Organizing International Science for Environmentally and Socially Sustainable Agricultural Development in a Globalized World: The U.S. Case[1]

Uma Lele[2,3]

[1] A paper prepared for presentation at the 1998 American Association for the Advancement of Science (AAAS) 150th Anniversary Annual Meeting and Science Innovation Exposition, February 12-17, 1998, Philadelphia, Pennsylvania. I am grateful to Gary Alex, Jock Anderson, Ronnie Coffman, Hunt Davis, David Hansen, Ravi Kanbur, William Lesser, Francisco Reifschneider and Ismail Serageldin for comments on an earlier draft, and to Jason Yauney for research assistance.

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List of Acronyms

CGIAR	Consultative Group on International Agricultural Research
CRSPs	Cooperative Research Support Programs
EAP	East Asia and Pacific Region
ECA	Europe and Central Asia Region
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária
FAO	Food and Agricultural Organization
IARCs	International Agricultural Research Centers
IFAD	International Fund for Agricultural Development
GASEPA	Globalizing Agricultural Science and Technology Education Programs for America
GDP	Gross Domestic Product
GREAN	Global Research on the Environmental and Agricultural Nexus
IDA	International Development Association
IPR	Intellectual Property Rights
LAC	Latin America and Caribbean Region
MNA	Middle East and North Africa Region
MTA	Material Transfer Agreements
NARS	National Agricultural Research Systems
NASULGC	The National Association of University Land Grant Colleges
NGOs	Nongovernmental Organizations
NIH	National Institute of Health
NRI	National Research Initiative
PROCISUR	Programa Cooperativo para el Desarrollo Tecnologico Agropecuario del cono Sur
PVP	Plant and Variety Patents
QIPG	Quintessential Public Goods
SAS	South Asia Region
SSA	Sub-Sahara Africa Region
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USPO	U.S. Patent Office
WTO	World Trade Organization

Organizing International Science for Environmentally and Socially Sustainable Agricultural Development in a Globalized World: The U.S. Case[4]

Uma Lele[5,6]

1. Introduction

The Green Revolution in developing countries in the mid 1970s was a revolution fueled by science. It substantially increased agricultural productivity and saved millions of lives. U.S. public sector and private foundations dominated in supplying the science and technology which generated the Green Revolution (Lele 1989 and 1995). The U.S. also reaped large benefits to its own economy. International rice and wheat research investments of $130 million alone yielded benefits worth $15 billion to U.S. agriculture (Pardey, et al. 1996). Biological science has advanced dramatically in recent years. Cloning of animals and building resistance to pests and diseases in plants can be achieved with precision and speed inconceivable just a few years ago. The U.S. has been at the center stage of this biological revolution. Agricultural development challenges in the developing world too have increased dramatically since the first Green Revolution. Yet U.S. support to international agricultural research has declined precipitously, both multilaterally to the Consultative Group on International Agricultural Research (CGIAR) as well as bilaterally in developing countries to the development of National Agricultural Research Systems (NARS), for advanced degree and nondegree training to agricultural professionals, and

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to agricultural development programs. U.S. Agency for International Development (USAID) funding for 587 research activities from 1952 to 1996 amounted to $3.62 billion (Alex 1996). Yet from 1985 to 1996, USAID support to international agriculture and USAID agricultural staff, each, decreased by 66 percent, whereas support to NARSs declined by 71 percent (Alex 1996). U.S. presence in agricultural research or development activities has virtually disappeared in most large low income countries such as India or Pakistan, or middle income countries such as Brazil or Mexico. These countries are either booming markets or actual or potential competitors for U.S. agricultural products. For both reasons, U.S. presence in the development of these countries would seem to be of strategic importance. Yet, U.S. bilateral support to agriculture is now present mainly in the small least developed countries of Africa, Central America and South Asia, or in the countries of strategic interest such as Egypt. No doubt this is a result of advancement in developing countries, but also one of decline in overall U.S. assistance and changed priorities within the limited assistance to such areas as democratization, private sector development and Eastern Europe. All reflect the dramatic changes in the geopolitical and economic situation since the fall of the Berlin Wall.

To mobilize the much needed U.S. support for international agricultural science and technology, a taskforce I co-chaired[7] with Ronnie Coffman[8] over the 1993-95 period, called for a bold new United States-funded initiative reaching a level of up to $100 million of new money annually in three to five years. The Initiative was conceived by a group of experienced scientists from U.S. land grant universities, International Agricultural Research Centers (IARCs) of the CGIAR and the NARSs of developing countries (Lele and Coffman, eds. 1995). It called for the establishment of a competitive grants program on priority research and development issues of global and regional importance in the areas of the environment and agriculture. The taskforce, funded by the Ford and Rockefeller Foundations, with additional funding support from the University of Florida and Cornell University and aided by a subsequent grant from the McKnight Foundation, called it GREAN (Global Research on the Environmental and Agricultural Nexus). GREAN's goal would be to meet the pressing triple challenges of global hunger, environmental degradation and rapid population growth still facing the world community at the dawn of the 21st century. The competitive grants program would bring to bear the best of those U.S. science and technology experts committed to work internationally, in collaboration with researchers in IARCs and NARSs. Together they would generate the next generation of environmentally friendly location specific mini-green revolutions throughout the developing world. Research priorities would be defined by the needs of the ultimate beneficiaries of research, namely the producers and consumers in developing countries, in consultation with the scientists in the U.S., the CGIAR centers, and developing countries. The programs in research and technology transfer would be carried out in such areas as soil and water management, germplasm improvement, food, water and air quality improvement, biological control of weeds, pests and diseases, etc.

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The report outlined the benefits such investment would bring globally and to the U.S. These investments may be characterized as leading to the generation of "quintessential international public goods" (QIPG). QIPG are generated by research and technology transfer activities which are needed due to a combination of market failure, and economies of scale and scope in their conduct. Such research needs considerable investments. Their benefits, while large, are slow to materialize, are difficult to capture for individual investors, and therefore would not attract private investment. Even if individual public sector research systems of advanced and developing countries each meet the demands of their respective clients efficiently they would not be able to achieve individually the goals that can only be achieved through international collaboration (Winkelmann 1994). Yet if undertaken, such collaborative *public investments*, would achieve global good of a kind which would not be achieved without them. A recent U.S. Commission on International Trade, Development and Cooperation headed by Whitney MacMillan with many distinguished U.S. citizens as its members reached many of the same conclusions in 1997, although it did not articulate a specific program as did GREAN for spending additional resources that the U.S. Congress may allocate to international agriculture.[9]

Regrettably a U.S. funded global competitive grants program has not yet materialized. Nevertheless, the global agricultural research community has made important strides in embracing the ideas envisaged by the GREAN Initiative. In the meantime the GREAN Initiative is evolving into an innovative mechanism operated by a coalition of 20 major U.S. land grant universities to establish long term collaborations in research, technology transfer, training and institutional development with those developing countries which demand such collaborations and which are increasing their public investments in agricultural research, among other things, with loans and credits from the World Bank. GREAN has become operational in Brazil and the Southern Cone countries of Latin America, with potential for it to expand in other parts of the world. The ideas being piloted in GREAN are also being developed by networks of European universities, albeit with greater government support. This paper outlines the reasons why the GREAN Initiative was conceived, possible reasons for the insufficient U.S. political support noted for it to date, lessons learnt in its operationalization, and their incorporation in the further development of international scientific collaborations in a new global context. The paper stresses the importance of the U.S. resuming leadership in international science for sustainable agricultural development at the global level.

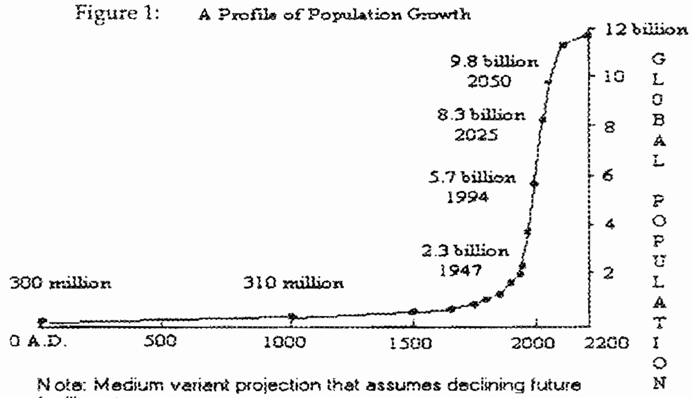
2. Reasoning Behind the GREAN Initiative

The 1992 Rio Conference served to heighten public awareness to the wide range of critical global environmental issues. The 1993 Cairo conference brought to the public attention the world's surging population growth, expected to reach between 10 billion to 12 billion by 2050 even under the most optimistic assumptions (see figure 1). The 1994 IFAD (International Fund for Agricultural Development) led NARSs declaration emphasized the need to strengthen the NARS' own capacity. The 1995 Beijing conference underlined the importance of improving

[9] Its members included Wane Boutwell, H.D. Cleberg, Rita Colwell, John Costello, John Hagaman, Dean Kleckner, Peter McPherson, G. Edward Schuh, John G. Stovall, Leland Swenson, Robert Thompson, Tom Urban, Ann Veneman, G. Clifton Wharton Jr., and E. T. York.

women's status, and the 1996 FAO (Food and Agricultural Organization) World Food Summit, held a year after the issuance of the GREAN report, stressed the central importance of increasing agricultural productivity to feed the global population. These various concerns are reflected in the vision statement of the CGIAR (CGIAR 1994 and Conway 1997).

Figure 1: A Profile of Population Growth



Note: Medium variant projection that assumes declining future fertility rates.
Source: Unite Nations Population Fund, 1994.

Unlike research in other sectors, agriculture has had a long tradition of public sector involvement, even in advanced countries. Indeed, even though the recent biotechnology revolution has stimulated substantial private sector investments in agricultural research, the public sectors of advanced countries, including the U.S., have maintained a significant presence in agricultural research. Yet the growing importance of private sector investments has profoundly changed the nature of the public sector role in agricultural research. These developments have vast implications at the global level. The GREAN report argued that a major goal of collaboration led by the three sets of *public institutions*, namely the U.S. land grant university system, IARCs and NARS would be to increase the scientific content of international cooperation, develop the capacity of developing countries' NARS to rapidly transmit already known technologies and *generate new sustainable technologies to be made freely available for the benefit of the poor households in developing countries.* Although led by the public sectors it would solicit active participation of private sector seed, fertilizer and chemical industries, nongovernmental organizations (NGOs) and farmers' organizations in the design, implementation and dissemination of results of the programs.

The report argued that the tasks now facing developing countries are so massive, and yet the gap between advanced industrial countries and developing countries, in science and technology including particularly the associated evolution in the organization and management of science and intellectual property, is so vast *and increasing*, that an enhanced effort is needed at the international level to build the capacities of developing countries to bridge the gap and meet the challenges they face. For ethical as well as pragmatic reasons, such effort must come from the public sectors of both developed and developing countries.

3. Synergy Between Agricultural Growth in Developing Countries and Global Growth

Some claim that the excess productive capacity in the United States can easily feed the world. But the GREAN Initiative argued that a large share of the future growth in food and fiber production to meet the growing demand must occur in developing countries by engaging the poor themselves (CGIAR 1994 and Conway 1997). It is the only way of creating livelihoods, increasing food security, lowering human fertility, protecting natural resources and establishing a foundation for long term and broadbased economic growth in developing countries, where nearly 1 billion poor reside. Most make a paltry income of less that $1 day. Most reside in rural areas and derive their livelihood directly or indirectly from agriculture (broadly defined to include livestock, aquaculture/fisheries and forestry). These poor are also the world's guardians of biodiversity, most of which resides in tropical countries.

Agriculturally based growth constitutes the surest means of stimulating demand for U.S. goods and services and protecting the world's disappearing natural resources. Countries that experience rapid agricultural growth also experience rapid overall economic growth. Economic growth in turn creates additional demand for food and fiber through a combination of income and employment growth, urbanization and changing tastes and preferences, typically at a rate higher than can be supplied by even the most dynamic agricultural sectors of developing countries. Quite paradoxically, this means countries with rapid agricultural growth also increase imports of agricultural commodities and services rapidly. The increased demand is typically met by imports from advanced industrial countries such as the United States, and is paid for by developing countries with their own surging exports. For example:

- U.S. agricultural exports to developing countries increased by $9 billion from 1986 to 1993, a significant portion to Asia creating additional 270,000 jobs.
- U.S. involvement in the establishment of the CGIAR, while providing developing countries a wider range of plant genetic material has also increased U.S. access to germplasm. More than two thirds of the rice and wheat cultivated in the U.S. are derived from improved germplasm developed at the IARCs. A single Ethiopian variety protects the barley production worth $160 million in California.
- U.S. scientists working overseas have helped to internationalize U.S. higher education while bringing to bear their international knowledge to address domestic problems.
- Agricultural productivity growth in developing countries has conserved biodiversity by saving 300 million hectares of land that would have been brought under cultivation to feed the growing population.

In a rapidly integrating and interdependent world there are also potential costs of neglect of the triple challenges by the U.S. They include:

- growing hunger, poverty and resource degradation in the developing world leading to ethnic strife such as that noted in the Chiapas region of Mexico, or in scores of countries in Sub-Saharan Africa;

- frequent U.S. humanitarian and military interventions making demands on the U.S. budget and U.S. human lives;
- loss of potential markets to the U.S. that broadbased and sustainable development in developing countries would ensure;
- rapid loss of biodiversity in plant and animal life, that science based agriculture would avert;
- worsened global warming;
- greater international migration;
- costly containment of imported pests and diseases which endanger U.S. plant, animal and human health and saddle U.S. agricultural producers and consumers with billions of dollars of damages, and;
- risk of increased use by the U.S. of non-tariff barriers on imports of agricultural commodities from developing countries that lack intellectual property protection, trade secrets protection and phytosanitory standards to meet World Trade Organization (WTO) rules, leading to smaller than desirable level of global trade, with adverse effects on global prosperity.

Developing countries' ability to increase production will depend on *their* ability to play a central role in dealing with these challenges of technology generation and diffusion. A great challenge is to help NARSs in developing countries to be productive in *their home countries* where severe constraints currently impact on their ability to deliver research and its effective transfer.

Establishment of a new competitive grants program would be the best way to build on the existing strengths of the three sets of public institutions, none of which can do the task at hand individually. These strengths are:

- The U.S. possesses the single largest pool of scientific talent in the world, with total public and private annual investments in agricultural and related environmental research of over $10 billion. It draws on the research of 23,000 Ph.D.s in agricultural sciences supported by the work of an additional 46,000 Ph.D.s in related fields allowing spin off for instance of medical research to research on plants and animals. R & D expenditures in agricultural biotechnology in the U.S. alone were estimated to be $2 billion in 1996 (ISAAA 1996). The latest corn genome project of the U.S. Congress is poised to launch is an indication of the promise of biotechnology (Cohen, Science 1997). The proposed budget of the National Institute of Health (NIH) for 1997 alone is $13 billion.
- Even after the decline of U.S. bilateral aid, the U.S. remains the world's largest provider of higher education to nationals of developing countries. Most of this is now either privately funded or funded by the governments of developing countries, e.g. nearly 70 percent of the Brazilian agricultural scientists with Ph.D.s in agriculturally related sciences today have been trained in the U.S. The small USAID-funded Cooperative Research Support Programs (CRSPs) discussed later in the paper, trained 1700 agricultural scientists since its inception in 1975 (Alex 1996). But the graduate training has now ended due to the decline in USAID funding (personal communication with Gary Alex). Due to the high cost of U.S. education, particularly in the current periods of rapid currency devaluations, developing countries are less able to finance such higher education. In turn the lack of a critical minimum mass of scientists trained in the modern systems of science management, limits the ability of

developing countries to bring about the necessary improvements in the organization and management of their own agricultural research systems. Research productivity and its impact are important indicators of scientific performance in advanced countries, but such objective criteria of accountability tend to be absent in developing countries.

- The strength of the CGIAR centers lies in their global reach, ability to convene a large number of international partners, collection of the world's largest repository of germplasm estimated to be 650,000, and an impressive track record in improving germplasm collaboratively with the NARSs of developed and developing countries for the benefit of the poor. But the annual outlay of the CGIAR for its 16 IARCs amounts to only $300 million and the CGIAR engages only about 900 scientists. The CGIAR centers already draw heavily on the U.S. expertise. During 1990 to 1995, 15 of the 16 IARCs had collaborative linkages with 89 U.S. universities resulting in a total of 263 separate linkages between them. Nearly 80 percent of those linkages were with land grant universities (Collins 1996). Yet these interactions tend to be of limited scope and duration and could be enhanced considerably if more resources were available.
- The NARSs are closest to the farm households and local problems. They have developed considerable scientific capacity in the last two decades. The total number of agricultural scientific staff in developing countries of 86,000 now equals that of developed countries (Pardey 1991). NARSs have comparative advantage in applied and adaptive research, extension and other related technology transfer functions. There is, however, great variability among NARSs. Those of large countries such as China (50,000 scientists), India (30,000 scientists) and Brazil (5,400 scientists,-a number which understates its scientific capacity since only the research time of the staff teaching in agricultural universities is counted) are also able to conduct basic and strategic research while resources barely suffice for adaptive research in small countries, many in Africa, whose donor dependence for research investments has also increased (Lele 1995).

4. Changing Pressures on Agricultures of Developing Countries

New and bold mechanisms are needed to bring the latest science to bear on the problems of developing countries' agriculture because the pressures of rapid population growth have caught up with the Green Revolution's gains. Stagnating agricultural production combined with widespread environmental degradation once again raise concerns of massive poverty and hunger, particularly in Asia and Africa where nearly 80 percent of the global poverty resides. In the wake of the first Green Revolution a new set of second generation problems has emerged including water logging and salinization of soils, depletion of groundwater tables, soil erosion, loss of crop diversity, contamination of water with agro-chemical residues and multiplying health hazards. Marginal return to the additional use of chemical inputs has decreased and even become negative. Increasing productivity has become more complex than ever before. In all but the least developed developing countries, such as those in Africa where modern input use is very low, productivity increases must now be brought about with the minimum additional use of chemical fertilizers, pesticides or water. *In the face of the looming land and water shortages agriculture must shift from input intensity of farms to knowledge intensity of farm households.* This poses immense demands on the scientific and development communities.

Indeed, developing countries are trying to achieve the institutional diversification needed to meet these challenges in less than 10 to 15 years whereas the U.S. achieved these same changes over a period of a century, for example, of establishing intellectual property management-related legislation and capacity for its implementation, fostering private investments and public-private partnerships, and more generally shifting from a monopoly of public research institutions to a more diversified system of research and technology transfer involving universities, the farmer's organizations, seed and fertilizer companies and extension services. While agricultural research and technology transfer systems are undergoing such reforms, other economy-wide reforms also have profound implications for the management of science and technology. For instance, the acquisition by multinational corporations of seed companies in developing countries and the related expansion of transgenic field trials has far reaching implications for the management of biosafety regulations and the scope of research by public research institutions of developing countries. During 1986 and 1996 more than 3,500 permits were granted for the conduct of more than 15,000 transgenic field trials consisting of at least 55 crops in 35 countries. Approximately 70 percent of these trials were conducted in North America and an additional 20 percent in Europe—although the first commercial transgenic field trial was conducted with tobacco plants in China—with the balance conducted in developing countries such as China, Argentina, and Mexico (ISAAA 1996). By year 2000 the global transgenic market is expected to grow to $2 to $3 billion and by 2005 to $6 billion. To date commercial crops such as corn, canola, cotton, tomatoes, tobacco and soybeans have been the main beneficiaries. But biotechnology can offer solutions to such problems as streak virus in the maize grown by the poorest farmers in Africa or to black Sigatoka, Fusarium wilt, nematodes and viral disease in the bananas and plantains grown by poor farmers in the Caribbean, Latin America and Africa. Benefits of biotechnology accrue from improved and more efficient weed control, insect and pest control, decreased post harvest losses, better shelf life, delayed ripening, improved nutrition, decreased losses from viruses and decreased pollution. Yet the release of genetically modified organisms has been a matter of intense debate even in the U.S. Exotic organisms have the potential to impact on their new environment leading to a complex set of risks and benefits. Developing countries have little internal capacity to monitor the impacts of these releases. They require biosafety guidelines to release and assess risks, through mechanisms such as national review bodies, but most importantly they need to develop human capital and a regulatory culture.

Regrettably while the demands on global agricultural research are mounting, resources available for such research are shrinking. International protection provided for an invention from one country by other countries is a case in point. It is now an integral part of trade negotiations, therefore important to international competitiveness and a major policy issue nationally and internationally. Mutual retribution for illegal infringement of intellectual property rights (IPRs) between the U.S. and developing countries has become an increasingly frequent occurrence. Legal systems for securing private rights to inventions entail diverse set of protection including (1) seed and breed certification; (2) copy rights; (3) trade secret enforcement; (4) invention patents; (5) utility models or petty patents; (6) inventor's certificates; (7) industrial design patents; and (8) plant and variety patents (PVP) (Evenson 1990). IPRs are the strongest in the U.S., developed through a series of court decisions, administrative decisions and changes in trade laws. They are greatly reducing the supply of new knowledge and technology to developing countries, unlike in the past when public sector dominated in basic and strategic research. With the patent protection now being given for living plant and animal organisms, these laws and their enforcement promise to be an increasingly important issue in the interactions among developed and developing countries, and the CGIAR centers. Section 7 below illustrates, in the case of Brazil, its potential significance for the training of students on U.S. campuses, or collaborative research between U.S. and Brazilian scientists. Evenson observes that the U.S. has tended to focus on protecting private intellectual property as being essential to stimulating private investment, whereas developing countries have tended to address the moral and ethical issues involved in protecting private intellectual property, arguing that poor's access to improved germplasm through biotechnology , and the rewards to the poor for their stewardship of natural resources, is essential on ethical and equity grounds (Evenson 1990).

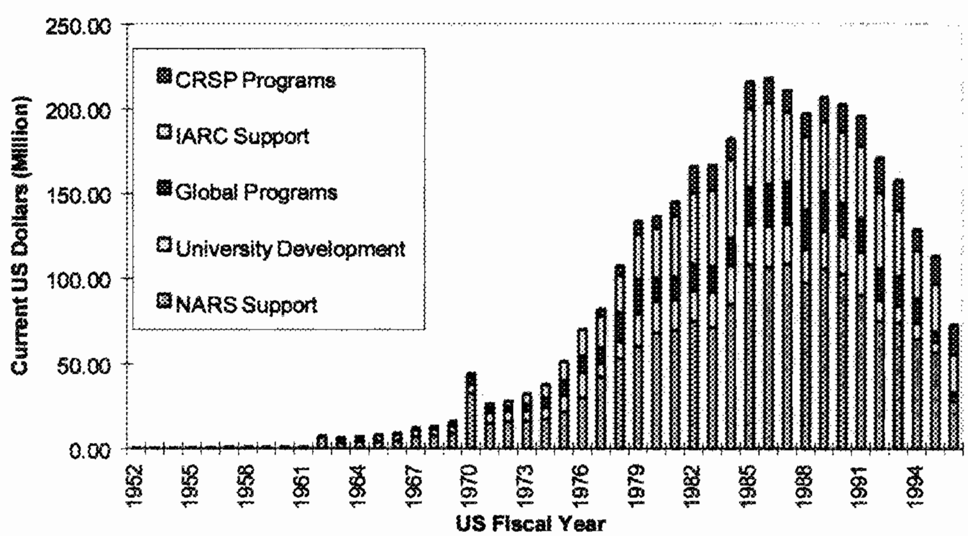
To date developing countries have provided very little protection to intellectual property, although recently many have passed laws which offer protection in some or all of the above areas. Yet, their implementation is a serious problem. Most countries do not have the legal training, institutions and the cultural tradition of protecting intellectual property. Simultaneously the foreign share of patents awarded by the U.S. Patent Office (USPO) has been increasing as have biotechnology patents. From the U.S. perspective, countries with considerable adaptive capacity—countries that Evenson calls technology imitators—have the highest potential to be seen as potential "biopirates," and therefore have the most contentious issues to resolve with the U.S. in international collaborations, technology transfer, etc., relative to poor countries who have no such capacity and therefore are not a threat. By the same token, developing countries have increasingly become concerned that the traditional indigenous knowledge about the biochemical properties of plant species may increasingly be acquired by industrial countries through patents, a point demonstrated by the contentious case of turmeric in which the USPO reversed the patent granted two years ago with considerable acclaim from the Indian scientific community for USPO's fairness and transparency (Marshall and Bagla, Science 1997). India has similarly challenged USPO's award of the patent for Basmati Rice to RiceTec Inc. in Texas. While the patent application was made in 1994, due to the secrecy procedures, information on pending patents is not available in the U.S. until they are awarded. The patent was reportedly awarded in September 1997, but Indian authorities came to know about this award only in February 1998 (Gopalakrishnan and Krishna, India Abroad, February 20, 1998). Due to changing governments and other internal problems India has not yet passed an IPR legislation. Developing countries such as India do not have the internal capacity to acquire full knowledge of the patents being granted worldwide, nor to get involved in such costly disputes. To date there are no clear policies and rules in the management of access and property rights at the international level.

Technology sellers clearly have different interests than do large developing countries with internal capacity for copying technologies, as well as large domestic markets to absorb new products. Yet in much the same way that the Indian software industry catapulted into prominence by the western development of basic and strategic research in the computer industry, the potential "biopirates" of industrial and developing countries each also have the possibility of collaborating through strategic alliances to produce technology for the international market, at least some of which can be in the public domain for the benefit of the poor, a direction in which many multinational corporations such as Monsanto have clearly considered moving. Private firms on the other hand tend to prefer monopoly rights to supply technology. But the public systems have the social responsibility to provide public goods and ensure that there is enough competition in the market place for the consumers to have a choice even when technology is being purchased. In international collaborations involving material transfer agreements (MTAs) for example, involving the use of germplasm in the CGIAR collection, distribution of intellectual property rights of the inventions and end products are emerging as important issues between scientists of industrial countries, the CGIAR centers, and developing countries.

Notwithstanding these challenges, expenditures by developing countries on agricultural research have stagnated at best and declined at worst following the debt crisis of the 1980s, leaving a large number of well trained research scientists underpaid and underutilized. Developing countries typically allocate only 0.5 percent or less or their agricultural GDP to public sector research compared to between 2 percent to 4 percent by industrial countries, (the higher percentages being in smaller countries such as Australia), a ratio 4 to 5 times as large. The gap is even greater (upto 10 times) if private sector research, which is virtually absent in most developing countries, is considered. Of course the absolute differences are even more staggering.

Agriculture has also become sidelined in the agendas of donors, a result of a combination of concerns for macroeconomic management, the environmental and social agendas, declining commodity prices, complacency in the face of food surpluses, preoccupation with Eastern Europe, domestic budgetary problems and a pervasive and mistaken belief that the private sector will take care of the problems. A major cost of the decline in U.S. assistance to agricultural science and technology bilaterally and multilaterally, shown in figures 2 and 3, is that at a time when these systems face enormous new challenges, the important human capital and institutional development role the U.S. once played has virtually disappeared.

Figure 2: USAID Funding for Agricultural Research (1952 to 1996)

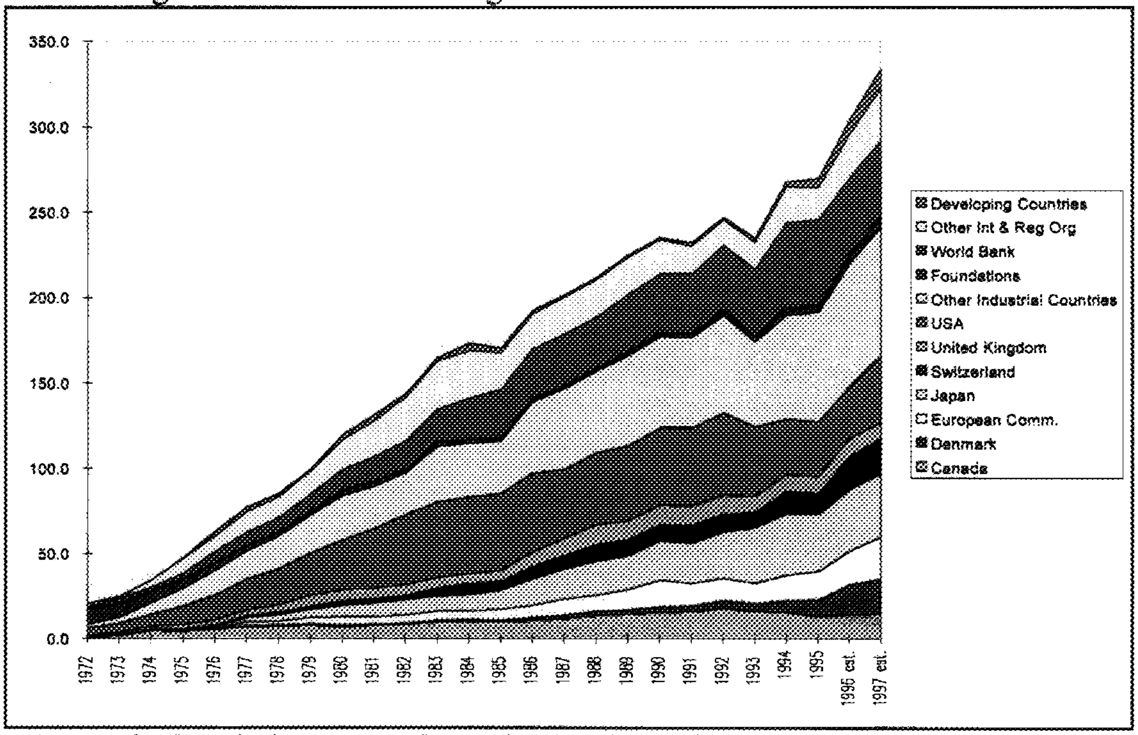


Source: Gary Alex, USAID and Agricultural Research: Review of USAID Support for Agricultural Research—1952-1996, Office of Agriculture and Food Security, U.S. Agency for International Development, Washington, DC.

The CGIAR, too has faced a funding crisis. The World Bank which was a donor of last resort has become the largest donor to the CGIAR making up the gap left by the decline in commitments by the U.S. which was its largest donor (see figure 3). Other donors (e.g. Denmark, Switzerland, Canada, the European Community and Japan) have increased their contributions, but they have been less able to meet the gap created by the scientific leadership which the U.S., backed by its vast institutional infrastructure, once deployed internationally.

Since all players in international agricultural research are under resource pressure, new more efficient ways must be found to increase research efficiency.

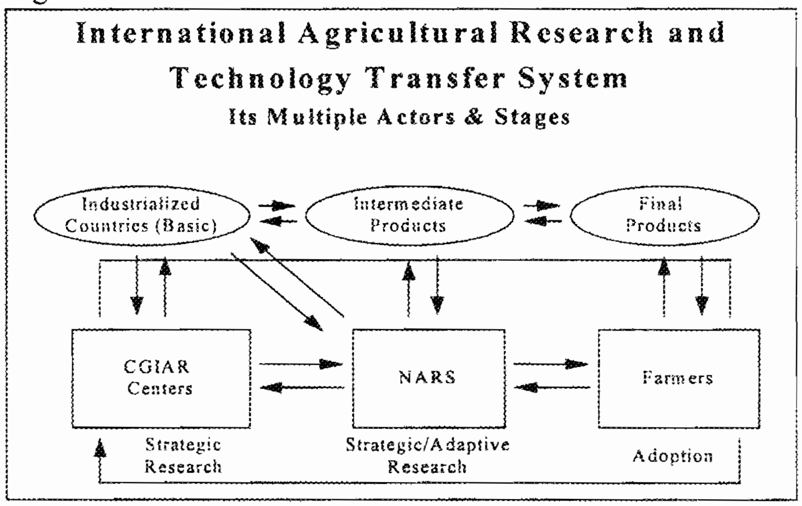
Figure 3: Sources of Funding to the CGIAR



Source: The Consultative Group on International Agricultural Research, Washington, DC.

The GREAN Initiative envisaged a major mobilization of U.S. scientific talent for international collaborations across the entire spectrum of research continuum outlined in figure 4, namely from basic laboratory research through strategic, applied and adaptive research. It recognized that the concept of research and technology transfer has changed fundamentally from a traditional linear "lab to land" approach, to a more complex web of interactions among multiple sets of actors involved in research and technology transfer. These interactions take place in several directions. The institutional, management and financing structure of the research system determines the quality of those interactions, which in turn determine the ability of a system to efficiently convert information into knowledge (Lele and Ekboir 1997). That process critically influences the efficiency with which research priorities are set and research output is converted into usable products or practices for the clients of research, influencing the speed with which technology transfer occurs on the ground. The U.S. possesses a relatively flat, decentralized research organization which enables such complex interactions, whereas information flows are still limited and rigidly top down in much of the developing world, calling for fundamental changes, not just in the organization of research, but in the management culture. The rapid changes in science however means that developing countries must leap frog into new systems of research organization and management relatively quickly, skipping many intermediate steps, by drawing on the experience of developed countries.

Figure 4



Source: Uma Lele and Javier Ekboir 1997.

5. The Competitive Grants Program

A competitive program on a global scale would utilize a well proven cost effective peer reviewed mechanism *as a complement to ongoing international efforts* to bring collaborative disciplinary and interdisciplinary research to bear on crucial problems on a consistent predictable basis. It would stimulate the interest of a broad range of scientists and balance established forms of scientific inquiry through regular funding with new and innovative approaches. Global competition will improve the quality of international science and its impact in a relatively short period of time.

6. Why a U.S. Funded Competitive Program has not Materialized

Investments in a competitive grants program that were envisaged by GREAN are minuscule in relation to the U.S. government's federal annual budget or indeed even the budget of the U.S. Department of Agriculture (USDA). Yet they are comparable in size and concept to USDA's National Research Initiative (NRI). Decisions about competitive and block funding for U.S. agriculture are affected by a different set of considerations than those internationally. Yet the NRI too has had difficulty maintaining stability in its annual funding on an assured predictable basis. Internationally the excellence of U.S. science is perceived to be based on the competitive environment in which it operates. Yet one of the frequently expressed concerns in U.S. agricultural research domestically tends to be that competitive grants programs, unlike block grants, limit the ability of research managers at State Experiment Stations to address problems highlighted by their stakeholders. This concern is perhaps a result of the fact that, at the state level, the share of competitive funding seems to be increasing relative to block funding over time. The second related concern is that allocation of resources to competitive grants and block grants is a zero sum game. Increases in competitive grants are perceived to come at the cost of block funding. Another concern is whereas block grants may meet the needs of specific constituencies on a long term predictable basis, competitive programs serve to address specific short term researchable issues. They create instability in the research thrusts by creating uncertainties in year to year funding. Competitive grant programs take control or resources away from political and bureaucratic processes. Rather, they are governed by scientists and peer reviews, and they tend to support research in disciplines and areas of the country with a strong research capability, leaving the weaker ones behind.

U.S. financing of international programs is, of course, hampered by additional constraints. In the post cold war era, with little or no threat of an opposing ideology, popular support for international "assistance" is less in the U.S. The benefits of such involvement while clearly large, are too diffused among U.S. producers and consumers, too long term, conducted too far away from the domestic constituencies, and too small in the overall scheme of things for the programs to generate strong enough interest groups in any constituency, including the U.S. university community, to organize itself and to lobby the U.S. Congress for new money. The USDA brings to bear strengths of a global view of agriculture through its impressive Economic Research Service with trade and research policy perspectives, and the scientific capacity of the federal and state agricultural research systems including the U.S. land grant universities, despite the highly decentralized nature of the U.S. government. USDA also tends to be connected to domestic agricultural interest groups, some of whom are concerned that global agricultural research programs will come at the *cost* of domestic programs, rather than being beneficial to them.

Because of the perceived reduced support for international programs, it is understandable that the USAID community, which has the most commitment to and experience in international work and an impressive track record of results in agriculture, tends to be concerned that competitive programs will come either at the cost of the already reduced U.S. annual contributions to the CGIAR system, or the CRSPs. These are the main remaining U.S. bilateral programs in agricultural sciences with developing countries funded under Title XII of the Foreign Assistance Act. Since 1975 10 CRSPs have received $263 million and have research activities in 42 countries. They currently have an annual budget of about $17 million (Alex 1996). CRSPs have been able to access the wealth of U.S. university agricultural science. But a recent USAID report indicates that the legislatures and constituents on which they depend have been ambivalent towards international agriculture because it is a potential source of competition. However, that concern is often overtaken by the need for U.S. universities to develop international perspectives in their programs and graduate training. Apart from the contribution by CRSPs to training through degree programs reported earlier, which seems unfortunately to be terminated, and to the establishment of long term collaborative linkages with developing country researchers, their design is more consistent with normal academic work at the universities compared to the earlier NARSs institution building efforts. There they have helped to create support, or at the least to diffuse opposition, to the foreign aid programs by building an academic constituency on U.S. campuses (Alex 1997 and Ruttan 1996). Yet CRSPs have often been criticized, even within

USAID, as a source of friction between USAID's country missions that represent country priorities and the long term needs of research (Alex 1996). Their evaluators have also argued that they have been hurt by being viewed as "entitlements" rather than as productive users of development resources, their limited coverage in terms of country, commodity and problem areas, for the reasons of USAID's own reduced reach mentioned earlier, their relatively limited client orientation and outreach, and limited NARSs involvement in program planning and management (Alex 1997 and Ruttan 1996). Many of these perceived weaknesses of CRSPs arise from their dual mandate of having to demonstrate benefits to U.S. agriculture, in addition to developing countries, rather than recognizing the kind of a broad and long term contribution of international collaborations to the U.S. economy and society outlined in section 3 above. The GREAN proposal was developed as a collaborative effort between U.S. and international scientists based on lessons learned about the strengths and limitations of the current U.S. programs and the reasons underlying them. Therefore the GREAN taskforce has advocated that the U.S. Congress should provide new money to support programs such as GREAN as a *complement* to, rather than at the cost of, existing programs.

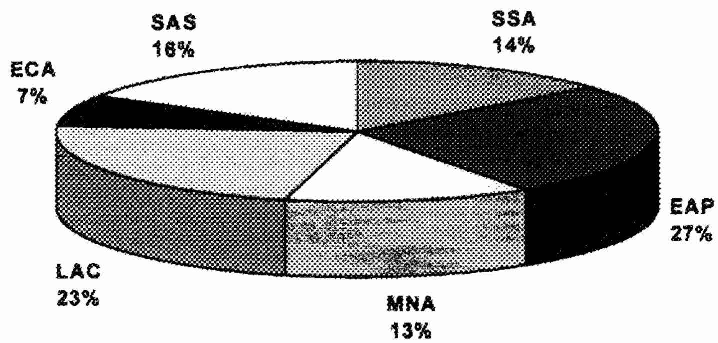
A competitive grants program would probably serve less well the interests of traditional constituencies that have benefited from the existing aid programs. This could further weaken the support base for foreign aid. Besides, a competitive grants program, by its very nature, would be less likely to serve the traditional foreign policy objectives of U.S. bilateral assistance in countries of strategic importance such as Egypt. Rather, it would be designed to address the issues of the post cold war era. It is not surprising then that the competitive grants program idea has not had many parents.

Yet over twenty land grant universities have decided to press on with the idea of international collaborations, where the collaborations must by necessity be demand led by the policymakers of developing countries, who must increasingly pay for such investments. They are in contrast to the traditional U.S. aid programs for developing countries with more limited financial resources and scientific know-how to formulate their own demands. Under the GREAN umbrella, U.S. universities have formed a coalition and a board to operationalize a program of cooperation. They have offered limited time of their faculty, at the cost of their respective universities, to engage in international collaborative research in the areas of interest to them. Operational funds for such research, or the training of nationals from developing countries come from other non-traditional sources, such as loans and credits given by the World Bank and regional banks to developing countries. Developing countries are also allocating their own resources to collaborative research, education and technology transfer.

7. Agricultural Technology Development in Brazil: The Roles of the World Bank and the GREAN Initiative

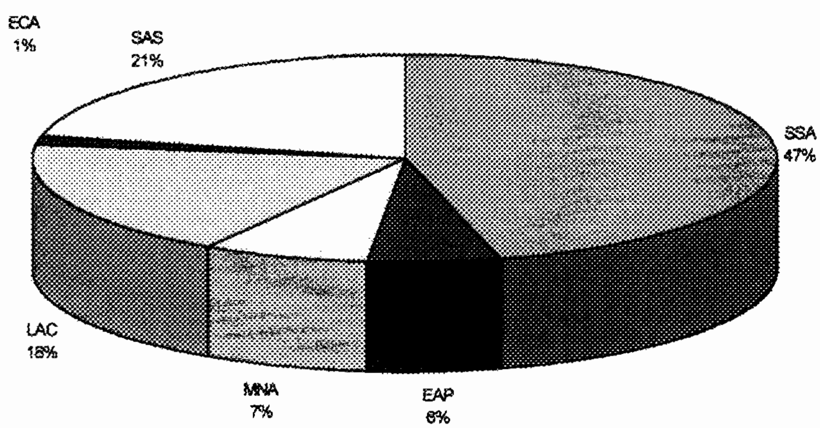
This section illustrates how ideas contained in the GREAN report have begun to germinate through World Bank loans and credits to developing countries. The World Bank is the largest single source of external finance. Total World Bank commitments to its ongoing projects in agriculture and rural development in 1997 amounted to $28.7 billion in the form of loans and credits to nearly 100 countries. Commitments to agricultural research as a share of the total has been increasing both as self standing agricultural research projects and other projects in which research was a component. As figures 5 and 6 show, during 1988 to 1994 they amounted to nearly $2 billion. Sub-Saharan Africa had the highest share of agricultural research commitments followed by South Asia, Latin America and the Middle East. These facts need to be interpreted with caution however, as a large share of the World Bank lending to agriculture goes to a few large countries such as China, India, Indonesia and Brazil. These countries have a significant body of scientists and the potential to be important adopters of the new scientific revolution. The shares of regions change over time with changes in loan commitments.

Figure 5: REGIONAL DISTRIBUTION OF WORLD BANK 1988-1994 DOLLAR COMMITMENTS TO AGRICULTURE



Source: World Bank data, (Lele 1995).

Figure 6: REGIONAL DISTRIBUTION OF WORLD BANK 1988-1994 DOLLAR COMMITMENTS TO AGRICULTURAL RESEARCH



Source: World Bank data, (Lele 1995).

Brazil is one such important borrower. The research staff strength of 2,300 researchers in EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária), the National Agricultural Research

Institute with responsibility to coordinate the Brazilian NARSs is comparable to that of the USDA. EMBRAPA has an annual budget of $550 million. The total Brazilian agricultural research staff are five and a half times and the annual budget is three times that of the CGIAR. Brazil has a clearly advanced research system, perhaps even compared to China or India, when considered in terms of the number of scientists trained in advanced countries who return to the motherland, the size and quality of the physical infrastructure for conducting science, number of publications in established journals per researcher, quality of research management and information systems, well documented assessment of research impact, integration of research among the various centers of the federal and the state governments, etc. Due to the proximity to North America and Europe, greater numbers of U.S. and European trained scientists, as well as perhaps a greater share of those trained abroad who return to the homeland, Brazilian policymakers are also more familiar with the challenges they face in modernizing their research system to adjust to the new globalized world. This is perhaps less the case in China and India. Each has had a more limited exposure to the western agricultural research systems in recent years, notwithstanding the substantial investment the U.S. made in developing the Indian National Agricultural Research System, including its impressive land grant universities, in the 1960s and 1970s. Many of the western trained Indian and Chinese scientists do not return home. There are also complex financing issues in China. Successful fiscal decentralization has led to the policy of cost recovery in a variety of activities including research (Pray 1997). The Government of China also requires that each borrowing entity must be responsible for paying back the loans directly to institutions from where funds are borrowed, including bearing the foreign exchange risks. While these policies have increased fiscal responsibility, they have also imposed constraints on mobilization of external financing for investments in research from institutions such as the World Bank since the payoff to research tends to be in the long term and returns are often difficult to capture (Lele, Nyberg, and Goldberg 1998).

Just as the GREAN report was being completed, the Government of Brazil requested a loan from the World Bank in support of the government's effort to stimulate the transition of the Brazilian National Agricultural Research System from its current heavy reliance on public sector research conducted by the national research organization, EMBRAPA, to a more integrated and diversified system of agricultural research, technology development and transfer led by EMBRAPA, such that the role of the clients of research will increase in the definition of research and technology transfer priorities and in their implementation. Furthermore, public sector research undertaken by EMBRAPA at the federal level, will focus on quintessential public goods, i.e., basic and strategic research, while other actors such as universities, the private sector, state research and extension systems and farmers' organizations will begin to play an active role in the conduct of applied and adaptive research and technology transfer.

A $120 million research project (with $ 60 million loan from the World Bank over a five year period) finances a competitive grants system ($72 million) for agricultural research, development and technology transfer, institutional strengthening of research management and training in the new areas of advanced (including bio) technologies, public-private partnerships, IPR management capacities, etc., as well as support for monitoring and evaluation.

The project is targeted to the producers and consumers of research. Scientists and science administrators are being trained in advance methods of research and technology transfer including biological and natural sciences, IPR, PVP, WTO rules, biosafety guidelines and social and management sciences. Any institution within Brazil will be able to present proposals in partnership with other Brazilian or external institutions in the nationwide competitive grants program in the areas designated to be of high priority including advanced (including bio) technologies, natural resource management, small farm development, agri-business and strategic studies.

As a way of substantially strengthening its linkages with science in advanced countries, EMBRAPA is establishing active cooperation with several CGIAR centers. It is establishing under the World Bank funded project several "virtual" laboratories, e.g. in the USDA, and with its own resources in France and perhaps Japan, placing its mid-career Brazilian scientists with advanced degrees from industrial countries to engage in joint research with the scientists in each of these advanced countries, as well as to scout technological developments which would be of particular interest to Brazil. Brazil has in turn offered to have scientists from advanced countries visit or reside in Brazil to conduct collaborative research with its scientists. In addition to traditional degree and nondegree training programs, Brazil also expects to engage in long term institutional arrangements with these institutions to gain knowledge and experience in a variety of issues related to research management including financing of research, public-private partnerships, etc. India is similarly poised to enter into arrangements with advanced countries through the support it has recently received from the World Bank through a substantially larger—$180 million—IDA credit.

EMBRAPA scientists were intrigued by the ideas contained in the GREAN report and entered into collaboration with the GREAN Initiative. Even in a relatively short period of time EMBRAPA's research scientists have identified their research needs to collaborate with scientists in 14 major land grant universities in wide ranging areas of biotechnology, soil and water management, pest and disease control, post harvest technologies, etc. EMBRAPA expects such collaborations to lead to fundable research proposals which will be presented to the various Brazilian competitive grants programs, including that funded by the World Bank loan. It will monitor the effectiveness of its borrowed funds by measuring the extent to which expenditures on collaborative arrangements result in concrete research programs and their ultimate impact on the Brazilian producers and consumers.

USDA and U.S. land grant universities with scientists interested in Brazil are interested in developing such collaborations. Brazil expects its GREAN partners to find other scientists whose research, training and technology transfer expertise would be of interest to Brazil from the point of view of the U.S. comparative advantage as seen in Brazil. For instance, so far Brazil has tended to turn to France and Europe rather than the U.S. for expertise on small farm development, while relying on the U.S. for the more advanced technologies. U.S. universities engaged in GREAN are beginning to search for their expertise in the areas of small farm development. The mutual exchanges are already helping both sets of institutions to develop a better understanding of how research priorities are set in each country, how research, teaching and technology transfer functions, public-private partnerships and IPR issues are managed, leading to the establishment of the rules by which intellectual property emanating from collaborative research will be apportioned between Brazilian and U.S. scientists. Brazil is perhaps ahead of other developing countries in envisaging entering into such agreements at a more collective level where issues of policy in international collaborations can be addressed rather than through individual agreements with universities for faculty or students sent abroad. FAO and USDA have sometimes served as intermediaries for these arrangements, but past arrangements have not addressed the types of new issues Brazil now faces.

The GREAN-Brazil collaboration in turn is leading to a regional collaboration of U.S. scientists with scientists in the Southern Cone countries' regional research organization called PROCISUR (Programa Cooperativo para el Desarrollo Tecnologico Agropecuario del cono Sur) involving Chile, Argentina, Brazil, Uruguay, Paraguay and Bolivia. These collaborations are also improving understanding among U.S. university and USDA administrators as to the types of international collaborations that would become important in the future.

The GASEPA (Globalizing Agricultural Science and Technology Education Programs for America) Initiative of NASULGC (The National Association of University Land Grant Colleges), which is also chaired by the Chair of the GREAN board[10], has taken many of the GREAN ideas on board and made GREAN an integral part of GASEPA. The research title of the Farm Bill before the Senate at the time of writing this paper includes a $780 million dollar competitive grants program to be administered by USDA. If approved by both the House and the Senate, *a portion may support international research and may well incorporate some of the ideas outlined in the GREAN Initiative.* It is clear from the Brazil-GREAN agreement that the locus of action is shifting from the traditional U.S. bilateral aid based research and education, to the one in which developing countries such as Brazil are increasingly paying for the services and expecting to strike a good bargain. Other developing countries such as India and China that borrow from the World Bank will look for a similar bargain for their scarce resources. It is also clear from the GASEPA Initiative that U.S. land grant universities are readying themselves to face the challenges of the post cold war, post bilateral aid era. Together GREAN, Brazil and the Southern Cone countries can help address research and technology transfer issues in other developing countries where Brazil's experience and that of the other Southern Cone countries would be relevant. This is why the evolving GREAN-Brazil partnership is of interest for the challenges the global community faces at the dawn of the 21st century where U.S. leadership is still urgently needed.

[10] Bobby Moser, Vice President for Agricultural Administration and the Dean of the College of Food, Agricultural and Environmental Sciences.

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