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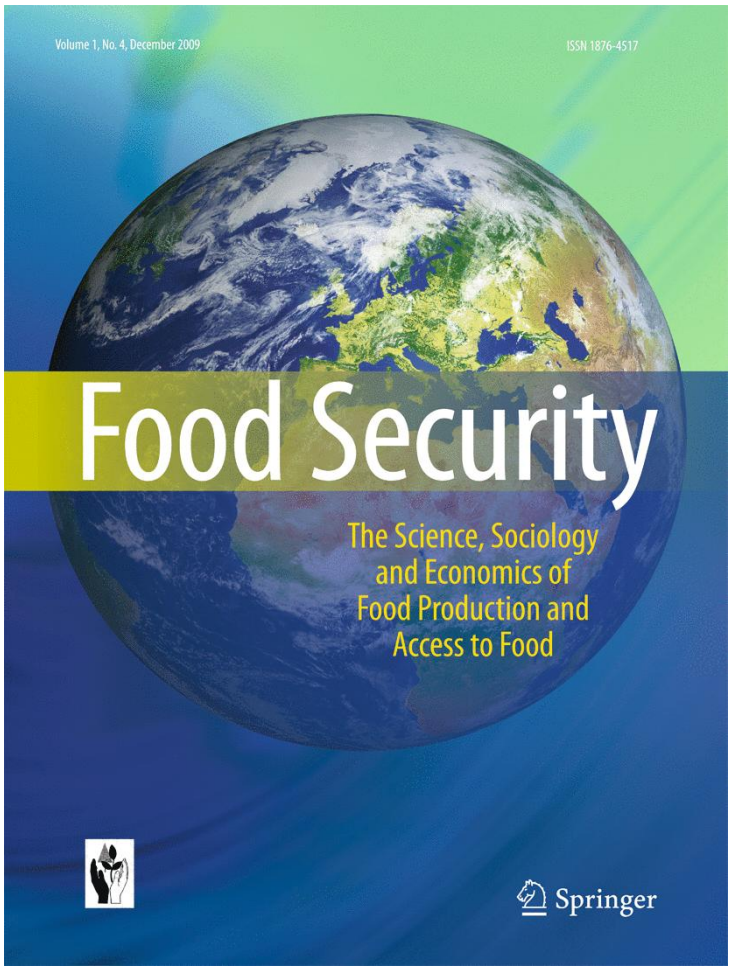

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ORIGINAL PAPER

Revitalizing agricultural research for global food security

Gebisa Ejeta

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Abstract An imaginative American legislation, the Morrill Act of 1862, established the U. S. Land Grant University Model, where such universities would adopt a uniform, tripartite function of education, research, and extension. It legislated that these universities would provide segments of society with practical and timely education that would be useful to their daily lives. A profound concept based on a system that focused on educating the next generation of agricultural scientists, providing support to the generation of new knowledge and technology, and communicating the results of the new discoveries to key stakeholders was born. Sustained support of this 19th century legislation and the commitment and drive of generations of agricultural scientists and farmers brought about remarkable advances, making 20th century American agriculture most productive and the envy of the world. These successes were replicated in North America, Europe, and in much of the developed world, and served as the impetus for the emergence of the Asian Green Revolution. Farming became a profitable business and consumers were accustomed to safe and relatively inexpensive supply of food, unfortunately leading to 21st century complacency. The recent food price crises seem to have reawakened world leaders and donor agencies to the necessity of assuring the food security of nations and to revitalizing and reinvesting in the agricultural sciences.

Keywords Modern agriculture · The Asian green revolution · The persistence of global hunger

Introduction

After nearly two decades of relative complacency about agriculture, world leaders and representatives of development agencies appear to have reawakened to its contribution to economic growth and political stability in the rich nations and in the developing world. They have also come to a new realization of the need for sustained support of agricultural science and technology generation to transform agriculture in developing countries and sustain the advances made in rich nations.

This sudden and dramatic shift in world opinion has been prompted by the convergence of several ominous trends. The Intergovernmental Panel on Climate Change has left no doubt that global climate change will have a profound impact on agriculture during the coming decades. The impact of climate change and the rapid pace of world population growth, threaten global food security. The recent energy crisis, food price inflation, and the global economic recession revealed the vulnerability of communities everywhere and, in particular, the lasting hardship imposed on the poor. Together, these trends present agriculture with a truly daunting set of challenges as well as a potentially great opportunity.

In this paper, I assert that we may have arrived at the emergence of a new realization. We now recognize that our world is not as food-awash as we once believed. Problems involving global food production and accessibility continue to linger as one of humanity's fundamental challenges. I believe that we have the capacity to rise to these emerging challenges and assure sustained global food security. We

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G. Ejeta (✉)
Department of Agronomy, Purdue University,
West Lafayette, IN, USA
e-mail: gejeta@purdue.edu

can do this by revitalizing our agricultural sciences and recommitting to the time-tested, mission-oriented legacy of the land grant university model and its ideals. The land grant model, legislated in the 19th century, helped build this great nation and made 20th century American agriculture the envy of the world. It has succeeded internationally, bringing about the Asian Green Revolution championed by Norman Borlaug, soldiered by M. S. Swaminathan and many others. I believe that even in the face of emerging 21st century issues like climate change and uncertainty of the global energy supply, the land grant model can be counted upon once again to address the challenges of doubling food and feed production.

The success of modern agriculture

Over the last century, the U.S. agricultural sector has become one of the most productive in the world. Citizens of this country as well as the rest of North America and Western Europe have become accustomed to a safe and relatively inexpensive supply of food. Agricultural research in genetics, crop and animal husbandry, weed, pest, and disease control through chemical inputs and integrated pest management approaches, modern farm machinery, development of post harvest technologies and value-added products spurred the nearly 10-fold increase in commodity yields in the United States over the last 100 years. The first agricultural revolution was brought about by the advent of corn hybrid technology that gave rise to the private seed industry and the associated complex of business services and partnerships.

One way the success of modern agriculture is reflected is in how much we pay for food. In 1933, according to the USDA's Economic Research Service (ERS), Americans spent more than 25% of their income on food. By 1940, the figure was 20%. By 1975, it had declined to 13.8%; by 1985 it was 11.7%. In 2000 it was below 10% for the first time in U.S. recorded history, and down to 9.6% in 2008.[1]

International statistics provided by ERS only account for the percentage of disposable income spent on food at home. Still, the numbers show huge differences between the U.S. and other countries. The U.S. percentage is 6.1%. The next lowest figure comes from consumers in the United Kingdom at 8.3%. German consumers spend 10.9% of their disposable income on food at home, followed by Japan (13.4%), South Korea (13.4%), and France (13.6%) among high income countries.

Among middle income countries, South Africa is at 17.5% and Mexico is at 21.7%. China (28.3%) and Russia (36.7%) are seeing rapid decreases in food expenditure percentages but are still relatively high. India (39.4%) and Indonesia (49.9%) are among the highest when it comes to the amount of disposable income spent on food.[2]

In contrast, the poorest nations of the world spend 70% or more of their disposable income on feeding their families.

The success of modern agriculture resulted not only in increased crop yields and decreased food prices, but also in the growth of the agribusiness sector. One example is the hybrid seed industry. Beginning in 1930, approximately 150 companies formed to produce hybrid corn seed and some 40 existing seed companies expanded their businesses to include production of hybrid corn seed.[3] The Hi-Bred Corn Company, founded in 1926 in Johnstown, Iowa, was the first business created for the specific purpose of developing and marketing hybrid seed corn. The company's first seed crop consisted of 40 acres of hand-planted, hand-picked corn and was sold by mail-order. The company's profits were $33.62 in its first year of sales in 1928, and sales doubled in 1929. After a period of slowed growth with wartime rationing in the 1940s, the company's sales of seed corn passed one million units in 1949. In 1970 the company established an international seed department and became Pioneer Hi-Bred International, Inc. Today the company, still headquartered in Johnston, Iowa, is the world's leading developer and supplier of advanced plant genetics to farmers in nearly 70 countries around the world.[4]

The Asian green revolution

It was the success of U.S. agriculture that spurred the advent of the Asian Green Revolution, converting nations such as India from "basket cases" to "bread baskets".

In my view, the transformative changes brought about by modern agricultural sciences in his native Iowa inspired Norman Borlaug to dream about helping the poor in developing countries overcome hunger with the breakthroughs he achieved in wheat genetics. He saw how the advent of hybrid corn and private sector initiatives with the seed industry and other agribusiness spurred not only productivity increases on farms, but also enhanced the livelihoods of both rural and urban Americans. Fresh from the economic hardship of the Great Depression, this must

[1] Economic Research Service, USDA, Food Consumer Price Index (CPI) and Expenditures Report, September 24, 2009, Table 7: Food expenditures by families and individuals as a share of disposable personal income. http://www.ers.usda.gov/Briefing/CPIFoodAndExpenditures/Data/Expenditures_tables/table7.htm.

[2] "Americans Spend Less Than 10% of Disposable Income on Food." Salem-News.com. July 19, 2006. http://www.salem-news.com/articles/july192006/food_prices_71906.php.

[3] Economic Research Service/USDA: The Seed Industry in U.S. Agriculture/AIB-786.

[4] Pioneer Hi-Bred International, Inc.: http://www.pioneer.com.

have been an easy lesson for young Borlaug to take to heart. But with his brilliance, he gave more. In my testimony before the U.S. Senate Committee on Foreign Relations hearing on Global Food Security last March,[5] I offered the following characterization of this great American's contributions to bringing modern agriculture to the poor:

> "Dr. Norman Borlaug, universally acknowledged as the "father of the Green Revolution" is a hero to me and very many others. I personally admire his single-minded devotion to science and agricultural development and his unending empathy and service for the poor. He has been a great example for scientific leadership and a life so well lived. As I reflect on his accomplishments and leadership, however, in my view the genius of Norm Borlaug was not in his creation of high yield potential and input responsive dwarf wheat varieties, not even in his early grasp of the catalytic effect of technology, but to a great extent in his relentless push to mobilize policy support to encourage the development of the agro-industry complex, to sustain the synergistic effects of technology, education, and markets."

The Asian Green Revolution transformed agriculture initially in Mexico, India, and Pakistan, expanding later into Indonesia, Thailand, Malaysia, the Philippines, Taiwan, China, and even to parts of South Asia. This successful venture to eradicate hunger and reduce rural poverty in these densely populated regions of the world was made possible, yes, through agricultural sciences. But it would have remained just another brilliant research finding as an end unto itself in the absence of sustained investments of governments and foundations in agricultural education, research, extension, infrastructure development and the support of local governments for credits, and markets for inputs and outputs.

An unintended consequence of this success was that the early achievements of the Green Revolution were dramatic enough to create a false impression that the world's food and farming problems had mostly been solved. As a consequence, the international donors who had provided strong support for agricultural innovation and investment in the 1960s and 1970s began pulling money and support away. America's official development assistance to agriculture in Africa declined approximately 85% from the mid-1980s to 2006. In FY08, the United States spent twenty times as much on food aid in Africa as it spent to help African farmers grow their own food. As always, others followed the trend set by the U. S. and global public investments to agricultural research dwindled.[6]

How the green revolution missed Africa

While the Asian Green Revolution was being launched in the 1960s, independent Africa was being born. Much of the human and institutional capacity essential for an agricultural revolution in Africa was weak or nonexistent. The discoveries of the miracle crop varieties that ignited the Asian Green Revolution were in wheat and rice—two globally important crops, but not the true staff of life for Africans. Most importantly, Africa was simply not ready for a science-based development campaign at the time.

At the end of World War II and into the mid-1960s, just after the flurry of newly independent African nations, few Africans earned graduate degrees in the agricultural sciences. Very little functional science infrastructure existed across the continent. The vestiges of the few entities left behind by colonial leaders had no substantive research programs aligned with Africa's national development. The colonial agricultural research farms were no more than test stations for commodities of European interests such as cotton, coffee, tea, and cacoa. Unfortunately, even when these budding research programs expanded into field crops and livestock, the lack of human capacity meant that the scope of their research remained very limited. They focused more on adoption of imported technologies than on developing new stocks from local sources.

Gradually with domestic and foreign investment, the long, time-consuming process of institution building and laying a foundation for science-based development began.

The persistence of global hunger

The last vestiges of mass hunger linger in Africa and South Asia, where millions of people live in abject poverty and are regular victims of hunger and occasional famine following nature's calamities. Hunger and poverty are humanitarian flash points. We saw during the 2007–08 period of extremely high world food prices that human distress in these areas can lead to violent political confrontation. The distress of the poor caused by these higher prices has focused greater political attention on food and hunger issues.

[5] Remarks by Dr. Gebisa Ejeta, Purdue University, before the Senate Committee on Foreign Relations hearing on Global Food Security, March 24, 2009.

[6] Remarks by Co-chairs of The Chicago Council on Global Affairs' Global Agricultural Development Project: Dan Glickman, former U.S. Secretary of Agriculture and Catherine Bertini, former Executive Director of the UN World Food Programme, before the U.S. Senate Committee on Foreign Relations hearing on Global Food Security, March 24, 2009.

Today, the world laments that some one billion people, nearly one-sixth of the world's population, suffer from chronic hunger. Some 25,000 people die each day from malnutrition. Sadly for these very poor one billion people, a food crisis becomes a chronic and permanent problem, not a temporary situation they can easily exit when the global economic recession shows signs of recovery or the per-barrel price of oil declines. All too often, it becomes a multi-generational condemnation of the body and soul that, it seems, only sacred intervention may undo.

Clearly, the causes of hunger are many including natural, social, economic, and political factors. Generally, global hunger is a result of poverty and lack of gainful employment. It can also result from broken social networks at home and in the community triggered by natural disaster, civil disturbance, war, or displacement due to forced migration of otherwise settled people. Food shortages can also result from curtailed total production and/or constrained distribution of existing supply.

Global hunger is a moral issue and a fundamental problem too big to ignore. It limits the potential of individuals, communities and nations—for generations. It also undermines all other development investments by and on behalf of poor nations. The political and social stability of all nations, poor and rich, can be compromised by national, regional, and global hunger.

Secretary of State Hilary Rodham Clinton eloquently articulated the problem at the announcement of the 2009 World Food Prize in Washington D.C. when she stated:

> "This morning, one billion people around the world woke up hungry. Tonight, they will go to sleep hungry. ….The effects of chronic hunger cannot be overstated. Hunger is not only a physical condition, it is a drain on economic development, a threat to global security, a barrier to health and education, and a trap for the millions of people worldwide who work from sunup to sundown every single day but can barely produce enough food to sustain their lives and the lives of their families."

The onset of complacency and neglect of agriculture

Farming became a profitable undertaking in the developed world where breakthroughs in the science of agriculture dramatically transformed production practices and increased farming efficiency. It drew great investments from both rural and urban businesses. Crop yield levels reached record heights, incomes grew, and food prices declined. An unfortunate result of this was that society began to take agriculture for granted. In light of the pressing need for public support of other societal needs, securing public funding for agriculture and agricultural sciences became difficult. Interestingly, the private sector was investing heavily in agriculture in the rich nations at about the same time that public funding was dwindling.

Although hunger still prevailed and rural poverty in developing countries was becoming rampant, the decline in public funding for agriculture in the developed world carried over to foreign assistance for agriculture. The decrease in foreign assistance created a further decline in public spending by the governments of developing countries, instead of increasing to compensate for the loss of foreign aid. Public spending on agriculture as a share of total public spending in most developing countries declined significantly (from 7% in 1980 to 4% in 2004). Sadly, the surplus production in the developed world was perceived as a solution to the shortages in developing countries. Food-aid became the biggest instrument of intervention to address the problem of food shortages in developing countries.

By 2007, rich countries devoted a mere four percent of their foreign assistance to agriculture. In Africa, which has the most severe food problems, donor aid to the farm sector plunged from $4.1 billion in 1989 to just $1.9 billion in 2006. Africa's per capita production of corn, its most important staple crop, has dropped by 14% since 1980.[7]

Equally troubling are sharp cutbacks in publicly supported research into new technologies, farming techniques, and seed varieties that could increase yields, cope with changing climate conditions, battle new pests and diseases, and make food more nutritious.

Agricultural science had become a victim of its own successes. The decline in public funding for agriculture and agricultural research both here and abroad led to fewer and fewer scientific interventions to advance production agriculture and more to address the emerging problems of natural resources and the environment.

Between 1970 and 1990, global aggregate crop yield rose by an average of 2% each year. Since 1990, however, aggregate crop yield has risen by an annual average of just 1.1%. The USDA projects that the rate of growth in global farm yields will continue to fall.[8]

U.S. commodity yields are growing at a much lower rate post-1990 compared to the Post WWII 1950–1989 period—only about half as much. Reduced support for public farm productivity enhancing research is the major cause of this slowing in farm-level productivity growth.

[7] U.S. Senate Committee on Foreign Relations, Senator Richard G. Lugar: Opening Statement for Hearing on Global Food Security, March 24, 2009.

[8] U.S. Senate Committee on Foreign Relations: Senator Richard G. Lugar Opening Statement for Hearing on Global Food Security, March 24, 2009.

The farm productivity component of U.S. public R&D funding has dropped from 68% in 1985 to 57% in 2006/07 in a continuous pattern. Research funds are being redirected to food safety, nutrition, environmental and other worthy goals.[9]

We know that rural hunger and poverty decline dramatically when education, investment, and new technologies give farmers access to better ways to be productive. This happened in Europe and North America in the middle decades of the twentieth century, then in Japan, and then on the irrigated lands of East and South Asia during the Green Revolution in the final decades of the twentieth century.

The rude awakening

Then came a rude awakening. The initial shock was general agreement by the Intergovernmental Panel on Climate Change that the warming trend felt in the last few years will continue and may endanger hundreds of millions of the poor in developing countries as early as 2020. The potential problems arising from climate change in terms of worsening food and water shortages in regions of the world where the poor dwell are huge. This is particularly true in sub-Saharan Africa and South Asia—aggravating the growing pressure on land, water, and food supplies—as disheartening developments.

The global economic recession and sky-rocketing costs of energy around the world made things worse as higher energy prices directly drove up the cost of agricultural inputs such as inorganic fertilizers, insecticides, and pesticides. Farmers in the developed world were able to work around this nexus because credit was still available, though tight. But the abililty of small farmers in developing countries to respond to the incentive of higher food prices through increased production was much more limited.

Furthermore, the 2008 food price crisis showed us that global food shortages could bring about disruptions in life that would resonate to the far fringes of the planet. Between 2006 and 2008, the average world price for rice rose by 217%, wheat by 136%, maize by 125% and soybeans by 107%. In late April 2008, rice prices hit 24 cents a pound, twice the price that it had been 7 months earlier.[10] Several factors contributed to the food price crisis: a "perfect storm" of poor harvests in various parts of the world, increasing biofuel usage, lower food reserves, growing consumer demand in Asia, rising oil prices, changes to the world economy, hoarding and governments closing export trade in some countries. Families in the United States and Western Europe felt the effects, as did the masses in developing countries, and with dire consequences. It became evident that without the general balance between food demand and supply to which we have been accustomed, food scarcity and volatility of food prices will pose a critical risk to global food security.

A call for a revitalized agricultural research

In spite of *and possibly because of* its proven success, as previously noted, U.S. public investments in agricultural research have dramatically declined in recent years. U.S. funding of national agricultural research institutions of developing countries has declined by 75% since the 1980s. Its support for the Consultative Group on International Agricultural Research, the leading network of international research centers responsible for developing innovations in agricultural production systems useful to poor farmers in the developing world, has been cut by 47%. And its funding for collaborative research projects between American and developing country scientists dropped 55%.

In the spring of 2009, a confluence of ideas emerged. Called for was an end to complacency and revitalization of agricultural research focused on alleviating hunger and energizing science-based development. Among the first voices that emerged on the topic was one that came through an excellent report developed by the Chicago Council for Global Affairs.[11] It made a compelling argument for renewing attention to agriculture in U.S development policy, calling for increased support in agricultural education, research, and extension both here and abroad. It argued for research support at multiple levels including domestic institutions, national programs in developing countries, and the international agricultural research centers.

The second major initiative to appear was the Lugar-Casey Global Food Security Act submitted to the U.S. Senate Committee on Foreign Relations. Senator Richard Lugar, co-author of the bill, summarized the challenge when he said:

> "The food security challenge is an opportunity for the United States. We are the indisputable leader in agricultural technology. A more focused effort on our part to join with other nations to increase yields,

[9] Pardey, P.G. (University of Minnesota Dept. of Applied Economics), Farm Foundation Conference: Agricultural Research and Productivity for the Future, April 28, 2009.

[10] FAO International Commodity Price Database, Syngenta Foundation for Sustainable Agriculture, 2008.

[11] Remarks by Co-chairs of The Chicago Council on Global Affairs' Global Agricultural Development Project—Dan Glickman, former U. S. Secretary of Agriculture and Catherine Bertini, former Executive Director of the UN World Food Programme Senate Committee on Foreign Relations, March 24, 2009.

create economic opportunities for the rural poor, and broaden agricultural knowledge could strengthen relationships around the world and open up a new era in U.S. diplomacy."

The Lugar-Casey bill seeks to re-orient U.S. foreign assistance to focus on hunger and poverty and to help counter the threat that a global food crisis will emerge. It seeks to streamline food security strategy, add resources for agricultural productivity and rural development, and improve the U.S. emergency response to food crises by creating a separate emergency food assistance department. The Lugar-Casey bill is a back-to-basics approach in its focus on science-based development. It calls for U.S. universities to engage in agricultural education, research, and extension programs with developing countries.

In July, 2009 at the L'Aquila G8 Summit, global leaders pledged more than $20 billion to support a renewed global effort toward food security. In addition to the financial commitments, global leaders established principles to follow. These included use of a comprehensive approach, investments in country-led plans, local, regional, and global coordination, involvement of multilateral institutions, and delivery of accountable commitments.

In the fall of 2009, a "Global Hunger and Food Security Initiative Consultation Document" was issued by the U.S. Agency for International Development to begin anew a process for "a comprehensive approach to food security based on country and community led planning and collaboration with partners".

Revitalized agricultural research to face grand challenges

Agriculture's renewed status is a vital resource for the sustainability of human civilization and the stability of peace and prosperity in the world. This opening creates a remarkable opportunity for the agricultural sciences to build on their legacy of success. Science and technology must continue to evolve at an uninterrupted pace if they are to have the capacity to respond to emerging societal challenges. It goes without saying that sustained investment in science is a basic essential for a society. Nevertheless, in my view it is critical that these investments be made in purpose-driven science. Societies that do not invest in revitalization of the agriculture sector and in advancing the agricultural sciences are in danger of facing another round of cruel surprises when the next series of food and resource shortages comes around.

Our food and natural resource problems are also becoming more and more complex, with highly interconnected ramifications. Solutions to these problems will require us to develop a more encompassing global perspective with respect to the nature of the issues we address as scientists. The following list reflects the types of emerging challenges, the complexity of their nature, and the diversity of tools required to address them adequately.

The population, food production, and natural resource nexus The population of the world is currently hovering around six billion and is expected to almost double by the year 2050. The population of some of the poorest regions, such as sub-Saharan Africa, is expected to more than double. The Food and Agricultural Organization (FAO) of the United Nations has determined that Africa will need to triple its food production by 2050 to provide adequate food for an African population that will then reach two billion. This means that global food production will probably need to at least double in the next four to five decades, a very tall order indeed. Furthermore, this badly needed increase in food production will have to be achieved via efficient vertical expansion of the yield gap and with more judicious use of chemical inputs so as not to aggravate the degradation of our natural resources.

Agriculture and global climate change Climatologists are in general agreement that a significant amount of global climate change will occur over the coming decades.[12] Greenhouse gas emissions from human activity will have a profound impact on agriculture during the coming decades. Across most of the tropics, crop yields will be lower and less stable because of rising temperatures, changing rainfall patterns, increased heat stress, as well as drought and flooding.

Accelerated greenhouse gas emissions are raising the earth's temperature, which causes frequent extreme weather patterns and shifting seasons—conditions potentially disastrous for agriculture. Erratic weather resulting from gradual climate change coupled with increased demand from a growing global population and income growth threatens global food security. Agriculture in sub-Saharan Africa — which already faces serious constraints – will be hit harder than in other regions. Many studies predict overall reductions of the order of 10–20% in the yields of Africa's key food crops within the next several decades. Some scientists warn that in particular places, like Africa's dry Sahelian region, production of even hardy crops like millet and sorghum could become impossible. There is a general consensus that investments in agricultural research for development of new crop varieties will be critical for successful adaptation, albeit the mode of research and the

[12] "Understanding and Responding to Climate Change", National Academy of Sciences Report, October 2005.

level of investments necessary have not been completely determined yet.

Food price inflation, economic recession and effect on poor consumers Unless vigorous efforts are made to help farmers adapt to climate change and contribute to its mitigation through better land use, global food price crises like the one that emerged in 2007 and peaked in 2008 could become a recurring nightmare. By the middle of 2008, the international prices of wheat and maize reached levels three times those in 2005. The price of rice rose fivefold over the same period. Such drastic increases imposed especially great hardship on the poor, who spend 50–70% of their income on food. According to the FAO,[13] the number of undernourished people in the world increased from 848 million in 1990 to 923 million by the end of 2007, mainly because of food price inflation. Today, the figure is probably close to 1 billion. The impact of the food crisis on poor households translated into major social and political turmoil. Mass protests emerged in dozens of cities across the developing world over high food prices.

By late 2008, the crisis in global financial markets had begun to put downward pressure on grain consumption. Reduced demand, together with record harvests of basic cereals, brought down prices by 30–40% toward the end of the year, restoring them to their mid-2007 levels. Despite that sharp drop, prices remained much higher than they were just a few years ago. Moreover, as international food prices fell, they did not drop as fast, if at all, in developing countries, especially those of sub-Saharan Africa. The global recession has worsened the effects of the food crisis on poor consumers, mainly by further reducing their purchasing power through the loss of jobs and remittances from relatives working abroad.

The agriculture-energy nexus The re-emergence of food price inflation is closely related to the trend toward higher and more volatile energy prices. In search of greater energy security, many governments embarked on ambitious and heavily subsidized biofuel schemes. The resulting boom, by intensifying competition between food, feed and fuel uses of crops, contributed significantly to the recent food price crisis. To make matters worse, higher energy prices drive up the cost of agricultural inputs such as chemical fertilizers and thereby limit the ability of small farmers to respond to the incentive of higher food prices through increased production. Biofuels will no doubt continue to occupy an important place in global agriculture. What remains to be seen is whether their economic and other benefits—including the potential contribution to reducing greenhouse gas emissions—can outweigh the negative effects on food security and on environmental destruction caused by land clearing for biofuel production if plans for expansion for biofuel crop production into marginal lands materialize.

The looming global water crisis Global food security is also linked to worsening water scarcity. Within 40 years, the world may have an additional four to five billion mouths to feed, most of them in developing countries doubling the global food demand. To meet that demand, the agriculture of tomorrow will need much more water. Given that one liter is used to produce one calorie of food, it will take up to almost 9,000 cubic kilometers of additional water each year to feed another four billion people. That is more than twice the amount of water that agriculture uses today. It is not at all clear where so much additional water will come from. Agriculture already accounts for 70–80% of total water use. Yet, by 2050, its share will have declined to about 60% or 70% as a result of competing water demands from urban expansion and industrial development.

Integrative models to the science of sustainable agricultural growth New policy frameworks, such as a more comprehensive post-Kyoto agreement on climate change, are essential for agriculture to cope with the multiple challenges it faces. But if farmers, especially the poor, are to benefit from such initiatives, they need new knowledge and methods from agricultural science. Only then can agriculture become part of the solution to climate change, water scarcity, conservation of natural genetic resources, and protection of the environment, not just part of the problem. Agricultural scientists have a solid record of significant contributions to sustainable increases in agricultural productivity as well as conservation of natural resources. Steadily declining food prices through the 1990s were the result of increased food production that was made possible by technological advances brought about by previous decades of agricultural research. These developments have also minimized the need to bring more land under production, leading to sustained conservation of natural resources.

Sustainability is an issue for both domestic (developed) and international (developing) agriculture that needs serious reevaluation. Environmentalists who study farming in Europe, North America, and East Asia may be correct to criticize the excessive use of nitrogen fertilizers and pesticides and the wasteful use of scarce surface water and groundwater supplies for crop irrigation in some environments. The call for judicious use of inputs is well placed. It is also not environmentally sustainable for Africa, for example, to feed its rapidly growing population using millennia-old technology that continues to mine the land—

[13] Committee on World Food Security of the Food and Agricultural Organization of the United Nations, Thirty-fourth Session, Rome, 14–17 October 2008: Assessment Of The World Food Security And Nutrition Situation.

plowing fragile lands, depleting nutrients, cutting down more trees, destroying wildlife habitats. It is a mistake, therefore, to equate the problems of agriculture in the developed world with those in Africa where current use of fertilizer is less than 15 kg/ha. In Africa and South Asia, most farmers do not use improved seeds, fertilizers, pesticides, or irrigation. To protect the environment in these regions, farmers will need much greater access to productivity-enhancing inputs. The environment is under threat not because input use is excessive and crop yields are too high, but because very few purchased inputs are being used at all, soil nutrients are being depleted, and crop yields are too low. As a result, fragile new lands have to be cleared.

Public-private partnership in agricultural research and development The success of 20th century agriculture in North America and Europe was made possible by the healthy partnership between public institutions of education, research, and the fast emerging private entrepreneurship in the input and output market and the array of businesses that emerged as a result of post-harvest value addition. The agribusiness industry that developed was instrumental in bringing further employment to the farm communities and expanding opportunities for many other individuals and businesses. The United States enjoyed a healthy division of labor between public and private agricultural organizations until a couple of decades ago, when the great reduction in family farms diminished the role of public institutions as honest-brokers and eventually even as sources of new badly needed applied research results.

In most developing countries, agricultural research and associated programs of formal and informal education and delivery of technologies are the responsibility of the public programs without any accountability. The private sector in the developing world is either non-existent or just emerging and struggling. Public programs are sources of employment for most educated people with little private industry to expand opportunities.

Strong public-private partnerships both at home and abroad will be needed to provide technical assistance to developing countries now and in the near future. As resources are limited, aligning the responsibilities and initiatives of public and private organizations becomes essential. The institutional and financial support of NGOs and the private sector along with official development assistance from traditional donor agencies will be critical in supplementing the crucial source of funding from national programs.

Globalizing U.S. agricultural research institutions

International technical assistance is often thought of in terms of humanitarian assistance. It is an issue that is more than compassion based. The nation's diplomatic, economic, and even security interests are involved. It is more than just the right thing to do. Nations that align their development, diplomatic, and defense interests along ethical grounds would not have their global structure compromised. Such nations hedge against serious dangers arising from failed states, have a greater chance of increasing their economic and trade exchange and heighten their moral standing and opportunities for the cultural growth of their populace.

U.S. universities have a great legacy of helping build and strengthen institutions in developing countries. Institutional and human capacity building can be among the most lasting contributions to the growth and development of nations. Institution building is a necessary foundation in nation building. Universities in the United States have played significant roles in the development of many such foundations.

Early investments have strengthened the economic development of numerous poor nations while enhancing the vitality of the better endowed countries. The history of U.S. Foreign Assistance is replete with several such experiences, and albeit with varied levels of success.

Some argue that old institutional building programs are no longer in vogue. I disagree. They need to be back in vogue. I can't think of a more long lasting contribution one can make to help a nation than to build its human capacity and strengthen its fledgling institutions. My own career is a product of a technical assistance program and can attest to its impact with great confidence.

Past involvements of U.S. universities

A. **Early Institution Building Efforts:** A number of our universities have made outstanding contributions to institution building in several developing nations, many of which are great success stories. Stellar examples abound in this area:

In the late 1950s through the 1960s, U.S. universities assisted in building institutions of higher learning in many parts of the world including India, Philippines, South America, Africa, and Southeast Asia.[14] These research, education and teaching institutions remain important training centers in agriculture. One of the fruits of American land grant research translated into Borlaug's discovery of dwarf varieties of wheat, rice, and other grains. Just as research done at land grant institutions had led to more efficient and productive

[14] Remarks by Peter McPherson, President of NASULGC, before the House Committee on Foreign Affairs, Subcommittee on Africa and Global Health, May 6, 2008: Higher Education in Africa: Making a Link Between Intellectual Capital and Regional Development.

agriculture in the U.S., giving Americans the time to be involved in innovation and discovery, agricultural research unleashed innovation and inventiveness in India.

In Brazil, Purdue University helped develop the Federal University of Vicosa (UFV), Minas Gerais State, Brazil, starting in 1957. This was the first agricultural university in that state. In 1963, the government made a political decision to build a human capital base for a modern agriculture. With USAID financing, four American land-grant universities including Purdue University spent a decade assisting four Brazilian universities in strengthening B.Sc.-level training in Brazil, followed by another 4 years of support for postgraduate education. In 1972, the government established EMBRAPA (Brazilian National Agricultural Research Corporation) to coordinate its national research program. EMBRAPA launched a massive human capital program and spent 20% of its total budget from 1974 to 1982 on training programs in Brazil and abroad.

In Ethiopia, Oklahoma State University, with USAID funding, assisted in building Alemaya College of Agriculture, my alma mater. Later, the College was upgraded to become Alemaya University of Agriculture. I am a product of this partnership. Another example is the longstanding involvement of Iowa State University in international agriculture since 1945 when the Corn Improvement Program established an Iowa State College-Guatemala Tropical Research Center. Since then, ISU had long-term involvements in Argentina, India, Peru, Brazil, Uruguay, Mexico, Panama, Thailand, and Indonesia.

B. **Collaborative Research Support Program (CRSP).** A creation of the Board for International Food and Agricultural Development (BIFAD), the CRSPs were put in place as a means of mobilizing the faculty talent at Land Grant Universities in the fight against hunger. In a recent testimony that I wrote for the Chicago Council for Global Affairs, I stated that "the CRSPs are among the most innovative technical assistance programs that the U.S. government has implemented". I have been a member of the Sorghum and Millet CRSP for the last 25 years.
C. **International Agricultural Research Centers (IARCs).** The Consultative Group for International Agricultural Research (CGIAR) runs a network of 15 global research centers. Located mostly in developing countries, they are mandated to advance agricultural research on different commodities yielding products and scientific creations called "international public goods". These centers have historically operated with close cooperation of national agricultural research programs in developing countries and advanced research institutions in the developed world. U.S. universities have worked with the CGIAR in various capacities. I currently serve as a member of the Science Council, a body that provides independent advice to the CGIAR. The Science Council has recently developed a think-piece entitled "Science for Development: Mobilizing Global Linkages". It argues for greater integration and coordination among research programs in the industrial and developing countries. It seeks to enhance scientific discoveries as well as the development and deployment of products and technologies for use in science-based development.

Essential actions for revitalizing agricultural research for global food security

Actions that are crucially important if we are to advance the cause of global food security with a revitalized agricultural research program include: revitalizing the U.S. Land Grant University model to meet the needs of today; mobilizing our universities and research centers in earnest global efforts; strengthening the public-private partnerships of our educational and research programs; and embracing and leading dialogue and developing options for meeting emerging societal challenges.

1. The U.S. Land Grant University model brought the best in our Colleges of Agriculture in the pursuit of mission-oriented science. The model was responsible for the success of the agricultural revolution that laid the foundation for the subsequent advances made and the economy that as a whole remains the envy of the world. As the agricultural landscape of the United States has changed, there are debates on if the model is still relevant or if there is sufficient stakeholder base that is broad enough to justify the necessary resource support to keep it as functional as it once was. We need to examine the classic Land Grant Model and look for ways to modify it in light of the changing landscape. It is a great model that has worked well. The expansion of stakeholders and the array of farm, service, and broader industry domain that university services have, tended to extend the limits of educational and research capacity at most universities. Niches for family farms have also expanded from conventional production to diverse production and utilization schemes. In light of the current reemergence of the need and stature of our great tradition of public service in this country, we need to repackage the model to fit the needs of today and not replace it with the assumption that the concept is obsolete.
2. We need to push our institutions of higher learning to develop a more global perspective today than ever before. More and more, shared problems are developing, and many are complex in nature. Global problems will

need global interventions. We need broadened perspective to effectively address the more complex scientific challenges in both research and education. Today, science is changing rapidly and new findings and new technologies are emerging at a fast pace. New knowledge is emerging from the traditional powerhouses, such as universities in North America and Western Europe. New knowledge is also coming from the newly emerging economic and scientific powerhouses of China, India, and Brazil. The opportunities for partnerships in educational programs, scientific research, as well as public-public and public-private partnerships with collaborators from around the world are becoming readily available. The justifications for building these partnerships are strong.

3. Our universities and major research centers need to pay particular attention to strengthening our public-private partnerships in all areas including in education, research, and economic development. The private sector today has become a great powerhouse of science and technology. The mutual benefit from a meaningful partnership could be immense. In addition to benefits in creativity, relevance, and team building, such partnerships could pay great dividends in the launching of the new generation of educators, scientists, inventors, and industry workers who are in tune with the real world.
4. Our institutions of higher learning should not only embrace but also lead the dialogue and plans for the emerging societal challenges and how we may address them through our tripartite functions of education, research, and public service. We need to dialogue on the issues not only with our educational and scientific peers or the stakeholders we serve, but also put ourselves at the table when policy considerations are made by our representatives and leadership. An academic community that respects policy-making and is willing to support and help shape global policy on agriculture and natural resources conservation, serves society and enriches its educational and research programs.

Revitalizing agricultural research for global food security will require commitment at multiple levels including: educators and researchers who uphold the ideals of public service; exposure of scholars to opportunities for social service; a push for appropriated funding at key state, federal, and global levels; and seek supplemental funding from foundations and the private sector

a) Educators and researchers must continue to uphold the ideals of public service, thinking of it as part and parcel of the scholarship and discovery efforts of their university assignments. Our institutions need to uphold their age-old commitments of engaging their faculty and staff with a growing list of stakeholders including those involved in the domestic and international food security concerns.
b) Past experience has shown that when opportunities arise, scholars often engage willingly in research and scholarship that is directed to serving society. Most are drawn to such pursuit whenever opportunities are presented—some even seek them out with passion. Many would like to serve but do not see how their work can fit into solving societal problems. Often when a national agenda is set for educational and research effort that involves solving societal problems in a multidisciplinary approach, I find that research scientists are willing to engage and dialogue about how their respective talents and skills can be brought into the fold on a mission oriented educational or research endeavor. It takes keen leadership to align these interests and direct them towards joint ventures and mission.
c) Finally, the key essential in policy support is needed for appropriated funding at key state, federal, and global levels. U.S. government funding for human health and medical research has increased tremendously in recent decades, with funding for research at the National Institutes of Health (NIH) growing from about $5 billion in 1976 to about $30 billion today. Agricultural research funding for the same period has remained basically flat at about $2.5 billion.[15]
d) Supplemental funding from foundations and the private sector to catalyze utility for the scientific discoveries will foster revitalization of badly needed public-private partnerships. For the U.S. domestic agriculture, a demand-pull with resource support, one that is generated as a national policy statement committed to the cause of research on agriculture and natural resource conservation for national and global food security, will be a welcome development.

Concluding comments

A revitalization of the agricultural sciences is badly needed to avert another food crisis and to assure global food security. In a world where demand for food is rising, assuring local food security is vital if we are to have global peace and prosperity. However, reinvigorating the world food system will require earnest commitments and major changes in national and international policies. These include renewed support for the science of agriculture, natural resource conservation, and protection of the environment. We need more than a change in the federal framework supporting

[15] American Association for the Advancement of Science: Trends in Research by Agency, FY 1976–2009 http://www.aaas.org/spp/rd/trres09p.pdf.

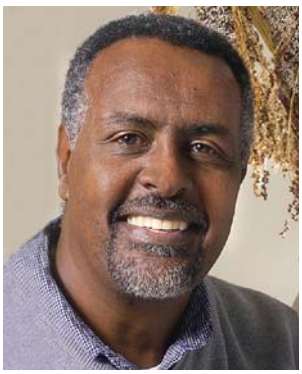
agricultural research; we need an infusion of federal funding to address the challenges facing us in food security and availability, preventing disruptions to food supplies, and managing agricultural and natural resource systems.

The problems of agriculture are becoming increasingly complex, requiring more holistic and integrated approaches to solving them. Tackling these complex problems adequately calls for the mobilization of the talent needed as well as the financial resources needed to support earnest efforts. Past investments in agricultural research have produced solutions for problems of yesteryears and we are proud of that legacy. We need to embrace the emerging challenges. We have a talented cadre that is eager to be mobilized to tackle these seemingly intractable problems of agriculture, natural resources, and the environment.

But we need to rekindle in the new generation of scientists the sense of purpose espoused in the wisdom of the Land Grant University model. I am certain that, with some rethinking, the available talent can be mobilized to effectively address these complex problems. New funding opportunities are emerging for catalyzing a revitalized global engagement in the agricultural sciences. If world leaders act on their recent pledges to boost support for global agricultural research and development, it will spark a new era. We will see new science-based solutions to problems of hunger, natural resource conservation, and protection of the environment.

I am hopeful that obligations being made for international technical assistance will be met by concurrent commitments from national governments for domestic agricultural research both in the U.S. and other countries. A revitalized agricultural research agenda with a holistic approach to sustainable growth in agriculture is the key to averting future food crises, dealing with natural resource conservation, energy and water shortages, and adapting to climate change.

Finally, permit me to relay my personal experience, growing up as I did in the developing country of Ethiopia. Opportunities in education and life were very limited for those of us that came from rural villages, as they are even today in so many African countries. I was at the end of the road with only a primary education when my life changed for good upon receiving admission to Jimma Agricultural and Technical School (a vocational agricultural high school) and later to Alemaya College of Agriculture and Mechanical Arts. Both of these programs were started by Oklahoma State University with sponsorship of the U. S. Agency for International Development. A world of opportunities opened up to me and very many others as a result of these two programs. Numerous graduates from those schools have now served Ethiopia through the last five decades providing the vision and leadership for modern agriculture. Some of us have become global citizens serving humanity with the rare opportunity we have been given. The history of U.S. technical assistance to developing countries is filled with similar success stories. I owe a great deal of gratitude to USAID since my high school, college, and graduate education were all supported by the agency. Furthermore, the research I have conducted since joining the faculty of Purdue University in the last 25 years was also supported by USAID. Human capacity development and building of functional institutions in developing countries are some of the most lasting and noble technical assistance programs ever envisioned. I have witnessed and demonstrated what well directed development assistance can do and achieve for an individual, institution, and a nation. I am very optimistic about what it can do for both the developed and developing world now that we are reawakened to the challenge of revitalizing agricultural education and research for global food security!



Gebisa Ejeta is a native of Ethiopia, where he received his early education, including a BSc in Plant Science from Alemaya College, before entering graduate school and receiving MSc and PhD degrees in Plant Breeding and Genetics from Purdue University, USA. Gebisa started his professional career as a Principal Plant Breeder at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) stationed in Sudan (1979–83). At ICRISAT, he developed and released the first sorghum hybrid in Africa and catalyzed the establishment of a private seed industry for its exploitation. He joined the Purdue University faculty in 1984, where he currently holds the position of Distinguished Professor of Plant Breeding & Genetics and International Agriculture.

Professor Ejeta is the 2009 World Food Prize Laureate. He is credited for scientific contributions in the development of drought tolerant and parasitic weed resistant sorghums, and facilitating the deployment and adoption of these crop cultivars in a number of African countries. Dr. Ejeta has also made significant contributions in human capacity and institution building efforts in several countries. He has served on review panels and advisory boards of major agricultural research and development organizations including the international agricultural research centers (IARCs), the Rockefeller Foundation, the Food and Agricultural Organization (FAO) of the United Nations, and a number of national and regional organizations in Africa. Recently, he spent a sabbatical year in Nairobi, Kenya assisting the Rockefeller and Gates Foundations launch their new joint initiative, the Alliance for Green Revolution in Africa. He is currently a member of the Science Council of the Consultative Group for International Agricultural Research (CGIAR).