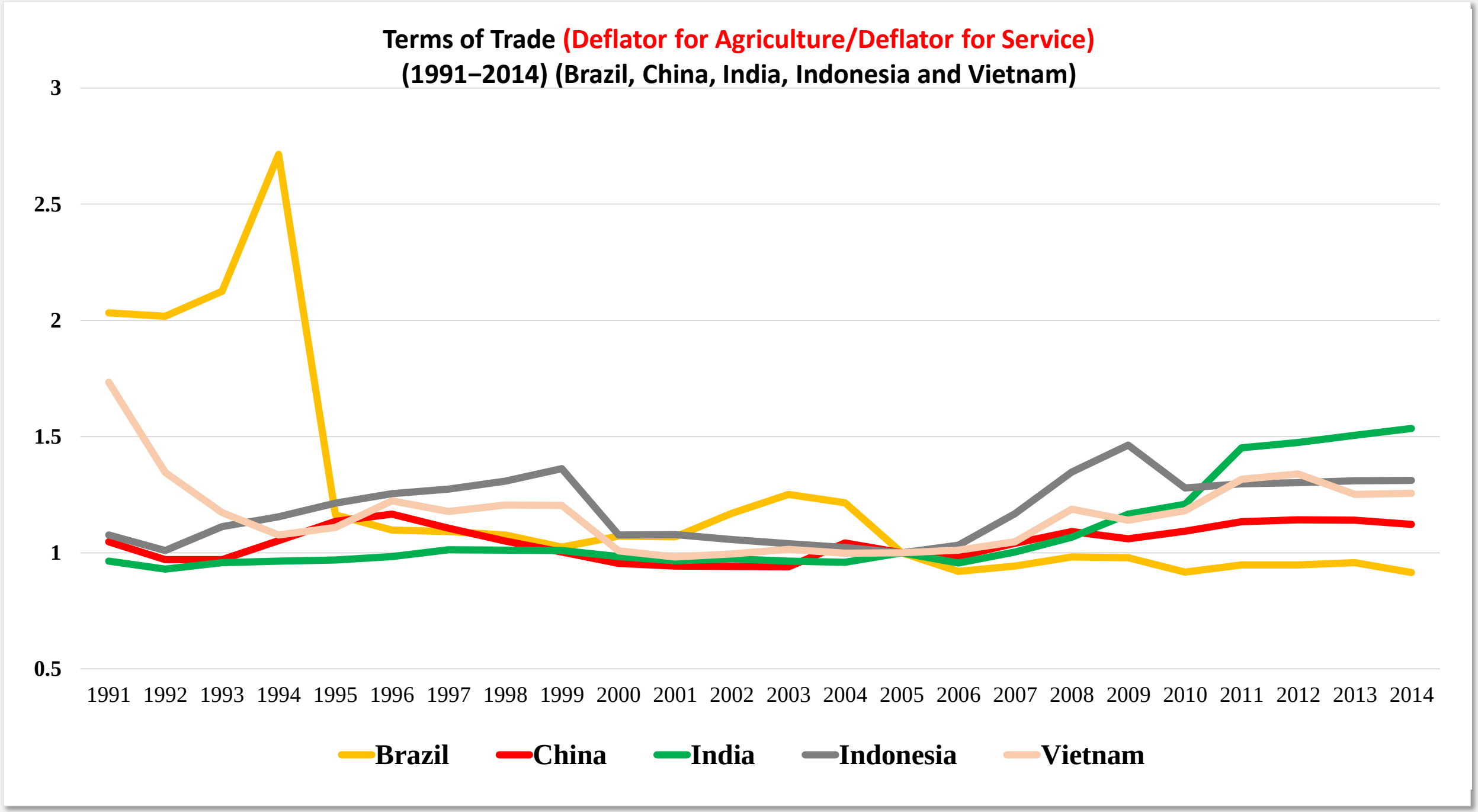


Source: Based on WDI, World DataBank, World Bank

TFP Estimates Do Not Include Environmental Costs Resource Loss

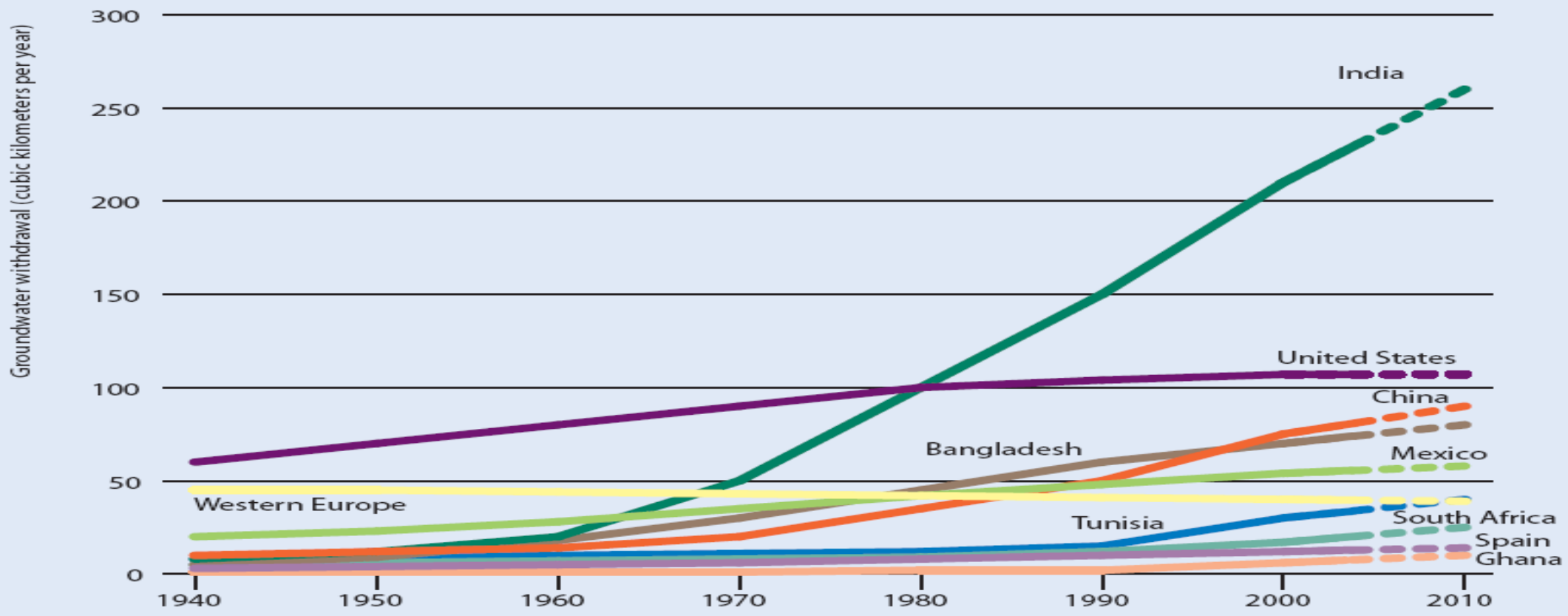
- Productivity Growth estimates do not measure growing water scarcities, soil loss, deforestation and forest degradation
- China has done better on climate mitigation in agriculture (Greater area under reforestation, payments for environmental services in forestry) than other countries;
- Better on water management—S and T, Investments, rewards, incentives and penalties
- Indonesia and Brazil—Productivity Growth but with largest emitters from deforestation

Going Forward

- More Frequent Floods and Droughts, Growing Water Shortages, including transboundary issues from local to global
- Growing Water-related conflicts

**"India inherited the world's largest canal infrastructure in 1947;
Today India is the world's groundwater champion!"----
Tushaar Shah, Senior Advisor, IWMI**

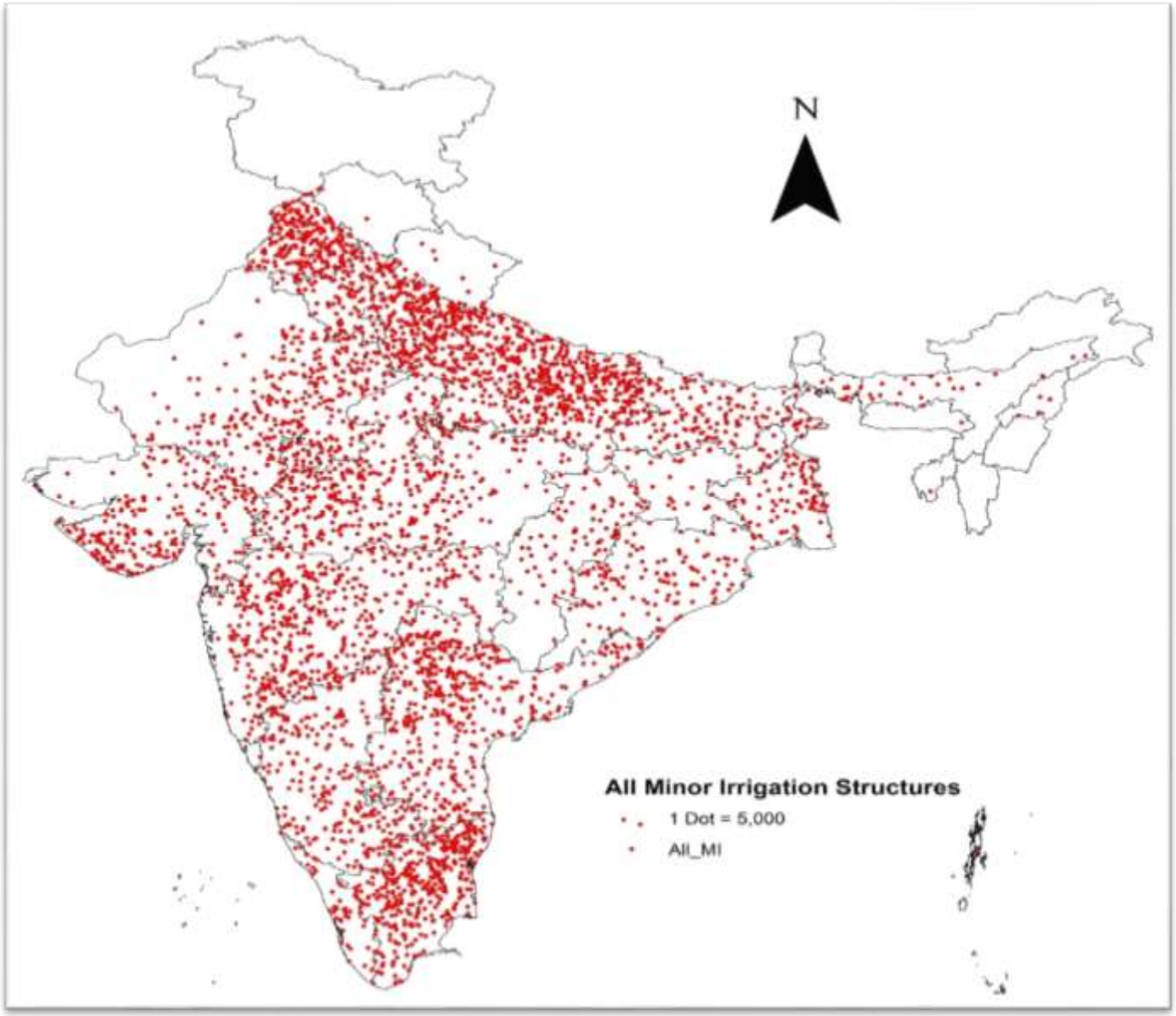
Development in groundwater withdrawal in selected countries



Source: Shah 2005.

Credit: Comprehensive Assessment of Water Management in Agriculture
Publisher: Earthscan www.earthscan.co.uk

Taming India's Groundwater Anarchy—Tushaar Shah

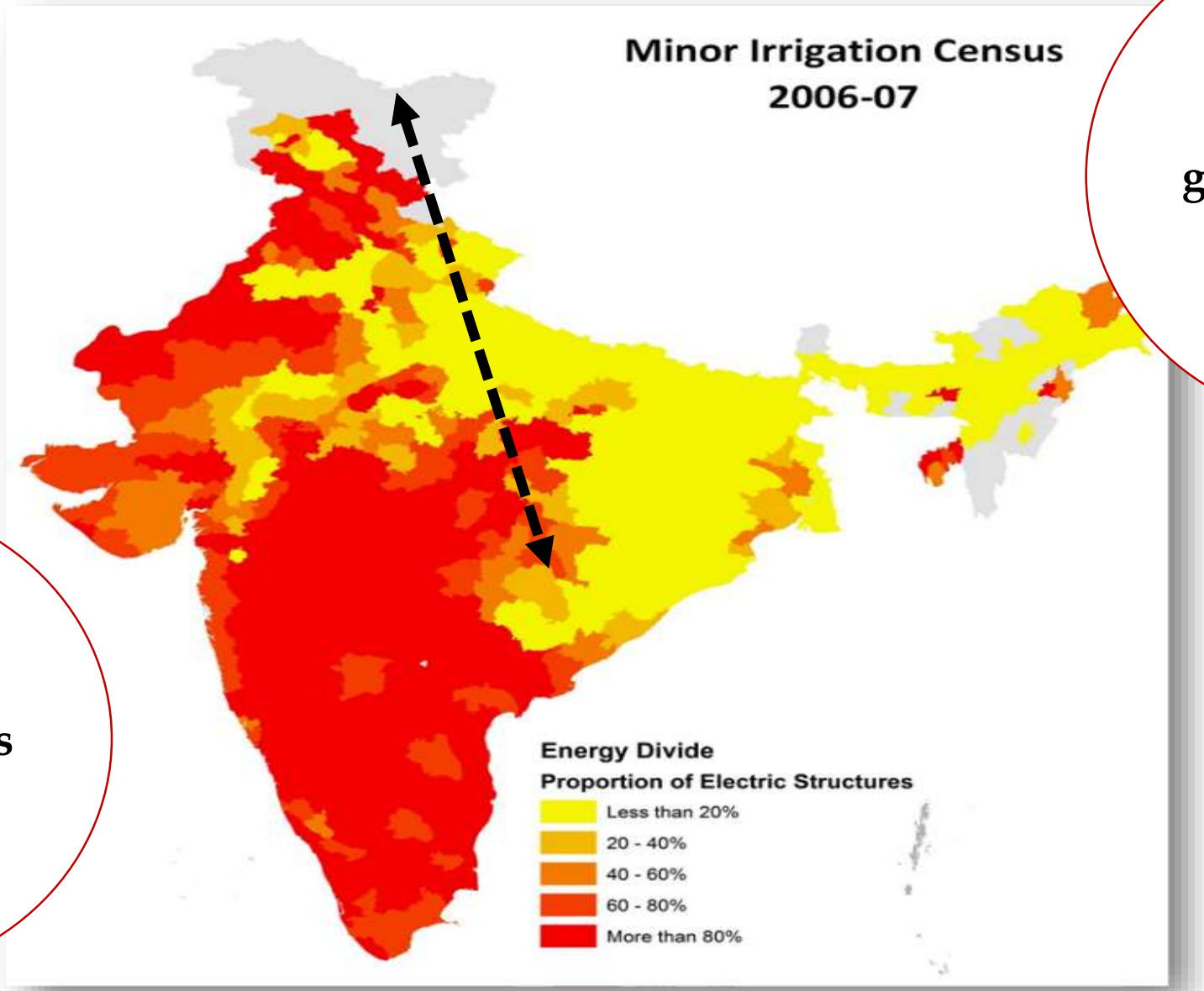


2006-07

Each dot equals 5000 irrigation wells. Irrigation low, where groundwater is not developed or managed

NUMBER OF STRUCTURES		
Number of Dugwells	million	9.20
Number of Shallow Tubewells	million	9.10
Number of Deep Tubewells	million	1.45
Number of Groundwater Structures	million	19.76
Number of Surface Flow Schemes	million	0.60
Number of Surface Lift Schemes	million	0.65
Number of Surface Water Schemes	million	1.25
Number of Minor Irrigation Structures	million	21.01

India's Energy Divide, 2006-07



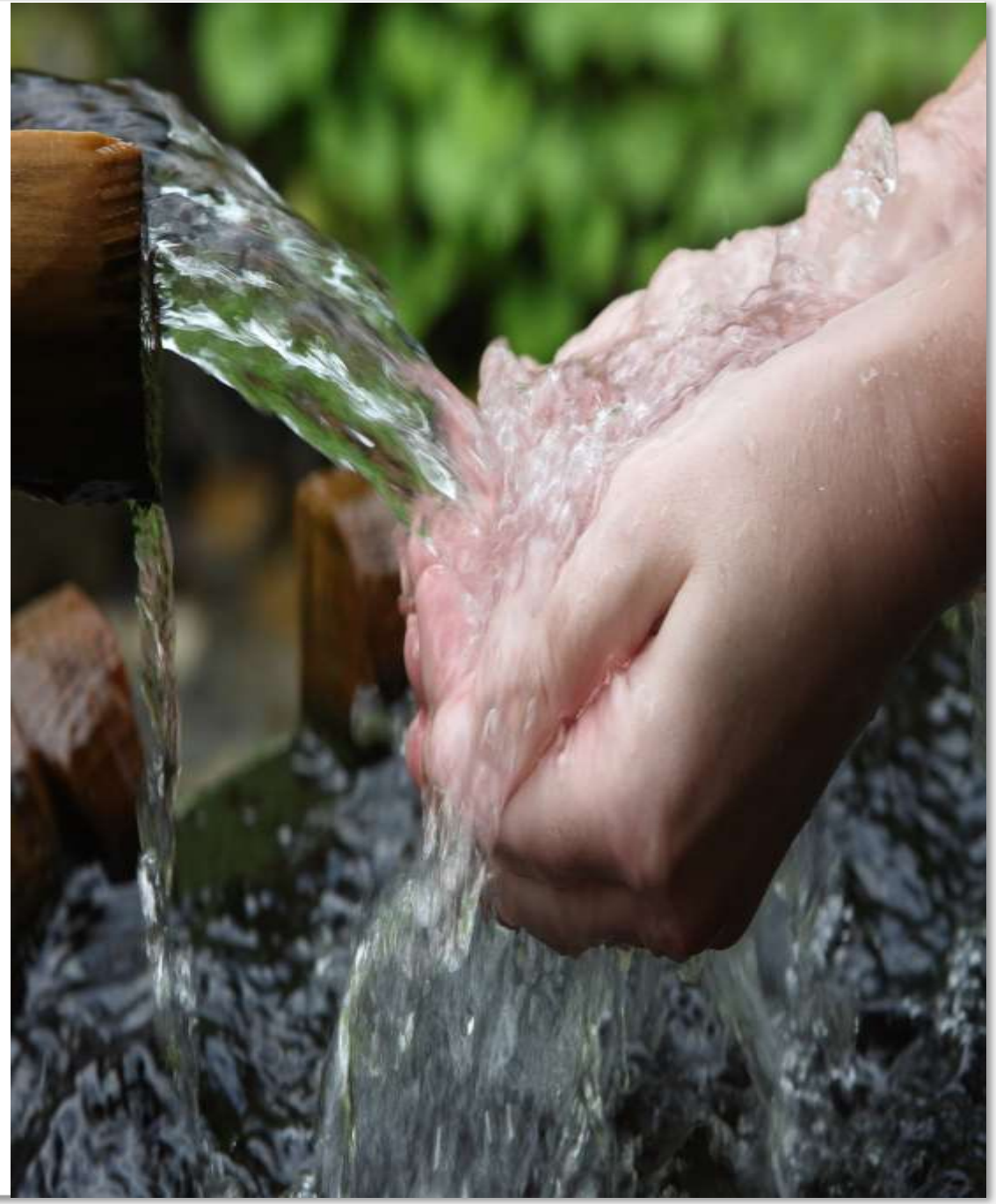
Eastern India has abundant groundwater but no energy to pump it

In western India, perverse power subsidies have ruined aquifers

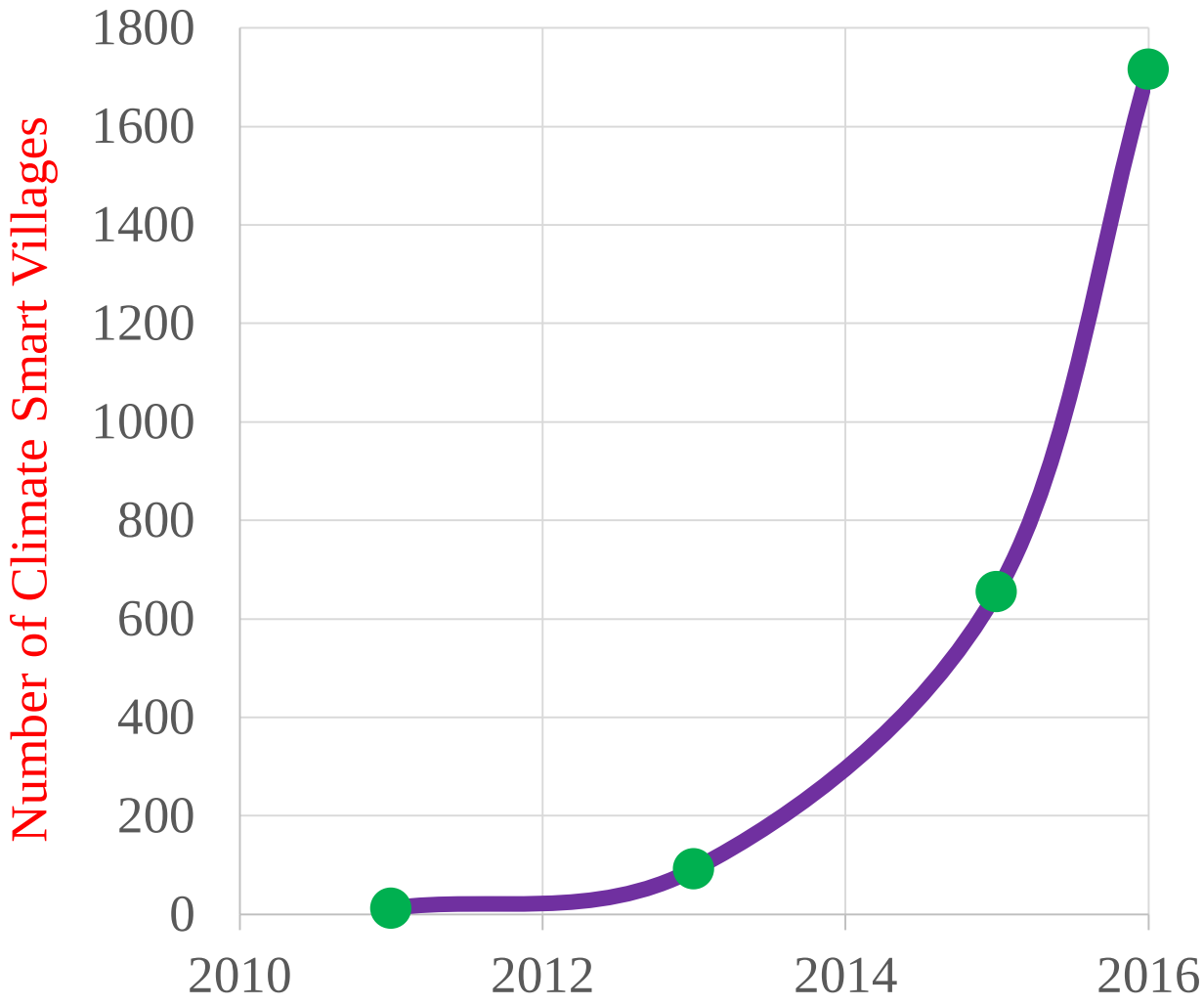
Lessons from Madhya Pradesh on Groundwater Management

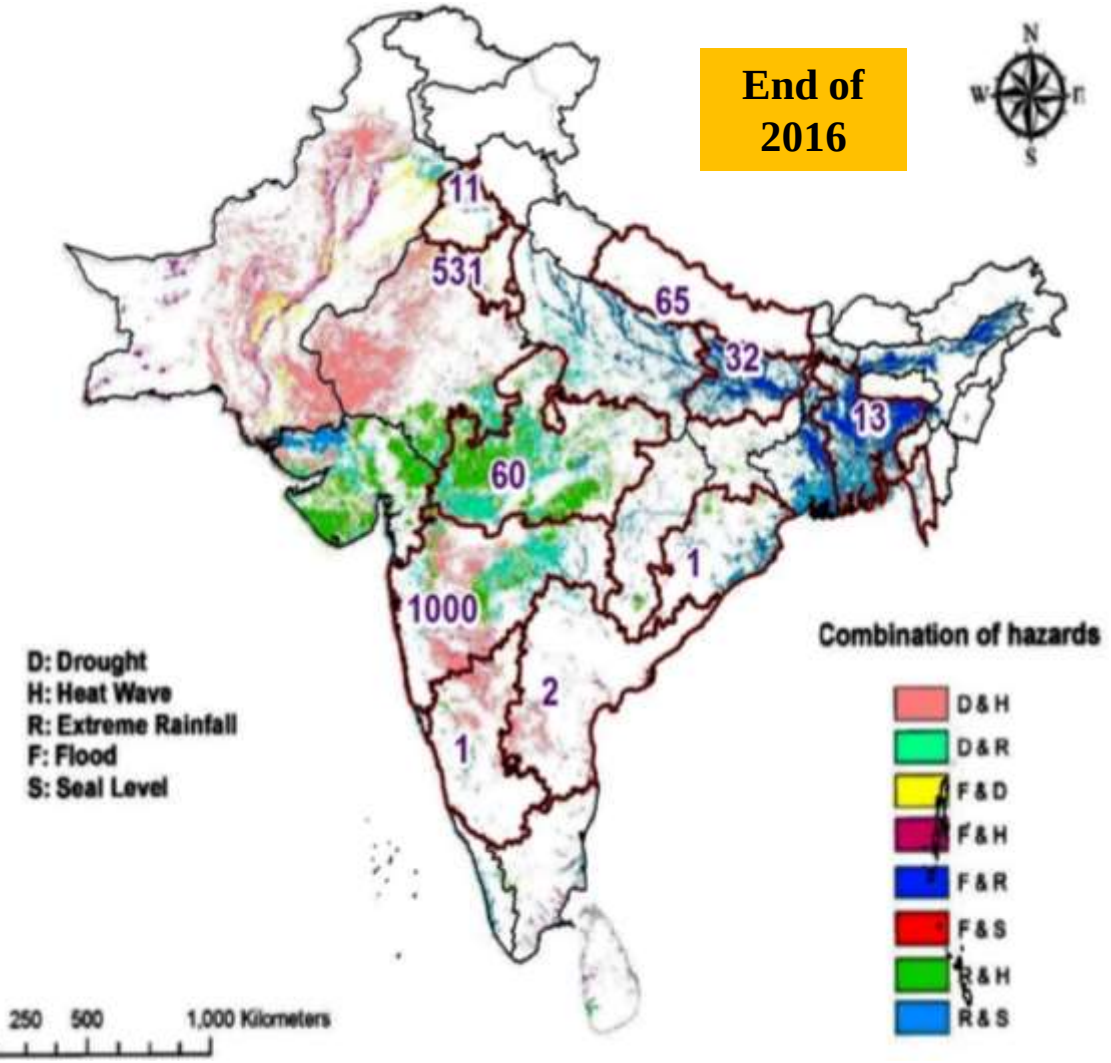
- MP utilized millions of ha of unutilized irrigation potential created in major, medium and
- minor irrigation projects.
- Provided reliable power ration to farmers during peak irrigation season. multiplied the state's irrigated
- area quickly, at small incremental cost, delivering
- double-digit agricultural growth.
- Had MP used the five successive years of normal monsoon during 2009-2013 to maximize groundwater recharge, and had effective mechanisms been put in place for judicious use of this recharge, Madhya Pradesh could well have sailed through even two successive drought years.
- Effective demand management of water must be the next priority of irrigation reforms.

Source: Tushaar Shah et al, Har Khet Ko Pani? (Water to Every Farm?), Emulate Madhya Pradesh's Irrigation Reform, IWMI-Tata Policy Paper



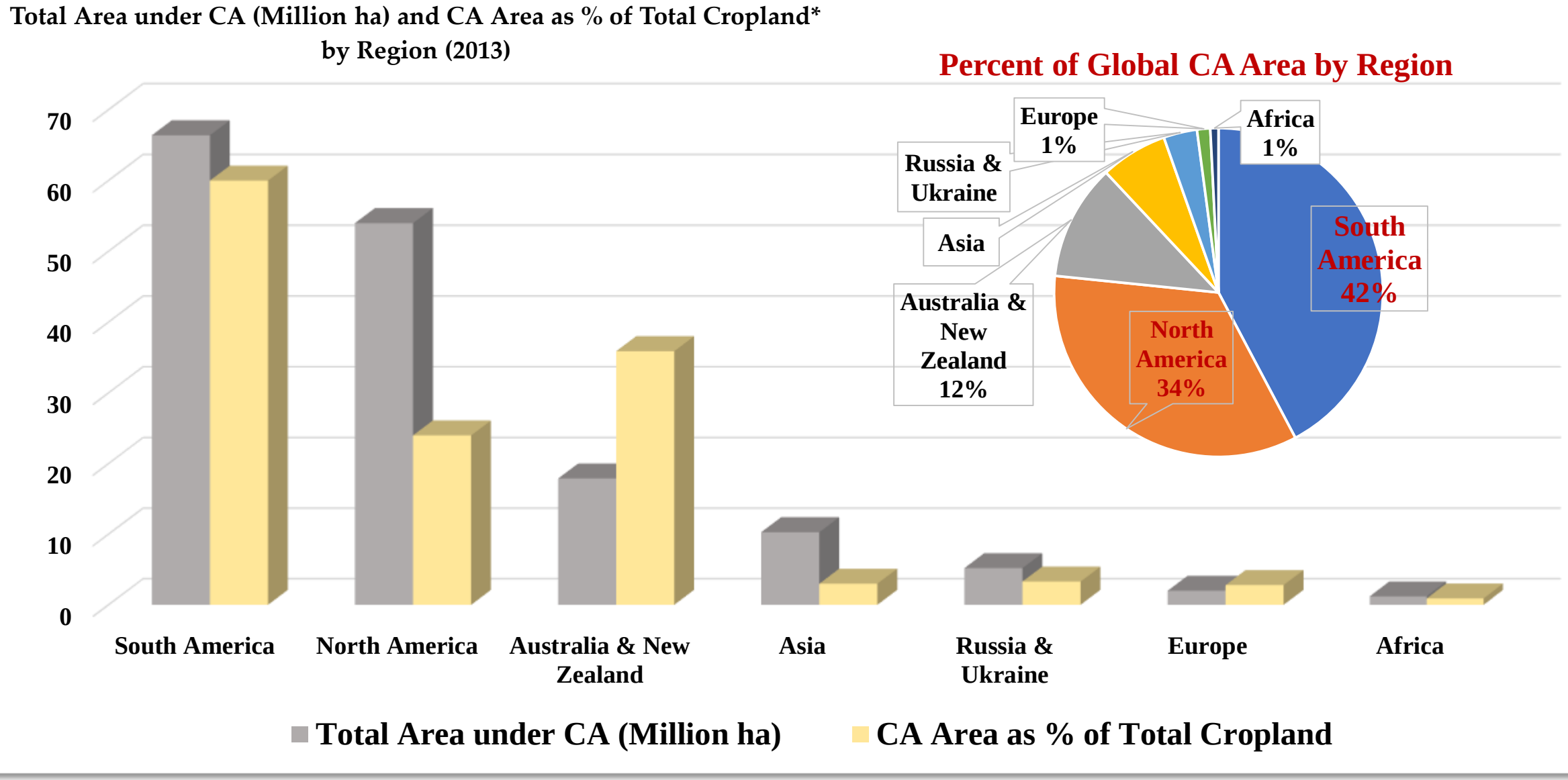
Climate Smart Villages in South Asia





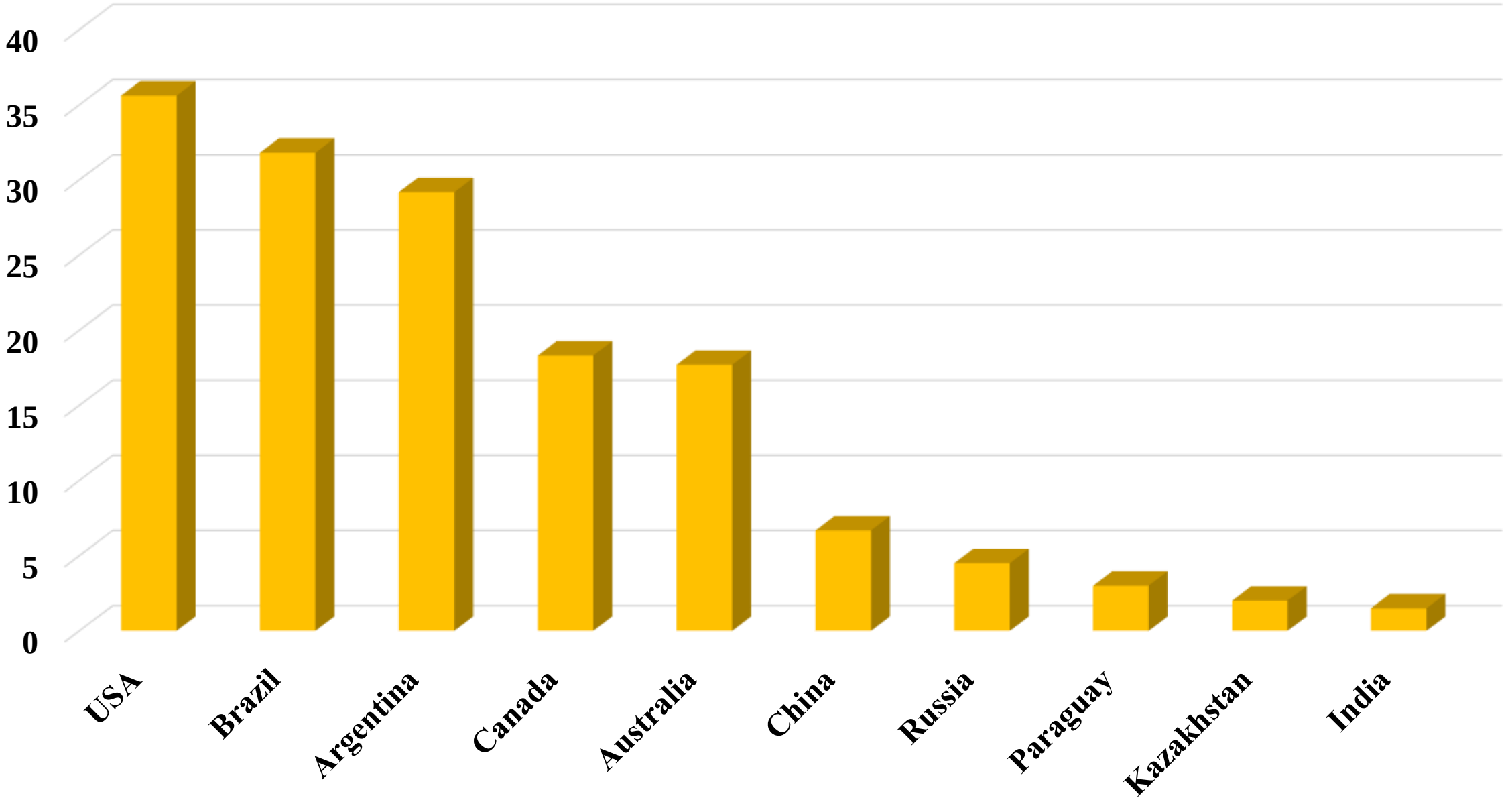
Source: Pramod Agarwal (2016). Climate-smart agriculture: Addressing weather-risks related agrarian distress, CGIAR Research Program on Climate Change, Agriculture and Food Security, Borlaug Institute for South Asia, CIMMYT, New Delhi-110012, India

Total Conservation Agriculture (CA): 157 Million ha, about 11% of Global Arable Cropland



Source: Based on FAO AquaStat: www.fao/ag/ca/6c.html

Area Under Conservation Agriculture in Top Ten Countries



Source: Based on FAO AquaStat: www.fao/ag/ca/6c.html

Some Frequently Offered Solutions to Climate Change Challenge

- Switch to varieties tolerant to heat, drought and salinity
- Increase irrigation efficiency
- Manage soil, nutrients and erosion
- Match livestock to supply of grazing land
- Promote Mixed farming-crops and animals
- Control Pastes and Diseases,
- Restore degraded habitats,
- Improve infrastructure
- Promote Crop Insurance
- USE Safety nets

Implications for Policy: No Silver Bullets! #1

- Improve climate data and climate forecasting at all levels
- Make data available to farmers well in advance
- Tailor Advice on Farming System Management to Changing Climate
- Promote climate resistant agriculture, e.g., integrated cropping and livestock- multiple resistance—resilient to weather, more pulses, fruit and vegetable, less irrigated cereals
- Promote Crop Varieties with multiple resistance
- Promote conservation agriculture, no till—improve soil, land and water management
- Promote Landscape Management
- Restore degraded lands through agro –forestry

Implications for Policy: No Silver Bullets! #2

Scaling Up Challenge:

- Reduce Emissions from Livestock—only 1% of livestock population under rationed balance
- GMOs??????
- Livestock—Rationed Balanced Diet—1% of 75 million livestock population under rationed balanced approach
- Conservation Agriculture—2% of India's ag under CA compared to what percent under China?
- Water Management—35 million under drip irrigation?
- Water rationing?
- Foster a national food and agricultural market—eliminate cross border restrictions
- Increase security of land tenure
- Invest in Physical Infrastructure—Roads, Renewable Energy

Implications for Policy: No Silver Bullets! #3

- **Implementation , Implementation, Implementation**
- **Establish Inter-Ministerial/Departmental Coordinating Mechanisms**
- **Use Monitoring and Evaluation to Improve Project Design and Implementation**
- Increase Focus on R and D—Strengthen ICAR, SAUs,

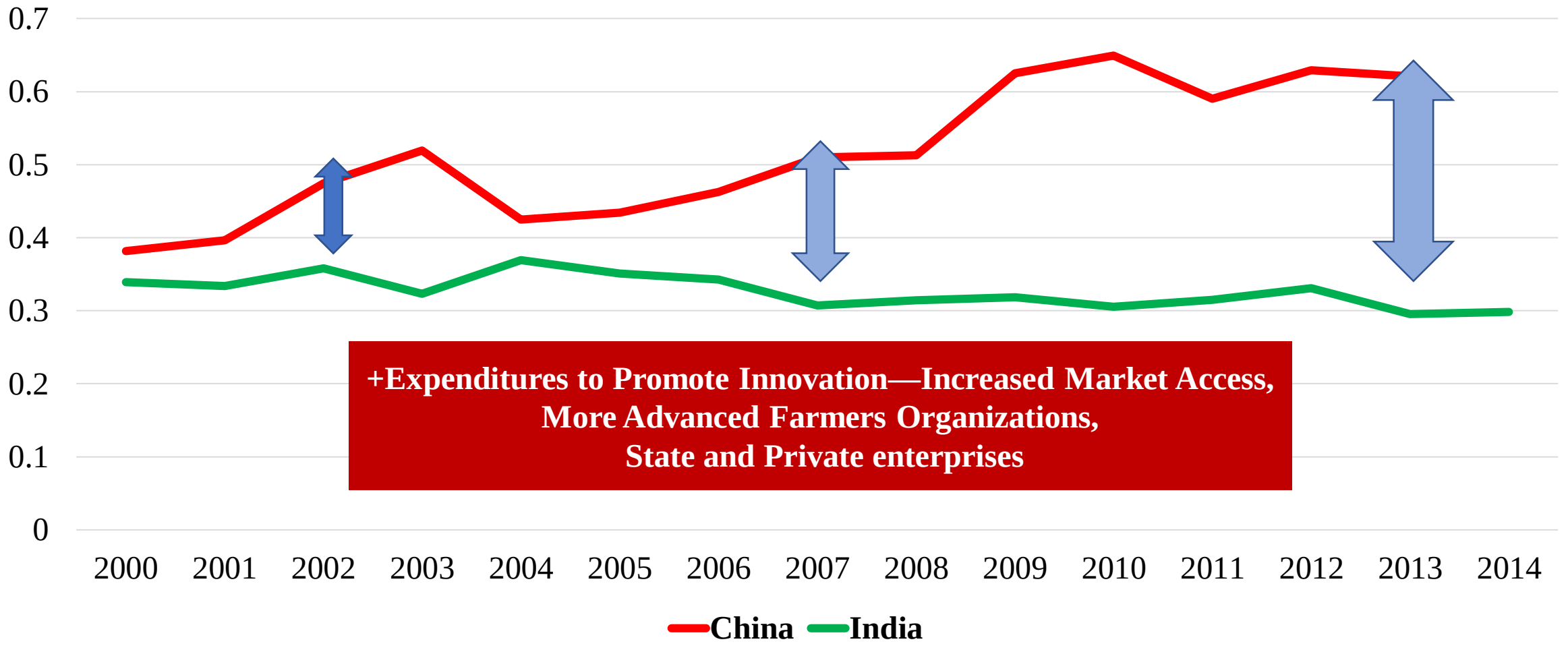
  Public-Private Partnerships
- Crop Insurance cannot be a new form of subsidy!
- Social Safety nets already exist and need to be streamlined
- Institutionalize Disaster Relief—
- Invest in Physical Infrastructure
- **Introduce Accountability Mechanisms to political and administrative actors**
- Make the most of the Indian IT industry.
- Invest in Human Capital, Get citizens involved.

Part 3

Deploying 4th Industrial Revolution to Agricultural and Overall Challenges

Opportunities of the 4th Industrial Revolution

Agricultural Research Expenditure as Share of Agricultural GDP (%) (2000–2014)



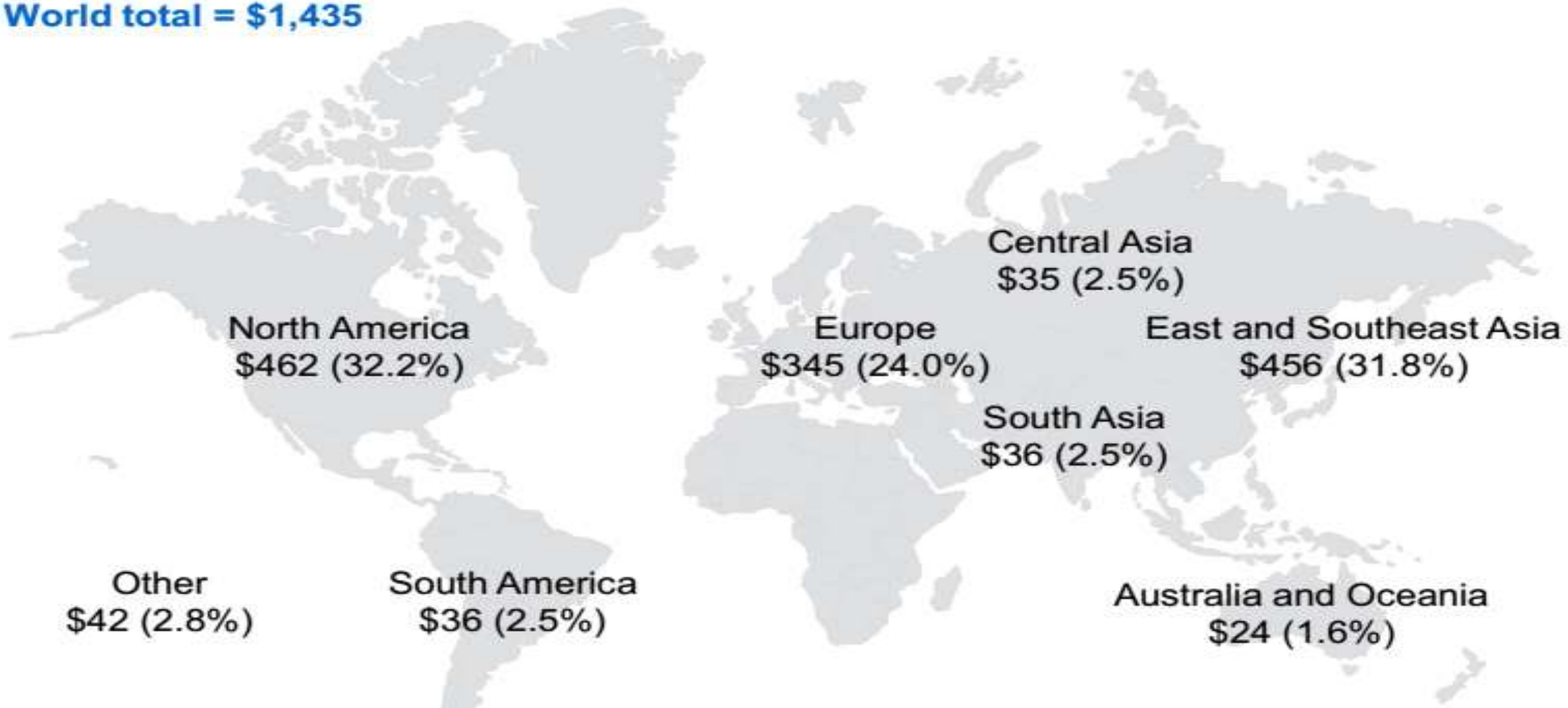
Source: Based on data from https://www.asti.cgiar.org/. *Note:* China's data available until 2013.

East Asia has become a major centre of global R&D activity

Global R&D expenditures, by region, 2011

$ billion, purchasing power parity

World total = $1,435



Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

India, largest software exporter Behind China in Digital Divide

- India had 227 million Internet users, compared to 665 million in China.
- Fewer than two out of every five Indian businesses had an online presence compared to almost two-thirds of firms in China.
- The cost of a 1 Mbit/s residential broadband service in India is 6-10 times higher than in China.
- Significantly higher digital divide across age, gender, geography and income within India than in China.
- **Aadhaar, digital ID programme**, India scores higher than China in digital adoption by governments,
- but the need to use Aadhaar more widely and effectively.

Gaps in Skill Levels to India becoming a digital economy: Basu Calls "India's formidable challenge"

- Indians in Silicon Valley in the United States, and yet **skills level of the average Indian worker** significantly behind his or her Chinese counterpart.
- A vast majority of its population still lacks the skills to meaningfully participate in the digital economy.
- **Around 25 per cent of India's adult population** cannot read and write compared to fewer than 5 per cent in China.
- **Test scores** in rural India show that 10 per cent of children aged 16 and below cannot identify single-digit numbers consistently. Fewer than one in five can do a subtraction, performing considerably below their grade level.

India's challenges include low productivity and inadequate access to basic services

Health care

1/3–1/2
as many doctors per capita compared with China and Brazil

43%
absentee rate of health workers

Education and skills

88%
of class 8 students in rural India unable to read class 1 text

500 million
without secondary education or skills training

Financial services

120 million
rural households without bank accounts

48%
"leakage" in employment guarantee programme payments

Agriculture and food

48%
of the agricultural yield per hectare of Asian countries

20 million
tonnes of grain lost each year due to bad warehouse facilities

Energy

30%
import share in fuel demand

24%
electricity lost in transmission and distribution

300 million
people lack electricity

Infrastructure

105
litres of water supplied per capita per day; 140 litres needed in urban India

2x
traffic congestion in urban India compared with best-in-class cities

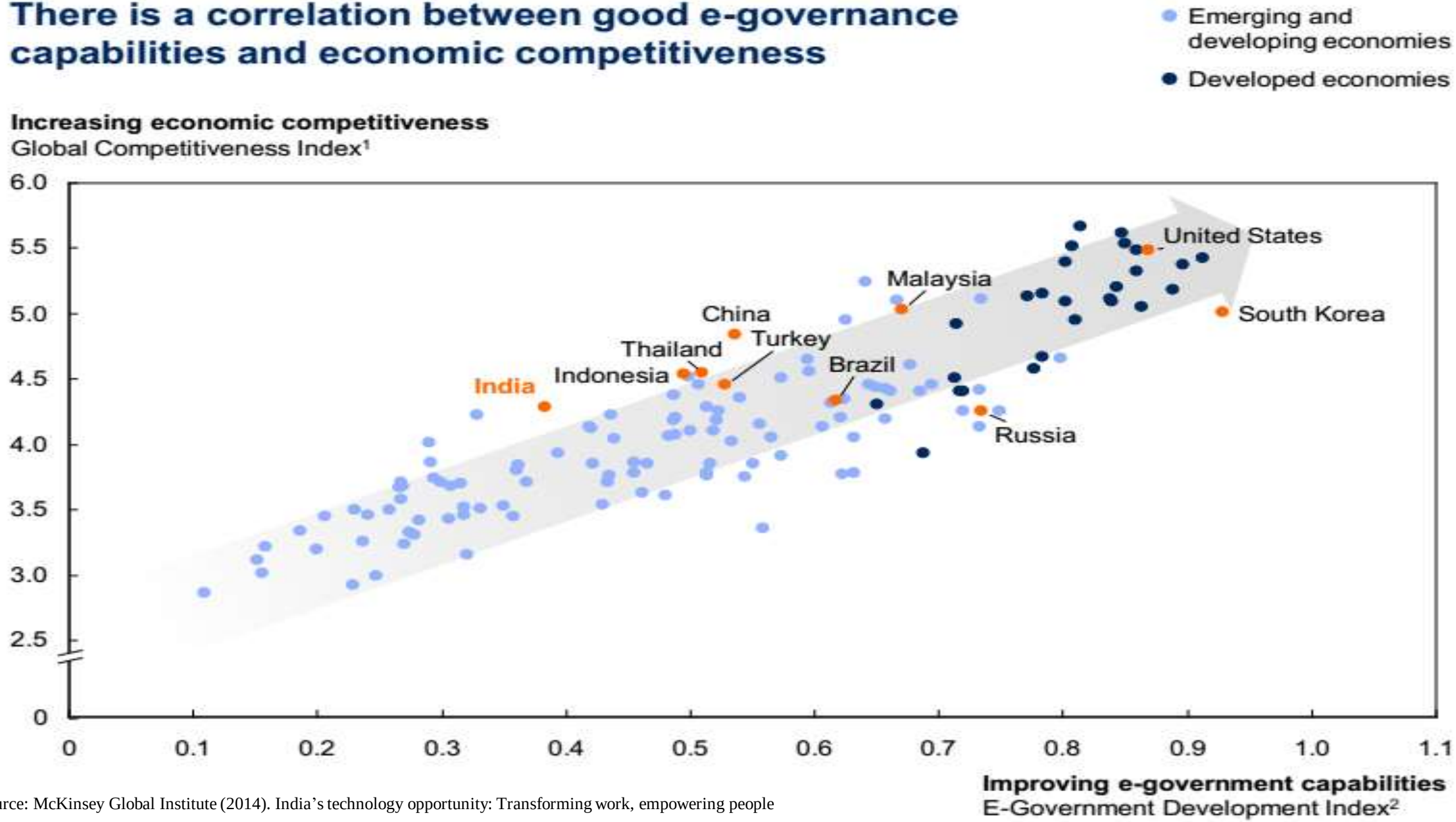
Government services

50%
of government spending does not translate into benefits for people

134
India's rank among 189 countries on ease of doing business

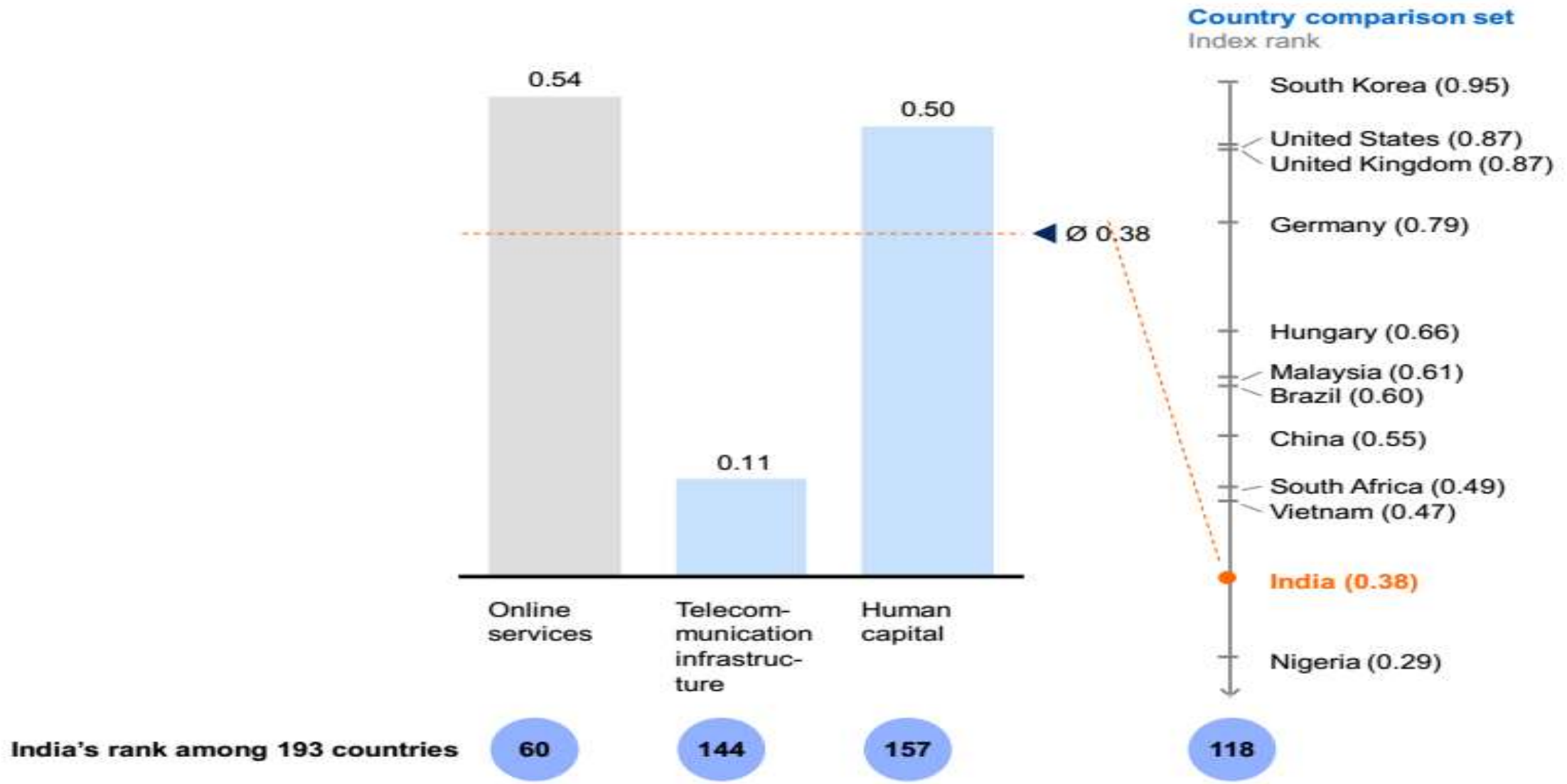
Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

There is a correlation between good e-governance capabilities and economic competitiveness



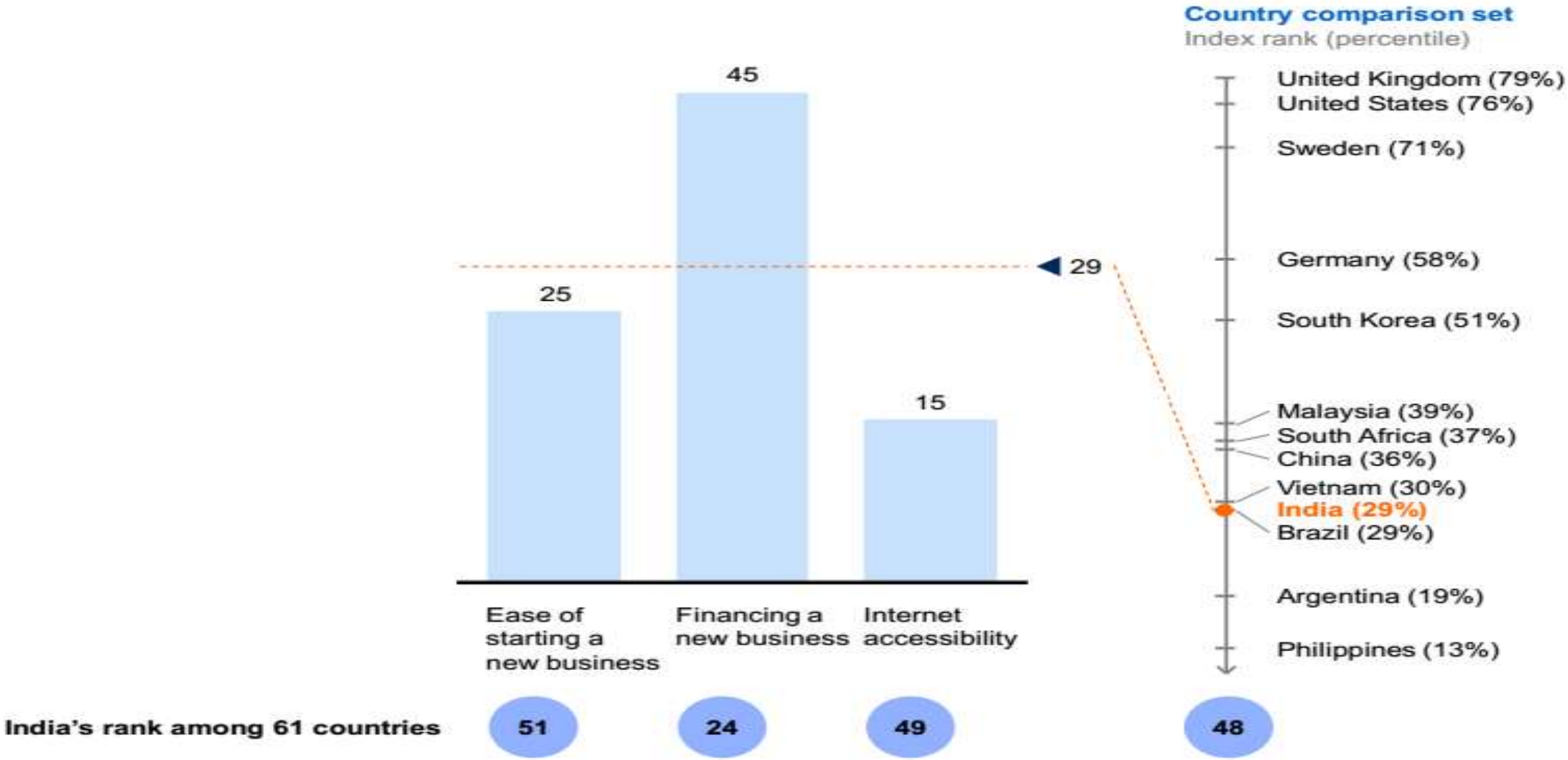
Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

India ranks poorly in e-governance due to limited connectivity and computer literacy



Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

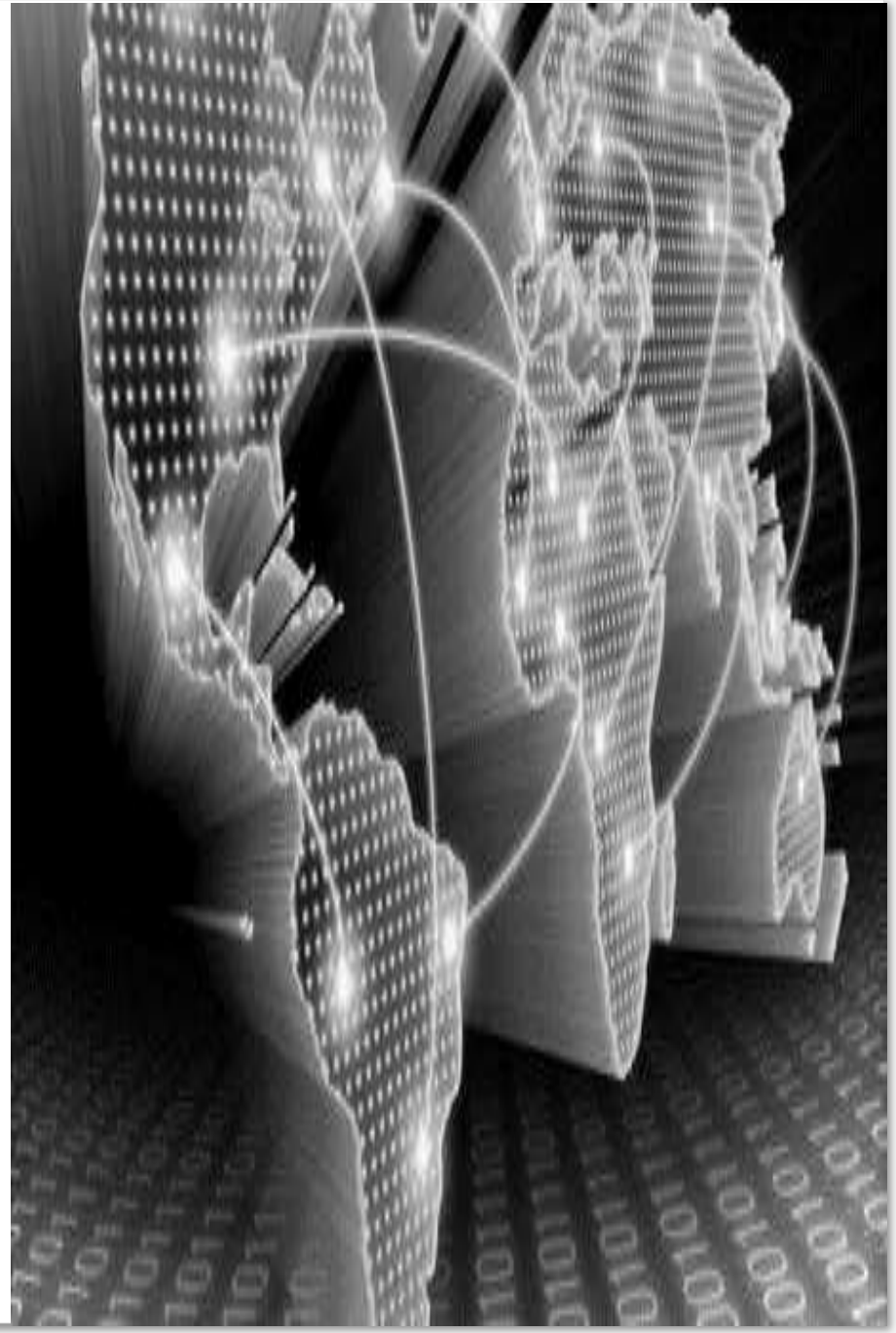
India's Internet entrepreneurship score reflects challenges in the business environment and Internet access



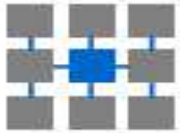
Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Potential impact of 12 empowering technologies by 2025?--McKinsey

- $550–1,000billion annual economic impact (20–30% of India's incremental GDP from 2012 to 2025)
- 300 million financially included people
- 400 million additional people with access to quality health care
- 14–24 million workers could gain more years of education
- 15–60% yield improvement for 22 million farmers due to precision agriculture
- $50–95billion savings and productivity gain from energy technologies
- $17–25billion economic value from intelligent transportation (roads and ports)
- 10 million tech-enabled workers in health care, education, agriculture, citizen services, and
- financial services 19–29million non-farm workers who will need new job opportunities and skills



Seven Technology-based Services can Transform Indian Agriculture

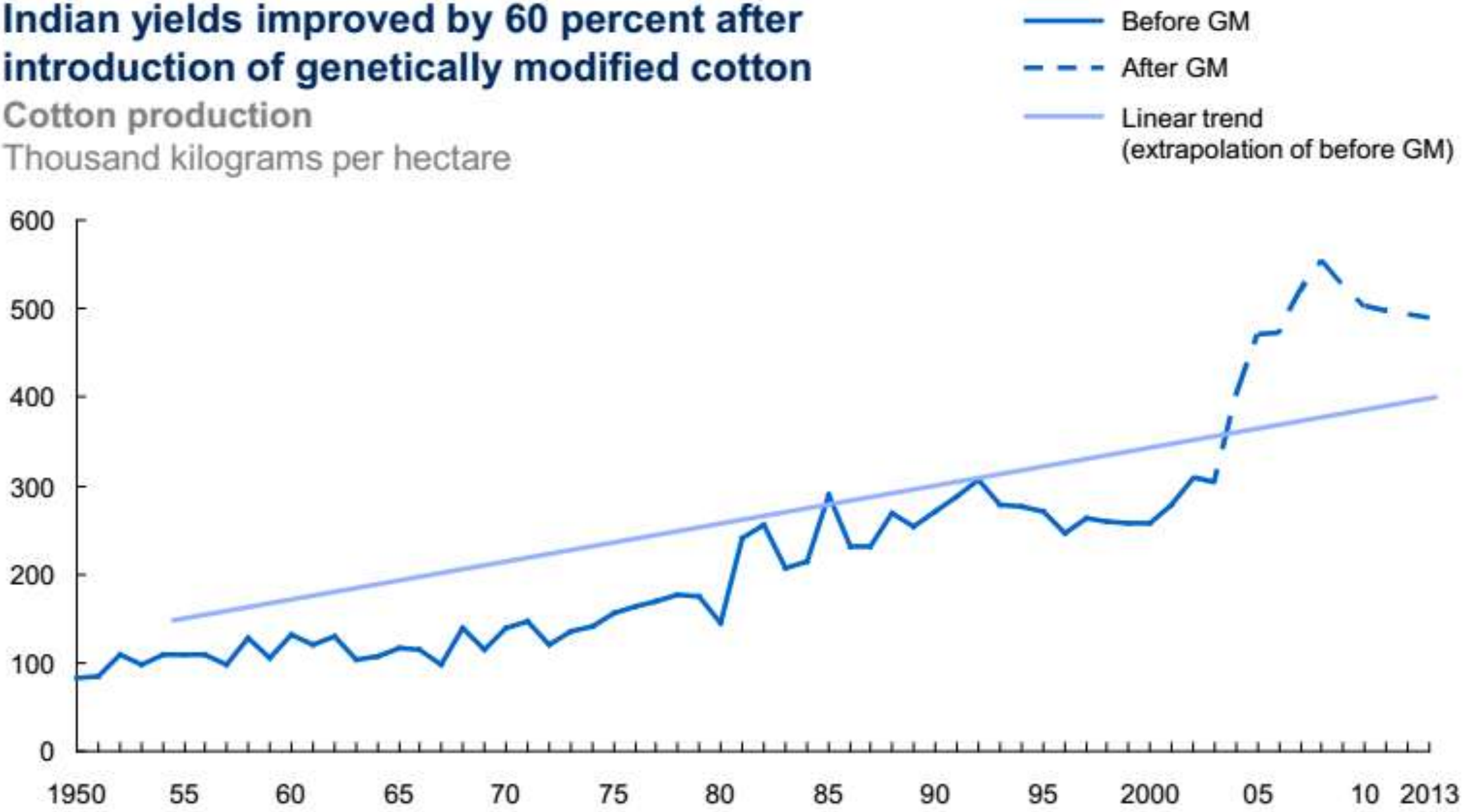
Hybrid and genetically modified crops 	Genetic engineering and hybridisation to increase yields and make crops resistant to pests, diseases, and environmental conditions; chemical treatments to add nutrients	**Precision farming** 	Use of advanced GIS/GPS and sensors to guide planting and irrigation; yield monitoring; variable rate technology to fine-tune inputs, improve yields, water, and fertiliser efficiency
Tech-enabled farm extension and advisory services 	Moderately skilled agricultural workers with access to smart apps via smartphones or tablets provide farm extension and advisory services	**Real-time market information** 	Using mobile communications, voice-based call centres, and expert systems for real-time price discovery, weather information, and cultivation trends
Technology-enabled supply chain 	Use of RFID, advanced GIS/ GPS tracking and traceability systems to reduce wastage and ensure quality throughout the agricultural supply chain	**Leakage-free public distribution system (PDS)** 	Reduced leakage in public distribution system (PDS) using GPS/SMS monitoring; verifiable digital identity; Web portal for public grievances
Technology-enabled crop insurance 	Use of real-time data from weather stations to predict rainfall and calculate insurance payouts, which can be automatically transferred to farmers through mobile banking		

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Indian yields improved by 60 percent after introduction of genetically modified cotton

Cotton production

Thousand kilograms per hectare



Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Tamil Nadu Precision Farming Project: An integrated approach raises farmer productivity

Pilot description

- Implemented from 2004–07 in the districts of Dharmapuri and Krishnagiri
- Covered 400 hectares with 23 kinds of vegetables planted over two years

Key technologies used

Remote sensing technology

GIS used to develop physiographic, soil, and land-use maps of the districts; precise application of nutrients based on data analyses

High-tech community nursery

Uniform seedlings raised under insect-proof netting

Chisel plough

Chisel-plough technology used for better aeration to root zone and effective rainwater drainage

Drip and fertigation system

Integrated drip irrigation and fertiliser systems ensured water economy and precise application of water-soluble fertilisers to root zone and also kept an ideal moisture regime

Other important interventions

Co-location of scientists with farmers

- Field scientists stayed in villages and provided technical support throughout growing season

Connecting efforts to market needs

- Farmers taken to markets in Cochin, Chennai, Bangalore, Safal, and Coimbatore to see the importance of minimal grading and sorting and timely delivery
- Buyers from the market were taken to the project site to showcase the healthy, high-tech production system

Impact

60–80%
Higher yield in all crops

95%
First-grade marketable produce

25%
Higher weight by volume

30%
Premium price in the market

30–40%
Water economy

5–6 days
More shelf life

- Extended harvest ensuring sales during the period of peak price
- Empowerment of farmers technically, economically, and socially
- Reduction in pesticide usage
- Availability of insurance coverage at attractive premiums

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Reuters Market Light provides real-time agricultural market information

Customised data service for farmers

Real-time information delivered via mobile phones:

- Crop advisory
- Tailored weather forecasts
- Local market price information
- Local and international commodity data
- Other relevant information

Impact

Reach

- Launched in Maharashtra in 2007; now available in 13 states, covering more than 300 crop varieties
- 1.3 million subscribers in more than 50,000 villages
- Available in eight languages and on all mobile networks and handsets

Benefits

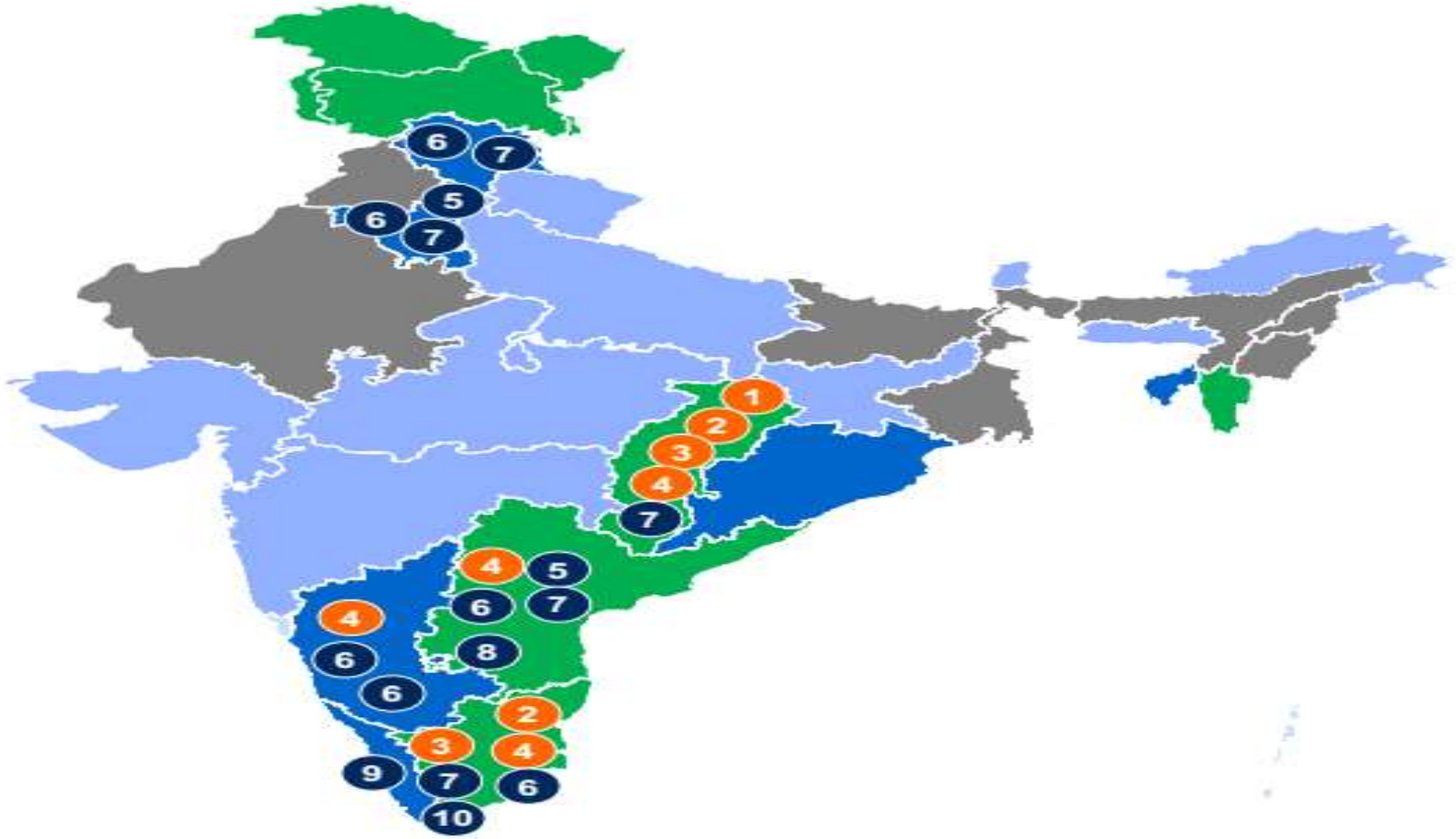
- Subscriber interviews report 5–25% increase in income
- 90% of surveyed farmers say they benefited from the service, and more than 80% say they would pay for it
- An estimated 12% reduction in price dispersion across markets

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Leakage in PDS payments has been cut by using computerised allocation, identity systems, tracking, and improved fair price shop operations

Interventions by states where more than 60% of PDS subsidy reaches consumers

PDS efficiency >80% 60–80% 40–60% <40% Technology-based reforms



Approaches used

Implementing digital systems

1. Computerised allocation of grain to fair price shops[1]
2. Web portal for addressing citizen grievances
3. Use of GPS and SMS for monitoring vehicles carrying grains and dispatch/arrival of grains

Strengthening identification mechanisms

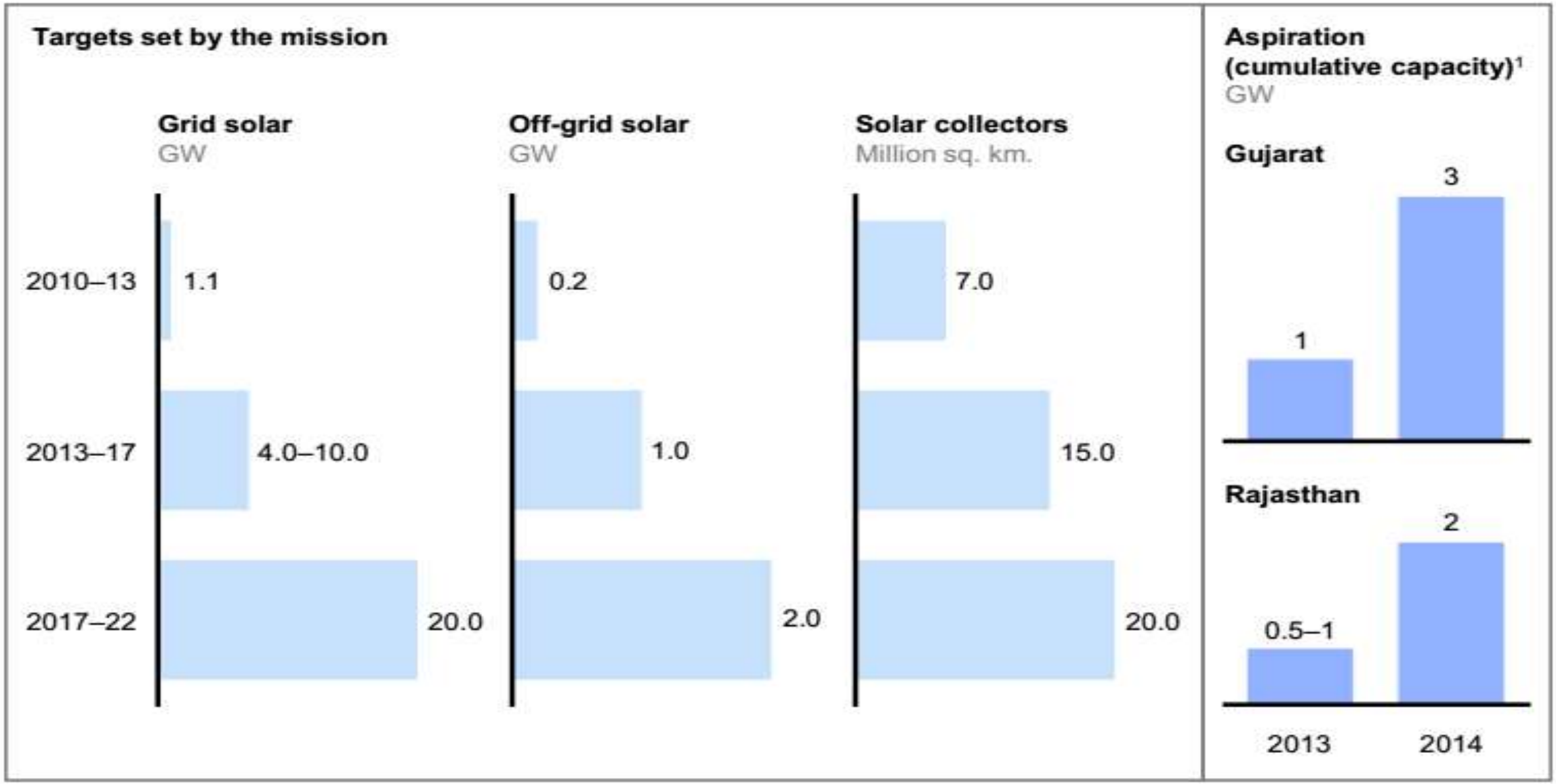
4. Digital ration cards
5. Use of *gram panchayats* (village councils) to identify qualified beneficiaries; publication of beneficiary lists
6. Ration cards with photos

Aiding operations of fair price shops

7. Direct delivery of food grain to shops
8. Sale of non-PDS items in shops
9. End of monthly quotas for shops
10. Credit for shops through cooperative banks, instead of requiring cash down payment

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

India has an ambitious National Solar Mission



Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Potential Adoption of 12 Empowering Technologies in India

Digitising life and work

	Metric	Current estimates	Realistic aspiration for 2025
Mobile internet 	Mobile Internet penetration in India	~8–10%	50–60%
	Mobile Internet users in India	100–130 million	700–900 million
Cloud technology 	Percent of SMEs with a Web presence	<10%	50–55%
	Number of SMEs that are potential cloud users	~2 million	~20 million
	Extent of cloud-based government services to citizens	Nascent	Virtually universal
Automation of knowledge work 	Number of smartphone users (potential intelligent app users)	~60 million	700–900 million
	Nature of applications	Basic, such as online information and booking	Adaptive, across sectors such as agriculture, health, education
Digital payments 	Number of retail electronic and card transactions per year	1.5 billion	12 billion
	Number of retail establishments accepting digital payments (% of total)	0.6 million (6%)	>6 million (>60%)
Verifiable digital identity 	Share of India's population with Aadhaar unique identity	~50%	~100%
	Share of financial and non-financial transactions linked to verifiable digital identity	<1%	~100% for all transactions needing identity verification

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Potential Adoption of 12 Empowering Technologies in India (contd.)

		Metric	Current estimates	Realistic aspiration for 2025
Smart physical systems	**Internet of Things** 	Number of connected devices globally	9 billion	>50 billion
		Potential number of connected devices in India	n/a	2–10 billion
	Intelligent transportation and distribution 	Penetration of smart grid technology in India	<1% of grid	60–80% of grid
		Number of cities in India with some form of smart transport	<5	At least 50 (all current Tier 1 and Tier 2 cities)
	Advanced geographic information systems (GIS) 	Scope of GIS assets in India	Basic satellite images of forests, ground-water, soil, minerals from multiple agencies	Integrated, up-to-date, easy-to-use maps overlaid with diverse geo-tagged data including 3D, under-ground, and crowdsourced data
		GIS-based applications in India	Used by a few state governments; few apps for citizens	Ubiquitous GIS apps for decision support by all segments
	Next-generation genomics 	Hectares under hybrid and genetically modified crops in India (% of total planted area)	18 million ha (9%)	40 million ha (20%)
		Medical therapies based on advanced genomics	Nascent	Personalised therapies for 0.5–1.5 million patients; prenatal screening of 5–10 million births

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Potential Adoption of 12 Empowering Technologies in India (contd.)

Rethinking energy

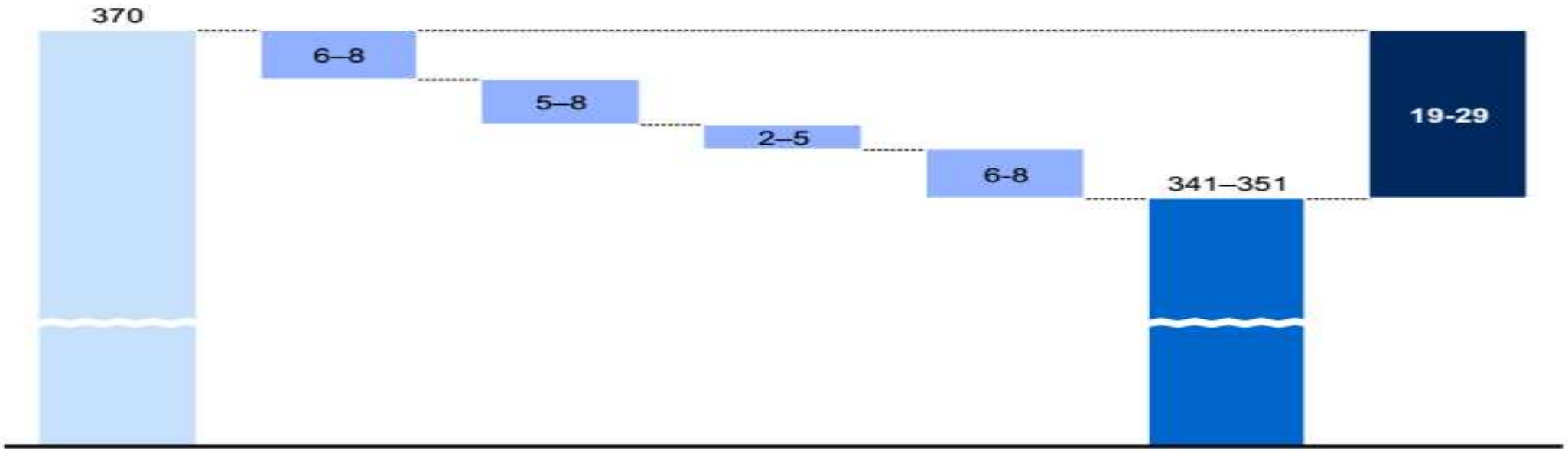
	Metric	Current estimates	Realistic aspiration for 2025
Advanced oil and gas exploration and recovery 	Unconventional gas production	~10 billion cubic feet	~235 billion cubic feet
Renewable energy 	Solar energy generating capacity (in gigawatts)	1.7 GW	43 GW
	% of total generating capacity from solar	0.7%	9%
Advanced energy storage 	Storage cost per megawatt-hours of energy	~$300	~$80
	Storage applications	Only large users	Universal use

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

19 million–29 million non-farm jobs could be affected, implying a need for new employment opportunities and skills training

Non-farm jobs potentially impacted by the 12 technologies, 2025

Million



	Baseline non-farm labour force, 2025	Knowledge-based jobs[1]	Manufacturing jobs	Construction jobs	Trade, hospitality, transport, and other	Non-farm labour force with 12 technologies	**Workers needing new skills to maintain baseline**
Efficiency improvement rate[2] %		40–50	10–15	10–25	10–15		
Million addressable jobs in 2025[3]		17	78	95	180		
Adoption rate of technology applications[4] %		100	70	20	30		

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Seven Technology Applications can Transform India's Financial Services Sector

Universal electronic bank accounts 	Zero balance accounts for all citizens above the age of 18, enabled by a unique verifiable digital identity	**Technology-enabled business correspondents** 	Agents appointed by banks to deliver basic financial services to non-tech users through mobile phones or micro-ATMs
Mobile money 	Cashless transactions for retail, merchant, and personal payments, using mobile phone-based money transfer systems	**Digital government transfers and payments** 	Government payments and transfers using verifiable digital identity, mobile payments, and universal electronic bank accounts to cut leakage
Advanced credit underwriting 	Use of unconventional data such as telecom payments to provide credit to the unbanked and improve underwriting and pricing for all customers	**Enhanced customer experience** 	Simple, integrated, intuitive, and personalised financial products and services on mobile and other channels
Digitally enabled sales and fulfilment 	Personalised, analytics-based customer acquisition, straight-through processing, and automatic provisioning, with virtual servicing and administration		

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Digital benefits transfers with mobile money can improve efficiency and reduce leakage

Identify beneficiaries

Using verifiable digital identity

Check conditions

School enrolment

Criminal records check

School attendance

Family health checkups

Disburse benefits

Female member of family is issued prepaid smart card or receives mobile money transfer

Staggered disbursement to avoid consumption spikes

Redemption

Withdrawal through micro-ATMs

Withdrawal at retail stores

Mobile money transfer

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Big data–based underwriting tools are being used to extend credit

New initiatives in the United States

zest

Uses thousands of variables in combination with machine learning to develop multiple models that "vote" on whether to make a loan

Kreditech

Creates credit scores based on online behaviour, including location data, social network data, web surfing, e-commerce behaviour, and device used

Kabbage

Makes loans to small online sellers based on transaction patterns, UPS shipping data, and social network data, such as number of Twitter followers

New initiatives in emerging markets

M-Shwari

Credit and savings program built on M-Pesa in Kenya; underwrites using mobile calling, texting, and payments data; threat of cutting off mobile access in case of non-repayment

CAPITEC BANK

South African startup serving lower mass market (2.5 million customers); uses transaction habits of previously unbanked for underwriting

cignifi

Latin America–focused bureau for mobile operators creates credit and propensity-to-buy scores based on calling and texting patterns

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Eight Technology-based Services can Transform Education in India

E-administration of educational institutions 	Computerised admissions, fee and vendor payments, payroll, student performance tracking	**Verifiable digital identity attendance systems** 	Attendance monitoring of teachers and students using biometric ID or smart cards
Tech-enabled teacher assess-ment, training, certification, collaboration 	Automated performance tracking; cloud-based review, training, and certification; social platforms to share curricula and content	**Low-cost instructional devices** 	Tablets and other inexpensive devices for instruction and content delivery
Adaptive learning 	Instructional software that monitors progress through frequent assessments and tailors lessons and drills for individual students to ensure mastery of skills and content	**Blended learning with MOOCs** 	Delivering MOOCs (massive open online courses) to classrooms with teachers to facilitate discussion and learning
Learning simulations for skills training 	Simulations for hands-on training in nursing, business, and other disciplines using immersive learning software, virtual reality, dummies/machinery with sensors	**Labour portals** 	Online platforms with job listings and requirements, market data, and career planning resources; employers use portals to recruit, and workers can post résumés and use portal information to make better-informed decisions (such as field of study)

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Nine Technology-based Services can Transform Health Care in India

Remote health care 	Access to expert medical advice via video chat over mobile Internet	**Technology-enabled health workers and health-care centres** 	Health workers and government health-care centres using cloud-based apps to manage patient enrolment, diagnosis, treatment, medication, and follow-up
Automated inpatient care 	E-learning and simulated learning to shrink training time for nurses; smart ICU systems for reminders, protocols, alarms, and recording patient data	**Electronic medical records** 	Easily accessed and consistent medical histories and clinical decision-support systems for improved care across locations and over time; accessible to patients with a variety of providers
Low-cost medical devices 	Affordable point-of-care diagnostics and mobile diagnostic capabilities for local health workers through easy-to-use medical devices that leverage low-cost Android smartphones	**Remote monitoring** 	Low-cost portable monitors that track health parameters; advanced drug delivery systems that provide customised dosing and remote monitoring
Big data disease tracking 	Detection and mapping of disease outbreaks; prevention and containment of epidemics; planning treatment capacities; tracking of progress using smartphones and social media	**Genomics-based medicine** 	Cheaper and faster gene sequencing to identify patients at risk for serious diseases; tailored therapies based on genetics of patient/tumour
Detection of counterfeit drugs 	Unique serial numbers, electronic tagging, and tracking technologies used at each stage of supply chain to detect and reduce counterfeiting		

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

In Uganda, technology has made farmers community knowledge workers

Traditional model: Farm extension worker

Too few workers	One farm extension worker for every 3,000 farmers
Low coverage	Services reach a small fraction of the farming population
High cost	Face-to-face field schools are expensive
Limited knowledge sharing	Mobile apps and written material not effective due to high illiteracy

Grameen: Tech-enabled community knowledge worker (CKW)

More resources	One CKW for every 160 farmers; more jobs for low-skilled agricultural workers
Higher coverage	Extension services reach most rural villages
Low cost	Cost per farmer is less than one-sixth of traditional programmes
Accessible knowledge	CKW can bring knowledge database to illiterate farmers

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Six Technology-based Services can Transform India's Energy Sector

Unconventional oil and gas 	Technologies such as non-water fracking, horizontal drilling, and fracture modelling enable recovery of previously inaccessible reserves including shale gas, coal-bed methane, and tight oil	**PV solar** 	On-grid and off-grid photovoltaic solar can reduce use of carbon-based fuels, limit emissions, and bring power to remote areas
Offshore wind, solar, and seaweed 	Offshore wind, solar, and seaweed biofuels, which do not require land and fresh water, may become sources of clean energy in India	**Smart metering** 	Smart meters enable demand management schemes, peak pricing, and theft detection to reduce losses
Advanced energy storage 	Low-cost and efficient energy storage devices (batteries) can bring power to remote areas, enable use of renewables, and make the grid more reliable	**Energy efficiency** 	Energy-saving measures such as use of CFL lighting and energy-efficient irrigation pumps; raising efficiency of power plants and trucks

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Energy-efficient technologies can help reduce energy use across sectors

Sector	Description	Possible interventions
Residential 	▪ Buildings account for ~30% of electricity used in India ▪ Potential energy savings in new buildings is 40% or more	▪ Increase penetration of CFL/LED bulbs from current 10% in residential to 90% ▪ Increase penetration of BEE Star-labelled appliances from ~20% to 90%
Agriculture 	▪ Pump sets account for ~20% of total agricultural energy demand	▪ Mandate use of BEE Star efficient pump sets for new connections ▪ Replace more diesel pumps with electric pumps
Power 	▪ Inefficient power plants ▪ T&D losses are ~24%	▪ Use supercritical technology and other improvements to raise efficiency of coal plants from 38% to 41% ▪ Implement national smart grid to cut theft by up to 90%
Transport 	▪ Fuel efficiency of Indian trucks is low ▪ Limited use of bio-ethanol fuel blend	▪ Investments in better technology for transportation ▪ Implement national biofuel policy to blend 5% bio-ethanol in petrol and diesel

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

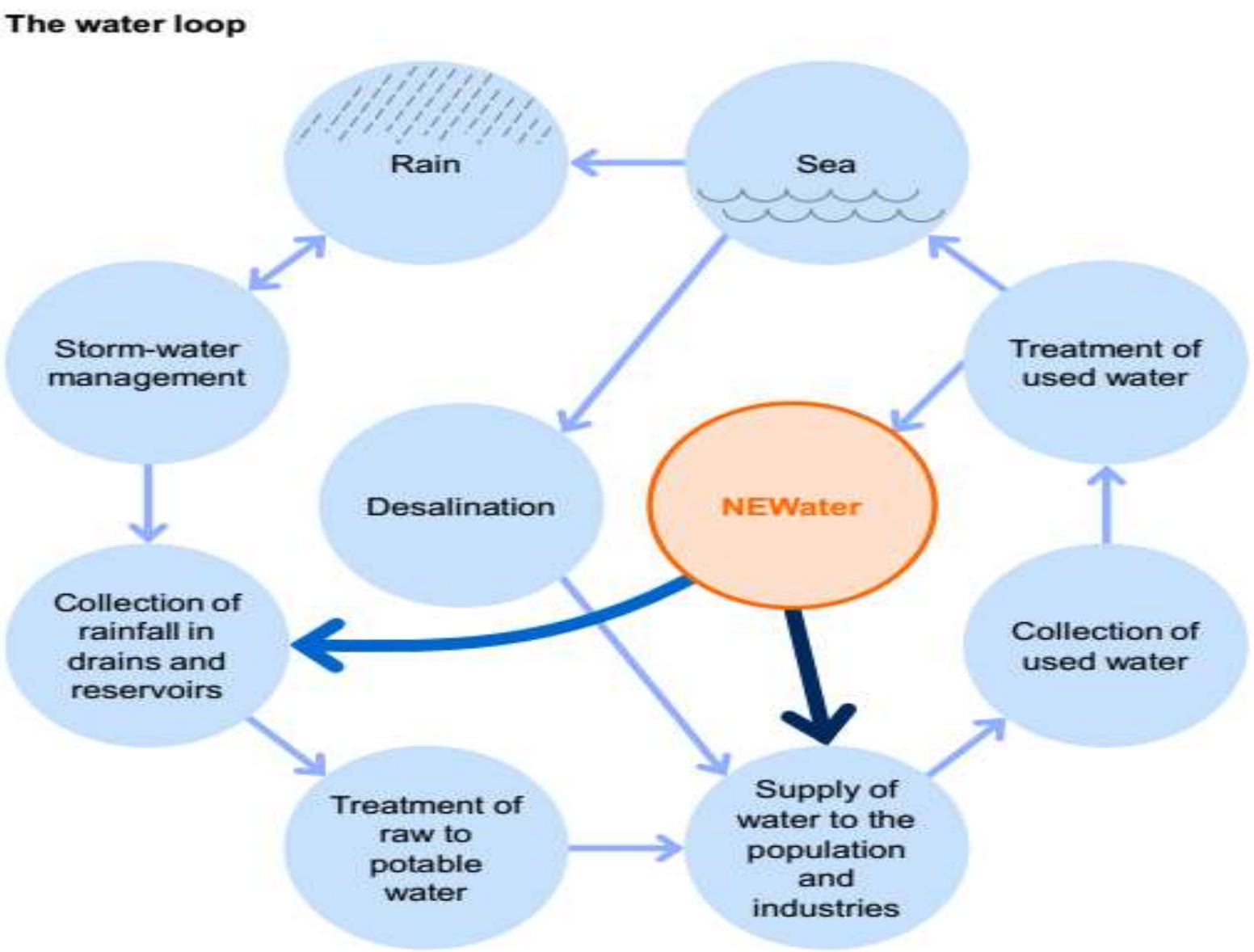
Six Technology-based Solutions to Improve India's Infrastructure

Smart cities 	Technology-based and data-driven urban planning and management approaches to improve energy efficiency, efficiency of public services, and quality of life; enabling economic growth	**Intelligent freight logistics** 	A range of technologies and applications (such as container number recognition and RFID tags) to track freight and manage the flow of cargo
Smart highways 	Internet of Things technologies such as sensors and cameras to monitor traffic flow, making possible real-time congestion planning, automated toll-collection, and access control	**Advanced water treatment systems** 	Nanofiltration and zero-liquid discharge to remove harmful dissolved solids, reduce effluent discharge in water, and enable wastewater reuse
Next-generation construction methods 	Adoption of new methods and materials such as prefabricated cast concrete to improve efficiency of infrastructure construction and other types of building	**IT-enabled project management systems** 	Modern IT systems to manage infrastructure projects and eliminate inefficiencies in procurement and other processes

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Singapore fills 30 percent of its water needs with reused water

The water loop



Indirect potable use

Direct non-potable use

NEWater turns wastewater into industrial and potable water

- $67.5 million (SGD 116 million) invested in 2003 to increase amount of wastewater treated
- Treated wastewater meets US environmental and World Health Organization standards for clean, potable water
- Demand for NEWater has grown 15-fold, from 4 million gallons (18,200 cubic metres) per day in 2003 to some 60 million gallons (273,000 cubic metres) per day today
- Primarily used for non-potable purposes in semiconductor manufacturing, air conditioning, and power industry
- Slowly introduced into reservoir water: 1% of domestic consumption, expected to rise to 3.5% by 2060

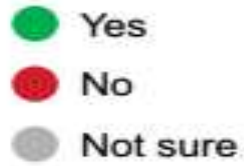
Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

Putting government data and services online can create value in six ways

Government efficiency initiatives 	Using IT systems to raise the productivity and effectiveness of government operations such as tax collection	**Online citizen services** 	Direct access to government information; self-service transactions, such as obtaining birth and death certificates, registering land, and applying for a passport
Online business services 	Simplified online processes to obtain business licenses, pay taxes, and comply with regulations	**Connections to other governments** 	Enabling effective collaboration across borders (interoperable digital identities and electronic visas, for example)
Open data 	Sharing government data sets (land records, geological data, demographics, GIS data) to enable new applications, products, services, and business models	**Enabling infrastructure and technology platforms** 	Hardware, connectivity, and software platforms (such as wide area networks, servers, and cloud) to offer e-government services

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

India has taken initial steps to create open databases but needs to make them more user-friendly



Data set	Score %	Do data exist?	In digital form?	Publicly available?	Machine readable?	Available in bulk?	Up to date?
Transport time tables	15	Yes	Yes	Yes	Not sure	No	No
Government budget	25	Yes	Yes	Yes	No	Yes	No
Government spending	15	Yes	Yes	Yes	No	No	No
Election results	35	Yes	Yes	Yes	No	No	Not sure
Company register	15	Yes	Yes	Yes	No	Not sure	No
National maps	15	Yes	Yes	Yes	No	Not sure	No
National statistics	35	Yes	Yes	Yes	No	Yes	Yes
Legislation	25	Yes	Yes	Yes	No	Yes	No
Post codes/Zip codes	0	Not sure	Not sure	Not sure	No	Not sure	Not sure
Emissions of pollutants	35	Yes	Yes	Yes	No	No	No

Source: McKinsey Global Institute (2014). India's technology opportunity: Transforming work, empowering people

To Exploit the 4th Industrial Revolution Fully

- Pursue a Total Governance Approach
  - Public, Private, Community Organizations, Civil Society and Citizens!
- Increase Investments in Physical Capital
- Increase Investment in Human Capital
- Improve Regulatory Frameworks
- Understand it as a dynamic, highly interactive, adaptive process

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