Agriculture's Strategic Role in Feeding and Fueling a Growing World

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Preface

As we look to the future, agriculture in the United States and around the world faces a difficult challenge: how to feed a growing world. Global population is expected to increase by one-third to reach 9 billion by 2040. Incomes are rising, too, bringing increased demand for agriculture to provide food, fiber and energy, and increasing pressure on global resources.

U.S. agriculture alone cannot feed a growing world. However, with its rich endowment of agricultural resources and its leadership in technology, the United States will play a critical role in determining if the world will meet this 30-year challenge.

Given the right tools and incentives, we are confident the world's agricultural producers and agribusinesses will rise to the challenge. But those incentives and tools are heavily influenced by public policy. Current food and agricultural programs and policies in the United States have been shaped by decades of abundance and declining real food prices. But consumers, environmental concerns and climate change are reshaping the public policy landscape. It is not clear that today's policies—designed to deal with issues of the last century—will provide appropriate tools and incentives to address the 30-year challenge.

Farm Foundation has a 75-year commitment to objectivity, fostering constructive debate that is essential to sound public policy development in a democracy. It is appropriate that Farm Foundation be the catalyst to spur all stakeholders to begin discussions on the 30-year challenge. The need is real and well recognized. A new Administration and a new Congress are about to begin their terms. The world stage is set for new directions and solutions. This is a "generational opportunity" to begin new discussions on public policies for the 21st Century.

This project was not conceived to recommend solutions but to start the discussion and debate among all stakeholders about the multitude of choices which lie before us if we are to meet the 30-year challenge.

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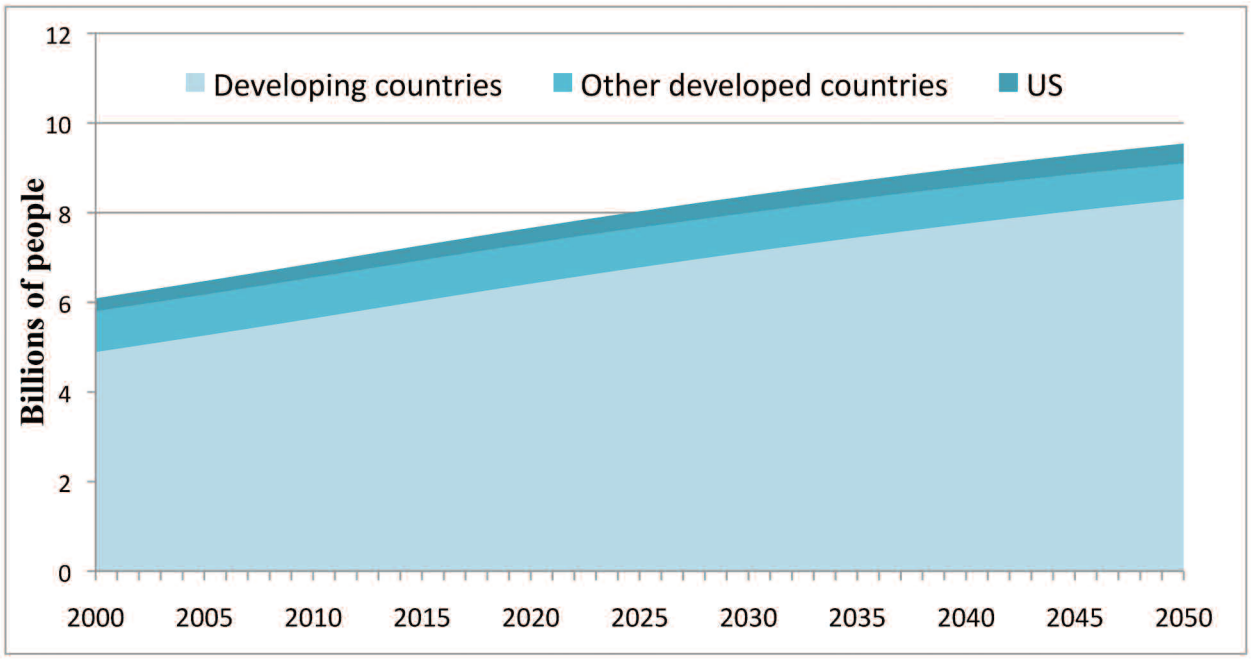
The 30-Year Challenge:
Agriculture's Strategic Role in Feeding and Fueling a Growing World

Over the next 30 years, agriculture will be challenged to provide food, fiber and fuel to a growing world population. World population is forecast to increase by more than one-third to 9 billion people by 2040 (Figure 1). The number of undernourished people is expected to remain in the hundreds of millions.

The setting for this challenge is characterized by growth in incomes that changes food demands, increasing competition for natural resources, expanding demand for agricultural output for non-food purposes such as biofuels, and concerns about a changing environment. Climate change may require agriculture to adapt to ongoing changes and to play a role in mitigating greenhouse gas emissions.

Improvements in technology and sound public policies will be needed to meet the 30-year challenge. Failure to do so is likely to mean an increasing number of malnourished people, depletion of natural resources and degradation of the environment.

Figure 1 : World population



Sources: (1) U.S. Census Bureau. Population, Population Change and Estimated Components of Population Change: April 1, 2000 to July 1, 2007. Retrieved Nov. 5, 2008: www.census.gov/popest/datasets.html; and (2) U.S. Census Bureau. Projected Population by Single Year of Age, Sex, Race, and Hispanic Origin for the United States: July 1, 2000 to July 1, 2050. Retrieved Nov. 5, 2008: www.census.gov/population/www/projections/downloadablefiles.html.

In the United States and most developed economies, both public policies and private-sector decisions have been shaped by decades of abundance and declining real food prices. The challenge today is to adjust to an era in which the agricultural sector will be challenged to meet competing and growing demand for its products with limited natural and financial resources. Inaction or reaction without clear vision of the long-term future invites inconsistency and unintended consequences. U.S. agriculture cannot meet this challenge alone—it cannot single-handedly feed a growing world. However, as a principal agricultural producer and a leader in the development of agricultural technology, the

United States will play a critical role in determining whether the world is able to meet the challenge of feeding and fueling a growing world over the next three decades.

The 30-year challenge for agriculture defies easy analysis or simple solutions. Farm Foundation initiated this project to provide public and private decision makers with insights into the complex nature of the challenge and the range of long-term strategies and policies that might be considered. In keeping with Farm Foundation's history of objectivity—the Foundation does not lobby or advocate—this project was not conceived to recommend specific approaches or solutions. Rather, this report is a catalyst to foster understanding among all stakeholders of the challenges ahead, potential options to address those challenges, and the consequences of those options. Meeting the 30-year challenge begins with discussion of the issues and options.

This Report

To develop this report, Farm Foundation drew on the insights of leaders from business, government, non-governmental organizations and academia. We began with a small group of individuals whose discussions defined the 30-year challenge in six broad categories:

1. global financial markets and recession,
2. global food security,
3. global energy security,
4. climate change,
5. competition for natural resources, and
6. global economic development.

Farm Foundation then invited a broader group of leaders to explore each of the six categories, identifying critical strategic problems, alternative strategies and potential policies. Those discussions are the basis of this report. The topics and options presented here are not intended to be inclusive; rather they are a template from which to expand discussion and debate. This is not a consensus document and it does not make recommendations. It does reflect the diverse opinions expressed by project participants, their analysis of the problems which must solved to meet the 30-year challenge, and their assessment of some potential options to deal with those problems.

Global financial markets and recession: The financial crisis may have disrupted the ability of agricultural producers and agribusinesses to access capital, and the looming recession will reduce demand for many agricultural goods. At this time, the extent of these effects is uncertain. The financial crisis and recession could create an agricultural business environment that discourages decision makers from looking ahead to meet the 30-year challenge. In this situation, decisions about management practices, investment and research to align public and private activities are likely to focus on short-term profitability and rising capital costs rather than long-run objectives relating to food security, energy security, natural resources, climate change, and economic development.

There are public policy options to support capital flows to the sector, including to foreign buyers and farmers, and to alleviate the negative effects of falling revenues brought about by a weakening demand. Each option offers its own answer to the problem, budgetary implications and unintended consequences. Public policies to lend directly to businesses risk pushing aside commercial finance.

Global food security: Agriculture has always been under pressure to feed a growing world, but the problem today is compounded by competing bioenergy demands, increasing competition for natural resources, climate change and income growth. Booming income growth in many developing countries causes consumers' diets to shift away from traditional staples in favor of livestock products. At the same time that more and more output is needed, consumers hold the agricultural sector to increasingly higher food safety standards.

Public policy options to increase food security target quantity and safety. These options include education to help consumers understand and participate in food safety, enhancing existing domestic nutrition assistance and international food aid, and support for international grain stocks or financial mechanisms that reduce the effects of high prices on the world's poorest consumers. Strong public policy efforts lead to larger expenditures and more risks of unintended consequences, such as greater competition for natural resources if agricultural production rises and less energy security. Failures in international food security lead to lower economic growth in developing countries.

Global energy security: One result of complacency toward energy security may be inconsistent and inefficient investment in alternative fuels. The recent run-up in the real petroleum price renewed interest in renewable fuels that had waned as prices fell after the peak in the early 1980s. An economy-wide shift to incorporate new energy sources invites long-term decision-making that looks beyond immediate price swings.

Leaders in the U.S. agricultural sector may not be the key players in deciding the role for public policies for energy security. However, they will make decisions to implement biofuel use mandates—or whether to waive them—and about biofuel credits and tariffs that expire in the coming years. Each option has different consequences for the budget and for markets, with unintended consequences that may increase competition for natural resources and impede food security.

Climate change: The agricultural sector must adapt to climate change that is already taking place and play a part in climate change mitigation strategies. Adaptation will occur and could be addressed proactively, before altering agricultural production environments affect supplies, or after the effects on food security and natural resources are clear. Mitigation invites a long-term planning horizon that focuses on the wider effects of producer and agribusiness practices.

There are public policy options that would coax private firms to reduce greenhouse gas emission voluntarily, speed research to develop and change agricultural practices, price greenhouse gas emissions directly with a tax or indirectly with a cap-and-trade regime and compel emissions reductions with strict regulations. Budgetary consequences of these options vary widely. The unintended consequences may include reductions in overall agricultural output, placing food and energy security at risk and slowing economic development.

Competition for natural resources: Without some public policy intervention, incentives for producers and agribusinesses would not reflect the off-site effects of their practices, causing the possibility that their actions may overuse or misuse natural resources relative to the wider public good. Existing public policies include U.S. conservation programs, Environmental Protection Agency regulations, and state and local government policies regarding natural resources.

Public policy options include extending existing programs and defining better national priorities for natural resources. Allocating money to fund these options is one problem. A larger concern may be to integrate any program, even voluntary ones or support for research, into the network of overlapping responsibilities of federal, state and local governments—without treading on individual property rights. An unintended consequence of policies that end up reducing natural resource use or stopping certain practices is likely to be lower agricultural output at least in the short-term future.

Global economic development: Agriculture is often the main source of income for the poorest people in the world, and food is usually their largest expense. Many efforts to increase global economic development try to improve the performance of the agricultural sector in developing countries.

Public policy options available to U.S. agricultural decision makers include reviewing the role of food aid as an instrument that can support economic development, both by sparking local markets and by providing the nutritional basis necessary for increasing human capital, and programs that target specific deficiencies in developing countries' agricultural sectors, such as infrastructure and research. While these programs tend to require small budgetary outlays, their potential benefits for the recipient and for the United States may be large, although delayed and only imprecisely measured.

Recurring Themes

Throughout the discussions of the six categories of issues within the 30-year challenge, a number of recurring themes became apparent. These were:

- uncertainty,
- public understanding,
- unintended consequences,
- trade-offs,
- research and development,
- infrastructure,
- trade, and
- the absence of a clear strategy for U.S. agriculture.

Uncertainty surrounds many critical questions about the 30-year challenge and policy options to meet it. The degree of damage to the financial infrastructure of the agricultural sector and the severity of the subsequent recession were unknown at the writing of this report. Looking ahead, climate change entails many uncertainties about what is evolving, what will happen in the future and how to limit further changes. There are many unknown factors in long-standing problems, such as the role of agriculture in economic development and the interaction of agriculture and natural resources.

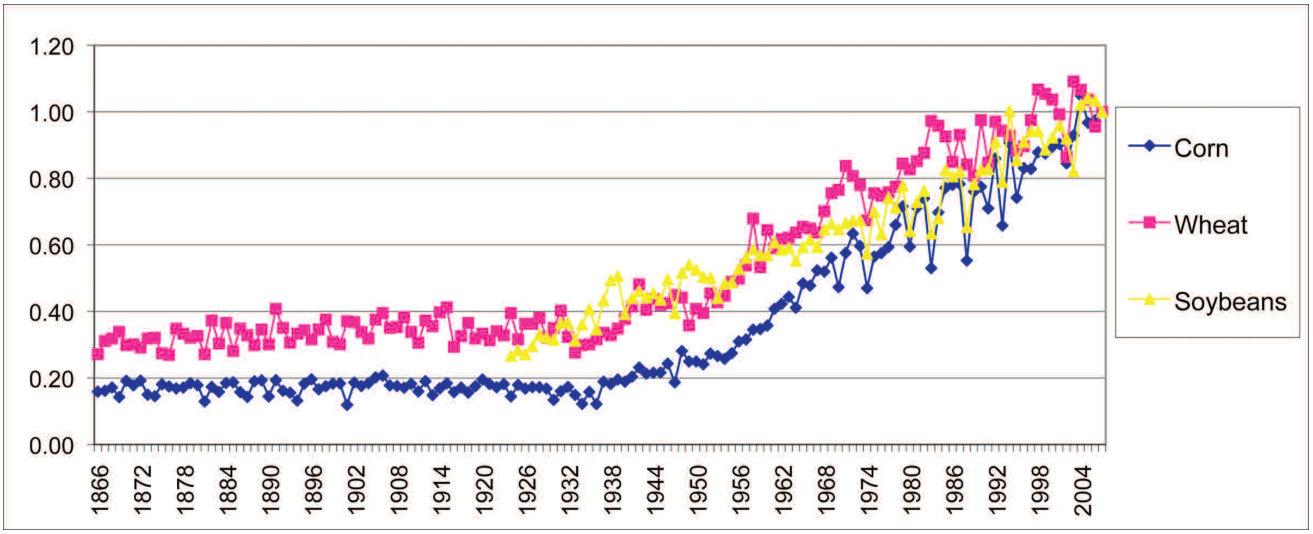
Public understanding of agriculture has changed significantly over the last half century. The segment of the population engaged in agriculture has dwindled so that farm households now represent only a small share of all households in the United States. At the same time, many consumers are increasingly concerned about how their food is produced. Some of these concerns are related to food safety, while others reflect such ethical concerns as labor standards and animal treatment. Agricultural producers sometimes struggle to understand public attitudes about these concerns. The absence of a clear mutual understanding is not conducive to developing policies to deal with the 30-year challenge.

Unintended consequences accompany any policy intervention. Neither consumers nor producers are passive with respect to changing incentives. Any change in policy or regulation that changes incentives is likely to have not only the intended direct effects, but also indirect effects as quantity and price adjustments cascade through markets. Policies to address one objective of the 30-year challenge may affect markets in ways that work against other objectives. Recent events in agricultural commodity markets illustrate the point. Incentives for increased bioenergy production in the United States and many other countries led to unanticipated changes in markets for feedstock commodities and across the full range of markets for agricultural products and inputs. Unintended consequences may even undermine the targeted strategic objective. For example, increasing publicly held stocks displaces private stocks and food aid typically does not lead to a one-for-one increase in consumption.

Trade-offs are a consequence of every policy option. The most obvious and pervasive trade-off is the budgetary cost of policy change, whether it is expanding research and development, repairing aging infrastructure or providing farmers with access to improved tools for risk management. Increasing the budget in one area ultimately implies reducing expenditures in another or increasing the cost to taxpayers. Beyond the budget, trade-offs between dealing with short-term disruptions and the need for long-term strategic investment and trade-offs between the environmental effects and the increasing demand for food, fiber and fuel stand out. Markets play a critical role in sorting out these trade-offs. However, the shift from a set of policies and programs oriented toward dealing with the problems of the past to policies dealing with the 30-year challenge can only be achieved if the political will exists to recognize and address these trade-offs.

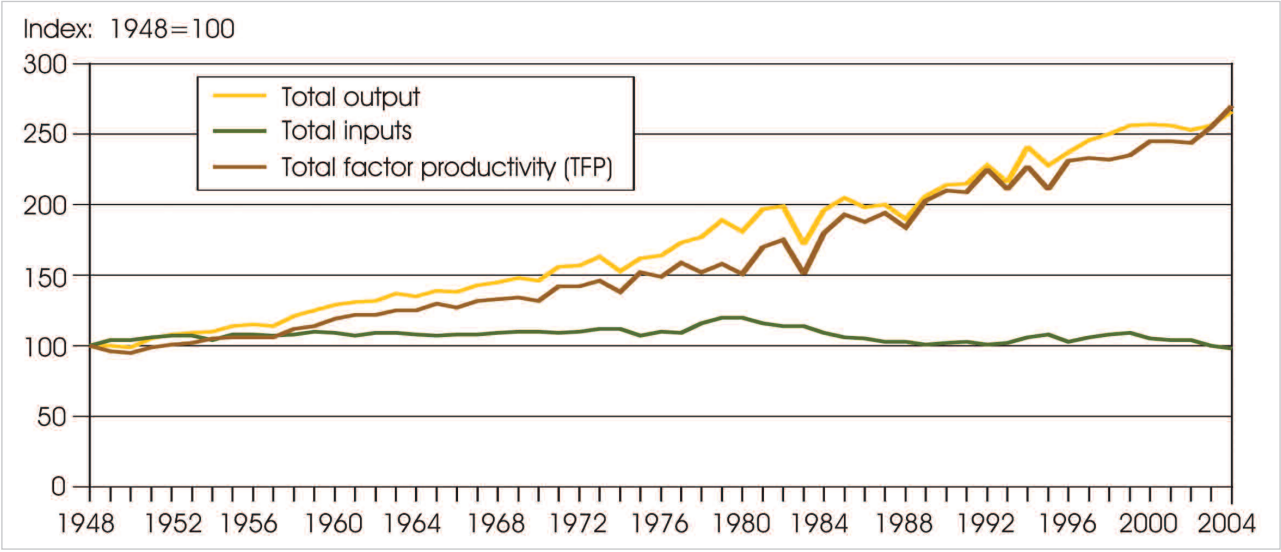
Research and development is not a panacea, but does have a critical role in agriculture's ability to meet the 30-year challenge. New technology may help to achieve goals for global food security and energy security without significant depletion of natural resources and environmental degradation. For almost a century, agriculture has a history of strong technological growth (Figure 2). The story for at least the last half-century has been one of doing more with fewer inputs overall (Figure 3). But the state of soil erosion and water depletion suggests that conservation of these resources still poses a major challenge. Air and water quality deterioration indicate that some current practices cannot to be continued for 30 years. Climate change hints at a potentially radical new setting and objective for the agricultural sector.

Figure 2 : U.S. average yields, index (2007=1)



Source: NASS (www.nass.usda.gov/index.asp).

Figure 3 : U.S. agricultural inputs, outputs, and productivity



Notes: average growth rates are given as 1.6% for crops and 1.8% for livestock; and input composition changes as energy and chemicals use increases and land and labor use decreases.
SOURCE: ERS (www.ers.usda.gov/Briefing/AgResearch/Questions/APRDQA2.HTM).

Private and public decision making about research investment does not take into account its full value to society. Too often, decision makers focus on the immediate costs of research without recognizing the long-term benefits. Left alone, private cost-benefit analysis omits the wider and long-lasting effects of resource misuse and greenhouse gas emissions. However, the benefits of research may also be undercounted in public debate. Many benefits are long delayed and indirect. It is difficult for public policy cost-benefit analysis to estimate the value of possible payouts in 10 years, let alone in 30. It is even more difficult to value the unglamorous bits of a new technology that might come together to transform the entire sector. The indirect benefits may also be undervalued. Public investment in research may not reflect the potential that better international research feeds back to the United States through such indirect channels as technological spill-over and trade.

Infrastructure is the system for the movement and exchange of goods, as well as inputs such as capital, water and labor. There are physical elements such as roads, rail, bridges, waterways and ports. Infrastructure also includes institutions that define markets, including contracting, the rule of law, labeling and the flow of information.

Much of the physical infrastructure to move and trade U.S. commodities is aging, and there are important capacity constraints in roads, rails, water-borne transport, and water storage and distribution systems. The institutional infrastructure is not perceived by all consumers to provide safe food. The physical and institutional infrastructure does not extend entirely to the rapidly developing markets for bioenergy and emerging markets for environmental services. Infrastructure deficiencies are an important impediment to agriculture playing a part in global economic development. The production and transport of commodities cannot be done efficiently without the physical and institutional systems that support transactions over distances.

Trade and the growth of global markets have not only brought about benefits to U.S. agricultural producers but have also created export opportunities that help generate broader economic activity and employment. Trade also provides consumers with a much wider variety of products at affordable prices. Producers and consumers around the world have experienced gains as trade barriers have been reduced and global markets have become increasingly integrated. The 30-year challenge requires efficient use of resources on a global basis, so trade will be critical.

Benefits of trade to producers and consumers may be obvious, but the adjustment costs associated with trade agreements and changing international conditions also stand out. The direction of United States' trade policy will not only be a signal to domestic interests but also to the world, including developing countries who look to trade as one pillar supporting economic development.

A recurring theme throughout the discussion was ***the absence of a clear strategy for U.S. agriculture***. There is no set of agreed national objectives to guide decision making. Several participants noted that in the context of continuous crises—financial, weather, political and international—the lack of a sense of strategic direction can lead to policy decisions designed to deal with short-term problems, without consideration for longer-term unintended consequences and trade-offs.

The United States currently lacks a clear strategy for meeting the 30-year challenge. A clear statement of goals that recognizes the global nature of the problems facing U.S. agriculture, the high levels of uncertainty surrounding many of these problems, the shift to an era of multiplying demands, increasing competition for resources, and climate change could lead to more consistency in both public- and private-sector decisions. Policy consistency could lead to fewer counter-productive, unintended consequences and more effective use of scarce resources, both natural and financial.

The 30-year challenge

History is cluttered with predictions of limited resources leading to malnutrition and population limits. In the late 18th century, Malthus argued that population growth would always push against resource limits, causing starvation. More recent assessments include *The Limits to Growth*, commissioned by the Club of Rome in 1972, which highlighted imbalances between resources and requirements. In the mid-1990s, Lester Brown questioned the ability of the world agricultural sector to satiate China's booming demand. This report does not address the question, "Can we do it?"

Neither Farm Foundation nor this report predicts doom or failure. It is true that today malnutrition, resource depletion and environmental degradation are evidence of the limits of our current system. But the shares of world and U.S. populations that are undernourished have decreased, and the average share of food in consumers' expenditures has fallen in the last half-century, albeit with important exceptions. The lethality of poor growing conditions has decreased (Table 1). It is not clear whether these improvements will endure as demand increases with population growth and dietary changes, particularly in the face of increasingly apparent resource constraints. It is not yet clear how agriculture can meet all of these demands in the presence of imperatives to adapt to climate changes and to mitigate further climate change.

Public action is an element of any prediction. There is already an array of public policies that address elements of the 30-year challenge, albeit often piecemeal. If continued, these policies could work to alleviate some of the pressures or to exacerbate them as some of the unintended consequences unfold. The public and private sectors are not passive. There will be policies to address these problems, whether based on pure reaction to short-term crisis or based on underlying strategic vision to meet the 30-year challenge.

Table 1 : Estimated death tolls from selected famines

Year of Famine	Country	Excess Mortality (million)	Death Rate (percent)	Observations
1693-94	France	1.5	7	Poor harvests
1740-41	Ireland	0.3	13	Cold weather
1846-52	Ireland	1	12	Potato blight; policy failure
1868	Finland	0.1	7	Poor harvests
1877-79	China	9.5 to 13	3	Drought, floods
1876-79	India	7	3	Drought, policy failure
1921-22	USSR	9	6	Drought, civil war
1927	China	3 to 6	1	Natural disasters
1932-33	USSR	5 to 6	4	Stalinism; harvest shortfall
1942-44	Bengal	2	3	War; policy failure; supply shortfall
1946-1947	Soviet Union	1.2	0.7	Poor harvest, policy failure
1959-61	China	15	2	Drought, floods; Great Leap Forward
1972-73	India	0.1	0.03	Drought
1974-75	Bangladesh	0.5	0.5	War, floods, harvest shortfall
1972-73	Ethiopia	0.06	0.2	Drought; poor governance
1975-79	Cambodia	0.5 to 0.8	7 to 11	Human agency
1980-81	Uganda	0.03	0.3	Drought, conflict
1984-85	Sudan	0.25	1	Drought
1985-86	Ethiopia	0.6 to 1	2	War; human agency; drought
1991-92	Somalia	0.3	4	Drought, civil war
1998	Sudan	0.07	0.2	Drought
1995-2000	North Korea	0.6 to 1	3 to 4	Poor harvest; policy failure
2002	Malawi	Negligible	0	Drought
2005	Niger	Negligible	0	Drought

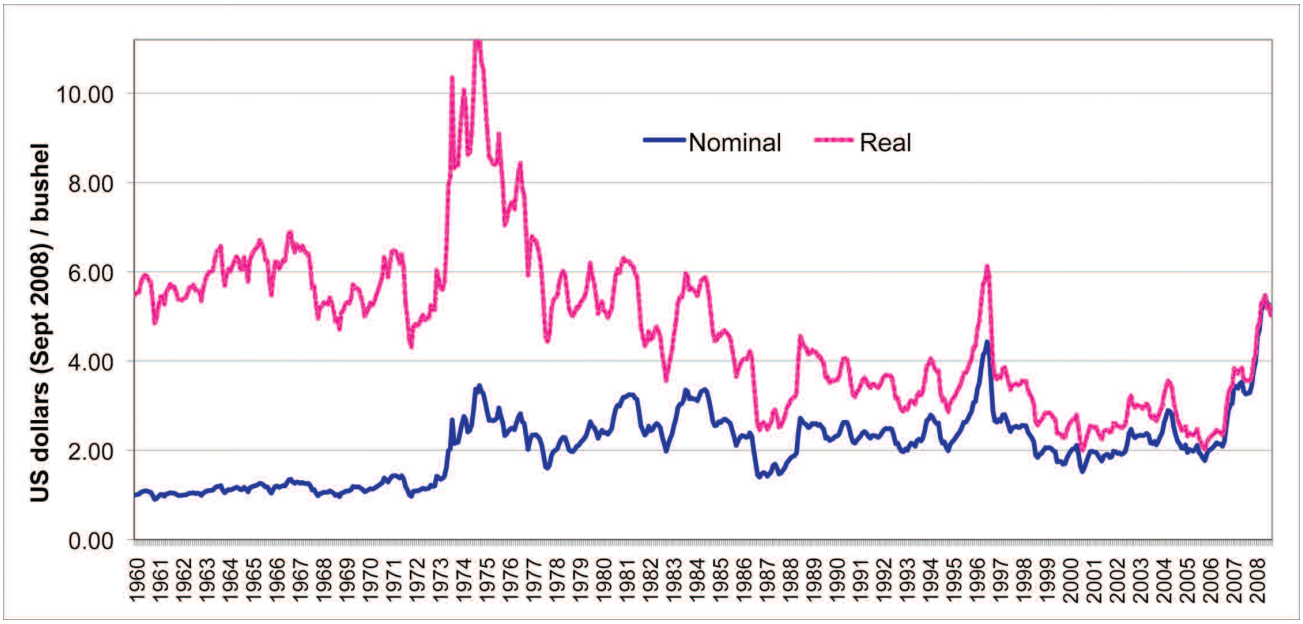
Source: Ó Gráda, C. "Making Famine History," Journal of Economic Literature, March 2007, p. 20.

Today, more than at any other time in recent decades, there is an opportunity to consider policy more broadly. It is what has been referred to as a "generational opportunity."

Recent swings in commodity prices (Figure 4), growing information about climate change, and the financial crisis and likelihood of recession have shone a new spotlight on agriculture's strategic role in feeding the world and supporting

the world's economy. With new agricultural and energy legislation in place and the election of a new President and Congress, the opportunity exists to review long-term policy priorities and mechanisms. This is a unique opportunity to set out a clear strategy to meet the 30-year challenge and institute the public and private mechanisms to achieve that strategy.

Figure 4 : U.S. average farm price of corn



Sources: (1) corn price from Economic Research Service, United States Department of Agriculture. Feed Grains Database retrieved Nov. 5, 2008: www.ers.usda.gov/data/feedgrains/FeedGrainsQueriable.aspx; and (2) deflator from Bureau of Labor Statistics, U.S. Department of Labor. Producer Price Indexes. Retrieved Nov. 5, 2008: www.bls.gov/ppi/home.htm.

In this report, Farm Foundation does not recommend any particular strategy or specific policies. Farm Foundation undertook this project to motivate a debate about how U.S. agriculture will meet the challenge to set the framework necessary to meet growing food, fiber and energy demands in a way that is consistent with natural resource and climate change imperatives.

It is time to begin.

Global Financial Markets and Recession

Modern agriculture is a capital-intensive industry. Producers rely on financial markets to provide the capital they need to access inputs. The 30-year challenge will require greater investments in technology on the farm and in the agribusinesses that connect producers and consumers. Without access to short-term operating credit and long-term investment capital, agriculture will be unable to meet this challenge.

Capital is also needed if the agricultural sector is to deal with other challenges discussed in this report—climate change, food security, energy security, competition for natural resources, and economic growth and development. The ability of producers and agribusinesses to obtain the capital needed in each of these areas depends on two key ingredients. First, the sector must be able to generate a risk-adjusted rate of return that is competitive with the rate of return in the rest of the economy. Second, producers and agribusinesses need access not just to credit but to the full range of financial services and products, including risk management tools appropriate to the industry. This requires stable and liquid financial markets and financial services companies that understand the sector's needs.

Since the sector's recovery from the financial crisis of the 1980s and the restructuring of financial institutions serving producers, access to capital for agriculture has not been viewed as an issue within the United States. However, the current volatility in commodity markets and the global financial crisis have raised the question of whether the global financial structure will be a key challenge for agriculture. Adequate data are not available to determine whether the current financial crisis has created new and critical credit gaps for the agricultural sector. But if the global financial meltdown does affect agricultural finance, decision makers would face three strategic problems:

- restoring and maintaining trust in financial markets serving agriculture,
- access to credit, and
- access to the financial tools needed to manage the risks of higher and more volatile prices.

Addressing the 30-year challenge requires a long-range planning horizon that can be undermined by financial instability. Private and public investments in systems or research intended to bear fruit over a number of years will be endangered if financial market instability persists. The sector may be slower to adopt technologies that could help mitigate climate change or better balance production needs with natural resource constraints.

Second, inability to access credit is a major barrier to improving agricultural sectors in many developing countries. The role of agriculture in broader economic growth is addressed later in this report (see Global Economic Development)

A third spill-over of today's financial crisis is the potential for a global economic recession. Although agriculture is likely to be less dramatically affected than other sectors, a global recession would weaken demand for agricultural output and slow dietary shifts in many countries. While this might be viewed as a respite from the pressures associated with strong demand growth that recently helped drive up prices, the impact of a recession on the food purchasing power of low-income groups can be alarming. And lower agricultural commodity prices reduce U.S. farm income.

The current situation is one of uncertainty. Unknown is whether the financial infrastructure of the agricultural sector has been shaken, if it has been cracked by the quake that hit all financial markets, or if worse damage may yet be inflicted.

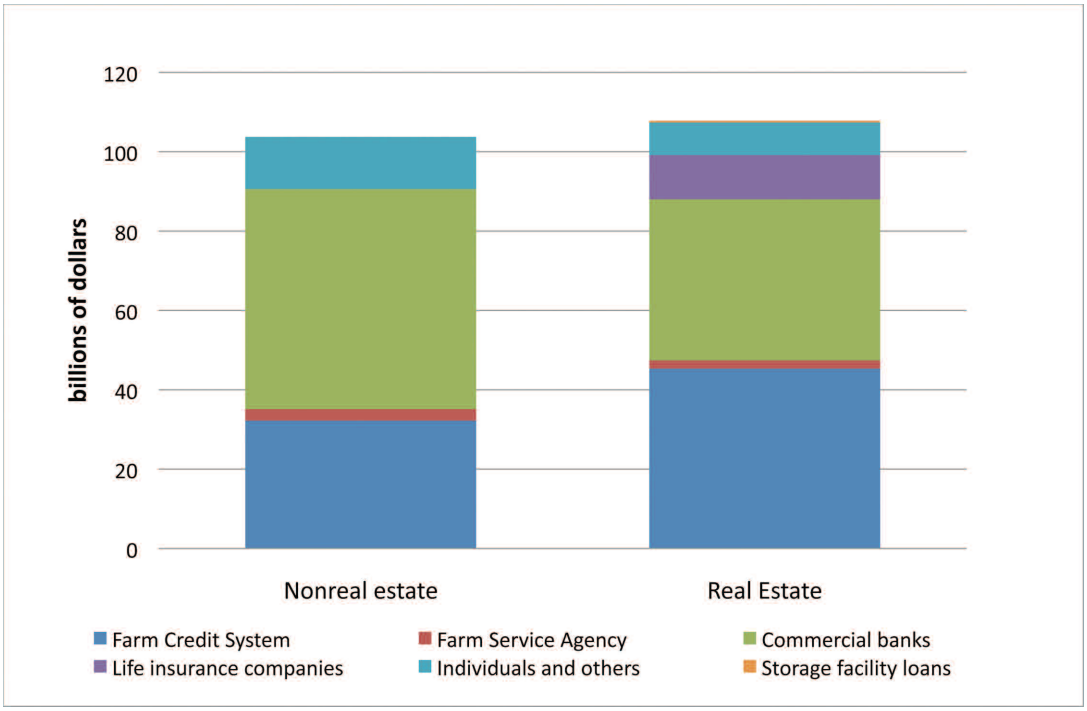
Long-term issues and policy options

Restoring and Maintaining Trust in Financial Markets. If trust in the financial markets and institutions serving agriculture deteriorates, there will be uncertainty, higher levels of risk, and more expensive lending—or simply less of it. In this respect, the problems facing agriculture as a result of the financial crisis are the same problems facing the global economy. Clearly, agriculture-specific policies will not resolve this problem. Critical to the future of agriculture is the success of policies adopted to restructure and restore confidence in global financial markets. While agriculture may not

be a principal concern of the policy makers confronting the current financial crisis, the nature of the financial institutions serving agriculture should be taken into account.

In the United States, a large share of the credit for production agriculture is provided by a government sponsored enterprise (GSE), the Farm Credit System (Figure 5). As a group of cooperatively-owned financial institutions, the Farm Credit System is quite different from Fannie Mae and Freddie Mac, the two large housing GSEs taken over by the federal government earlier this year. Farm Credit's access to global financial markets has played a critical role in providing production agriculture with access to long-term credit. The borrower-owned cooperative structure of Farm Credit incorporates different incentives and risks than other GSEs. These unique characteristics need to be recognized as the regulatory changes of GSEs are debated.

Figure 5 : Farm debt by lender in 2007



Source: USDA Economic Research Service www.ers.usda.gov/data/farmincome/finfidmu.htm.

Smaller community and regional banks are another key source of credit for the U.S. agricultural sector. To date, these banks have generally been less affected by the financial crisis than larger financial institutions. They rely heavily on deposits, rather than borrowing, as a source of funds, and because of conservative lending practices were less heavily exposed to shocks associated with deteriorating credit quality in mortgage markets. While these banks represent a relatively small part of global financial markets, they are critical to U.S. agriculture and rural communities. They should be taken into account as changes in financial market regulation are debated.

Immediate issues and policy options

Access to Credit. Commercial banks and insurance companies are important sources of credit for production agriculture. While access to credit has not been a significant issue for U.S. agriculture in recent years, the potential exists for problems to develop as an offshoot of the current financial crisis in overall economy. If that happens, two general approaches to address those problems are to:

- rely on broader macroeconomic and financial market policies, or
- use existing or new government programs for direct and guaranteed lending.

A key factor in the decision may be commodity prices. Finance demands increase with price levels. The fact that prices have generally eased from recent highs lessens the scale of credit demanded by the sector, although prices remain higher than historical averages so credit demand is probably higher, too. However, generally lower prices may bring lower profitability, weakening short-term credit-worthiness. More timely information on prices and financial conditions within agriculture are needed to guide any public policy responses.

The possible consequences of a hands-off approach by leaders in the agricultural sector include: problems for input suppliers and grain elevators that may depend on large financial institutions to access credit; limits to producers' access to point-of-sale financing; and producers' increased need for risk management for both inputs and marketing. These problems extend to agribusinesses involved in the supply chain between raw commodity and final product, whether delivered in the United States or abroad. Of course, if macroeconomic and financial market policies work, these problems fade. If those solutions fail and the crisis widens, these problems worsen. While the hands-off approach to any problems in agricultural sector financing causes no new expenditures now, it may entail the risk of widening and deepening problems that will need to be addressed in the future with larger policy responses.

Direct or guaranteed lending could take several forms. Federal loan guarantees for agribusiness could be used. Programs could be targeted to a particular type of business, such as elevators or ethanol plants. Foreign buyers could be targeted by expanding existing export credit programs or introducing new ones, within the bounds of multilateral disciplines, or by giving more food aid. One consequence is greater exposure to risk for the federal government and greater budgetary expenditure. The success and side-effects of programs that provide direct or guaranteed lending depend on how they are administered. They may provide security and allow firms to bridge a difficult period, but they may also misallocate capital, displace commercial lending, and give recipients an incentive to engage in riskier behavior in the future.

Assistance that targets particular types of businesses may raise questions about equity. For example, public support to assist the financial position of ethanol plants could help with respect to energy security, but not food security. Export support, particularly in the form of food aid, could help global food security but not U.S. food and energy security. Any financial support to the agricultural sector could have conflicting effects related to natural resource and climate change. Financial support might increase agricultural production, leading to more greenhouse gas emissions and competition for natural resources, but it might also help set the right context for long-term decision-making, as is necessary for investments in new technologies to help achieve these objectives.

There has been a long-standing concern about financing young, beginning and small-scale producers. It is uncertain at this time if the financial crisis is having stronger impacts on these borrowers than on others and it is unknown if existing programs that target these borrowers' credit are able to offer solutions if their situation is deteriorating.

Risk Management. Agricultural producers are bearing more risk. Financial and commodity market volatility imply more variations in revenues and costs, as well as higher costs for accessing tools to reduce these risks. Risk will increase further if climate change introduces greater fluctuations in supplies. There is a general impression that producers are shouldering a increasing share of the risk in the sector. Some public policies already exist that address risk, including certain elements of tax policy. There are also several programs specific to the agricultural sector intended to provide a safety net for producers with respect to price, yield or revenue risk.

The consequences of greater risk include higher costs and greater probability of bankruptcy for many producers. Some suggest there would also be implications to concentration in the sector. The overall effect would be to reduce agricultural supply on average, leading to at least somewhat higher market prices to the detriment of goals relating to food and energy security.

As the nature and level of risk changes, one policy option is to provide more educational opportunities about new risk management tools and strategies. But more information does not lead to more risk management if the real barrier to producers is a rising price of accessing these tools.

Another option is to support research that helps the commercial sector develop better risk management tools. There is always the risk that public expenditure could displace commercial efforts. It may also be that there is currently little appetite for new financial instruments.

Agricultural sector leaders could opt to subsidize risk management. Expanding farmer savings accounts is one mechanism. This or other programs that subsidize producer risk management seem likely to increase producers' ability to manage risk through self-insurance. This possible consequence must be balanced against other negative ones. There is budget cost and the possibility that commercial efforts would be displaced.

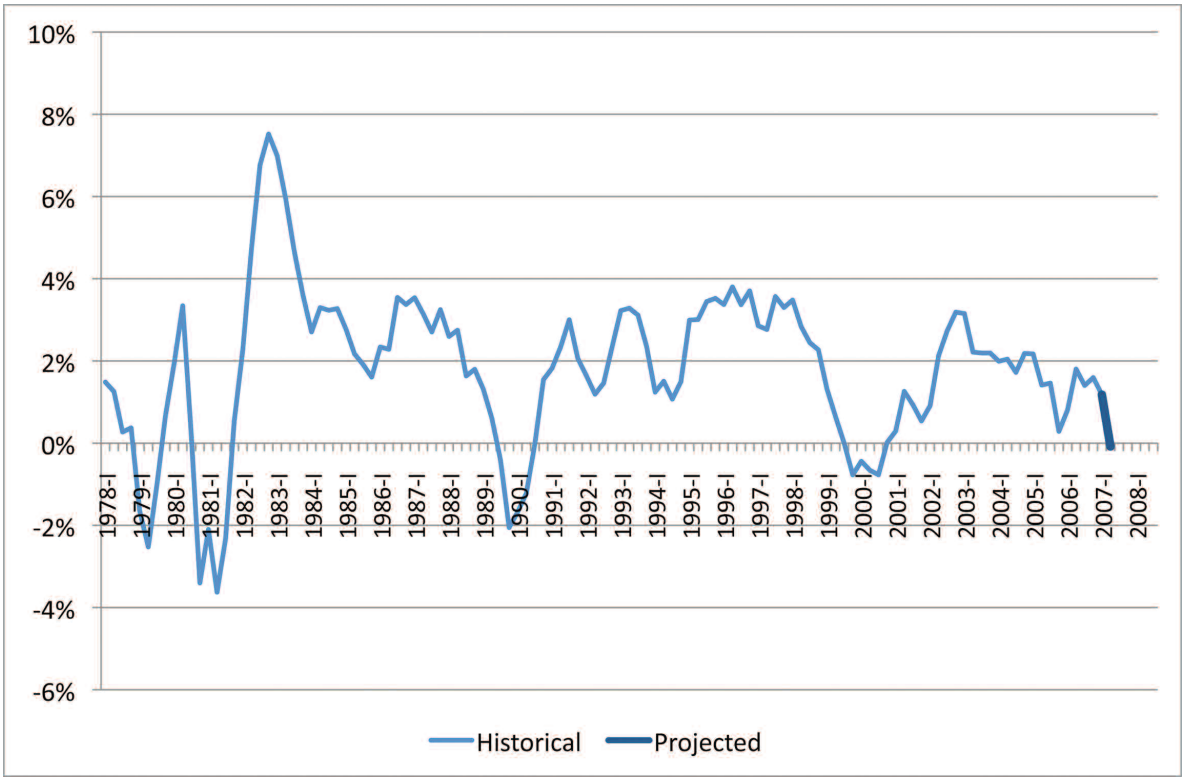
Developing Country Credit. Policy options to address the effects of the current financial crisis on developing countries may be distinct from options to help developing country producers overcome the inability to access credit that they have suffered for a long time. Access to credit will be critical in determining the ability of developing country producers to increase output. However, the problems these producers face in accessing credit vary widely across countries, resulting from such diverse factors as poorly-defined property rights, poorly functioning internal capital markets, a lack of financial institutions, and underdeveloped transportation and market infrastructure to serve poor and widely dispersed small-scale producers. These are beyond the reach of U.S. agricultural policy, but foreign aid programs targeted at agricultural development need to recognize the critical role that access to credit plays in producers' ability to adopt new technology and increase productivity.

Some developing countries have experienced problems financing food imports, especially during periods of high prices or credit market disruptions. Within U.S. agricultural policy, there are policies that address such problems, including export credits and food aid.

Export credits and food aid programs might be retargeted or expanded, at a cost, in response to the immediate effects of the crisis on access to food. These efforts clearly overlap the question of global food security to the extent they help foreign consumers buy food. If they raise U.S. prices, such policies could work against domestic food and energy security goals. If price increases induce more production, the programs could have indirect negative effects on natural resources and the climate. These programs target a subset of food-importing countries; a response to the financial crisis could also address the difficulties faced by all developing country importers and exporters.

Recession. Current economic signs point toward a recession—both in the United States and globally—that some predict could be long and deep (Figure 6). The implications of a recession for U.S. agriculture are uncertain. The value of the U.S. dollar and petroleum prices depend on the global environment. The dollar value is a critical element in determining the prices for inputs and outputs of the agricultural sector. Fossil fuel markets also affect input and output prices and are a factor determining consumer willingness to buy bioenergies (see Global Energy Security.)

Figure 6 : Growth in U.S. GDP per person



Sources: (1) GDP from Bureau of Economic Analysis, U.S. Department of Commerce. National Economic Accounts.: www.bea.gov/national/nipaweb. Population data from (2) U.S. Census Bureau. Historical National Population Estimates: July 1, 1900 to July 1, 1999. Retrieved Nov. 5, 2008: www.census.gov/popest/archives/1990s/popclockest.txt; (3) U.S. Census Bureau. Population, Population change and estimated components of population change: April 1, 2000 to July 1, 2007. Retrieved Nov. 5, 2008: www.census.gov/popest/datasets.html; and (4) U.S. Census Bureau. Projected Population by Single Year of Age, Sex, Race, and Hispanic Origin for the United States: July 1, 2000 to July 1, 2050. Retrieved Nov. 5, 2008: www.census.gov/population/www/projections/downloadablefiles.html.

Reduced income growth will dampen demand for food, fiber and bioenergy, leading to lower commodity prices. The magnitude of the change may not be great given that demand for agricultural output in aggregate tends to react little to changes in income. Agriculture is not as vulnerable to recession as other sectors. The story is different if comparing goods within the sector, as consumers may quickly switch to less expensive goods if budgets are tight, and forego certain aspects of quality or convenience. Adjustments within the sector seem likely, with various businesses and commodities performing in different ways, even if overall demand contracts little barring a particularly deep and long recession that unwinds many of the recent dietary changes in developing countries. A shift away from livestock products, for example, would lower a country's need for agricultural output.

Options are available for different problems a recession might create. Domestic nutrition programs and foreign food aid are existing tools the U.S. could increase to target access to food (see Global Food Security.) Apart from higher budgetary expenditures, the likely consequences would include higher commodity prices. But domestic assistance does not increase domestic consumption dollar-for-dollar, and foreign food aid risks some displacement of commercial transactions. Reliance on export credits to enable imports could have the similar effects as food aid, but of a lesser magnitude. While U.S. domestic assistance programs target consumers, some U.S. international programs target countries or regions, so the local effects may be lower prices that may not support long-term goals relating to economic development.

Another public policy option, already in place, would be to subsidize U.S. producer revenues. Many U.S. programs have automatic measures to address sudden changes in prices, such as revenue insurance, or lasting pressures that push prices below certain thresholds, such as counter-cyclical payments and marketing loans. If triggered, these payments would increase agricultural program costs. If the triggers for payments were raised as a step to make more payments as prices fall, the budgetary costs would also rise. Some policies tie payments closely to output, so producers would be encouraged to increase production. Prices would be lower for all consumers, including those consumers who may have limited access to food, but the greater production could work against objectives relating to natural resources or greenhouse gas emission reductions. Mechanisms of agricultural or tax policy that are less tied to commodity output would have fewer of these unintended consequences.

In developing countries, the impact of falling prices in the context of poor credit infrastructure may undermine producers' abilities to buy inputs, much less to invest in projects with long-term payouts. One policy option is for the United States to commit more budgetary support to international organizations that provide targeted credit to food production programs, or that undertake research efforts focusing on these producers. The possibilities for displacing commercial investment or misdirecting the overall effort are lower in cases where little private interest in long-term development exists. The immediate costs of such efforts are readily evident, whereas the benefits are distant and unclear, particularly when taking into account any possible spillover effects. The United States may benefit indirectly from technology improvements if they influence domestic research efforts, and any improvement in the recipient countries' long-term economic performance may benefit the United States in more trade flows.

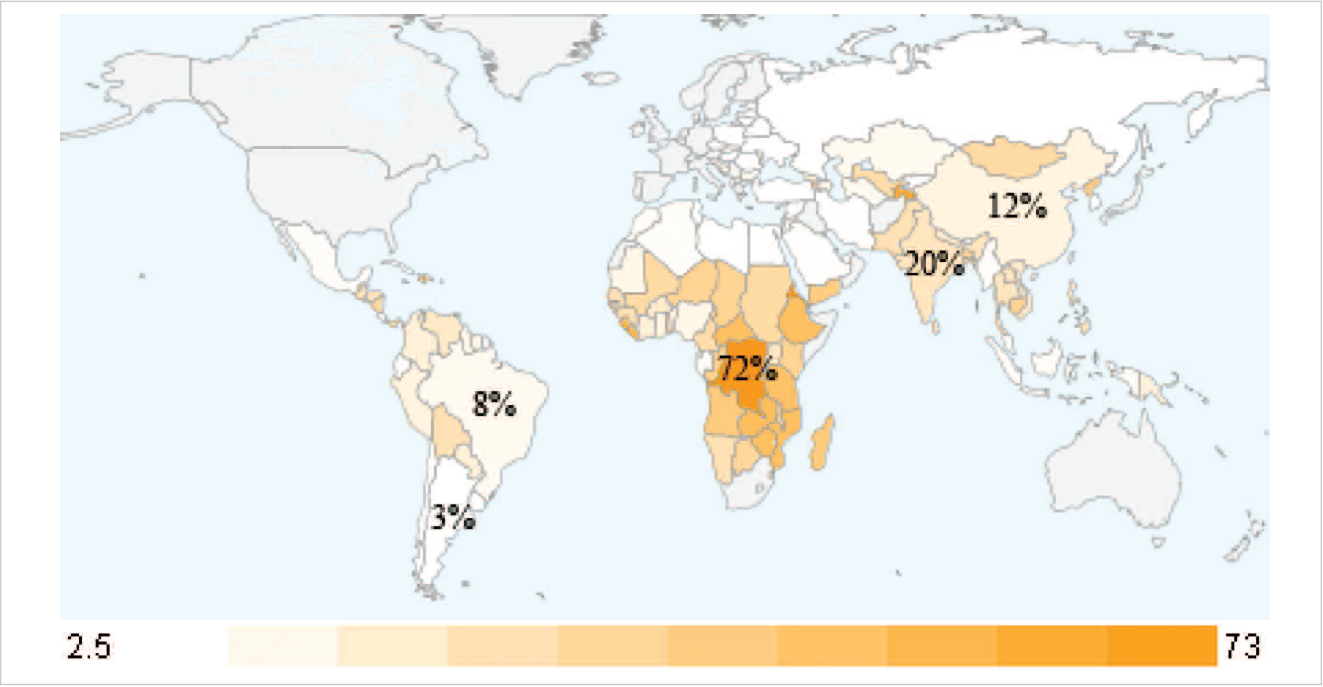
Global Food Security

Recent spikes in agricultural commodity prices reminded the world that food security remains precarious for many people. Even as prices retreat from their recent highs and public interest wanes, the situation of hundreds of millions of people who were malnourished even before the recent crisis remains dire. Some observers contrast food waste and the high incidence of obesity in many developed and some developing countries with the situation in some developing countries where there are large numbers of people without sufficient nutrition because of low purchasing power. There is continuing frustration that many people suffer malnutrition while there is growing incidence of obesity and food waste in other parts of the world. The agricultural sector must meet a growing population's needs for safe and sufficient food despite the obstacles of limited natural resources and climate change. Dietary shifts associated with income growth and greater bioenergy demands will multiply the pressures on the sector.

For the purposes of this report, *food security is defined as stable access to sufficient and safe food supplies*. This definition does not take into account where or how food is produced, as long as it is available and safe. For high-income consumers, the priority is on food safety and quality; for low-income consumers, the more pressing concern may be having enough food at all times (Figure 7). Most consumers feel the effect of food price spikes.

Global food security is not separate from other categories of the 30-year challenge. Food uses of agricultural output currently compete with energy uses, as grains and vegetable oils are used as biofuel feedstocks. Even when or if non-food feedstocks become commercially viable, food and fuel uses would continue to compete for such underlying resources as land, labor, capital and research investment. Natural resource limits clash with the view that food security be equated with maximizing output, as discussed below. Climate change may undermine food security unless adaptive processes consider changes in global agricultural capacity. Finally, as noted in the previous section, the current financial crisis may harm food security in the immediate future, and a recession will reduce food purchasing power.

Figure 7 : Share of population that is undernourished



Note: Shading indicates share of population that is undernourished from 2.5% to 73%.
Source: The United Nations. Millennium Development Goals Indicators. Retrieved November 5, 2008: http://mdgs.un.org/unsd/mdg/Data.aspx.

Long-term issues and policy options

The United States has numerous programs that contribute to domestic food security. Inspection services and labeling rules contribute to the safety of the food supply. The commercial sector responds to price signals within a legal framework that includes consumers' recourse to file a lawsuit. Several mechanisms are in place to target domestic nutrition needs; nutrition assistance programs account for the largest share of U.S. agricultural policy budgetary expenditures. The United States provides food aid to other countries. Charities and non-governmental organizations do similar work domestically and abroad.

National food security strategy. Although farm programs and nutrition assistance programs, such as food stamps, are both included in the Farm Bill, they remain distinct and independent policies. As a result, the United States lacks a comprehensive food policy. Development of a national food security strategy might define the strategic role of the domestic food system, potentially addressing such issues as: food safety and stable access to food; research and development; approach to trade; interrelationships of food, water, land use, energy, and the environment; and the roles of public agencies, private groups, non-governmental organizations and charities.

Drafting a national food security strategy must overcome key obstacles, not the least of which would be establishing responsibility for writing the strategy, and determining the role of existing policies and programs. Another obstacle would be crafting a national food security strategy dynamic enough to survive crises or evolving knowledge. Developing a strategy requires resources of both money and labor. There are risks that the strategy would not be implemented, or be misdirected and lead to inappropriate programs and investments.

There are also risks to maintaining a patchwork policy approach. Inconsistencies and underperformance may result if programs target different goals or are initiated in response to different problems. Research funding targeting a narrowly defined goal may lead to technologies with limited applicability. Programs targeted to a specific purpose are unlikely to adapt quickly to changing circumstances. Simply put, the current patchwork approach limits the ability to reduce malnutrition in a context of growing population, competition for natural resources and climate change.

Maximizing production. A policy objective sometimes equated with stable access to food supplies is maximizing agricultural production. Support tied to output would seek to increase domestic supply as much as possible. Publicly funded research that serves this objective would seek the greatest output possible from whatever combination of inputs. As a result, available quantities increase and consumer prices fall.

Policies to maximize agricultural production have unintended consequences. Maximizing production risks depletion of natural resources, including soil, water, air and wildlife habitat. It may also discount the usefulness of adaptive and mitigating technologies that could play a role in addressing climate change. For example, low grain prices lead to low feed prices that, in turn, encourage livestock herd expansion and hence more greenhouse gas emissions. Subsidized supplies sold in the global market may reduce incentives for developing nations to build their own food production systems, even in cases where they might have a comparative advantage.

A policy of maximizing production may not achieve the intended consequence. While low prices encourage consumption, most of the benefit goes to consumers who could already buy enough food. Commercial bioenergy producers buying feedstock commodities would benefit, potentially helping the sector to contribute to energy security. In contrast, low-income consumers who buy food in markets that are not well integrated with world markets may realize few if any benefits. Some policy mechanisms to increase producer revenues, such as tariffs and other trade barriers, raise consumer prices and reduce their ability to buy food.

Agricultural productivity. Another option is to increase agricultural productivity. Productivity takes into account the relationship of outputs to inputs used. The level and the stability of output in the face of varying limited natural resources and climactic conditions are elements of this type of strategy (see Climate Change.)

While research has tended to focus on commodities grown and consumed in developed countries, global productivity gains are an important factor in achieving global food security. The measure of success of such an objective could include the potential to increase output and the ability to shift input use away from over-used natural resources. Another measure of success would be reducing the impact of weather variability such as droughts, excessive moisture or temperature extremes. This type of research would be consistent with some other components of the 30-year challenge.

Public support of such research would be important under this policy option. There may be little commercial reason to invest in some technologies, such as those used in some of the least developed places of the world. Such "orphan crops" have often been overlooked. Public support could be in the form of direct investment in research and dissemination, possibly through international organizations, subsidies to commercial investment, or efforts at research coordination. Public support of research always runs the risk of displacing commercial research or misdirecting research efforts more broadly towards second-best or worse technologies. One certain consequence is that all these public investment options imply budgetary expenditures.

Infrastructure. A parallel policy option is to focus on infrastructure to meet the needs of people while minimizing the use of resources. Infrastructure includes such physical elements as roads, rail, waterways and ports. There are also institutional aspects that deal with the operations of the market, such as contracting and information flows. In the case of food security, a better infrastructure could help consumers to buy foods based on price and their desired level of safety. Information about food quality might be embodied in prices or product labeling. An advanced infrastructure also can facilitate policies that target objectives relating to natural resources or climate change, as discussed in the Climate Change and Competition for Natural Resources sections.

This policy option has many of the same possible negative consequences as research and development expenditures: infrastructure costs likely must be paid in part or in whole by budgetary expenditures; public expenditures may displace some commercial effort such as private labeling initiatives; and publicly funded infrastructure projects may not be the best choices.

Food and nutrition assistance. Existing U.S. domestic nutrition programs and international food aid contribute to food security among low-income or disadvantaged populations and could be enhanced. Domestic nutrition assistance programs adjust at intervals to changing food prices, but a more frequent adjustment cycle with greater responsiveness to food affordability might be envisioned, albeit with such consequences as greater volatility in the budget. These programs do increase food consumption and give an income boost, but the effect of one more dollar of expenditure on these programs is typically less than one more dollar of food consumption expenditure. The same concern has been raised regarding international food aid, particularly if delivered in commodity form, although competing exporting countries may focus more on the displacement of commercial trade rather than on the degree to which food consumption is increased.

Trade. Another multilateral World Trade Organization (WTO) agreement that introduces further reductions in barriers to trade and to support tied to output would lead to some reallocation in the sector. The United States would presumably export more of the goods it produces well and import more goods that other nations produce well. "Produce well" is defined on the basis of comparative advantage, which is relative efficiency of resource use, instead of competitive advantage calculated using specific prices at a point in time.

If more trade changes production patterns, lowers food prices, contributes to increased incomes, and diversifies food sources for the poorest consumers, it could increase stable food access. To the extent an agreement falls short of these effects, the potential to increase stable access to food by of low-income or disadvantaged consumers diminishes. Bilateral and regional trade agreements might be measured on the same standard, but the effects on consumers in excluded countries should also be considered. The disruptions to income or sharp movements in markets that may take place as a new trade agreement is implemented have often been a focus of debate about trade policy changes. These adjustments to the new policy environment may undermine the stability of food access in the wake of an agreement, although in the past compensatory policies have been explored as a way to address this point.

Food safety concerns relating to trade arise in part because of differences in food inspection systems in different countries. Harmonization of food safety systems would be costly and perhaps inappropriate. The U.S. food safety environment frowns on some products that carry greater-than-average food risk, such as blowfish or cheeses from unpasteurized milk. Yet Japanese and French consumers have different opinions of the risks of these foods. Rather than the extreme of a global food safety system, options include more frequent inspection of imported goods and foreign plants. Private standards of multi-national corporations that exceed government standards have become increasingly common in Latin America. Each of these options has consequences with respect to budgetary costs and the ability to screen out unsafe goods.

Immediate issues and policy options

Public understanding. Many consumers are increasingly concerned about how their food is produced. Some of these concerns relate to food safety, while others reflect such ethical concerns as labor standards and animal treatment. Agricultural producers sometimes struggle to understand public attitudes about these concerns. One policy option is to develop an educational effort to bridge the gap in understanding in both directions.

The consequences of a successful education campaign could include a clearer statement of public food security targets and a better assessment of optimal policies to achieve those goals. One example is purchasing local foods. "Local" may not be synonymous with "safe." Locally produced food also may not minimize natural resource use if factors considered include more than the distance the final good is shipped. A better informed public and agricultural sector would help identify long-term goals, contributing to improved food system decision making.

Negative consequences of such an education system include the cost of implementation and the risk of failure. If a good understanding is not achieved, the public might not define clear, long-term goals or approve the system that supports those goals. If agricultural leaders are not attentive to the public's views, their decisions may not have lasting support. In either case, goals may become moving targets that devolve over time, creating a poor environment for long-term private and public investments.

Food security is another area where wide differences in definition or understanding may exist. Measures of food access, stability of a food supply, and what constitutes adequate food quality and food quantity are all highly subjective. The respective value placed on each of those elements of food security varies, as well. Low-income consumers are likely more concerned about quantity as long as quality achieves some minimum level. In contrast, higher-income consumers may focus on quality, even working to control or reduce quantity over concerns with obesity.

Commodity price spikes. The recent run-up in commodity prices spotlights the links among policy, commodity prices and stable food supplies. It has also given rise to some calls for policy response. Although prices have fallen, pressure remains for some policy response to address the risk of further increases in commodity prices. Such calls may intensify whether the reason for rising prices is demand growth outpacing productivity or limits to such resources as fossil fuels or water. The following policy options may address any increase in production volatility, including effects associated with climate change.

Grain reserves are one option. Current global grain stocks are at or near historical lows relative to use. Grain reserves would build stocks in periods of low prices and sell stocks when prices are high, thus reducing the swings in market prices. One consequence of this option is the cost to buy and store stocks and the presumably smaller benefits of sales. Additionally, the definition of "low" and "high" prices is subjective and may be judged differently by producers than by consumers. In any case, this policy may tend to influence average commodity prices over time. Another possible consequence is that the reduction in price swings may be a service to many consumers who are sensitive to these prices, but may not help low-income consumers who buy in local markets that are not well integrated with world markets. Moreover, much of the benefit will be reaped by consumers in developed countries who presumably can already manage risk through existing commercial risk management tools.

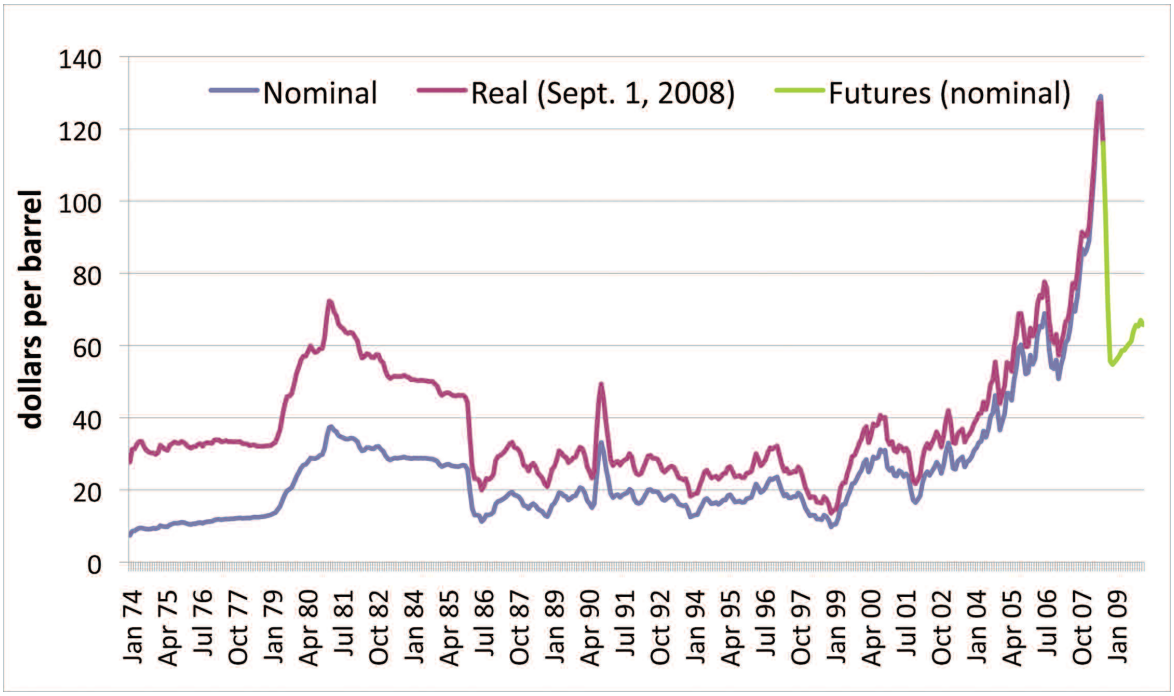
A virtual reserve is a financial reserve to be drawn on in times of high food commodity prices. Such a program could lead to some of the same consequences, but might replace the cost of storing the commodity with the costs and potential benefits of holding any financial reserves. Virtual grain reserves have the advantage that they can be targeted to specific groups to raise their purchasing power, although it is not clear exactly how those groups would be determined. By increasing their purchasing power, the virtual reserve would sustain demand at times of high prices so price spikes would be exacerbated. This consequence may be positive for producers and negative for consumers who do not have access to the virtual reserve.

Many countries explored options to use trade policy to insulate their domestic markets when world commodity prices recently peaked. These choices highlight some of the consequences of trade policy to achieve domestic food security objectives. In this case, export restrictions or reduced import tariffs tend to lower domestic market prices, which helps all domestic consumers. Those individuals who can no longer afford some basic consumption level at the time are helped if prices they pay are tied to broader domestic markets. An unintended consequence is that domestic producers also receive less money and consequently have less incentive to increase output, potentially prolonging the high prices and possibly conflicting with long-term development goals. Budgetary implications may go either way, as such export restrictions as taxes would raise revenues at the producers' expense, whereas lower tariffs would reduce budgetary revenues to the advantage of domestic consumers. Another potential consequence is that trade restrictions tend to increase variability in international prices. These prices may have to move even higher to balance world markets if a smaller share of world demand and supply is sensitive to them.

Global Energy Security and Cost

Rising – even skyrocketing – energy prices of the last half-dozen years and expectations of further increases gave rise to predictions that energy markets would drive demands for many agricultural commodities. The public grew interested in the possibility of biofuels to displace some fossil fuels and for the economy to rely more on bioenergy in time. Now energy prices have fallen dramatically, leading to a new public debate about market volatility (Figure 8). But the debate may be fading: polls showed voters' interest in energy security parallels the trajectory in oil prices.

Figure 8 : Refiners acquisition cost of petroleum



Sources: (1) refiners acquisition cost (R.A.C.) from Energy Information Administration, Department of Energy. Crude Oil Domestic First Purchase Prices, 1949-2007. Retrieved November 5, 2008: www.eia.doe.gov/emeu/aer/txt/ptb0518.html; (2) deflator from Bureau of Labor Statistics, U.S. Department of Labor. Producer Price Indexes. Retrieved Nov. 5, 2008: www.bls.gov/ppi/home.htm.; and (3) nominal price projection based on historical links and NYMEX Light Sweet Crude Oil closing price. Retrieved Nov. 11, 2008: www.nymex.com.

The 30-year challenge regarding energy security is easily lost in the monthly trends in petroleum price, even in its day-to-day fluctuations. Interest in investments in alternative energies during the similarly high petroleum price booms of the 1970s and early 1980s declined sharply when price pressures waned. But the 30-year challenge endures price spikes, even if the sense of peril does not. Prices will continue to be volatile and eventually follow a sustained upward trajectory as fossil fuel supplies are gradually drawn down and global energy demand continues to climb.

Decision makers may choose to be passive in this context. Each price spike may introduce a new surge in renewable energy investments that fades as immediate pressure wanes. With this approach, commercial and public forces may ramp up renewable energy production and use capacity only when fossil fuel markets prove capable of sustaining high and climbing real prices. A forward-looking strategy that reflects national needs and optimal policy mechanisms is another way to try to achieve long-term energy objectives that bears its own risks. Investments in alternative fuels may be misguided or too early, spending money on technologies that might not be widely used for some time to come.

Energy security is not independent of the broader 30-year challenge discussed in this report, nor is it a matter for agricultural policy alone. Food security and energy security, two often competing uses of agricultural outputs or inputs,

necessarily affect one another through prices. Even if these uses do not bid against one another for commodities themselves, energy and food security may compete in the allocation of productive resources such as land, capital, labor and water. Thus, policies that affect one may have consequences for the other. Climate change mitigation efforts that target greenhouse gas emissions may induce or restrict the production of various fuels or energies. Bioenergy is closely tied to broader economic performance, with policies relating to fossil and renewable energies such as taxation, investment incentives, and property rights of resource extraction.

The clearest example of interdependence may be taxes or cap-and-trade regimes that could be used to address greenhouse gas emissions (see Climate Change.) Such policies could be chosen to reduce greenhouse gas emissions or to reduce dependence on foreign energy supplies with an accompanying mixture of costs and benefits. Agriculture-sector decision makers may play a part in decisions about such policies in the future. A carbon tax would raise the costs of producing, processing and distributing agricultural goods, increase the demand for bioenergy as a substitute to carbon-generating fuels, and generate government revenue. These revenues may more than offset measurement and monitoring costs. A cap-and-trade scheme could lead to opportunities to buy and sell emissions for the agricultural sector, with the net benefits depending on initial allocations (caps) and the relative ability of agriculture to reduce greenhouse gas emissions and thus benefit in subsequent transactions with other sectors (trade). Unless the initial caps were auctioned, there would be no government revenues—only the costs of measurement and monitoring. In either case, the effects would probably not be neutral within agriculture, as certain activities are more energy-intensive than others, and there would likely be large effects from economy-wide adjustments.

Long-term issues and policy options

National energy strategy. The United States does not currently have an integrated, national energy strategy that seeks to provide a robust energy supply consistent with a balance between sustainability and affordability goals, and addresses agriculture's role in energy security. The absence of such a broad strategy may cause inefficiency in the existing energy infrastructure, uncertainty in investments, and tension between food and fuel uses resulting from tight supplies and volatile global markets.

One policy option is to define such a national energy strategy to identify a long-term role for agriculture in energy production that is consistent with natural resource constraints, climactic effects, and other objectives relating to food security and economic development. This strategy could define the roles of private and public investment in energy research and infrastructure. There is the risk that public investment would displace private efforts, thus reducing the value of public expenditures, or that coordination could reduce competition and the pace of innovation overall. Public direction of research and development might avoid some dead ends but also risks choosing some. While it is not clear that the tension between competing food, energy, and fiber uses of agricultural outputs could be totally resolved, such a strategy might help to define measurements of mutual effects and weigh the trade-offs that could guide subsequent policy making. Another possible benefit of a strategy is to address broad public opinion.

The costs of developing a national energy strategy include the allocation of staff and money to create it. Time spent gathering information and building a consensus might be seen as time lost, particularly if it is seen to get in the way of some more expedient measures. There is the risk that the strategy proves impermanent. It may be drawn from insufficiently broad support or too narrowly focused to survive a political cycle, may lack the flexibility to be updated as information improves, or fail to endure crises.

Long-term investment. A possible strategic objective for energy security is to address the unstable and unpredictable investment environment. Typically, investments in research and infrastructure for bioenergies require many years to pay off. These investments might require a certain scale to be nationally viable. Commercial investments are less likely, or at least more expensive, when returns are unpredictable. Public investment to support the evolution of renewable energies is one option, particularly if these energies are known to bring about public benefit relative to alternatives. But public investment comes at a budgetary cost and a risk that the government will not pick the right technologies.

Public transportation is an option used in many areas. Public investment in infrastructure might be more technological neutral, although still costly, and improve efficiency of all energy use. Improved roads, rail, waterways and ports would incur costs and encourage fossil fuel use, albeit more efficient use.

Immediate issues and policy options

Changing policies and markets. The unpredictable investment environment is due in part to uncertainty about various programs that affect bioenergy markets. This problem might be resolved by the first strategic option—a national energy strategy. Removing variability in policies could reduce uncertainty for investors considering long-term investments. This is not to say that investment only responds to policies that remain in place forever, but that investments are likely to be greater if policy parameters are slow to change. That said, however, the recent sharp fall in petroleum prices proves that uncertainty is not caused by policy alone. A lower petroleum price reduces demand for alternative fuels and may be ruinous to the profitability of renewable fuels, reducing investment incentives.

Another option that would give flexibility in policy design and somewhat greater certainty is a policy mechanism linked to the petroleum price. One example is a variable tax on petroleum (or motor fuel) that increases if the price falls below some threshold. Such a variable petroleum tax would bring in government revenue and avoid choosing the winning technology. But fossil fuel producers and consumers (such as agriculture) would pay, and the tax could drag on the economy at a time when a likely recession may dominate decision making (see Global Financial Markets and Recession.)

Tax credit and ethanol tariff. U.S. support of biofuels currently includes tariffs on ethanol imports and tax credits for biofuel production and use. Tariffs and credits are set to expire in the coming years. The question of whether to let them expire or to extend them could be considered as a means of replacing fossil fuels with biofuels for purposes of energy security. A tax credit provided to fuel blenders for biofuel use probably does increase biofuel consumption. The credit encourages blenders to buy more biofuels from domestic or foreign producers and sell the biofuels to final consumers. Another consequence of tax credits is budgetary expenditures. Tariffs on ethanol imports increase the cost of imports and cause higher domestic biofuel prices. The consequences are greater biofuel production and lower biofuel consumption in the United States. As regards the budgetary consequences, a tariff is a source of revenue for the government. The contribution of these policies to energy security depends on the whether the focus is on biofuel consumption or production.

Mandates and waivers. Public and private decision makers may soon face critical questions about the implementation of U.S. biofuel mandates. Weaker petroleum prices and lower economic performance may cause a sharp reduction in biofuel demand. The U.S. Environmental Protection Agency is defining regulations to implement biofuel mandates—minimum levels of biofuels that fuel blenders must use—as set out in the Energy Independence and Security Act of 2007. These regulations will detail the conditions under which a biofuel will count against a particular mandate, taking into account feedstocks used and greenhouse gas emission effects. Within the bounds defined by the law, decision makers may have the opportunity to judge if these rules serve the long-term strategic objectives in a flexible way.

Based on current trends, weakening biofuel demand and rising mandated use levels could result in more calls to waive the mandates. In this event, decision makers will be required to apply the general criteria of the law to decide whether to reduce or discard the mandates as they become binding. If mandates are maintained, the biofuel use may not fall below the mandated levels. Some combination of domestic production and imports will be needed to meet the mandate, driving biofuel producer prices higher even if the petroleum price is low. The costs are paid by fuel blenders initially, but probably passed on to other sectors and eventually to consumers. Another consequence is that production of biofuels in the United States or elsewhere is sustained even though petroleum prices fall. By maintaining biofuel profitability and production, there would be more reason for further investments in biofuel processes and distribution. Higher biofuel production would mean higher feedstock purchases, so there would be some upward pressure on commodity market prices, with possible negative impacts for food security and, to the extent production increases, natural resource use.

The alternative option is to waive the mandates. One potential consequence would be that use falls below mandated levels, reducing or eliminating the costs of the mandate to consumers. In this case, the price paid to biofuel producers and importers also falls, decreasing profitability so less biofuel is supplied and biofuel investors take on greater risk. If waived, the lower profitability and production would have the opposite effects on commodity markets to those described above, starting with lower prices.

Climate change

Over the next 30 years, public and private decision makers must address how best to mitigate climate change and adapt to it as it evolves. Questions include how the agricultural sector may be able to contribute to mitigation, while meeting the world's needs for food, energy and fiber, even as climate change puts additional pressure on natural resources and may force changes in production practices.

Much of this debate goes well beyond the scope of decision-making in the agricultural sector. But leaders in the sector will need to address the role of agriculture in mitigation and how best to achieve that role. Responsibility to adapt to changes may inevitably fall to private and public decision makers in agriculture.

This aspect of the 30-year challenge is closely related to bioenergy policies, some of which target greenhouse gas emissions. Climate change is tied to natural resources, with the potential to affect resource availability globally and economic growth through its potential influence on long-term productivity. Food, energy and fiber demands may prove sensitive to the indirect effects of climate changes, such as any impacts on overall economic activity, and of policies that seek to use agriculture as one lever to reduce climate change.

Long-term issues and policy options-Adaptation

Some strategic adaptive options relate to risks associated with climate change. These include the risks that climate change may result in greater variability in output; costs of agricultural production may increase; and current production methods may contribute to overuse of natural resources in some places.

Greater variability. One policy option related to the risk of greater variability in agricultural outputs is to maintain current policy. Budgetary support might be higher if market prices become more volatile. Several U.S. programs make payments to producers based on the relation of market prices to designated trigger levels. Greater fluctuation in prices would cause more expenditures under certain conditions. Recent experience suggests that commodity price variability makes food access unstable for many consumers in developing countries, even spurring civil unrest in extreme cases.

More price variability could lead to private sector responses within the current policy framework. Wider price swings could give greater incentive to private stock-holding for example. With higher market volatility, producers, processors and large-scale consumers might opt to make greater use of commercial risk management tools. But in many developing countries, futures markets, contracting possibilities, and other necessary local market institutions for risk management might not be in place. Over time, agricultural producers might also express a greater willingness to pay for risk-reducing technologies, such as for crops that can withstand wider ranges of temperature or moisture, thereby encouraging more research and development in this direction. However, the imperative for such development must meet the standards of commercial investment, which typically require more certainty of payout over a defined time horizon. That means the response could occur after the need becomes evident or not occur at all.

There are existing public policies and the potential for new ones which could facilitate adaptation by assisting U.S. producers to manage new risks. This raises numerous questions about design and implementation. Should the target be revenue or, to reflect the potential of cost variability, income? If income, how should it supplement existing tax policies to address both income variability (such as smoothing) and income level (such as a progressive marginal tax rate?) If based on revenue, how closely would it be tied to specific commodities? Would a strongly-tied payment affect resource allocation, possibly running afoul of natural resource objectives and multilateral agreements? If tied to historical land use, how to define the base and what to do as land allocation changes?

Fundamental questions include the degree of policy neutrality with respect to operation scale and commodity mix, and the combination of private and public participation in risk management.

These policies may well result in greater agricultural output overall by helping to reduce the down-side risk to producers. By themselves, however, these policies probably would not result in reduced market price volatility for consumers and other producers.

Trade, stocks, safety nets and research. Trade may offer a way to diversify risk. Access to foreign supplies could allow consumption to continue even if domestic production failures became more frequent. Increases in trade could allow adaptation to climate change as local producers could allocate resources to any commodity in a broader market, rather than being restricted to commodities in local demand. Conversely, one potential consequence of more trade is concentration of world supply of some commodities in fewer countries.

One policy option is some type of real or virtual grain reserve, as discussed in the Global Food Security section of this report. Grain stocks could smooth out market swings, buying up commodities in periods of low prices and selling them during price spikes. Virtual reserves would be internationally supported financial devices that increase the ability of people with low incomes to purchase food commodities at times of high prices. Potential consequences are higher taxpayer cost, possible displacement of commercial stocks in the case of a grain reserve, possible long-term effects on price levels, and market-wide price effects for all market participants.

Some policy options target specific groups who may be most negatively affected by market variations, such as the groups of consumers and producers in developing countries with the lowest income. These options are addressed in the Global Food Security, Global Finance and Recession and Global Economic Development sections of this report. To summarize, food aid and nutrition assistance expenditures that already address malnutrition could be expanded by spending more money domestically, bilaterally, or through multilateral institutions. Although potentially effective at reaching identified groups, there is not a one-for-one increase in food consumption per unit of expenditure. Despite monitoring efforts, some benefits go to unintended recipients and some intended recipients will be excluded.

Safety nets, or at least better risk management tools for low-income producers in developing countries, seem an unlikely or perhaps very modest option unless a source of funding is identified. Investment in techniques or technologies that mitigate risk give rise to the usual list of positive and negative consequences, as defined below. But the list might be amended to reflect the fact that commodities that are grown almost exclusively in developing countries have typically not been subject to much research—the "orphan crops" of research—so there may be greater potential for quick gains from investments in research. However, the public costs necessary to disseminate technologies targeting commodities grown in places with underdeveloped market infrastructures are likely to be high.

Public support for or coordination of research and development of technologies that help producers endure greater production variability is another policy option. Examples include stress-tolerant crops that can withstand a wider range of temperature or moisture levels. As a proactive rather than reactive approach, such technologies could help reduce production variability even if climate change generates greater weather variability. Consequences include greater public expenditure, potential displacement of private investment, and the possibility that public support goes to something other than the best technology. Even more modest efforts to coordinate research could misdirect it somewhat or lessen the competitive element, in that laboratories may no longer race to get solutions to the market.

Broader implications. Climate change may generate greater possibilities for invasive species and foreign animal diseases to move outside their present ranges. Existing mechanisms to reduce the likelihood of these outcomes could be strengthened—at greater budgetary costs. However, the degree of risk and the potential effects may be too idiosyncratic to give a firm footing for broad statements of policy option consequences.

Increasing pressure on and competition for limited natural resources raises a set of policy options that are discussed in the Competition for Natural Resources section. Uncertainty about future climate change makes it difficult to identify the potential consequences of various policy options, other than budgetary costs. To narrow down these uncertainties is an invitation to further study, an option with more than budgetary consequences alone. There is the risk that studies prove inconclusive. There is also a risk that delays lead to more costs later: if proactive action today could halt a growing problem early, then waiting may allow the problem to grow. For example, if measures are undertaken only after climate change is clearly seen to diminish a region's water supplies, then food security and economic growth may be diminished in the interim.

Long-term issues and policy options-Mitigation

The private sector would adapt, in some way, to climate change with or without public support. However, there is little reason to expect the private sector to take great strides towards mitigating climate change in the absence of public policy. To whatever extent greenhouse gas emission reductions are judged to be necessary for the greater good, these signals are not presently communicated to businesses in the form of prices, permits, or regulatory requirements. A range of policy options could lead the agricultural sector to help mitigate greenhouse gas emissions. Agricultural policy to mitigate climate change seems likely to be a part of a broader policy framework that spans all sectors and fits within an international context.

There has been public debate about the potential to reduce greenhouse gas emissions by targeting those emissions with a penalty, such as a carbon tax, or with explicit nationwide limits, as would be introduced by a cap-and-trade system.

Greenhouse gas emissions tax. A tax on greenhouse gas emissions would increase the costs of all energy and other fossil fuel-based products. For agriculture, production costs would rise for fuels, electricity and many agricultural chemicals. For the sector as a whole, processing and distribution costs would rise. This would also tend to raise the costs of inputs delivered to producers and increase the marketing margin between production and final consumption. Wider effects might include slower economic growth as the United States tries to lower its emissions. But the reduction in economic growth based on traditional measures may overlook such important benefits as lower pollution and a shift towards, if not to, production practices that are neutral to the environment.

A tax on greenhouse gas emissions would encourage consumers and industry to find alternative energy sources. The consequence could be strong new demands for some agricultural products. Some of these products could be newly commercialized, based on as-yet-unrealized technologies that could be profitable in the context of an emissions tax. A consequence of pulling commodities or agricultural inputs, such as land and capital, towards bioenergy use is higher prices for food commodities, although the exact increase is unknown. There is no certainty that the renewable fuel of choice would be a bioenergy.

A greenhouse gas emission tax has important budgetary implications. It would generate government revenue that could more than cover the costs of implementing the tax. There are many potential uses for this tax revenue. One possibility would be to help the economy to adjust to a greenhouse gas tax. For example, the money could be used as adjustment assistance that does not directly offset the tax itself.

Cap-and-trade. The impact of a cap-and-trade system on greenhouse gas emissions would depend on the amount of the cap for each sector and the ability of each sector to reduce its emissions. Those sectors less able to reduce emissions would be more likely to be in a position to buy permits. Sectors allocated a low cap relative to future needs, such as those expanding quickly from a given base-period for determining allocations, would be more likely to buy. Conversely, a sector that could reduce emissions and had a high initial cap relative to its future expansion would likely sell permits. The effect on agriculture, defined to include all activities in the sector not just production alone, depends on these conditions. Since there is no cap-and-trade system in the United States, the ability of agriculture to reduce emissions more quickly than other sectors is unknown.

The costs of meeting caps would be built into relative prices. If consumers buy products that are and continue to be made from processes that generate a lot of emissions, then producers of those goods may buy permits. Much of the extra cost would likely be passed on to consumers. In cases where new production methods are introduced to reduce emissions below the cap, allowing the extra to be sold, the final price of such a good would rise less than others and could even be reduced. These changes in relative prices may have important impacts on the input costs of production agriculture, as well as on processing and distribution activities.

This highlights an important likely difference between cap-and-trade and taxation approaches to mitigate emissions. Cap-and-trade leads to transfers among and within sectors. Transfer would be from products or processes that have trouble meeting the cap to products or processes that can meet the cap at lower cost. Some sectors will pay more than

others, and some could be net beneficiaries. This would be the result if the initial caps are allocated for free, such as on the basis of historical emissions, and not auctioned. The taxation approach leads to greater government revenue, as could an auction of caps.

With either cap-and-trade or taxation, there would be a price associated with greenhouse gas emissions that would affect private market incentives. Production practices would presumably change, with implications for prices of other goods and for final consumers. There would be more incentive to commercial investment in emission-reducing technologies. Economic activity could likely slow overall in the face of a tax or cap on emissions, but the emissions should also be reduced by either policy—as intended.

A tax or a cap on emissions incurs monitoring costs. A possible consequence may be extremely high monitoring costs for some sources of emission, or the use of less-than-perfect measures of emissions, such as the use of a particular input or the quantity of output. Inaccurate measurement and monitoring processes may hamper the overall effort to reduce greenhouse gas emissions. If measuring and monitoring mechanisms are weak or changing, then the intended greenhouse gas emission reductions may cost more or generate unintended consequences. Changing mechanisms discourage long-term investments that might otherwise help to reduce greenhouse gas emissions. Using proxies to measure greenhouse gas emissions, such as the use of a particular input or the quantity of an output, will give an incentive to reduce the use of that input or the amount of output rather than to reduce actual emissions. Methods that reduce the greenhouse emissions per unit of monitored input or output will be overlooked, and the impacts on these particular goods will tend to be exaggerated relative to the ideal.

Carbon sequestration. Compensating landowners or producers for carbon sequestration, sometimes referred to as "offsets," could help mitigate climate change. The intention of carbon sequestration is not to reduce greenhouse gas emissions, but to remove them from the air and store them in soils or biomass. This policy option could be undertaken with or without a tax or cap on emissions. Firms would presumably be willing to pay up to the cost of the tax or of the transactions in the cap-and-trade system for each unit sequestered. However, if there is no price associated with carbon emissions, as in the absence of a tax or cap on them, this policy option would require some incentive payment to encourage producers or land owners to sequester carbon.

Consequences of carbon sequestration include the potential to be a new revenue source for some agents in the agricultural sector. Carbon sequestration would represent an alternative "good" that could be generated from land and other resources. To the extent that this good competed with other agricultural output, reallocating resources to this activity would be at the expense of other consumers. This could lead to higher prices for some or many agricultural goods, potentially working against other challenges to agricultural decision makers, such as those relating to food and energy security.

Carbon sequestration policies could have some budgetary implications. Clearly, subsidies to encourage sequestration cost money. More subtly, sequestration in the presence of a tax on greenhouse gas emissions would have budgetary implications by reducing tax revenues as the carbon offset would presumably not be taxed. No matter the exact policy, budgetary expenditures on measuring and monitoring costs are likely.

Another important consequence is that sequestered carbon is stored, not eliminated. In considering this policy option, the planning horizon could have a decisive impact on estimated effects. For example, if a short time period is used, then the estimated effect on emissions would not include the impacts of reversing the storage which might occur sometime further in the future if land is converted to other uses. A short planning horizon for budgetary costs might overlook the potential that payments to landowners, based on the total amount of carbon sequestered would be rising over time with the amount of carbon stored.

Land use changes. A current debate about U.S. biofuels includes concerns about the indirect effects on land use. This is somewhat the reverse of carbon sequestration. The core question is whether higher biofuel demands for certain feedstocks have, through market prices, generated a change in land use that has released enough carbon to offset the benefits of the biofuel. In this debate, policies that target energy security and climate change may or may not be as effective in

mitigating climate change as originally envisioned, depending critically on unintended consequences. This possibility is acknowledged in current U.S. energy policy. For example, estimates of land-use effects are included in the life cycle analysis of biofuel greenhouse gas emissions.

There are other possible policy options to address land use changes. Such policies include various means of rewarding or penalizing different types of land use to reflect the impacts on the wider public (see Competition for Natural Resources section). An alternative to an economy-wide policy or paying to reduce emissions would be a policy to penalize greenhouse gas emissions from agriculture. Examples include focusing on greenhouse gas emissions as a part of environmental cross-compliance rules. Under this option, commodity program payments would be contingent on the producer choosing to use practices that reduce greenhouse gas emissions. Cross-compliance could reduce overall expenditures. Regulation could prohibit some practices, implying an even greater penalty for non-compliance. Examples include restrictions on the amount or timing of fertilizer application, manure management, and other production practices.

In any case, there would be budgetary costs of measurement and monitoring. There would also be costs within the sector, since the most commercially successful methods of some agricultural production would now be penalized or prohibited. The shift to other methods would likely entail higher production costs, some of which would be passed on to consumers.

Research and development. Research and development may help the agricultural sector contribute to climate mitigation, a potential consequence of all the preceding broad policy options relating to greenhouse gas mitigation. Policies that affect prices of fossil fuels will encourage commercial enterprises to find alternative energy sources and less energy-intensive practices. Cross-compliance and regulations that penalize certain practices would give incentives to producers to find alternative practices, leading to pressures for new innovations.

There are options to coordinate or spur research and development activities that are not now commercially attractive. Benefits may accrue more widely than to the investors alone, or the time-horizon may be much longer to engage public interest than it is for commercial imperatives. As ever, public support of research has certain consequences: it costs money, it may displace commercial efforts and it may misdirect research efforts. It also has the potential for long-term direct and indirect gains through spill-over across sectors and national boundaries.

Support for research and development alone is likely to be insufficient unless there are also incentives to promote adoption. Unless technologies that reduce greenhouse gas emissions or sequester such gases happen to generate commercial benefits, it is likely to require some other policy effort to encourage producers, processors and others to adopt these technologies.

Immediate issues and policy options

Certain policy decisions are likely to be faced in the near future. Existing biofuel policies include tax credits for biofuel use, ethanol import tariffs, and mandated minimum use levels of different biofuels. These mandated volumes are scheduled to grow, with greater increase in the mandates requiring greater reductions in greenhouse gas emissions and with potentially smaller unintended consequences for food security. An earlier law, setting a long timetable for similar policies, was over-written after two years. As petroleum and other commodity prices change, the question arises about whether current policy will have a similar lifespan.

Under current policy, decision makers may be asked to extend biofuel import tariffs and tax credits. While linked in some sense, the two items are determined separately and their consequences are different. A consequence of the tariff on ethanol imports is to decrease the ability of imported ethanol to compete, thus raising domestic ethanol prices to producers and consumers. Indirect consequences are higher domestic biofuel feedstock use which, in turn, drives at least somewhat higher agricultural commodity prices. The tariff is a source of government revenue. Domestic biofuel consumption is lower because consumers are paying higher domestic prices. The tax credit for biofuel use, specifically to fuel blenders, likely drives up the prices blenders are willing to pay to all suppliers of biofuels, both domestic and foreign.

The indirect consequences include higher feedstock purchases and commodity prices. Some of the credit is presumably passed on to biofuel consumers in the form of lower prices, in which case biofuel use increases. Another difference between the effects of tariff and tax credit is that the credit tends to increase ethanol imports. To the extent that imported ethanol could help displace fuels that have more greenhouse gas emissions, the tariff may be counter-productive with respect to the goal of mitigating climate change. The need for climate change adaptation would lead to calls for action, particularly if production volatility increases. Such action might relate to food security, such as grain stocks, or economic development and are discussed in other sections of this report.

Competition for Natural Resources

Leaders worldwide are confronted with predictions that the coming decades will bring dwindling water supplies, diminished water quality, vanishing topsoil, and other possible outcomes of over- or misuse of natural resources. At the same time, competition for use of natural resources is expected to increase. The challenge is to identify policy options, or combinations of public and private incentives that may help to improve this outlook.

Agriculture is not the only user of natural resources, current policy towards natural resources is broader than agricultural policy alone. Many of the policy options below may fit an economy-wide approach. One consequence of subsidies to residential or industrial development for other societal objectives is to pull land and water away from agricultural or environmental uses. Estate, income, property and other taxes have important consequences for resource use, especially regarding land. More generally, the various roles of the federal government, including the U.S. Environmental Protection Agency, and municipal and state governments often create a complex array of policies. This report recognizes the highly sensitive nature of changes in policy that would create a greater role for the federal government in defining property rights for natural resources. Any policies on natural resources represent a highly sensitive topic that involves long-standing debates over the roles of federal, state and local governments, as well as private property holders.

Growing demands for agricultural outputs to meet food and energy demands suggest greater production and, in turn, greater pressure on natural resources. Economic development achieved through greater agricultural activity may be fleeting if not based on a balanced approach to natural resource uses. Some might view climate change and natural resource limits as dual environmental concerns to be addressed by many of the same policies.

Some programs target objectives with possibly unintended consequences for natural resource use. For example, subsidies that encourage agricultural output tend to encourage the use of more natural resources, unless this support is conditional on environmental performance. Indirect effects of policies—such as higher prices caused by limits to commodity imports or incentives to increase biofuel feedstock purchases—also tend to encourage producers to draw more heavily on natural resources. However, there are limits on when cross-compliance can be implemented. Unlike direct payments, it is not possible for programs that raise prices to be conditional on resource use.

The next section focuses on broad questions relating to land and water resources. The omission of such topics as air quality, soil erosion and biodiversity, does not reflect any judgment that these topics are less important, nor that their answers are any easier.

Long-term issues and policy options-water quantity and quality

Current policies may not stop problems that exist today from growing worse in the coming decades. Water quantity and quality are examples. Water supplies are overdrawn in some places in the U.S. and around the world (Figure 9). At question is the future quality of ground and surface water, and if frameworks in place will withstand the growing tension between agricultural water uses environmental uses and other municipal and industrial uses.

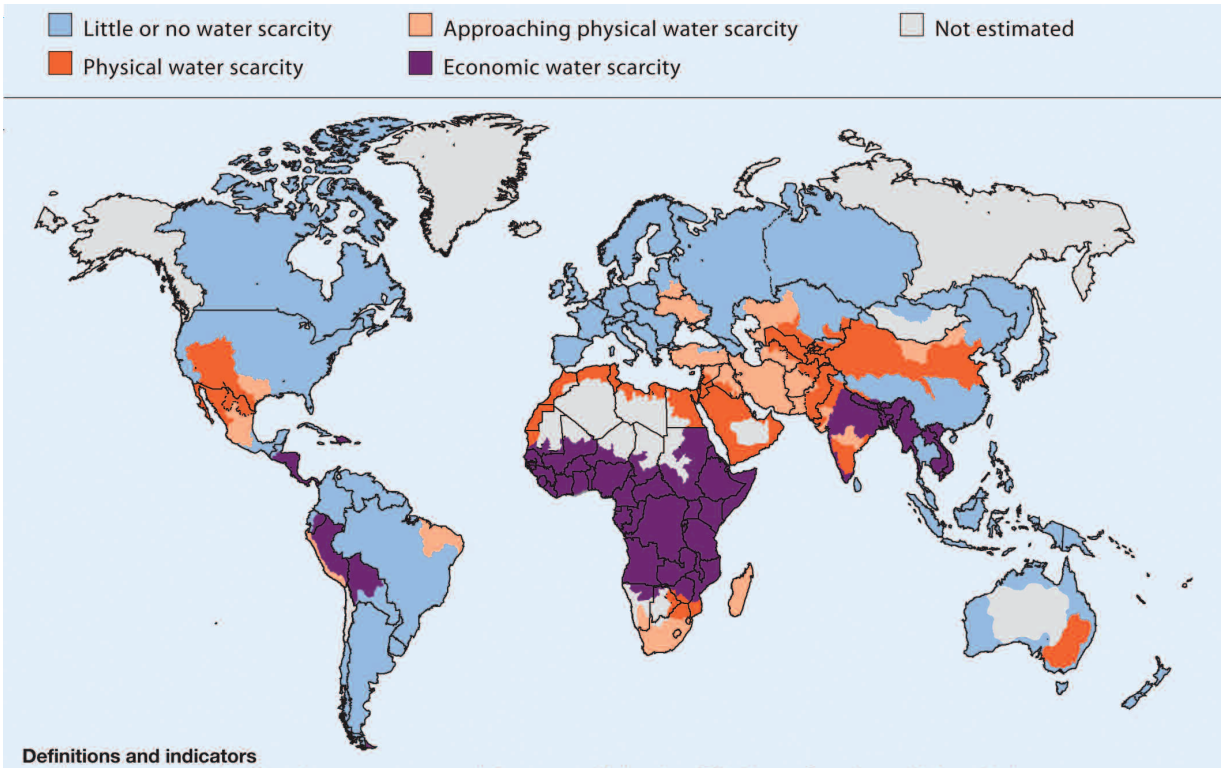
Enhance current policy. Broad policy options exist that leaders in the agricultural sector could consider as alternatives to current policy. Their success would likely depend in part on support at local and state government levels, as well as at the federal level, and their consistency with private property rights. Some options represent modest changes to current policy. For example, current conservation policies could more directly target water use and quality. But trying to serve all purposes may prevent these programs from satisfying any of them. One potential outcome is that a new focus on water priorities would lessen these programs' ability to address soil conservation or other environmental targets they had before. This might be offset by increasing the scale of the program overall, at greater budgetary expense.

An alternative that would likely decrease total budgetary cost on agricultural programs would be to enhance cross-compliance. If conditions on other program payments created stronger disincentives to certain uses of water, fewer producers might choose these options. Another consequence would be the budgetary costs of measuring and monitoring.

Prices and penalties. Another policy option is water pricing based on quality as well as on quantity. A consequence could be to encourage more efficient use of available surface and ground water, as the costs of use would be borne by the user. Without water pricing, businesses cannot value investments that reduce water use overall or that leave fewer pollutants in waste water. A consequence in principle could be some means for water transfers among different users and areas that, through pricing, are mutually beneficial. However, some elements of the water market infrastructure may be extremely difficult to establish, possibly leading to calls for government investment. Potential costs include physical waterways and the water market infrastructure, such as defining initial water rights, measurement and monitoring. Given the specificity of each situation and the many vast areas involved, such costs may be prohibitive.

Another policy option is to penalize or tax poor water quality based on such measures such as excess nutrients or bacteria. In theory, a program might even reward operations that improve water quality. Here again, the costs of measurement and monitoring seem potentially prohibitive, and could more than offset the revenues of any tax. Similarly, policies to regulate water use outright, such as through restricted removal rates, are likely to generate large costs of measurement and monitoring.

Figure 9 : Water balances



Definitions and indicators

- *Little or no water scarcity*. Abundant water resources relative to use, with less than 25% of water from rivers withdrawn for human purposes.
- *Physical water scarcity (water resources development is approaching or has exceeded sustainable limits)*. More than 75% of river flows are withdrawn for agriculture, industry, and domestic purposes (accounting for recycling of return flows). This definition—relating water availability to water demand—implies that dry areas are not necessarily water scarce.
- *Approaching physical water scarcity.* More than 60% of river flows are withdrawn. These basins will experience physical water scarcity in the near future.
- *Economic water scarcity (human, institutional, and financial capital limit access to water even though water in nature is available locally to meet human demands)*. Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists.

Source: International Water Management Institute analysis done for the Comprehensive Assessment of Water Management in Agriculture using the Watersim model; chapter 2.

http://maps.grida.no/go/graphic/areas-of-physical-and-economic-water-scarcity

By way of unintended consequence, a program that reduces agriculture's access to water would likely decrease agricultural supply overall, leading to higher prices. This could prove counter-productive with respect to other challenges, such as food and energy security. Objectives regarding the use of other natural resources could be disserved if less access to water–and consequent higher prices–encourages producers to use more of other natural resources.

Support or guidance to research and development could prioritize methods to reduce the amount of water needed to produce agricultural output or lessens any negative effects on water quality. In the absence of water pricing or restrictions, the benefits of such technologies may not accrue to the investor, so the private sector might tend to under-invest relative to societal needs.

Research and infrastructure. Public investment in research and development comes at a budgetary cost. Such activity may displace some commercial investment, although the logic above suggests the possibility may be small. There is also the risk that public investment will back the wrong horse, leading to an outcome that is not as good as it could be for the investment. A lesser degree of competition from commercial investment could disadvantage research efforts overall. New technologies generated might not be adopted in the absence of commercial or regulatory incentives. That policy option may be successful only in the context of another policy that prices water or a supplemental policy to induce voluntary technology adoption.

Another policy option is to support more development of the water infrastructure for retention and delivery. The outcome could be more efficient water use over time and space at public expense. If there was predictable access to water in a manner that did not encourage overuse, the effect could be to reduce agricultural production variability. For example, a region with better water storage and distribution could save water at times of ample rainfall for use during periods of drought. If that is the case, another consequence could be somewhat more stability in agricultural commodity supplies and reduced market price volatility, with positive effects on the stability of food access. But this option may also pose difficulties in measuring and allocating water resources among users.

Division of rights and responsibilities. Two critical issues in water use and quality are private property rights and overlapping governmental responsibilities. Private property rights over water are not always clearly defined. Even if rights are defined, water users may be unable to exchange them. In that case, water pooled in a single source can be valued differently by different users, who are unable to trade their water rights. Government at local, state, and federal levels may all play a part in local water use. Two producers in a watershed with identical circumstances may have different water access rights because they fall under the jurisdiction of different local governments. But the policy options to address these problems could require participation by many individuals and public bodies. This need is already recognized up to a point. Several federal agricultural programs involve cooperation with states. Water quality legislation also results in interaction between state and federal levels.

Water concerns also span international boundaries (Figure 9). Projections for population growth suggest that water demand will rise quickly in some regions with the least access to it. In the extreme case, competing users of declining surface and ground water supplies could become desperate, creating tensions that could degenerate into intra- or international conflict. The options available to U.S. agricultural leaders to ease these water constraints are limited. Again, well-directed public research and development could help ease pressures, but adoption might not take place readily unless private agents had some incentive to do so—be it a price, subsidy, or penalty. As in the case of economic development and food security, support for international organizations that assist policy dialogue could play a part in finding solutions. The budgetary costs of either option must be weighed against the probability of a long-term pay-out.

Long-term issues and policy options-land use

There is often competition for land use—for agricultural production, environmental benefits and other uses. Current public policies recognize this competition at least in part, and attempts to influence private behavior through a combination of varying tax treatment, agricultural policy subsidies or penalties, and regulations. There are many different land conditions, and local conditions vary widely, so the topic defies easy generalizations.

Current policy may be inconsistent with the 30-year challenge to feed and fuel a growing world. For example, inconsistencies among state and local governments over land use may continue. Local authorities consider the effects of proposed land use for the local economy and tax base, but may not have the information or rationales to consider wider effects. Local decisions may not reflect the implications for wildlife, biodiversity or other benefits of non-urban uses. And there may be unintended consequences that work against the broader 30-year challenge. The implications for food and energy security might only be considered in local decisions if these imperatives are manifested in the market prices private agents receive and pay.

If the disharmony in land-use controls leads to vastly different societal costs for providing different environmental services from land, there is potential to obtain these services for much less cost. Current policy recognizes this possibility for some services. For example, private agents may be able to convert wetland to commercial use in one place if it is offset by expanding wetlands elsewhere.

National land use strategy. Another policy option is a national land use strategy, possibly as part of a broader environmental strategy. Such a strategy would try to seek some agreement on the ultimate objectives of land use policy and look for ways that a federal framework could lead to local decisions that better suit these objectives. If appropriate, for example, such a strategy might be the basis of policies that provide incentives for more compact growth, maintaining good farm land in production, removing poor quality or environmentally sensitive lands out of production, and providing ecosystem services. Such a strategy could anchor existing policy and possibly reprioritize some current efforts.

A strategy, of course, requires resources to build it and could unravel over time if it is too narrowly defined in terms of support or goals. The implementation may rest on incentives—such budgetary expenditures as subsidies or tax breaks—more so than other mechanisms because voluntary participation may dominate. Any foray into land-use policy may run afoul of private property rights or state or local government duties.

Nevertheless, even a defined framework that sets out national objectives and appropriate means could give guidance to local decisions. What form of land use supports "smart growth?" What degree of local diversity in wildlife and agricultural production is appropriate, and how is it to be measured? What steps best serve the purposes of providing ecoservices? While the answers may vary dramatically based on local conditions, the framework could provide a flexible basis for local decision-making.

Enhance current policy. Specific policy options that address land use may be considered independently of whether or not a national strategy is developed. Each has positive and negative consequences to consider. One option is to expand farm land preservation. Programs are in place that pay for conservation easements that restrict or transfer development rights. Programs subsidize land quality improvements on working lands. Either or both of these thrusts could be enhanced. As with any land use policy, an important element would be state and local support. So, too, would the availability of money to buy easements or coax land owners to participate in programs targeting working lands. A consequence of these actions is that the money paid to protect farm land might stay in agriculture, potentially increasing the capital in the sector.

Land conservation policies may have unintended consequences. New policies that would increase the amount or quality of agricultural land would tend to increase agricultural output and lower prices. Greater output may put further demand on other resources, such as water. Lower prices may serve food and energy security objectives. Conversely, policies that reduce the amount of working land would have the opposite consequences. A key question about a long-term preservation program that highlights these potential inconsistencies is how it handles changing conditions. For example, should the amount of land enrolled in such a program be reconsidered and, if so, under what conditions?

Research and development. Research and development provide one avenue to produce more output with less land or with fewer negative consequences on land quality. The value of ecoservices generated by land are not likely to be reflected in such private incentives as prices or fees, including agricultural commodity prices, and the planning horizon of commercial agents may be too short relative to society's needs. In this case, the pace of strictly private research and

development in technologies that provide ecoservices may fall short of what the public would like to see. Public investment could spur a faster rate, but at taxpayer expense and with the possibility that the funding might not hit the best mark. The long-run benefits of such efforts are difficult to calculate, given possible spillover effects such as the long-term effects on supply and the implications for other countries facing similar problems.

Commercial incentives may not lead producers to adopt new land use technologies resulting from research investments. Such a program might have to be coupled with others that provide incentives to adopt or disincentives for failing to adopt a new method. U.S. conservation policies already include programs to assist producers who choose to adopt practices that improve environmental performance. Cross-compliance is an example of a policy that makes payments in one program conditional on environmental performance. While not strictly an element of conservation policy, U.S. fixed direct payments associated with historical base acreages are conditional on land use.

Immediate issues and policy options

Matching long-term demand growth and natural resource limits may be fundamental to the 30-year challenge. But public and private decision makers must also reflect on urgent calls for action that address current problems. Droughts and floods spur calls for immediate response. Now under consideration are large water projects involving water transfers. In the absence of prices that reflect the value of the natural resources and can ration availability among different uses, the burden of such decisions may be a matter for public policy.

Cross-compliance. Other potential near-term decisions relate to the scope of cross-compliance. Should additional payments to producers be conditional? Should there be more conditions? Cross-compliance may have particular appeal during a time of tight overall spending limits because the costs of measurement and monitoring may be more than offset by reductions in expenditures on other programs. Indirect consequences result from the costs of meeting conditions presumably borne initially by producers, leading to less agricultural output and higher prices. Unintended consequences may include more difficulty meeting food and energy security objectives, and possibly by greater pull on other natural resources. On the other hand, an expansion of cross-compliance coupled with greater subsidies to producers to adopt environmentally sound practices would have different consequences. Under this option, the cost of changing production practices would be paid, at least in part, by federal budgetary support so agricultural output might not fall since the cost would be shifted from producers to taxpayers. In all of these options, it should be remembered that the intended long-run consequence is to sustain the quality of natural resources overall, including the land and water used by agriculture. Hence, the future effect may well be to increase agricultural supply.

Prioritization. With or without a clear set of objectives defined by a national strategy, there are immediate needs to reconcile often conflicting imperatives. As noted above, there are potential inconsistencies between policies to meet natural resource objectives and other categories of the 30-year challenge, such as food and energy security. In U.S. conservation policy, there have been experiments with environmental performance indices that summarize several measures of natural resource use and quality associated with, for example, a piece of land. At times, this index has been coupled with a bidding process that lets landowners consider the productive power of land and thus implicitly reflects the value of the land if allocated to producing foods, fibers or bioenergy feedstocks. It seems likely that an index which spans as wide a list as possible societal objectives depends on a clear view of those objectives and an ability to weight them according to changing conditions. In the absence of a national strategy that encompasses the array of natural resource objectives and recognizes unintended consequences, this potential is diminished.

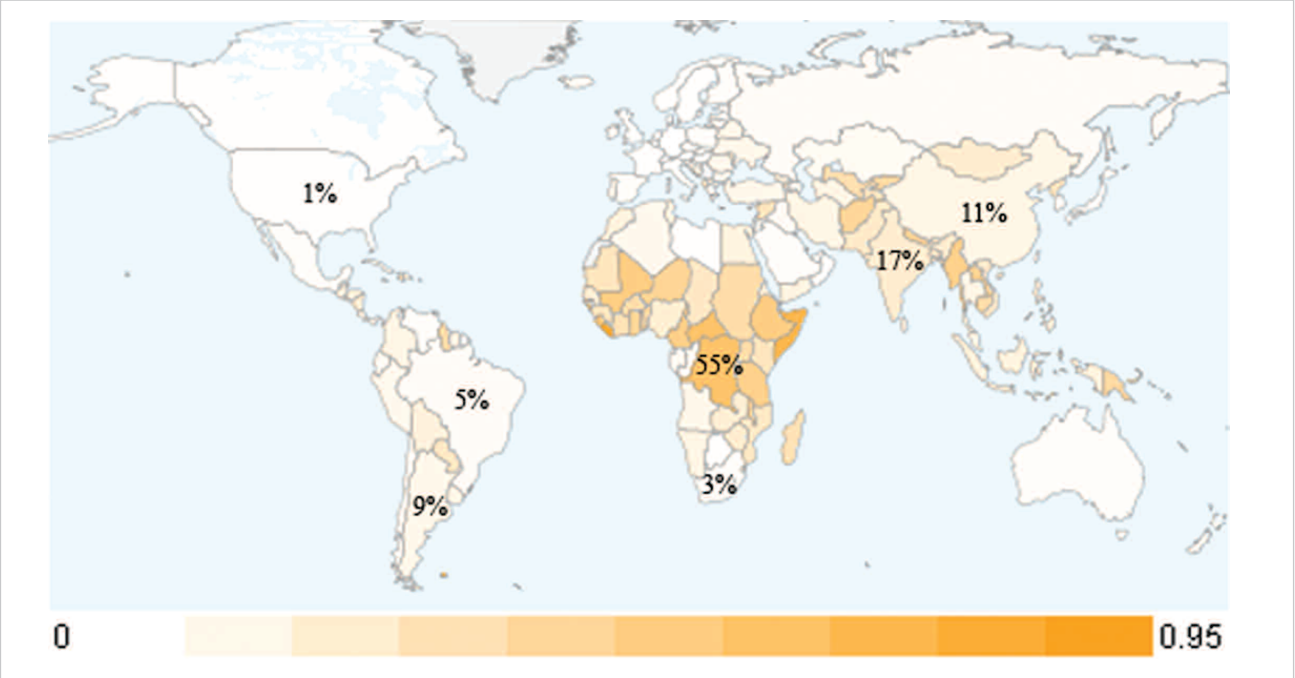
All of these considerations are couched in a network of overlapping jurisdiction and fundamental questions about the appropriate role of government, particularly in balancing personal property rights and societal needs.

Global economic development

One of the most significant challenges over the next 30 years will be to define the role of agriculture in economic growth throughout the world, given growing food demands and competition for natural resources. Choices made today by public and private decision makers could improve the contribution of agriculture to economic growth in developing countries now and in the future.

Economics does not offer a clear list of steps a country must follow to become prosperous. The share of agricultural GDP in total GDP tends to be higher in developing countries (Figure 10). One question is whether support to agriculture must be increased, or whether support must be provided to other sectors to give workers more options. People in developing countries tend to spend a larger share of their expenditures on food (Figure 11), raising the question of whether support to agriculture through higher domestic prices actually harms rather than helps them. The debate about how different policies may succeed in different situations goes well beyond the scope of this report.

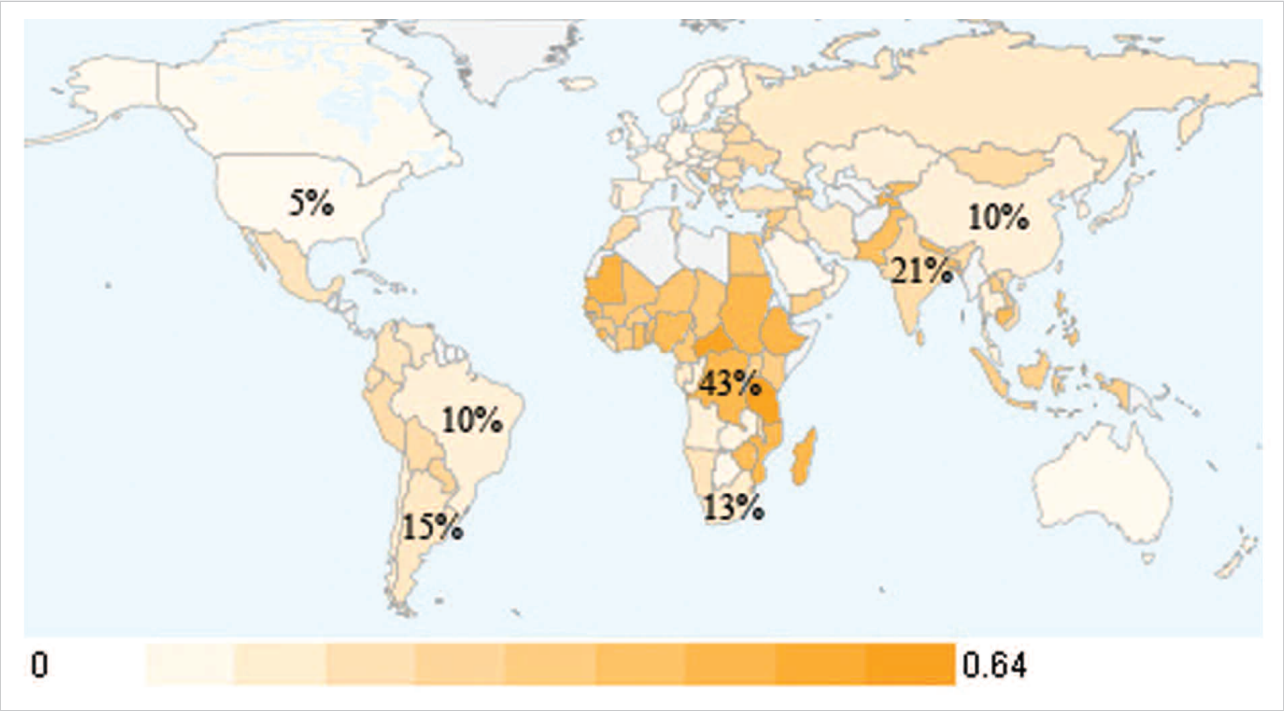
Figure 10 : Share of agricultural GDP in total GDP



Note: Shading indicates share of agriculture in total GDP up to 0.95, or 95%.
Source: Central Intelligence Agency. The World Factbook. Retrieved Nov. 5, 2008: www.cia.gov/library/publications/the-world-factbook/fields/2012.html.

How the U.S. agricultural sector could contribute to economic growth in other nations is linked to other challenges previously discussed in this report. The current financial crisis and slowing economy contribute to short-run, urgent problems for developing countries as food purchasing power wanes and export revenues fall. Long-term problems may evolve if financial markets remain impaired. Increasing food security, if defined as affordability and stability of food consumption, is an important condition for broader economic growth and a likely consequence of strong growth. Natural resource limitations that undermine a country's ability to produce food can imperil economic growth. Crises of water availability may have the potential to generate conflict. In developing countries, agriculture may have opportunities to benefit by mitigating climate change, but may face immense challenges in adapting to climate changes that are already underway.

Figure 11 : Share of food and non-alcoholic beverage expenditures in total expenditures.



Note: Shading indicates share of expenditures spent on food and non-alcoholic beverages up to 0.64, or 64%.
Source: The World Bank Group. DDP Quick Query. Retrieved November 5, 2008: http://ddp-ext.worldbank.org/ext/DDPQQ/member.do?method=getMembers.

Long-term issues and policy options

Some observers believe that broad economic development in less developed countries depends in part on the growth of agricultural production capacity. Many people in those countries are involved in agricultural production, and food expenditures tend to be a large share of their total consumption expenditures. Agriculture in developing countries relies on labor more than on such purchased inputs as fertilizers and machinery (Table 2). Maintaining current approaches would continue low economic growth rates in the agricultural sector of less developed countries, or even foster declining output due to natural resource constraints or limited ability to adapt to climate change. Developing nations that rely more and more on food imports would be increasingly vulnerable to exchange rate fluctuations and to external shocks. At the same time, nations with decreasing opportunities to import food would be more exposed to domestic supply disruptions.

Research and development. Public support for research and development is one policy option. More support could be given directly to fund research. International research organizations, such as those in the Consultative Group on International Agricultural Research (CGIAR) system, could be tapped to help prioritize funding needs or to coordinate research work of private business, public centers, non-governmental organizations and charities. Another approach would be to encourage more private research and development activity through incentives, such as tax treatment or intellectual property right rules.

There are budgetary consequences to funding research and development, providing incentives to private firms, or even coordinating activities. These costs will precede the benefits due to the often long lags between investment and impact. The potential exists for publicly funded research to displace, in part, privately-funded research, possibly decreasing its effectiveness. If a publicly-funded effort put all its weight behind a particular technology, there would be a risk that it was not the best choice, and better alternatives would be overlooked. This possibility is lessened if public investment

focuses on public goods and products unlikely to be undertaken by the private sector. Potential benefits include greater productivity as research is developed and defused more quickly, resulting in higher incomes to producers.

Multiple goals could be accomplished if investment decisions reflect other strategic goals, such as those relating to natural resource use or climate change. Conversely, if these goals are ignored, unintended consequences could result. For example, resource depletion or environmental degradation could be exacerbated by production-maximizing technologies.

Table 2 : Agricultural inputs

	Agricultural land		Irrigated land		Fertilizer use		Agric. employment		Agric. machinery	
	1990-92	2003-05	1990-92	2003-05	1990-92	2003-05	1990-92	2003-05	1990-92	2003-05
	(% of total land)		(% of crop land)		(100g/ha of arable)		(% of total employment)		(tractors/100sq km arable)	
World	37.7	38.3	17.7	18.4	925	1,020	41.8	..	186	200
High income	38.5	38.6	10.7	11.8	1,213	1,212	5.7	3.8	417	431
Middle income	34.6	35.5	20.1	18.5	970	1,110	44.2	35.8	127	137
Low income	44.3	45.2	21.8	24.4	541	686	..	..	52	84
U.S.	46.6	45.3	11.3	12.5	1,015	1,096	2.9	2.2	245	270
France	55.3	53.9	11.0	13.3	2,918	2,221	..	4.3	784	685
Germany	49.6	48.8	4.0	4.0	2,616	2,245	4.0	2.5	1,253	801
Japan	15.5	12.9	54.3	54.7	3,779	3,066	6.8	4.7	4,297	4,588
Australia	60.5	57.5	4.2	5.2	275	479	5.5	4.4	67	65
New Zealand	65.0	64.3	7.6	8.5	1,892	5,704	10.7	8.7	322	507
Brazil	28.9	31.2	4.6	4.4	656	1,201	25.6	20.6	142	137
Argentina	46.6	47.0	5.6	5.4	73	295	0.4	1.1	103	108
China	57.0	59.5	43.6	47.5	2,777	3,519	53.5	44.7	77	89
India	60.9	60.6	28.3	32.7	758	1,044	68.1	..	65	141
Bangladesh	73.5	69.3	33.8	54.3	1,136	1,738	66.4	51.7	6	7
Vietnam	21.0	30.8	44.6	33.9	1,299	3,172	73.8	61.9	60	247
Ethiopia	51	31.8	1.4	2.6	..	145	..	..	..	3
Nigeria	79.4	79.7	0.7	0.8	142	66	..	..	8	10
Russia	13.0	13.2	4.2	3.7	410	121	14.5	11.4	92	52
Ukraine	69.8	71.4	7.6	6.8	792	154	..	19.5	145	124

Notes: Gross National Income (GNI) per capita is $875 or less in low income countries, $875 to $10,725 in middle income countries, and greater than $10,725 in high income countries; and permanent pasture, arable land, and land allocated to permanent crops are included in agricultural land.
Source: World Bank's World Development Indicators, 2007, Table 3.2 (www.worldbank.org).

Infrastructure. Another option to increase capacity for growth in agricultural production is to improve infrastructure. This includes not only roads, rails, navigable waterways, and port facilities, but also market institutions, such as contract enforcement and information flows. All of these factors are needed to maximize the ability of producers in different areas to specialize. As in the case of research and development, infrastructure spending would result in costs and benefits. Public expenditures might be lessened through partnerships with private agents, non-governmental organizations or charities. There may also be some potential to drive out private investment, or direct funds away from projects with potentially greater returns. Benefits could include greater producer access to markets, increasing the potential for income gains. If infrastructure improvements were accompanied by recognition of natural resource limits, another benefit might be better natural resource use, as producers specialize in the commodities best suited to their local production conditions. This scenario is one of reliance on trade with other localities in the country, if not internationally, for foods or other agricultural outputs.

Serve broader economic growth. Another possible strategic objective relates to the ability of agriculture to contribute to broader economic growth—specifically contributing to human capital through food aid programs that alleviate short- and long-run malnutrition (see Global Food Security). For example, school feeding programs may be seen as an agriculture-based policy intended to achieve long-term increases in human capital and, consequently, productivity and growth. However, in addition to the budgetary costs of such programs, current agricultural production in targeted locales may decline if children go to school rather than work.

Agriculture can contribute to broader economic growth by encouraging affordable and stable food prices without overburdening natural resources. Having sufficient food helps people to work productively. Even outside of school feeding programs, good nutrition is a solid basis for long-term human capital development. If a country has more and higher quality natural resources, income and overall well-being should improve. For example, more clean water would reduce the direct costs associated with poor water-borne diseases, improve human health, and lead indirectly to better economic growth.

Immediate issues and policy options

The current financial crisis may be restricting the availability of credit. Evidence of a global recession is increasing (see Global Financial Markets and Recession section). After reaching near-record highs, commodity prices are falling, as are oil prices. The implications of these events on developing countries are only now becoming apparent.

Financial crisis and recession. One policy option is to better monitor the effects of the financial crisis and the potential for and potential impacts of recession on agriculture. While the budgetary costs of this option may be relatively low, a greater possible cost could be a missed opportunity to forestall a larger problem later on. For example, if some sort of credit assistance could help a country bridge a financing gap to enable trade to continue, then a long delay in implementing such a policy could lower overall economic activities and incomes, as well as weaken food security if food prices were affected.

Options available to address these concerns are defined in an earlier section (see Global Financial Markets and Recession.) Many public policies that target U.S. agriculture are likely to have unintended consequences on other countries. Options that support U.S. agriculture may maintain or possibly increase output. The international effect of these options may be to lower commodity prices. This consequence would likely be to the detriment of competing producers abroad and to the benefit of foreign consumers. The net effect on the overall economic well-being of people in developing countries is unclear.

Public policies could attempt to alleviate the effects of financial crisis and recession on developing countries. These options are considered again here in light of their consistency with possible strategic objectives for global economic development. Direct market intervention to support commodity prices, such as trade barriers or subsidies tied to output, may lead producers to earn more money, but may not help them overcome financial constraints. Higher producer prices supported by trade barriers could increase costs for consumers. Direct subsidies are a budgetary expense.

Support for research and development efforts or to international institutions may help define the problem and potential solutions. However, results may not be available in time to address immediate problems.

Food aid targets certain recipients (see Global Food Security.) Food aid could be a policy instrument that addresses the fall-out of the current financial crisis, as well as a long-term tool to provide assistance to developing countries. There is debate about whether food aid should be delivered in commodity form or monetized so that food can be purchased locally. This debate, too, can be viewed in terms of consequences for economic development. One consequence of aid in the form of commodity shipments may be to displace commercial trade and local production, potentially depressing producers' incomes. Food aid in the form of money could help desperate consumers buy food which, in turn, might lead to higher local commodity prices that benefit producers. High prices, however, would also lead to higher costs for other local consumers who do not receive food aid. Another issue is the relative effectiveness of the expenditures. Commodities given as food aid incur transportation costs. Food aid given as money requires local purchases, the price of which may include the costs of overcoming potentially serious obstacles in the local infrastructure. Monitoring costs may be a factor in either case.

Trade. Trade policy represents one mechanism that may have effects on developing-country growth. The Doha Development Round of the World Trade Organization is predicated in part on the expectation that trade liberalization, coupled with development and adjustment assistance, could be one key to broad economic growth. For example, fewer

trade barriers and lower domestic support to agriculture in developed countries could lead to higher prices. This might generate new opportunities for producers in developing countries but would also imposing higher costs on consumers in those countries. At the same time, the oft-held principle that developing countries should be permitted to maintain higher import barriers implies that they may use tariffs as a revenue source and means to increase producer returns, but may not fully recognize the impact of higher local prices on consumers. Recent price spikes may have raised awareness that higher agricultural commodity prices are not always and universally better for all people in developing countries. It remains to be seen if lessons about the complex effects of higher prices will be reflected in trade policy negotiations.

Trade and direct investment are the chief mechanisms by which U.S. agriculture interacts with agriculture in other nations. The voluntary exchange of goods, based on local prices, is likely to shift resources to most productive uses, reflecting each country's abilities and needs. There are obstacles to this outcome, such as deficiencies in infrastructure, including aspects of food safety (see Global Food Security). Trade might tend to diversify supply sources, but it also introduces new sources of risk. Trade policy that supports these outcomes and helps to overcome these obstacles might facilitate foreign economic development. But trade policy changes lead to adjustment as production patterns change. More openness to trade may introduce new sources of shocks because changing world market conditions will more directly affect domestic markets. These effects may create domestic and multilateral calls for policies to facilitate or compensate for such adjustments and external shocks.

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