Accelerating Productivity Growth: The 21st Century Global Agriculture Challenge

A White Paper on Agricultural Policy

By

Global Harvest Initiative

April, 2009

Foreword

In recent months, broad concerns have re-emerged about the future capacity of the world to feed itself—and, especially, to do so while meeting important social and environmental goals.

Since the 1950s, advances in output generally have been sufficient to support better and more secure diets for most of the world's people, but that success fostered complacency and slowed investment in agriculture in many areas. More recently, that complacent view changed dramatically as food prices surged to expose the productivity gaps between developed and developing nations—a situation that suggests that examination of alternative approaches to increase future agricultural productivity is warranted.

As a result, this paper, at its core, is about innovation and productivity, using those terms in their broadest sense. Agricultural yields are a very important component of productivity, of course, but the value of commodities is not fixed at the farm gate. It depends on processes throughout the system as grains, oilseeds, livestock products and fibers are produced, stored and protected, transported, processed and packaged to serve consumers.

This examination begins with a review of the food production/consumption story over time—how global growth has quietly boosted food demand while the agricultural plant has struggled to keep pace, largely because of decades of inattention and underinvestment. It then proceeds to review the "productivity story" in both developed and developing countries, and reveals a large gap in rates of productivity growth. It reveals that innovation and productivity must be stimulated, first to close the gap and then accelerate overall growth, if future challenges are to be met.

The report then discusses policy prescriptions and recommendations, not only for the United States but for other governments and organizations involved in economic development. It especially focuses on ways the anticipated productivity gap can be closed by stimulating investment where it is lagging—mainly in the developing world—while meeting new challenges over the longer-term, through 2050 and beyond.

This report is intended to present available facts and to propose selected prescriptions and recommendations for discussion. It was prepared in Washington, D.C. by the *Global Harvest Initiative* in March, 2009.

Contents

Executive Summary

This report is intended to inform the discussions that are now re-emerging about the future capacity of the world to feed itself—and, especially, to do so while meeting important social and environmental goals.

The growing concern about future food adequacy reflects several new developments. Expanding, increasingly wealthy populations in developing countries are demanding higher quality diets and boosting commodity demands globally—trends that intensify the ongoing competition for limited agricultural resources, especially by urban, infrastructure and industrial users. Additionally, while concerns about the environment are not new, they are receiving broader attention now, especially as changes in the climate emphasize the need to better control greenhouse gas emissions.

Since the 1950s, advances in output generally have been sufficient to support better and more secure diets for most of the world's people, but that success fostered complacency and slowed investment in agriculture in many areas. More recently, that complacent view changed dramatically as food prices surged to expose the productivity gaps between developed and developing nations—a situation that suggests that examination of alternative approaches to increase future agricultural productivity is warranted.

A paramount danger is that global agriculture will continue to function much as it has, largely ignoring its growing disparities in efficiency and productivity. The recent economic downturn and commodity price retreats provide a reprieve from market pressures—but, possibly one that will last only briefly.

While it is true that food supplies have always been volatile, the current situation is different. Today, it is the growing demand for agricultural products that is changing the outlook and raising questions about the adequacy of current policies--pressures that likely are not temporary, as many past supply interruptions were. This report is intended to contribute to an ongoing evaluation of current and future agricultural policies that reflect this new economic and social context.

The growing demand for food

Global food commodity markets have become increasingly volatile, and face continued future pressures from a number of directions, including population and income growth. This study concludes that over the longer term, global food requirements will rise sharply, by:

- 50% by 2025; and
- More than 100% by 2050.

In addition, expanding industrial use of agricultural commodities has further emphasized the constraints on agricultural resources—and, clearly underscored the growing urgency

of creating policies that effectively stimulate stronger productivity growth in developed and developing countries alike.

The agricultural response

Developed countries have long invested heavily in agriculture and agricultural systems and productivity growth has been rapid as a result. By contrast, many developing countries lack both supportive macroeconomic and agricultural policies and sources of private investment, so productivity there has lagged—mainly the result of weak policies rather than technical constraints.

Comparisons between developed and developing country yields emphasize both the source of developed-country growth and the potential for better performance in the future. And, they indicate that the potential for future growth in developing countries is high, ranging from eight to ten-fold increases for coarse grains, to four-or-five fold for oilseeds and two or three-fold for food grains, depending on country resources and policies.

Productivity, of course, extends far beyond crop yields, and includes livestock yields (pigs per litter, meat per pound of feed, etc.) as well as technical advances in processing, packaging, transport, etc. And, productivity growth requires investment in the entire food system—its infrastructure, marketing chain, information systems and the public policies that affect farming, trade and the economy, as well as research and development, extension services, etc.

New constraints

Increasingly, the global food system is being required to produce much more from the same—or declining—amounts of resources, a performance goal that could become even more difficult as climate shifts emerge. In many cases, these changes are extremely difficult to anticipate since their causes and impacts are still not well understood. Nevertheless, five important challenges to increasing production to meet future needs are described in the study, including:

- Better protecting the environment;
- Producing with less land per person;
- Producing more with less water per unit of output;
- Producing efficiently with less labor; and
- Adapting to the changing climate.

Need for investment in innovation

The report concludes that the lack of resources in developing countries appears to be retarding investment in technology and productivity growth very significantly. This is especially true in many developing countries where real (inflation-adjusted) research

spending has slowed since the 1970s even though most regions experienced high economic growth rates.

The reasons why investment in agriculture, including agricultural science, has been low on the global development agenda are numerous and complex. They include the persistently low global commodity prices of the 1980s and 1990s as well as comparatively easy access to food aid—developments that shifted attention to the apparently more urgent urban projects.

In addition, many governments and international agencies gave agricultural investments lower priorities than several new social concerns—at least in part because rural residents typically have less political clout than those in urban areas where development problems are more visible. Finally, some transnational non-governmental organizations remain skeptical about development projects that depend heavily on modern agricultural technologies. At the same time, a number of important new agricultural research needs have been indentified, including many well within the capabilities of modern R&D systems. Examples include:

- The need to make presently unusable soils productive;
- The need to increase the genetic potential of individual production and farming systems for both crops and animals, and to achieve as much of that potential as possible by:
    - Improving nutrition for that crop;
    - Increasing water availability and control and management techniques;
    - Reducing competition from weeds for water, nutrients and sunlight;
    - Reducing losses from disease or insects; and
- The need to reduce post-harvest losses.

Technology's New Frontier

As the use of improved technologies has continued to expand, a new frontier—biotechnology—has emerged with the capacity to provide important benefits for both developed and developing countries, and to target technologies more specifically to local needs and conditions. Biotechnology is accelerating the pace of traditional plant hybridization as well as bringing wholly new performance characteristics to crops.

Promising as the advances from biotechnology have proven to be, policy makers in Europe, and in developing countries that trade with Europe, frequently have declined to use many of them. This reluctance is limiting both the development and adoption of advanced genetics in large areas of the developing world—even in spite of the very large gains in productivity these technologies have been shown to support.

The expansion of private research in developed countries and its lack in developing regions also has been one of several factors that are stimulating efforts to boost productivity by large, well-funded but private foundations which long have been active in productivity-focused R&D. These include the Gates-Rockefeller (AGRA) group in

Africa, among others. Supportive investments are being made by the Millennium Challenge Corporation, a government-funded US corporation that is actively encouraging good governance and policy reform in designated, developing countries in order to help boost productivity.

A Productivity Based Development Strategy

This report observes that successful future efforts to expand global agriculture depend on a dual approach—first to help accelerate productivity gains where production lags, and then to effectively address important constraints on agricultural growth and infrastructure in both developed and developing countries.

Global experience since World War II identifies a number of fundamental requirements for sustained productivity growth and suggests that development efforts, whether public or private, could profitably focus more directly on meeting these preconditions. And, it concludes that productivity growth depends on both access to resources and a balance of skillful management, well adapted inputs and access to supply- and market-chain services as well as efficient markets. It further suggests that the lack of balance in any part of the system tends to inhibit growth, as do constraints on the use productivity-focused technologies and the lack of developed-country support for basic infrastructure in least developed countries.

The report also identifies the need for better organized, more visible and more effective support for research and developing-country aid—and, for US programs to reverse the decline in foreign assistance for agriculture, which has declined nearly 70 percent since the 1980s. An additional indication of the decline in agricultural support is the fact that the share of official development assistance allocated for agriculture has declined to 4 percent of total aid spending.

Meeting the Challenge: Some Specific Recommendations

This report concludes that the answer to the challenges posed in earlier sections—and, perhaps the only effective answer, given the increasingly binding constraints faced by global agriculture, is to produce far more output with the same, or even fewer resources, a development that will require significant increases in productivity.

The current economic crisis is temporarily slowing food consumption growth and providing a brief reprieve from the pressure the global agricultural system faces. However, this window almost certainly will be temporary, before the longer-term upward trends in food demand resume.

As a result, the Global Harvest Initiative believes that a global dialogue is essential, and that it be undertaken at once about how to meet the 21st Century agricultural challenges. These concerns need to be discussed seriously and extensively, with a focus on what should and can be done, who must do it, when, and, in what manner.

In the United States, there is an unusual opportunity now, provided by the new administration, new Congress, and, we believe, a new resolve to tackle formidable problems. We welcome this opportunity to open a dialogue and hope that it can be extended worldwide. To that end, we are suggesting six very specific areas for discussion:

- **How to effectively expand the global R&D capacity to enhance agricultural productivity**. This includes increased support for agriculture research, including in the developing world, with additional emphasis on and support for competitive, outcome-driven basic research and advanced technology training;

- **How to increase the visibility and role of international development for agriculture,** including the creation of a high-level coordination role and entity in the US government to oversee and coordinate efforts among various organizations that now provide agricultural development assistance.

- **How to broaden the recognition of the need for balanced agricultural sector development, including both hard and soft infrastructure—and, how to increase support for infrastructure investment in the least developed countries, especially**, including farm to market roads, electricity, communications, storage facilities, water control, transportation and shipping, among others, and how to expand support for these facilities in developing nations;

- **How to expand domestic and developing world agricultural research** and development capacity, and:
  - Increase the competitive focus in US government R&D and federal support for agricultural research and extension services in partnership with developing nations.

- **How to coordinate and expedite the sharing of agricultural information with developing countries**;

- **How to accelerate the development of "next generation" cellulosic and other advanced biofuels** and maintain current favorable biofuels policies necessary to support the buildout of advanced fuels.

I. Meeting the Global Demand for Food

Growing concerns about the capacity of the global food system to meet its main goals are setting the stage for a series of increasingly important policy confrontations. Many of these issues have the potential to affect the economic and social well-being of billions of people far into the future.

In effect, global agriculture can continue to function much as it has, largely ignoring the causes of widespread food insecurity and the growing disparity among developed and developing nations. Or, it can recognize emerging new opportunities to invest in more efficient systems. The following report provides background information for this debate, and the choices involved.

It is true that food supplies have always been volatile in response to factors such as weather and trade limitations. However, the current outlook is different. Today, it is not a matter of brief supply interruptions, but the demand for food that has grown and is changing the outlook and raising questions about the adequacy of current policies. As a result, the growing pressures on the system likely are not temporary, as many have been in the past. And, they are highly unlikely to disappear after one or two good harvests, as also happened in the past.

The Modern Food Equation

The main driver of global food system change is expanding, increasingly wealthy populations who are demanding higher quality diets. This is especially important because not only are agricultural resources limited but they are being sought increasingly for competing urban, infrastructure and industrial uses. And, the impacts of these trends are amplified by new demands that the system contribute to energy security and properly safeguard the environment. The facts are clear:

- **Population**. Today, the world has more than 6 billion people, with more than 5 billion of those in developing countries. Developing country populations are projected to continue to grow relatively rapidly—1.2 percent annually for the 2000-2030 period before declining to an 0.9 percent annual average for the longer, 2000-2050 period.[1]

  By contrast, population growth in industrial countries is projected to be 0.3 percent annually during 2000-2030 and to decline to a 0.2 percent annual rate during the 2000-50.

- **Global Wealth.** While world population growth will be important to future global markets for food, economic growth also will be extremely important. Not

[1] FAO, ***World Agriculture Towards 2030/2050: Interim Report, 2006***

> only has the rate of growth in developing countries outpaced that in developed areas, but it has made them increasingly urban, as well.
> Most of the world's wealth traditionally has been concentrated in developed, industrial countries, but that global profile is changing. In recent years, the most rapid growth in global wealth has been in developing countries, a new trend with enormous implications for global agriculture. It now is creating new groups of middle-class and higher-income consumers, defined in terms of local economic conditions—with dramatic effects on food spending. [2]
>
> The impacts of the shift from grain-based, subsistence diets to livestock-product-based foods can be seen in the very sharp consumption increases for grains and oilseeds in recent years—strong trends likely to continue in the future. In fact, across much of Asia, for example, recent changes in dietary trends have been huge, especially shifts from reliance on one or a few staple foods such as rice, to a more varied diet that includes, notably, more animal proteins.[3]

While population and income growth have increased global demand for agricultural products, renewable fuels production also has grown sharply and now consumes significant amounts of sugar, grains and oilseeds in several countries. This growth has been both policy and market driven, and reflects efforts to reduce the buildup of greenhouse gasses in the atmosphere and as well as concerns in many countries about dependence on volatile Middle-Eastern petroleum supplies.

In the United States, two recent energy policy laws, enacted in 2005 and 2007, provide blenders' excise tax credits, blending mandates and import tariffs. Additionally, government R&D programs help the subsector boost production efficiency steadily, and support the development of new technologies for producing renewable fuels from food crops. The 2007 Act mandates that the United States motor fuel supply include 36 billion gallons of renewable fuels by 2022, with 15 billion gallons of that amount from corn and starch ethanol.

Somewhat similar policies in several countries have increased global biofuel production rapidly, primarily in the United States, Brazil, China and India which account for 90 percent of the supply. All told, some 19 countries have significant biofuels programs and continued future growth appears likely, given the current widespread political support for these programs. For example, global production of ethanol is projected to expand at nearly 6 percent annually for the coming decade, according to recent estimates and while biodiesel production is smaller, it also could increase rapidly. [4]

---

[2] See, for example, Collier, Paul, ***The Bottom Billion***, Oxford University Press, 2007; International Food Policy Research Institute, "***High Food Prices: The What, Who and How of Proposed Policy Actions***," Washington, D.C. May, 2008.

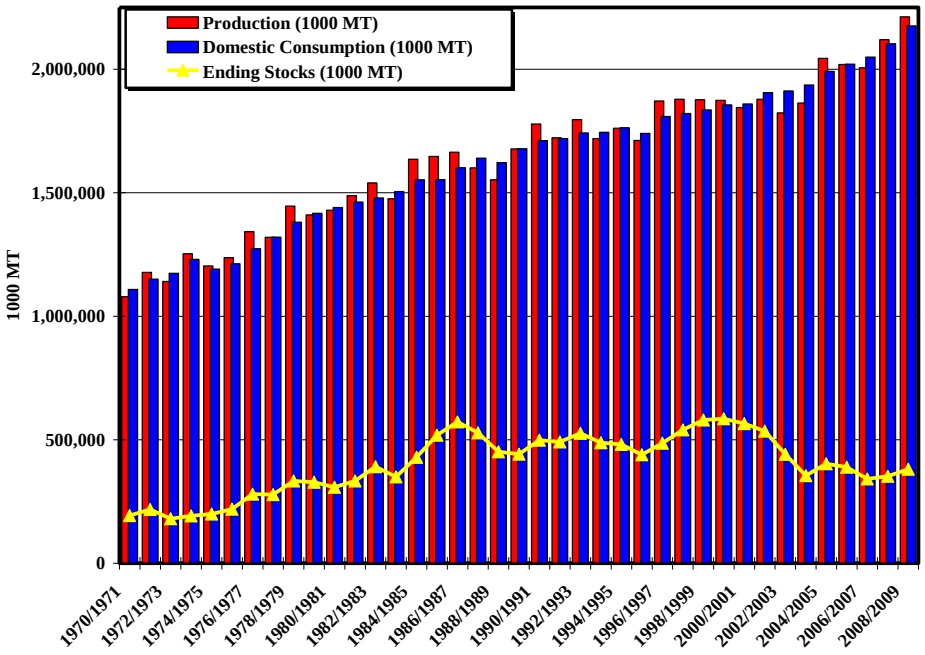
[3] It is increasingly apparent that Asians are not nearly as lactose intolerant as once thought. For example, the demand for cheese—and, pizzas—has grown sharply. And, increasingly, noodles are being made with wheat flour instead of rice flour.

[4] OECD and FAO Secretariats.

Impacts of synchronous demand growth

By the mid-1990s, the combination of growing grain and oilseed demands and competition for limited land resources between food and feed, urban and industrial uses began to make itself felt consistently in the form of steadily declining global grain stocks (Chart 1). Since 2001, the reductions in stocks have led to significantly higher and more volatile prices.

Chart 1. Global Grain Production, Consumption and Stocks, 1970-2008

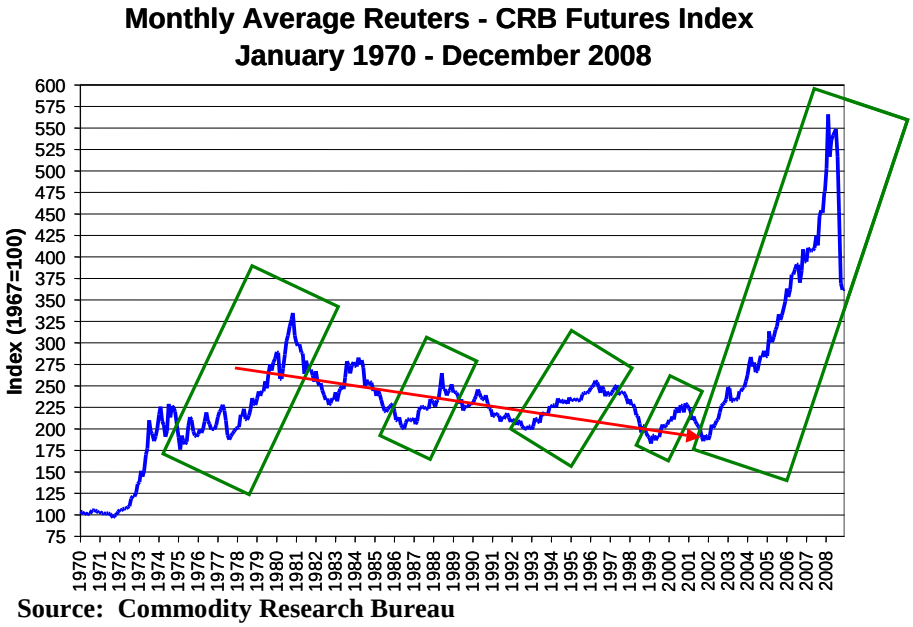


The current pressure on global stocks has been evolving for some time. For example, grain stocks increased sharply through the 1970s and 1980s—when they were widely seen as surpluses, and evidence of chronic economic policy problems. However, this trend stagnated in the mid-1980s and began to decline dramatically in 2000. Today we have a just-in-time grain and oilseeds production/consumption system, marked by stocks levels that are somewhat higher than they were in the 1970s in physical terms, but much, much lower as a share of total annual use. One result of the declining stocks levels has been much more volatile prices.

Many of the same market growth trends that are boosting global grain demand have broadly affected other commodities including metals, minerals and, most notably, petroleum—and, almost certainly represent a fundamental shift from traditional patterns and trends.

For example, the four cyclical, supply driven price upturns in commodity prices in the 1970s, 1980s and 1990s reflected almost entirely supply interruptions. By contrast, the most recent trend reversal represents much stronger, more persistent and more fundamental changes in the structure of global commodity demand systems (Chart 2).

Chart 2. Commodity Price Trends, 1970-2008



Source: Commodity Research Bureau

Current Economic Outlook

At this time, it is clear that developed countries have entered a recessionary period of uncertain length and severity—and global economic growth is declining as a result. For example, the global real growth rate was 4 percent in 2006, and almost that high in 2007—with significantly higher rates in the newly industrial and emerging countries and somewhat lower rates for the United States and other developing countries.[5] Beginning in 2008 and continuing through at least 2009, much slower growth is projected (Table 1).

Two patterns are expected to dominate that outlook. First, the recession is expected to be severe in developed countries, and to reduce global growth sharply—in 2009, to less than one-half the rate in 2006.

---

[5] Most economic analysts, including the major multilateral institutions such as the IMF and the World Bank, now recognize that global food production will be negatively affected by the economic downturn as tighter credit limits the capacity of producers to buy inputs, thus limiting affordable supplies. In addition, declining consumer purchasing power is expected to reduce consumer demand. And, the appreciation of the dollar makes dollar-denominated agricultural products expensive to import—trends that can, at least temporarily, more than offset falling petroleum and transportation costs. The first potential test of these impacts is likely to come this spring when Southern Hemisphere crops are harvested.

Second, while the recession is proving to be global in scope, it is projected to be less severe in developing countries, especially those with very large internal markets who have low hard currency debt, like China. Even for China, India and other less-developed countries, growth rates are projected to be sharply lower than in recent years.

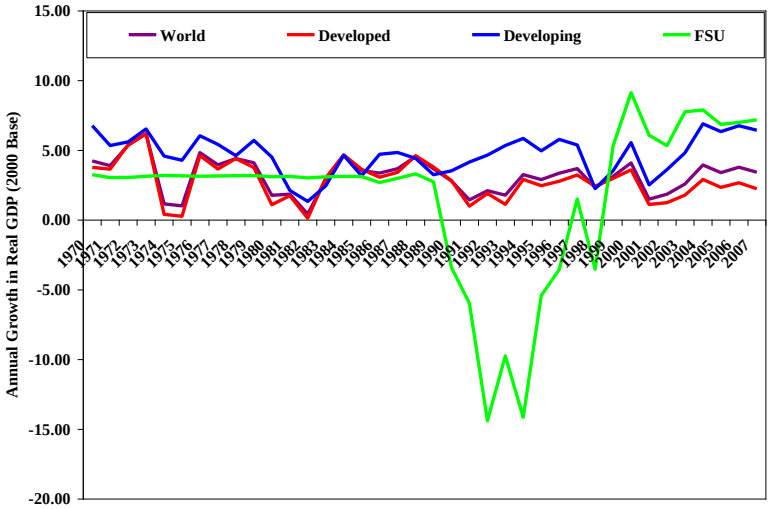
Table 1. Global Economic Outlook 2006-2009, Selected Countries

	2007	2008	2009	2010
	Real Growth (% change)			
World	3.8	1.9	-1.0	2.4
Asia/NIC/Emerging 1/	9.1	6.5	3.8	5.6
Latin America	5.2	4.1	1.3	3.4
Eurozone	2.6	0.7	-2.2	1.2
Country Specific				
United States	2.0	1.1	-2.6	2.2
Canada	2.7	0.5	-0.8	2.1
United Kingdom	3.0	0.7	-2.9	1.0
Japan	2.4	-0.7	-3.5	1.5
China (09 inflation, 8.5%)	11.8	9.1	6.1	7.2
India	9.2	7.4	5.9	6.8

Note: NIC, Newly Industrialized Countries: Korea, Taiwan, Hong Kong, Singapore
Emerging: China, India, Indonesia, Malaysia, Thailand
Source: Informa Economics

Past declines in GDP in developed countries have meant reductions in markets for developing country exports, and some loss of economic momentum in each case (Chart 3). However, those interruptions proved temporary and the general pattern of higher economic growth in developing countries continued throughout the past three decades.

Chart 3. Global Real GDP Trends, by Developing, Developed and FSU Countries, 1970-2008



Source: USDA

Although the current economic downturn has interrupted the previously strong upward trends in global and developing country growth. The danger, of course, is that the temporary lull in growth will once again diminish investment and development of agricultural sectors worldwide—and, cause productivity to fall further behind needs, setting the stage for much greater food and commodity price pressure and volatility in the future.

Agricultural Response—Global Perspective

Most of the major multi-lateral development institutions now recognize that, in spite of the current economic downturn, longer-term pressure on agricultural commodity production systems can be expected to continue to grow for the foreseeable future. And, they expect that the system's uneven production responses reflect significant limitations on agricultural resources. An example is the recent analysis by the Food and Agriculture Organization of the UN, which concluded:

- The *global* cereal and oilseeds systems were in close balance on average during the two decades 1970 to 1990—with both demand and production growing 2.2 percent annually. Consumption per person expanded a modest 0.4 percent annually.

- That balance is seen as tightening over the next 50 years, but still could permit per capita consumption to grow slightly—at about one-half the earlier rate.

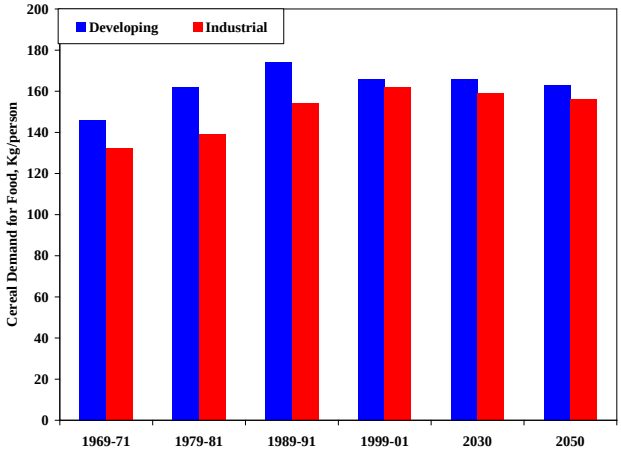
- Production systems in developed industrial countries have significantly higher levels of productivity than those in developing countries. Developed-country production traditionally exceeds consumption, although even that edge could decline steadily as industrial demands for grain use grow.

- For developing countries, the trends are negative and demand pressure is significant and growing. For example, the growth rate of consumption was about 10 percent greater than for production during 1970-90. This constraint is projected to slow demand growth over the longer-term future to less than one-half the earlier rate—even though it is seen as continuing to exceed production growth significantly.

It is important to note that the prevailing view is not that the world is on the verge of starvation—few institutions predict such an outcome in the absence of a global catastrophe. In fact the demand for cereals for food is seen as quite similar for both developing and developed countries, and little changed from recent levels throughout the

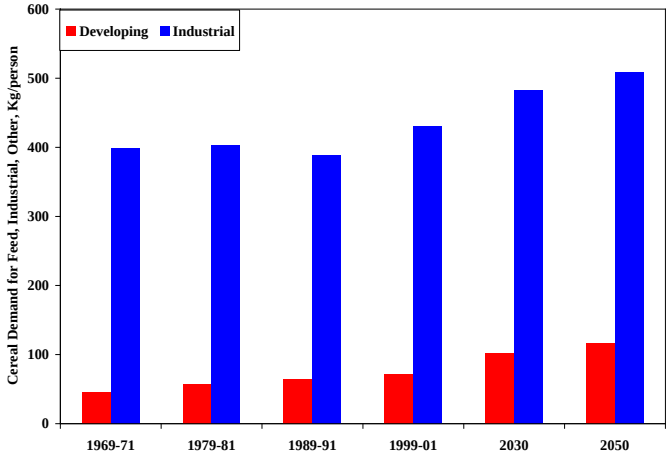
coming half century (Chart 4). However, the growing demands for both greater food and industrial use are seen as driving demand in excess of production (Chart 5).[6]

Chart 4. Cereal Demand for Food, Developing and Industrial Countries, 1969-2050



Source: FAO World Agriculture Towards 2030/2050

Chart 5. Cereal Demand for Feed, Industrial and Other Uses, Developing and Industrial Countries, 1969-2050.



Source: FAO World Agriculture Towards 2030/2050

[6] Professor Robert Thompson, Gardner Endowed Chair in Agricultural Policy, University of Illinois—and former World Bank official estimated in December, 2008 that World food demand could double by 2050, with:

- 50% of the increase from world population growth – all in developing countries
- 50% of the increase from broad-based economic growth in low income countries

He also observes that The World Bank estimates that the number of people in developing countries living in households with incomes above $16,000 per year will rise from 352 million in 2000 to 2.1 billion by 2030. He expects this trend to be the *most important* determinant of the future global demand for food.

As an indication of the importance of the growing global appetite for livestock products (meat, dairy products and eggs), global demand is forecast to rise by more than 55 percent between 1997 and 2020, with most of the increase in developing countries (Table 2).

China alone is expected to account for more than 40 percent of this increase, compared with India's 4 percent. However, even with the doubling of meat consumption expected for South Asia, Southeast Asia, and Sub-Saharan Africa, consumption per person in these areas likely will remain far below levels in the developed world, a gap suggesting that the market potential in these regions could be even greater than that now expected.

Table 2. Global Meat Demand, 1997 and 2020

	1997	2020	Increase	
		mmt		*%*
Beef	56	78	22	40
Pork	83	101	18	22
Poultry	58	131	73	125
Sheep & Goats	10	16	6	57
Total	208	327	119	57

Source: IFPRI IMPACT Model

Developing-Developed Country Yield Gap

Over the coming decade, current expectations are that a modest amount of additional land will be developed and devoted to grain and oilseed production. Based on recent patterns and projections of economic incentives, a modest increase of about 5 percent is expected, mainly in Latin America, but extending to other regions, as well (Table 3).

Table 3. Growth in Global Grain and Oilseed Area, By Country/Region, 2005-1017

Global Grain and Oilseed Area

million ha

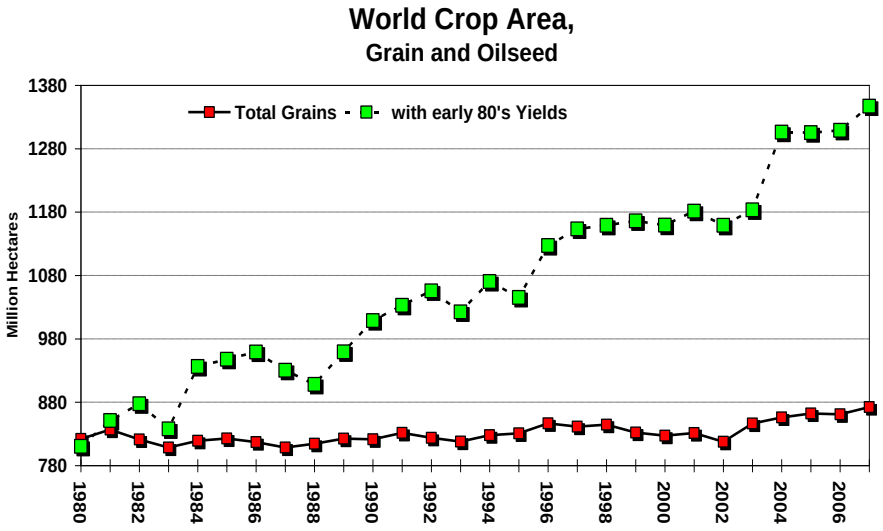
	2005	2006	2007	2008	2012	2017	*Ha Ch*	*% Ch*
USA	93	89	93	95	95	94	*0.8*	*1.9*
Brazil	43	42	43	45	46	49	*5.9*	*13.3*
Argentina	26	29	30	30	31	34	*7.1*	*16.1*
Other America	45	46	48	49	49	50	*4.3*	*9.6*
EU-27	62	61	61	64	63	63	*1.9*	*4.2*
Russia	46	46	46	49	49	50	*4.4*	*9.9*
Ukraine	17	18	17	20	19	19	*1.6*	*3.5*
Other Europe	29	29	29	30	30	30	*1.4*	*3.2*
China	109	109	109	110	110	110	*0.8*	*1.9*
India	131	130	133	133	134	136	*5.1*	*11.4*
Other Asia	113	113	113	112	114	115	*1.9*	*4.3*
Australia	20	19	20	20	20	20	*0.3*	*0.6*
Africa & ME	129	130	130	126	133	137	*9.0*	*20.1*
WORLD	862	861	872	883	891	907	*44.4*	*100.0*

1/ Includes corn, sorghum, barley, oats, millet, wheat, rice, soybeans, canola/rape, sunflower, peanut and cotton.

Source: Informa Economics

Much of the concern regarding the impacts of current and expected global trends food availability and security highlights the need for continued productivity growth. For example, as grain and oilseed production has grown, yields in major producing areas—and, especially in exporting countries—have grown, as well (Chart 5). Grain and oilseed production area has actually grown less than 100 million hectares since 1980—but, to achieve the same production levels with yields of the early 1980s would have required the use of nearly 600 million additional hectares, land that simply is not available.

Chart 5. World Grain and Oilseed Crop Area, 1980-2009



Source: Informa Economics

Comparing yields

While data concerning productivity growth in developed countries and a few other areas are readily available and widely used, much less is known about productivity in many developing countries—and there often is disagreement about longer term yield trends.[7],[8]

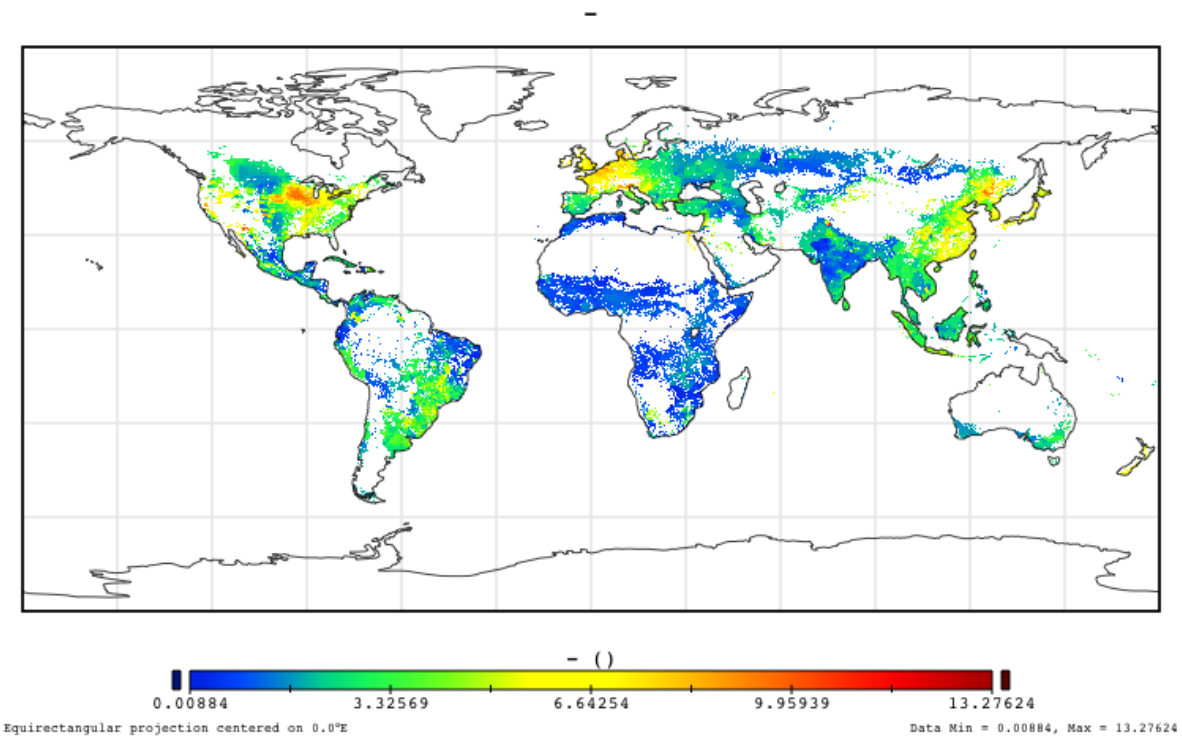
Yields depend on natural factors, including soil fertility, growing season length and temperature, rainfall amount and reliability or access to irrigation, among others. However, yields also depend on investment—in better genetics, fertilizer, machinery, management practices, crop protection and other inputs; credit to buy them and on supportive agricultural, economic and trade policies to support such investment. While

[7] Source: International Food Policy Research Institute, Washington, D.C.

[8] Many official and private institutions project crop and livestock yields, including the World Bank, FAO, IFPRI, USDA, OECD and many others. These differ modestly in terms of specific estimates for individual countries, but most expect faster growth in developed than in developing countries. In general, most projections also reflect expectations that developing country involvement in R&D, infrastructure and other supportive investments will continue to be near current levels. This means that increases in the amount or effectiveness of these investment have the potential to stimulate productivity growth in developing countries at a faster pace than is currently assumed.

developing countries often are favored with favorable natural factors—and sometimes with favorable policies, as well, the latter conditions are frequently lacking. As a result, only a few global locations have consistently high yields, and these are primarily in developed countries (Chart 6).

Chart 6. Global Grain Yields



Source: FAO

More specific comparisons indicate the magnitude of the yield differences, both between developed and developing countries, and for specific areas of the developing world, especially for Africa (Table 4).

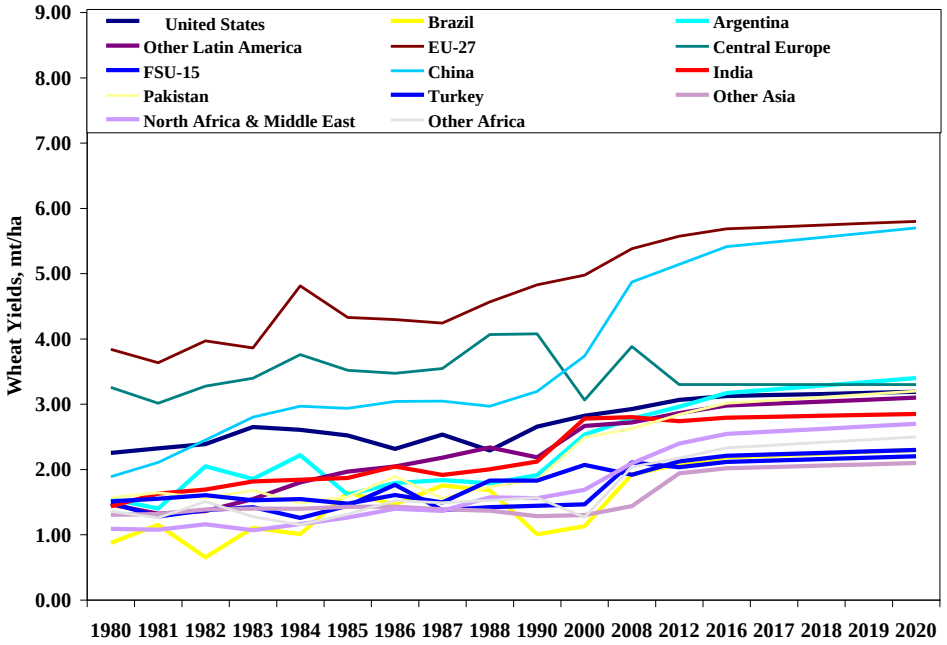
Table 4. Regional Cereal Yields Compared, 2001

	High UN Pop Proj	Low UN Pop Proj	Index Dev Ave 100
	mt/ha		
South Asia	2.5	2.4	62
Southeast Asia	3.0	3.0	77
East Asia	5.5	5.4	138
Sub-Saharan Africa	1.4	1.4	36
Latin America	3.7	3.6	92
West Asia/North Africa	2.6	2.5	64
Developing world	3.1	3.0	77
Developed World	4.0	3.9	100

Source IFPRI Impact Projections, 2001

While the differences between regions in yield trends is great, there is strong evidence that many developing areas can increase productivity—for example, China. That country's average yield for wheat has increased very significantly in response to better market and policy incentives, access to improved inputs and the availability of broader technical assistance (Chart 7).

Chart 7. Wheat Yield Trends Compared, Selected Developed and Developing Countries, 1980-2020



Source: Informa Economics

As a result, prospects seem strong for China's wheat yields to approach those of the EU-27 by 2020. India has used similar approaches, dating back to the beginning of the Green Revolution and its wheat yields grew as a result. For most of the other main producers, yield growth, especially for developing countries, has been quite sedate and is expected to continue to be in the coming decade.[9]

Global Agricultural Constraints

For the global food system to achieve its economic objectives in the future, it will be required to produce much more from the same or declining amounts of resources, especially, land and water. In addition, these difficult goals will become even more challenging if, as expected, the global climate changes significantly—a prospect that is still not well understood, either in terms of their causes or their impacts.

[9] The yields in Chart were developed by Informa Economics, based on detailed evaluations of historical trends in individual countries and analyst judgment regarding expected future economic and agricultural policies, incentives, adoption rates and input quality, availability and prices. The trends implied are routinely evaluated and reviewed extensively by commercial clients, government agencies and others.

The Environmental Challenge

While protection of the quality of agricultural soil and water has long been a main agricultural priority, it also has become a powerful and popular urban cause in developed countries, at least since the 1960s.

Furthermore, in both urban and rural quarters there now is a clear understanding that although pre-industrial agriculture did not intrude significantly on the environment, it also achieved low productivity, but that the introduction of the industrial techniques that sharply increase productivity can mean increased pressure for the environment.

Thus, a major future challenge is to continue to enhance productivity, but also to continue to reduce environmental intrusions. This implies, among other things:

- The prevention of degradation of the land base by erosion, by depletion of soil nutrition and by protection from water and wind erosion;

- The prevention of degradation of water quality;

- Improvement of air quality by controlling emissions from agricultural production, especially from concentrated livestock production operations;

- The development of more efficient controls of animal waste, and more efficient use of these valuable products; and

- The protection of the genetic diversity of the production systems, and avoiding loss or erosion of biodiversity as structural efficiency is enhanced to boost output to meet growing needs.

To succeed, these systems also must provide significantly improved wildlife habitat, as well as the attractive qualities of the "cultural" landscape—a less specifically definable objective, but one widely appreciated. To an important extent, protections for the rural "viewscape" imply constraints that affect not only scenic amenities, but also the structure of agriculture.

Producing with Less Land

Nearly all of the world's total arable land is now in agricultural use at varying levels of intensity, although better genetics and investment in infrastructure continue to increase the amount of land that can be safely cropped. Current estimates are that, over the coming decade, land in cereals and oilseeds will grow by about 5 percent, for example.[10]

[10] Informa Economics, Intermediate-term agricultural outlook, 2008.

Most of the remaining land area has serious constraints, and would be extremely expensive to improve.[11] These include low natural rainfall and thin rocky soils with low basic fertility and/or high mineral toxicity. Other land is very hilly or has other difficult terrain features—and, is in remote areas, often with short growing seasons, with very little in the way of infrastructure.

In addition, much of the remaining area is already in use in forests or a combination of forests and grasses, and much of it is in protected areas so that development would require changes in policy. Most this land is found in Africa and Latin America.

As a result, further expansion of crop area is controversial and risky in many areas such as the Amazon and many savannah areas. In addition, the development of these areas requires very considerable capital investment in soil amendments, irrigation and in the development of road or rail access.

The Land and Water Link

In many areas of the world, new land development would require new sources of water—sources that frequently are not available. In addition, the magnitude of the pressure on water supplies from improving diets is already enormous. For example:[12]

- To provide adequate drinking water requires only ½ to 1.3 gallons per person per day;
- However, crop production takes more. For example, to produce one pound of wheat requires about 200 gallons of water; about 1,500 lbs;
- Production of livestock products takes much more water—to produce one pound of beef requires about ten-times as much water as a pound of wheat.

The increasing requirements for water for agriculture are especially important because 80% of the world's cultivated land depends on natural rainfall and provides more than 60% of world's food—a constraint that is becoming increasingly important because agriculture already accounts for about 70% of the world's freshwater use (90% in India and China). Already, perhaps 30 developing countries are facing growing water shortages.[13]

---

[11] There is, at most, 12% more arable land available that is not now forested or subject to erosion or desertification—and, degradation of soils in many areas is continuing.

- In general, sharply increasing land in crop production could entail massive destruction of grassland, forests and loss of wildlife habitat, biodiversity and carbon sequestration capacity;
- Thus, the only environmentally sustainable alternative the global system faces is to at least double productivity on the fertile, non-erodible soils already in production.

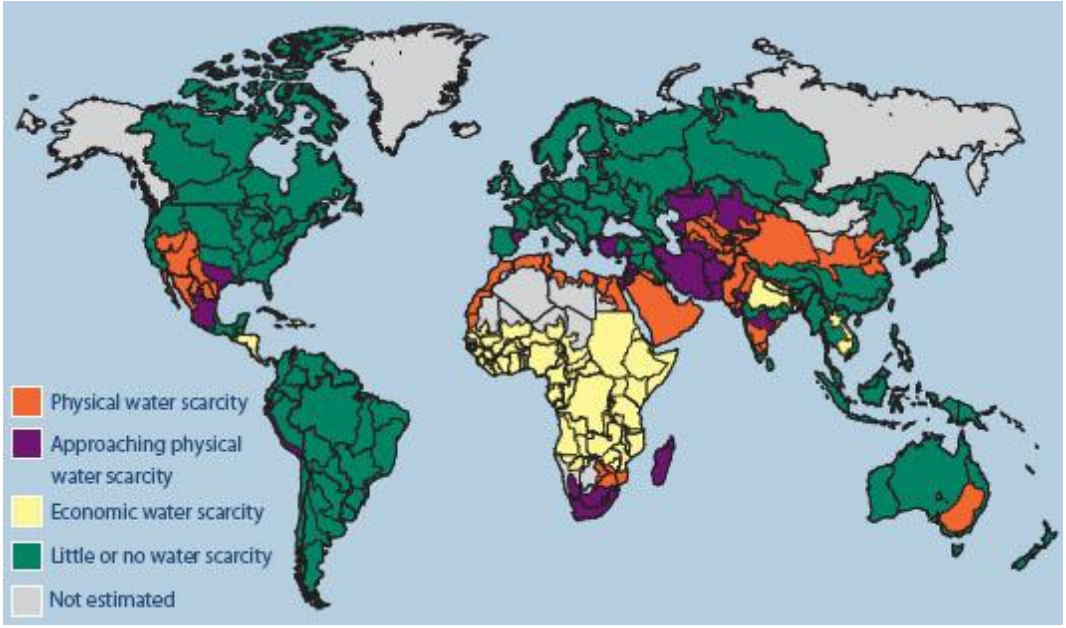
Professor Robert Thompson, Gardner Endowed Chair in Agricultural Policy, University of Illinois—and former World Bank official estimates, December, 2008.

[12] Source: UN-Water, 2007

[13] *ibid.*

It also is true that water and population are distributed very unevenly – and, that by 2025, 1.8 bil. people will live in areas with growing and severe water scarcities. By 2050, perhaps two-thirds of the world's population will live in water-stressed areas (Chart 8).

Chart 8. Global Areas of Physical and Economic Water Scarcity[14]



Source: Food and Agricultural Organization. "Areas of Physical and Economic Water Scarcity."

Agriculture's need for access to irrigation is increasingly acute in many areas, because it provides a way to increase yields of most crops two- to four-fold. New irrigation technologies can reduce water use or increase water use efficiency 30 percent to 60 percent compared with current surface irrigation techniques.

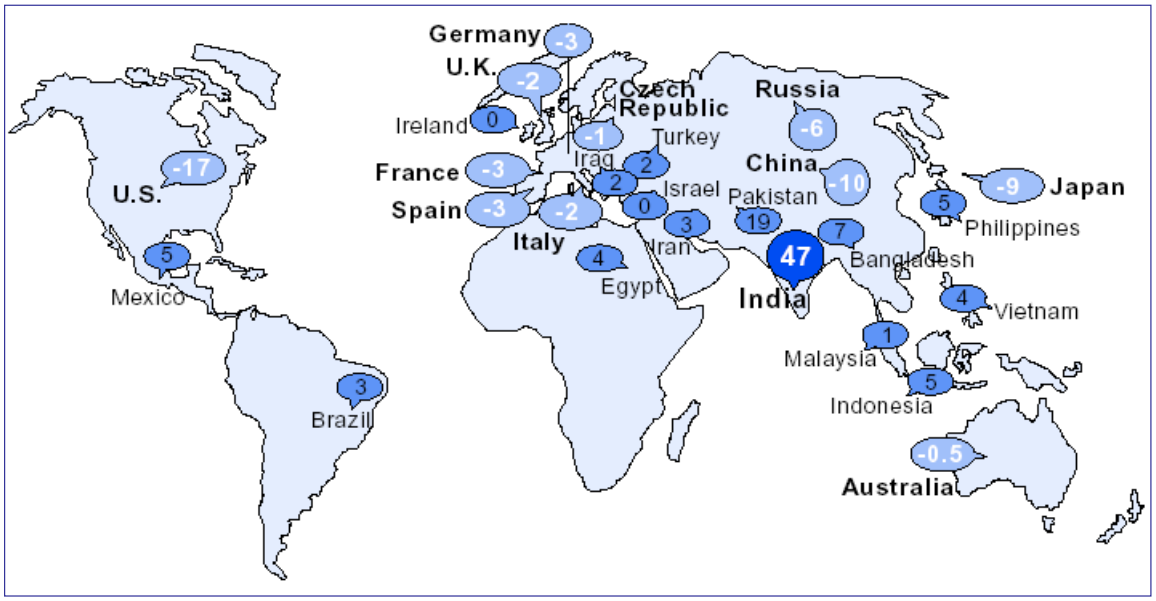
Demographics and Growing Labor Shortages

Slow population growth in most developed countries means aging populations and shortages of the young, highly skilled laborers need to operate high-tech machines, complex production processes and to comply with increasingly complex regulations.

Also, in many developed countries, tighter immigration rules and policies that encourage mechanization and innovation are sharply increasing pressure on the labor force. In many areas, these trends imply that shortages of skilled labor could persist and intensify unless training is part of any solution considered (Chart 9).

[14] *ibid.*

Chart 9. Labor Supply Shortages in Most Developed Regions
Worldwide Skilled Labor Supply, millions

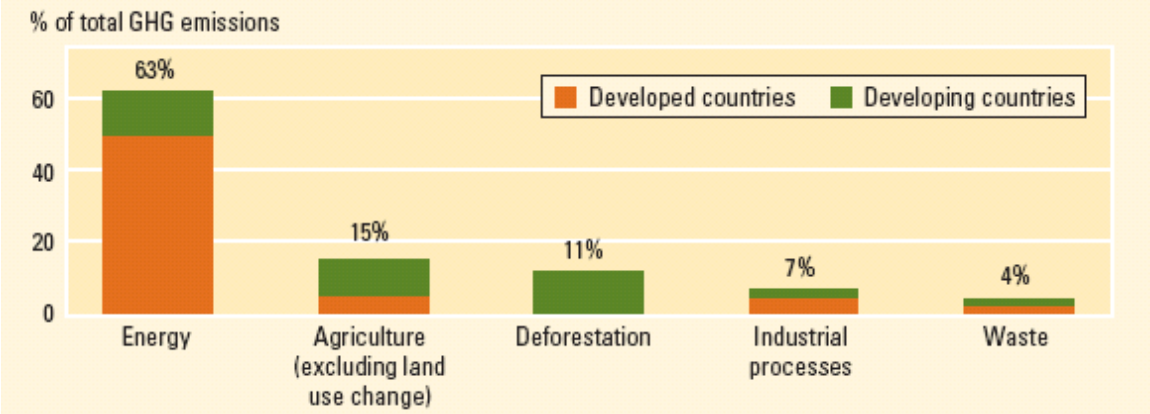


Source: BCG Analysis, US Census Bureau

Climate Change

Agriculture is generally considered to account for 20-30% of greenhouse gas emissions—and, is considered likely to be one focus of mitigation and adaptation strategies. Energy, including combustion of motor fuels, production of electricity and home heating is the main source GHG emissions, but agriculture is generally seen as a second-ranked source (Chart 10).

Chart 10. Green House Gas Emissions, By Source



Source: Intergovernmental Panel on Climate Change, World Bank

While the intermediate- or longer-term impacts of climate change are uncertain, they are expected to amplify the challenges the global food system faces. The expected impacts could mean:

- Drier parts of the world likely could become drier still, while wetter parts get wetter—and storms become more intense and frequent;

- Sea levels could rise to inundate some of the world's most productive cropland, especially in tropical areas. Partly as the result of the loss of some of the best land, tropical food crop yields could decline.

- Pest damage could increase as numbers increase, especially in warmer areas. The resulting reductions in output could raise costs;

- Equity issues could be exacerbated because of the disproportionate effect on agricultural productivity in lower latitudes – where most of the world's poor live.

Dealing with Climate Change. A wide variety of policies and instruments are under consideration by governments to create incentives to help constrain greenhouse gas emissions and buildup. Possible options include technologies either currently available or expected in coming years, including reforestation of pasture and cropland along with improved forest management and improved fertilizers and fertilizer (manure) management, along with the additional use of conservation tillage (no-till) and winter cover crops and the development of new crops, better suited to the evolving climate.

In addition, the sector is expected to face new opportunities from new approaches to carbon sequestration and carbon markets that create marketable offsets.

Observation

Not only do the changes expected in the global climate have enormous potential implications, but they could mean even greater pressures for additional, higher quality grains and oilseeds. At the same time, the new constraints brought by measures designed to reduce greenhouse gasses and to boost production as climate changes actually occur could be severe, as well, making the task even more difficult and demanding.

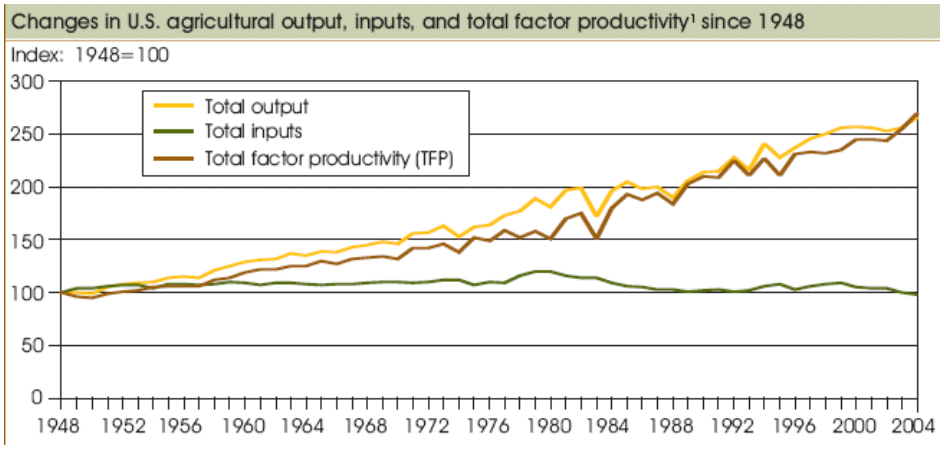
To an important extent, the conventional approach used to meet additional agricultural needs—cultivating more land—is increasingly likely to fall short of that goal because of the quality of remaining land, the high cost of improving it and social constraints on its use. Increasingly, enhanced productivity is not only the most attractive route to expanded production, but in some regions, is nearly the only alternative available that has the potential to keep pace with growing global needs.

II. Innovation and Productivity

The United States has a remarkable record of agricultural productivity growth since World War II. While the quantity of agricultural inputs used has declined during the period, total output has more than doubled—suggesting that productivity also has more than doubled. For example, long-term productivity growth for the sector has averaged 2.7% annually since 1948, far greater than for the rest of the world (Chart 11).

However, innovation and the development of new technology will become even more important in achieving future goals for global food and renewable energy growth while avoiding significant depletion of natural resources and environmental degradation. And, although the agricultural research system has a very strong record of progress extending for more than a century, both future challenges and opportunities will be increasingly important.

Chart 11. Agricultural Output, Input and Productivity, 1948-2004



Source: NASS, USDA

The private/public research balance—focus on developing countries

Beginning in the 1980s, a series of court decisions in the United States and elsewhere permitted private firms to patent intellectual traits in crops and livestock.[15] This development permitted large inflows of private capital into agricultural research and development, especially that research focused on agricultural productivity.

However, the trend has not been uniform among regions, with the result that private research continues to play a very small role in developing countries—an estimated 6% of

[15] See, for example, Wright, B.D. and Pardey, P.G. (2006) 'The evolving rights to intellectual property protection in the agricultural biosciences', *Int. J. Technology and Globalisation*, Vol. 2, Nos. 1/2, pp.12–29. The report concludes, among other things that pressures from the USA and Europe have resulted in the proliferation of stronger intellectual property protection worldwide, as a condition for continued access to world markets

research spending there in 2000, in contrast to the more than 50% share in the United States and developed countries, overall. As private research has become increasingly important globally, its near absence in developing countries has become a growing production constraint (Table 5).

Table 5. Global Research Funding, by Type and Region. 2000

	Public	Private	Total	Private
	millions of international dollars 1/			*%*
Latin America and Caribbean	2454	124	2578	4.8
Asia and Pacific	7523	663	8186	8.1
China	3150	862	4012	21.5
Developing Countries	12819	862	13681	6.3
Developed Countries	10191	12086	22277	54.3
United States	3828	4601	8429	54.6
Total	23010	12948	35958	36.0

1/ Conversions from local currencies to US dollar equivalents using purahasing power parity rates, rather than currency exchange rates.

Source: Farm Foundation Issue Report, May 2007

Available R&D funding data show significant global disparities in support for agriculture—and, they emphasize the role played by private investment and intellectual property protections (Table).

Table 6. Public Agricultural Research Spending by Income Class and Region, 1981-2000

	Public Agricultural R&D Spending		***Share***	
	1981	2000	1981	2000
Country Grouping by Income Class	(mil 2005 PPP $)		%	
Low income (46)	1,410	2,564	9	11
Middle income (62)	4,639	7,555	29	32
High income (32)	9,774	13,313	62	57
Total (140)	15,823	23,432	100	100
By Region				
Subsaharan Africa (45)	1,084	1,239	7	5
China	713	1,891	5	8
India	400	1,301	3	6
Asian-Pacific (26)	1,971	4,758	12	20
Brazil	1,005	1,209	6	5
Latin America and the Caribbean (25)	2,274	2,710	14	12
West Asia and North Africa (12)	720	1,412	5	6
Subtotal (108)	6,049	10,119	38	43

Source: ASTI Datasets; Measuring Agricultural Research, A Revised Global Picture Agricultural Science and Technology Indicators, October, 2008

In 2000, global public agricultural research investments totaled $23 billion (2005 Producer-parity price dollars, that is, in inflation-adjusted terms), up 47 percent from the 1981 total of $16 billion.[16]

Public spending for R&D in the Asia–Pacific region rose nearly two and a half times during the two-decade period, largely as a result of high growth in China and India. In contrast, the corresponding shares for Sub-Saharan Africa and Latin America and the Caribbean declined over this time period.[17]

Overall R&D spending in developing countries (low- and middle-income countries) increased by 1.9 percent per year on average during the 1990s, down from the 3.0 percent growth rate recorded a decade earlier—a trend that clearly has the potential to undercut global efforts to increase agricultural output in the future.

Annual spending growth in the Asia–Pacific region and in West Asia and North Africa remained comparatively high during the 1990s (3 percent a year), while Latin America and the Caribbean region and high-income countries as a whole experienced moderate spending growth over this time (0.3 and 0.5 percent, respectively).

In contrast, total public agricultural R&D spending in Sub-Saharan Africa decreased at an annual average rate of 0.2 percent during the 1990s. And in about half of the region's 24 countries (for which time-series data were available), the public sector spent less on agricultural R&D in 2000 than it had 10 years earlier—a trend that has raised significant concerns among development analysts throughout the region.

Need for Innovation

The reasons why investment in agriculture, including agricultural science, has been low on the global development agenda are numerous and complex. They likely include the persistently low commodity prices of the 1980s and 1990s as well as comparatively easy access to food aid—developments that make agricultural development issues appear riskier than they really are, and, in many cases, riskier than competing urban projects.

In addition, many governments and international agencies gave agricultural investments lower priorities than other environmental concerns and social issues—at least in part because rural residents typically have less political clout than those in urban areas where development problems are more visible. Finally, transnational NGOs often are skeptical of development that include emphasis on modern technologies.[18]

In spite of the fact that international interest in agricultural development has been low, and investment stagnant in recent years, important new research needs, many of which

---

[16] Beintema, Nienke M, and Stadts, Gert-Jan, ***Measuring Agricultural Research Investment: A Revised Global Picture***, Agricultural Science and Technology Indicators, ASTI Background Note October, 2008

[17] ***ibid.***

[18] Source: Professor Robert Thompson, Gardner Endowed Chair in Agricultural Policy, University of Illinois—and former World Bank official, December, 2008.

are well within the capabilities of well funded, modern R&D systems have been widely identified. Examples include:

- The need to make presently unusable soils productive;

- The need to increase the potential yields of individual production and farming systems for both crops and animals, and to achieve as much of that potential as possible by:

    - Improving nutrition for that crop or animal;
    - Increasing water availability and control;
    - Reducing competition from weeds for water, nutrients and sunlight;
    - Reducing losses from disease or insects; and

- The need to reduce post-harvest, post-farm losses.

Technology's New Frontier

While the technological advances brought by the Green Revolution have been fully exploited by now, a new frontier—biotechnology—has emerged with the capacity to provide important new benefits for both developed and developing countries, and even to target new technologies specifically to local needs and conditions, including those in developing countries.

As promising as many of these technological advances have proven to be, policy makers in Europe, and in developing countries that trade with Europe, frequently have declined to adopt them, apparently on the basis of a "precautionary" principle which is invoked in spite of the widespread use of biotech-derived crops in North and South America, and elsewhere. This means that many developing countries face continued, restricted access to bio-based technologies that are expected to be able to:[19]

- Improve the nutritional content of grains and other crops;
- Increase crop tolerance to drought, wetness, temperature, salt, aluminum toxicity and there by improve yields and allow productive use of poor quality land;
- Internalize resistance to diseases and viruses;
- Reduce pesticide use, especially insecticides; and
- Slow product deterioration.

[19] Professor Robert Thompson, Gardner Endowed Chair in Agricultural Policy, University of Illinois—and former World Bank official, December, 2008. Professor Thompson concludes that, "Future world market price trends will depend on whether research can increase land and water productivity faster than demand grows."

Observation

The importance of private research in developed countries, and its lack in developing countries has been one of several factors stimulating productivity growth. In addition, efforts by large, well-funded private foundations which long have been active in productivity-focused R&D, including some research responsible for important advances during the Green Revolution of the 1950s and 1960s. These include the Gates-Rockefeller (AGRA) group in Africa, among others. Supportive investments are being made by the Millennium Challenge Corporation, a government-funded US corporation that is actively encouraging good governance and policy reform in designated, developing countries in order to help boost productivity.

III. A Productivity-Focused Food System Development Strategy

Successful efforts to expand global food production almost certainly will depend on their capacity to focus on both developed and developing countries. One important effort will be to help close the "productivity gap" so developing countries have better access to existing technologies and practices.

An equally important need is to address more basic productivity constraints in both developed and developing countries and to support the R&D necessary to produce more effective genetics, more efficient machinery and other inputs, better management practices and to further enhance infrastructure throughout the value-chain.[20]

Many developing countries likely will continue to need help to boost their productivity. While that task remains ultimately their own responsibility, it is important that they be able to count on support from international organizations such as the World Bank, the regional development banks and other multilateral institutions, as well as bilateral efforts such as those of the US Millennium Challenge Corporation and USAID and other developed country programs, as well as from the World Trade Organization.

At the same time, closing the productivity gaps will require a clear understanding of what caused them in the first place. Reviews of global experience since World War II offer both positive and negative examples, but, to an important degree, suggest that strong growth reflects supportive policies and programs, including:

- Open markets, national economic stability and effective policy support for investment and trade, as well as assistance for the poor and protection from domestic or international exploitation, including;
    - Access to stable, abundant capital and credit; and
    - Access to international markets—there is a powerful and demonstrable correlation between the openness of an economy and its citizens' prosperity.

- National social policies that promote health and education, and food safety;

- National agricultural policies to promote investment in food and fiber production, infrastructure and markets; and
- Access to technology in the form of farming machinery, inputs (including improved seeds, nutrients and protections), water management and training.

[20] The value of an efficient, well developed marketing chain is difficult to overstate. These services and inputs include transportation and storage, agricultural finance and access to low-cost credit. They include commodity processing and food product market development and the information services required to make these systems efficient. And, to increase efficiency and productivity throughout the chain, systems in both developed and developing countries depend heavily on public and private R&D and technical assistance systems.

Not only have these "development fundamentals" been crucial to growth but the degree to which they were present is highly correlated with growth rates. In fact, only within such structures do investment flows reliably support competitive business operations and an effective balance of:

- Investment in "hard infrastructure" including farm-to-market roads, electrical power facilities, storage, water management facilities for flood control and irrigation, inland waterways, locks and dams and docks as well as rail lines to facilitate distribution and trade, research facilities, among others.

- Development of "soft infrastructure" including the elimination of legal, financial and social barriers to land ownership, property rights delineations, definitions and protections. In addition, development often depends upon outreach and extension services to farmers that promote improved farming practices, effective land and water stewardship and utilization, market information systems, and creation of appropriate rural and farm policy environments.

- Dependence on trade, as food production and consumption increasingly occur in different places.

Both challenges—closing the "gaps" and increasing the overall pace of productivity growth are difficult, especially the former. However, while efforts to boost developing country productivity have been an international goal for many decades, they have not always received priority attention and progress has often been disappointing.

For example, international famine relief and development assistance efforts were mobilized extensively following the devastation of World Wars I and II, with the Marshall Plan of the 1940s and 1950s the most prominent. In the 1950s and 1960s, private and public groups combined to mount a series of highly successful agricultural R&D and technical assistance programs that resulted in the "Green Revolution" of that period. Subsequently, international development assistance has focused heavily—if intermittently—on agriculture, in part because those sectors account for most of the income and employment in many countries.[21]

The United States, Western Europe and Japan, along with a few other countries—continue to support extensive aid programs, both bi-laterally and through private and public sources including the United Nations and a number of its agencies, regional development banks and others.
Nevertheless, developing country productivity continues to lag for a number of reasons, most frequently, the absence of the fundamental pre-conditions for growth. In many

[21] Because this assistance has included literally hundreds of projects in countries around the globe over many years, it is not possible to characterize the approaches used. In general, they tended to assist producers through technology transfers, direct and indirect technical assistance in production, crop and livestock management and in marketing, investments in irrigation, crop and farm management, financial assistance and credit, in market development and with other approaches.

cases, this means that the basic stability to permit investment is absent and political tensions, even armed conflicts or their remnants (e.g., damaged infrastructure, mined agricultural areas, continuing military threats) constrain investment. Frequently, economic and agricultural policies support market interventions, as well as taxes and border measures that reduce returns, increase costs and undercut development. Such policy-based investment roadblocks are especially difficult to overcome.

However, in many cases, communities with productive land, favorable climates and strong agricultural traditions have been slow to attract investment and to experience sustained productivity growth for one or more of three main reasons:

Lack of balance in outside investment. Agricultural productivity depends on access to productive land and adequate water, together with trained management. However, it also requires a balanced system with access to well adapted inputs, supply- and market-chain services and efficient markets. Each of these elements is essential to strong productivity growth.

In developed economies, efficient agricultural production units and supply- and market-chains largely develop privately, even though they often depend heavily on public institutions with private investment the main economic engine, a model that reflects long-term development trends in Europe, Japan and the United States, much of Latin America and elsewhere. Such systems expand not only because of the investment they attract but also because of the balance provided among economic and social components. When the potential for additional productivity growth exists, the increased economic returns implied lead to additional investment and overall system growth.

By contrast, the lack of balance in any part of the system inhibits growth. Obviously, the lack of productive land or adequate water constrains growth directly, but the lack of other components of a balanced system also have important, if less direct impacts. While upgrading agricultural technology for farms facing "system constraints" can still boost productivity, its benefits tend to fall short of those from a similar investment in a balanced system.

Balanced systems often have flexibility to substitute private for public support in many areas such as transportation or technology development or processing—as has occurred in Brazil, the United States and elsewhere. In these economies, larger-scale operations frequently develop their own private transportation and other infrastructures in the absence of public services, and, in some cases, operate virtually integrated marketing chains (joined by information technology) while meeting modern regulatory standards.[22]

By contrast, developed-country investments in developing-country agriculture frequently focus primarily on one segment of the system and provide too little attention to the system itself. In other cases, social constraints limit investment by interfering directly

[22] Observation from Paul Collier, ***How Illusion and Greed Fan the Food Crisis***, Foreign Affairs, December, 2008.

with balance. Examples include preventing the use of land as collateral for credit, or an exclusive focus on small-scale operations. To the extent that such constraints prevent system balance, they constrain capacity for growth.

For development programs that focus heavily on communities of small-scale farmers to succeed requires special attention to the economic and social support these operations require. Too little emphasis on the support elements can mean communities that continue to have too few resources and too little interaction to stimulate significant productivity growth. This is especially true in regions that have never developed the expensive, publicly-funded research-extension and marketing networks that were extremely important in the development of agriculture in Europe and the United States.[23]

Skepticism about agricultural technology. In today's increasingly global market environment, a number of largely European groups have advanced policies that reflect skepticism about the widespread application of advanced technologies to agricultural production. These include opposition, at differing levels, to the use of agricultural chemicals (pesticides and fertilizers), the use of hormones, antibiotics and other treatments and to biotech-modified plants and animals.[24],[25]

As European policies have constrained use of biotech-derived crops, many developing countries have restricted their use as well, especially those which depend on European markets or who simply have strong links to Europe. Such policies now restrict the use of several productivity-enhancing technologies, including biotech crops, especially in Africa.[26],[27]

---

[23] ***Ibid***. Collier suggests that this development model can provide too few economic or social benefits for rural people. In other cases, he suggests, development appears to be constrained by policy rules that prevent commercial land sales, especially in cases where land farmers' most important asset and its use as collateral for necessary investments is crucial for efficient farming operations. Source: ***ibid***.

[24] Paarlberg, Robert, ***Starved for Science: How Biotechnology is Being Kept Out of Africa***, Harvard University Press, 2008. Suggests that genetic modification was kept out of Europe because it was developed by American corporations, and was successfully labeled "Frankenfoods" by the European Left—and by European agricultural groups to protect local producers from international competition.

[25] Paul Collier, ***How Illusion and Greed Fan the Food Crisis***, Foreign Affairs, December, 2008. The author suggests that the impacts of this policy on productivity have been negative, and that before 1996, when GM varieties became widely available in the United States, European crop yield growth tracked that in the United States. Since then, he concludes, they have fallen behind by 1-2 percent annually, a major loss to global production.

[26] ***ibid***. Collier also points out a circular aspect of the ban, in that the ban has prevented applications of discoveries in GM research, and is therefore subject to the criticism that GM crops are "irrelevant to Africa."

[27] Some developing countries appear to face an additional, self-imposed threat. The trend for major food importing countries such as China, South Korea and a number of Gulf countries is to seek long-term food purchase agreements, land-leases or land purchases. While such agreements could provide needed capital, technical assistance and other benefits to developing countries in return for greater food security for the purchasing countries, there are strong indications that at least some of these have resulted in inequitable deals, at the same time they reduce production capacity in already vulnerable developing countries. Source: ***The Feeding of the Nine Billion; Global Food Security for the 21st Century***, Chatham House, Royal Institute for International Affairs, London, January, 2009

In effect, this means that important technological advances readily available in other regions are denied to them with the result that their options to improve productivity are narrowed, pressures on available crop land are increased and, in some cases, environmental problems are worsened.[28], [29]

In spite of their negative impacts, policies with such powerful public support as those opposing important agricultural technology applications in Europe are difficult to change quickly and will require powerful political leadership from the United States and other governments. Thus, organizing and supporting such efforts could be important to the growth of agricultural productivity sufficient to narrow the developing-developed country productivity gap.

Lagging investment in infrastructure. Infrastructure is the backbone of economic competitiveness, but because these facilities are so costly to develop and maintain they are often lacking or in bad repair. This is especially true in countries where economic resources are strained, as they often are in developing countries.

Traditionally, infrastructure investment comes from both public and private sources, but developing countries have recently begun to attract support from private investors, especially as technological and other changes have reduced the natural monopoly elements as a whole (e.g., in most telecommunications) or in part (e.g, electricity generation). [30],[31]

While direct foreign investment in infrastructure has been quite cyclical, it has become increasingly important for developing countries, except for those least developed. For example, in its 2008 investment survey, the Food and Agriculture Organization of the United Nations concludes that during 1990-2006, the stock of foreign direct investment in infrastructure in developing countries increased 29-fold to $199 billion, and was important for most infrastructure industries, though the expansion in water has flattened out since 2000.[32] However, the agency concludes that foreign investment, "…is still small compared to the overall investment needs, especially in the least developed countries that need it most."[33]

---

[28] Climate forecasts suggest that most of Africa will get hotter, that the semi-arid parts will get drier, and rainfall variability will increase.

[29] Jenifer Thomson, Department of Molecular and Cell Biology at the University of Cape Town reports that maize can be made more drought-resistant; that grain can be made more resistant to fungi, reducing the need for chemicals and cutting losses during storage, which now run 15 to 40 percent.

[30] UN, FAO, ***World Investment Report, 2008*** This report has a special, very extensive section of the evolution of investments by international corporations in infrastructure.

[31] *Ibid*.

[32] *Ibid.*

[33] FAO's 2008 survey observes that, "Until 2000, Latin America had the largest amount of international corporate involvement, both in absolute and proportional terms, but following a sharp decline there, Asia now has the highest in absolute terms. Corporate involvement in Africa has been significant in transport and telecommunications, but less so in electricity and water."
Overall, allowing for data limitations, Asia accounted for about 47% of the total stock of infrastructure foreign direct investment in developing countries in 2006, with Latin America and the Caribbean accounting for 46% and Africa for about 7%.

Additionally, the needs in these countries are more basic and often offer little prospect of revenues to attract investors since they include needs for farm-to-market rural roads, storage facilities to reduce post-harvest losses that often exceed 30 percent, for flood control, land leveling, ports, bridges and other basic facilities. The agency concluded that investment in these countries accounted for about 2% of the stock of infrastructure-related direct foreign investment in developing countries in 2006.

Given the scale of the developing country infrastructure gap, and the importance of improving their productivity to meet global needs, it is clear that private investment alone cannot be relied upon alone to close the infrastructure financing gap. This will require very significant amounts of capital that can only be provided by coordinated efforts by developed countries.

Observation

The foregoing sections identified a number of fundamental requirements for sustained productivity growth and suggested that future development efforts, whether public or private, should focus, perhaps more directly, on establishing these preconditions to development assistance projects. They also described three essential elements for sustained productivity growth, including strengthening system balance to stimulate growth, increasing both the access to and use of productivity-focused technologies, and strengthening developed-country support for basic infrastructure in least developed countries.

The following section discusses the importance of support by developed countries for both developing new technologies, and extending their use in developed countries.

IV. Meeting the Challenge: Recommendations

In mid-2008, the Congress passed replacement legislation for the expiring 2002 Farm Act that continues most of the main programs of the 2002 Act with relatively few changes. In addition to continued support for commodity programs, the Act expanded programs for biofuels, horticultural crops, and disaster assistance.

The Act also authorized a new organization, the National Institute of Food and Agriculture, intended to monitor and, to some extent, consolidate federal agricultural research across numerous agencies. The Institute's Office of Scientific Assessment is responsible for monitoring programs and spending, and an Office of Scientific Personal will monitor the number and need for agricultural scientists in the United States.

Additionally, the new Act reflects a growing level of national concern about international poverty, the lack of development among the least developed nations, and about the potential impact of rising food costs on people in developing countries, and people and nations with few resources. It suggests a new commitment by both the new administration and by bi-partisan groups in Congress to support organizational changes and provide additional funding to meet these concerns.

For example, the new administration has stated its commitment to:

- Progress toward the Millennium Development Goals within four years, that is, to reduce by half the number of people living on less than a dollar a day and suffering from hunger, and reversing the number of new HIV infections and malaria cases;

- Doubling US foreign assistance, to $50 billion by 2012—although, in the wake of the economic crisis, President elect Obama says he expects to "slow down" efforts toward this goal;

- Expand the President's Emergency Plan for AIDS Relief (PEPFAR) by at least $1 billion a year in new money and to remove the 33% cap on US contributions;

- Expand access to clean water and sanitation through increased funding of up to $1.3 billion annually and support for innovative programs;

- Capitalize a "Global Education Fund" with at least $2 billion in funding towards the goal of universal access and to be leveraged through the World Bank's Fast Track Initiative;

- Consider creating a cabinet-level position for development aid, and to consolidate PEPFAR, the federal Millennium Challenge Corporation, the Middle East Partnership Initiative, and other foreign assistance programs into a streamlined US Agency for International Development;

- Fully funding debt cancellation for Heavily Indebted Poor Countries, pressing for reforms at the World Bank to ensure that poor countries receive grants rather than loans, and leading a multilateral effort to address the issue of "odious debt;"

- To provide initial capital for a Small and Medium Enterprises Fund that would be administered through the federal Overseas Private Investment Corporation;

In addition, a bi-partisan congressional effort to reform and expand US international development programs has been proposed to boost US international aid appropriations for fiscal years in an effort to promote food security, to stimulate rural economies, and to improve emergency response to food crises.

In addition, a number of bills in Congress would elevate the visibility of foreign aid programs by creating a Special Coordinator for Global Food Security responsible for creating a US food security strategy. In general, these efforts recognize that US foreign assistance for agriculture has declined by nearly 70 percent since the 1980s, and that only 4 percent of global, official development assistance is allocated for agriculture—and, suggest that there is a pressing need to better balance agriculture resources and needs in the future.

An expanded dialogue

The foregoing sections identified a number of main trends affecting global food needs, and the major factors constraining productivity growth, especially in developing countries. Clearly, the answer—perhaps the only effective answer—to these challenges, is to produce far more agricultural output with the same or fewer resources, a goal that will require significant increases in productivity.

Meeting these challenges will mean very different things for different regions. There are big roles for government to play, but also much depends on successful investment by the private sector, by non-government organizations and by individual citizens the world over.

The current economic crisis is temporarily slowing food consumption growth, and is providing a brief reprieve from the building pressure on global agriculture. However, this window likely will be small and almost certainly mean a temporary interlude before the longer-term upward trends in food demand resume.

As a result, the GHI believes that it is essential that a global dialogue be undertaken at once about how to meet the 21st Century agricultural challenges. These need to be discussed with a focus on what should and can be done, who must do it, when, and, in what manner.

In the United States, there is a unique opportunity now with a new administration and a new Congress—and, we suggest, new resolve to tackle formidable problems. We

welcome this opportunity and hope that it can be extended worldwide. To that end, we are suggesting six specific areas for discussion.

- **How to effectively expand the global capacity to enhance agricultural productivity**. This includes increased support for agriculture research, with additional emphasis on and support for competitive, outcome-driven basic research and advanced technology training;
  - This includes the question of how to increase international support for science-based agricultural policies that enhance consumer confidence in technology and innovation globally;

- **How to increase the visibility and role of international development for agriculture,** including the creation of a high-level coordination role and entity in the US government to oversee and coordinate efforts among various organizations that now provide agricultural development assistance.

- **How to broaden the recognition of the need for balanced agricultural sector development, including both hard and soft infrastructure—and, how to increase support for infrastructure investment in the least developed countries, especially**, including farm to market roads, electricity, communications, storage facilities, water control, transportation and shipping, among others, and how to expand support for these facilities in developing nations;

- **How to expand domestic and developing world agricultural research** and development capacity, and:
  - Increase the competitive focus in US government R&D; and
  - Increase federal support for agricultural research and extension services in partnership with developing nations.

- **How to coordinate and expedite the sharing of agricultural information with developing countries**;

- **How to accelerate the development of "next generation" cellulosic and other advanced biofuels**, and maintain current favorable biofuels policies necessary to support the buildout of advanced fuels. Other actions should include fully funding and implementing the provisions of the recent Agriculture and Energy bills.