Global Food Security: Market Forces and Selected Case Studies

NATIONAL INTELLIGENCE COUNCIL REPORT

NICR 2012-23, 10 May 2012

This is not an IC-coordinated report.

This paper does not represent US Government views.

Scope Note

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The National Intelligence Council (NIC) published in May 2008 the National Intelligence Assessment, National Security Implications of Global Climate Change to 2030. The key findings were that climate change would have wide-ranging implications for US national security interests in the next 20 years. The most significant implications for US national security interests will be indirect and will result from climate-driven effects on other countries. Climate change alone is unlikely to trigger state failure by 2030, but the effects of climate change—reduced water availability, degraded agriculture production, damage to infrastructure, and changes in disease patterns—will very likely worsen existing problems such as poverty, social tensions, environmental degradation, ineffectual leadership, and weak political institutions.

The NIC asked Eurasia Group in April 2011 to explore those market forces that will affect food security to 2040. Eurasia Group through a series of case studies identified states that may be particularly susceptible to food security issues. Eurasia Group used its internal expertise and outside research to prepare this report. The core report was completed in August 2011, and updated in May 2012.

The year 2040 was selected as the year for this research to consider longer-term consequences from climate change, growing populations, and continued global economic development. However, the data referenced in this paper covers a wide variety of dates (e.g. 2030, 2050). Annex A provides selected case studies to illustrate the key themes of the report or explore areas important to the United States.

This report is the second of four external efforts the NIC will conduct over the next four months to explore global food security. The first report—Global Food Security: Key Drivers—was a conference report introducing the topic of food security. The third report will be an investigation exploring trends in agriculture technology. The fourth and final report will be a 20-plus nation study that looks at global food security and the implications for US national security. Following these external studies, the NIC will prepare an Intelligence Community analytic product on food security and implications for US national security.

Food Security Definition

The World Food Summit of 1996 defined food security as existing “when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life.” The concept of food security is commonly defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences.

Global Food Security: Market Forces and Selected Case Studies

Executive Summary

Our Bottom Line: In the next ten years positive economic development in emerging markets, combined with an increase in biofuels production, will almost certainly add stress to global food markets and increase their vulnerability to high food prices and price volatility. In the long term, there is an even chance a number of supply and demand factors will undermine global food security. However, with the aggressive application of existing technology—to include transportation infrastructure, fertilizers, and watering techniques—along with the development of new biofuels technology, the risk of price spikes and food insecurity will very likely decline.

A. In the next ten years, positive economic growth and development in emerging markets, combined with an increase in biofuels production will almost certainly add stress to global food markets and increase their vulnerability to high food prices or price volatility. Extreme weather events and policy choices that restrict supply can trigger such shocks. The ongoing demands from population growth and the shift to a meat-based diet will place strong upward pressure on food prices. High food prices will create both winners and losers. The losers will be the urban poor and the landless rural populations who will be required to pay more for the same amount of food, or, in many cases, cut back on their dietary intake. The winners will be farmers with access to technology and markets who can benefit from higher prices.

- Soaring prices for agricultural commodities in 2007 and 2008, including wheat, rice, corn, and soybeans—a phenomenon known as "agflation"—led to shortages of food and general unrest principally in North Africa and the Middle East.[1] While boom cycles are not uncommon in global commodities markets, there was a legitimate fear that the 2007–2008 bout of agflation represented a structural shift that would result in sustained tight markets. Food price spikes in early 2011 reinforced these worries; however, prices fell through the end of the year but rose again slightly in early 2012. Nonetheless, levels in May 2012 remain well above prices seen in the 1990s and early 2000s.
    - During periods of excessive food-price inflation, such as in 2007–2008, the urban poor generally have the least ability to absorb price shocks and tend to be the primary drivers of social unrest.
- The countries most vulnerable to the impact of food-price inflation are import-dependent poor countries, such as Egypt, Pakistan, Bangladesh, and Sudan. For these countries, the primary line of defense to reduce the impact of food prices on their populations is to maintain or, if necessary, expand existing subsidies on basic foodstuffs. But this strategy

[1] Food riots and social unrest associated with high food prices occurred in Somalia, India, Mauritania, Mozambique, Yemen, Cameroon, Sudan, Cote d'Ivoire, Haiti, Egypt, Tunisia, and Sudan.

will have its limits, as governments run up against budgetary constraints.

- There is a second set of countries (e.g., China, India, and Russia) in which country-wide inflationary trends, largely driven by food prices, have been especially burdensome to the poor.
    - However, Russia and China are better able to shield themselves domestically from rising food prices by restricting food exports.
- Supply-side management policies to boost food crop production, mitigate the potentially negative impact of climate change, and ensure stable trade flows can, in the near-term, avoid a fundamental shortage of food. However, even if this achieved, there will be tighter markets, higher prices and increased price volatility.
    - Most experts agree that the removal of import tariffs is a sensible policy response to agflation. Both developed and developing countries often implement import barriers to protect domestic agriculture industries. While removing import barriers helps moderate commodities prices, countries such as Russia, Ukraine, India, Vietnam, and China have taken the added step in recent years of erecting export controls. Export barriers—while used as a short-term measure to address immediate concerns of soaring food prices—reduce the supply of grains on international markets, causing prices to rise, and food importing countries to question the reliability of global markets.
    - Cultural and environmental opposition to genetically modified (GM) crops, continues to slow down their deployment globally and deny global agriculture markets the benefit of increased supply.

B. In the long term, there is an even chance a number of supply and demand factors will undermine global food security. These factors include increasing extreme weather-related disruptions, prolonged periods of poor management of water and soil, inadequate use of modern agricultural technologies, land use for biofuels, and unforeseen stresses from population growth.

- Scientific consensus points to a growing incidence of variable weather conditions such as droughts, flooding, heat waves, and severe storms because of climate change. The impact of climate change will be modest until 2050, resulting in a moderate rise in food prices, but weather-related disruptions will still lead to increased intermittent food shortages and therefore increase volatility in food markets through 2040 and beyond.
- In many parts of the world, fresh water is already scarce and will become more so. The historical pattern of integrated agriculture and water policy is insufficient to meet the challenge. Among the most severely water constrained areas are the Indo-Gangetic Plain in South Asia, the North China Plain, and the Nile River basin.
- The limited availability of new agricultural land means that improving crop efficiency and infrastructure will become increasingly important to get crops to markets to meet global food needs. The nutrients in fertilizers are also crucial to boosting crop yields as well improving the nutritional content of crops.
    - Certain types of geographically dispersed fertilizer resources have unique risks. Potash, in particular, is highly concentrated in Russia, Belarus, and Canada, which account for around 75 percent of global potash exports. Nitrogen and phosphate fertilizers are also geographically dispersed. Further, the price of nitrogen

fertilizer is closely correlated with that of natural gas (which accounts for 70 to 90 percent of the cost of production).

  - The worldwide growth of biofuel mandates has driven major investments—predominately from the private sector—in agricultural land. Estimates of the exact contribution of biofuels to rising grain and food prices vary considerably.

- The shift in labor and land away from rural farming areas to cities will deal a setback to food production. Moreover, this population shift will add a massive new class of net food consumers to the world's cities.

C. Despite the pressures of supply and demand, policies that support efficient global agricultural trade flows and increased deployment of existing technologies offer a path to global food security. With the aggressive application of existing technology—to include transportation infrastructure, fertilizers, and watering techniques—along with the development of new biofuels technology, the risk of price spikes and food insecurity will very likely decline.

- Russia, Kazakhstan, and Ukraine have the potential to greatly increase grain exports. However, to take advantage of unused land, these countries must permanently refrain from export barriers, invest in storage and transportation infrastructure, and provide improved credit access for farmers. Such policies would not only help farmers in each of these countries, but would also alleviate global shortages of grains and thereby ease prices as well.

- While much of the world benefited from the results of the Green Revolution, sub-Saharan Africa did not, mainly because the strains of seeds developed during the revolution were not suitable to local conditions in the region. Since the early 1960s, grain yields in the rest of the world increased almost 2.5 percent annually, while in sub-Saharan Africa they grew approximately 1 percent. Therefore, there is significant scope for expanding the Green Revolution to Africa by undertaking research efforts to develop grain strains that are matched to Africa's conditions.

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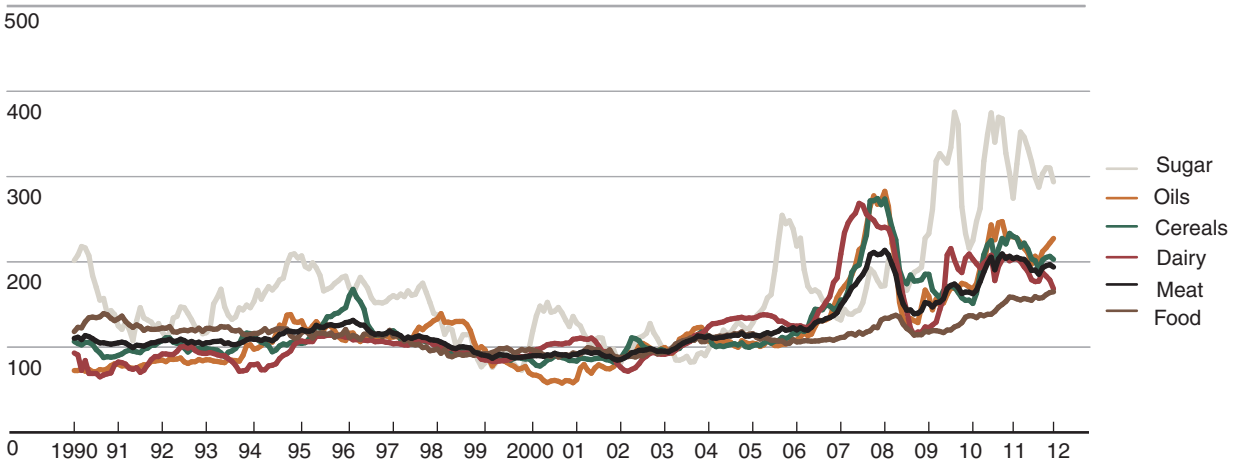
Contents

This report was prepared under the auspices of the Director, Strategic Futures Group. It was reviewed by the National Intelligence Council, provided to the Intelligence Community for comments, but was not formally coordinated.

United Nations Food and Agriculture Organization (FOA) Price Index

2002-04 = 100



Source: UN Food and Agriculture Organization.

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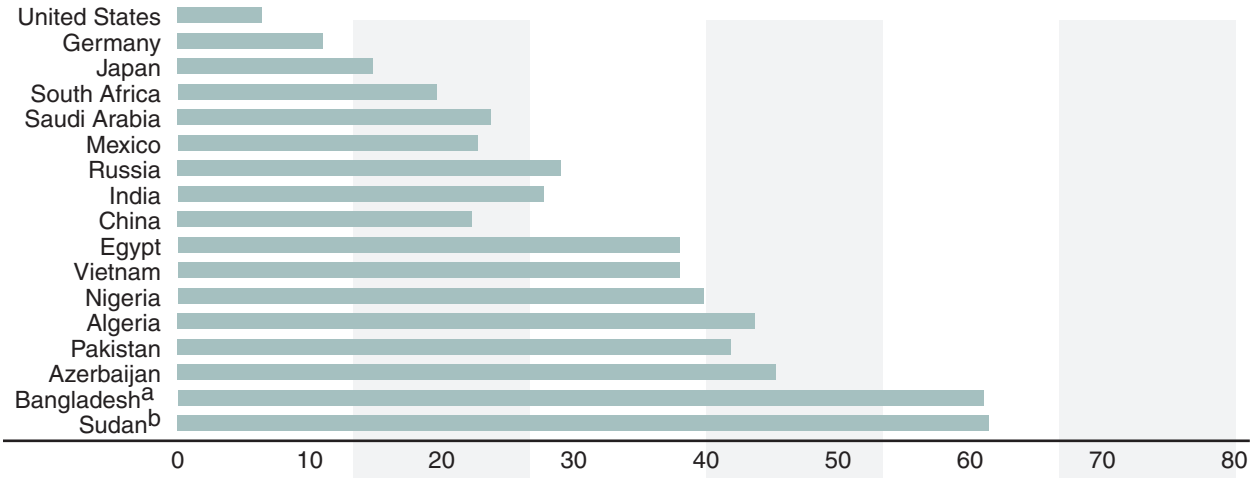
Percent of Household Expenditures Spent on Food, Select Countries (2010)

Percent



[a]Non-USDA data based upon a World Bank 2005 survey; poverty rate has dropped significantly since 2005 so data is judged to be high.
[b] Non-USDA data based upon a 2009 survey and reflecting a composite for both North and South Sudan.

Source: USDA Economic Research Service Briefing Room, "Food CPI, Prices and Expenditures," Table 97.

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Discussion

Near Term: Higher Prices and Price Volatility

Introduction

Despite widespread concern about food security, the dynamics of global agricultural markets will create both winners and losers. Farmers in the United States and EU will encounter a more favorable policy environment than their counterparts in developing countries, where governments are more likely to rush to stem price increases to avoid social disruptions. Several emerging-market countries including Russia, Pakistan, India, and China, however, are providing subsidies and raising purchase prices to farmers to induce them to expand their plantings.

The primary consequence of rising agricultural commodities prices is the commensurate hike in staple food prices for average households. While rich countries will also feel the pinch, the share of food spending in the average low-income household in poorer countries is far greater, and these families will be affected to a greater extent. As a result, food-price inflation will likely fuel social discontent when accompanied by other economic issues such as low wages and poor governance.

A. In the next ten years, positive economic growth and development trends in emerging markets, combined with an increase in biofuels production will almost certainly add stress to global food markets and increase their vulnerability to high food prices or price volatility. Extreme weather events and policy choices that restrict supply can trigger such shocks. The ongoing demands from population growth and the shift to a meat-based diet will place strong upward pressure on food prices. High food prices will create both winners and losers. The losers will be the urban poor and the landless rural populations who will be required to pay more for the same amount of food, or, in many cases, cut back on their dietary intake. The winners will be farmers with access to technology and markets who can benefit from higher prices.

- Soaring prices for agricultural commodities in 2007 and 2008, including wheat, rice, corn, and soybeans—a phenomenon known as "agflation"—led to shortages of food and general unrest principally in North Africa and the Middle East.[2]

- While boom cycles are not uncommon in global commodities markets, there was a legitimate fear that the 2007–2008 bout of agflation represented a structural shift that would result in sustained tight markets and keep food security concerns at the forefront of policymakers' agendas. Food price spikes in early 2011 reinforced these worries; however, prices fell through the end of the year but rose again slightly in early 2012. Levels in May 2012 remain well above prices seen in the 1990s and early 2000s.

Economic Development

The rise of incomes in developing countries, mainly China and India, has prompted a shift away from a grain-based diet to one based on meat. As a result, demand for grains to use as animal feed has increased significantly. Meat yields only one-third the nutritional value of the grain consumed by livestock (resulting in a feed-to-food ratio of 3 to 1), so demand for meat places

[2] Food riots and social unrest associated with high food prices occurred in Somalia, India, Mauritania, Mozambique, Yemen, Cameroon, Sudan, Cote d'Ivoire, Haiti, Egypt, Tunisia, and Sudan.

extra pressure on the grain market. Given China's and India's expected economic growth trajectories over the coming years, this shift in demand will continue.

Even if high prices cause a decline in grain demand from livestock producers in industrialized countries such as the United States, Chinese and increasingly Indian demand will more than compensate for the shortfall. The USDA forecasts Chinese production of 51.6 million tons of pork for 2012, an increase of 320,000 tons over the previous year. Pork production along with chicken production will contribute to an all-time high consumption of corn in the year beginning in October 2011.

Biofuels

Biofuels, a new source of demand, push prices higher and divert crops away from use as food. The expansion of US biofuels, for example, consumes an average of 30 to 40 percent of the US corn crop. This new demand also prompts farmers to shift land away from other non-fuel crops, driving up the prices of those commodities, as well. The United Nations Food and Agriculture Organization (FAO) estimates that by 2020, 13 percent of global coarse grain production, 15 percent of vegetable oil production, and 30 percent of sugarcane production will be used as feedstock for biofuels.

Estimates of the exact contribution of biofuels to rising grain and food prices vary considerably, however, and pinning down a precise causal relationship has proven difficult. Studies conducted during the 2007–2008 bout of food-price inflation produced widely divergent conclusions.

- The International Food Policy Research Institute estimates that between 2000 and 2007, biofuels demand accounted for 30 percent of the average increase in grain prices. The organization also estimates that current policy demands for biofuels would drive up global corn prices by 26 percent and oilseeds prices by 18 percent by 2020. A policy requiring twice as much biofuel production would lead to a 72 percent surge in corn prices and a 44 percent spike in oilseeds prices.

- On the lower end, the USDA estimated that ethanol accounted for just 3 to 4 percent of the rise in US food prices in 2007.

- At the high end, a World Bank working paper found that biofuels were responsible for 75 percent of the rise in global food prices from 2002 to February 2008, although subsequent research has backed away from that claim.

It is therefore clear that estimating the precise correlation between biofuels and food prices is challenging, given the number of inter-connected variables involved in the analysis. The parameters of each study matter and the projected impact is closely correlated with the composition of the average household's diet. In countries such as the United States, where highly processed foods account for a large part of final consumption, grain prices will form a smaller part of food prices compared to transportation and packaging costs. By contrast, in countries where average food consumption is closer to the farm, the hike in grain prices will have a more direct effect on final food-price inflation.

Vulnerability to Price Shocks

Given that agricultural production is disproportionately spread geographically, some countries will be more at risk of higher prices than others. No country should be at extreme risk if global agricultural trade operates smoothly. However, the tendency of producing countries to impose export restrictions means import-dependent countries are likely to see disproportionate upticks in food prices.

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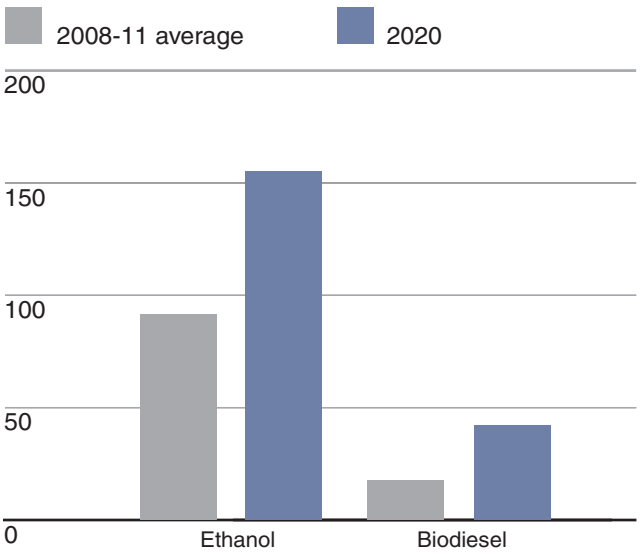
Biofuels Growth (2007)

Billion liters



Source: OECD-FAO *Agricultural Outlook* 2011-20.

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The most vulnerable to food-price inflation are import-dependent poor countries, such as Egypt, Pakistan, Bangladesh, and Sudan. For this set of countries, the primary line of defense to stem food-price inflation will be to maintain, or, if necessary expand, existing subsidies on basic foodstuffs. But this strategy will have its limits, as governments run up against budgetary constraints or cut funding for other programs in order to keep food prices down. As a result, governments in these countries are likely to remain susceptible to global food-price inflation, particularly if exporting countries enact export restrictions to tame their own domestic food prices. Moreover, poor import-dependent countries are not in a position to undertake overseas investments to secure more crop output.

- In emerging markets such as China, India, and Russia overall inflationary trends are often driven by food prices. All of these countries have seen a significant spike in inflation. Authorities in these countries have a more diverse set of policy tools for tackling inflation, however, and are therefore less likely to see meaningfully disruptive upticks in social unrest. In particular, large grain-producing countries such as Russia and China will be better able to shield themselves from rising food prices by imposing restrictions on the export of harvests, although such policies exacerbate food-price inflation and food scarcity globally. In addition to export curbs, these countries have more robust balance sheets to provide and maintain subsidies and domestic price controls, as well as leeway to use monetary policy tools to control inflation with more efficacy than smaller, less developed states.
    - Countries that can produce domestically but are dependent on imports for inputs such as oil and fertilizer could see meaningful food-price spikes as a result of rising input prices. These countries include large emerging markets such as China and India, as well as smaller island countries such as those in Central America and the Caribbean, where broader economic vulnerability to global commodity-price spikes could spill over into food-price inflation, as well.
    - During periods of excessive food-price inflation, such as in 2007–2008, the urban poor generally have the least ability to absorb price shocks and tend to be the primary drivers of social unrest.
- Lastly, large producer and exporter countries such as the United States, Canada, and some European states probably would see less impact on regional food prices because of their surplus production. Populations in these wealthier countries tend to eat more processed foods, of which grain prices contribute a relatively smaller share to final prices on retail shelves. These richer countries are therefore less vulnerable to swings in crop prices compared with poorer

countries. As emerging markets grow and develop, these shifts in dietary consumption could also mitigate their vulnerabilities to grain price spikes.

Weather

The most important near-term driver for agriculture commodity prices is weather. Significant weather-related disruptions could have a major impact on crop availability and prices under tight market conditions. Poor harvests caused by bad weather, droughts, or crop infestations in major producing regions have already contributed to high food prices. During the 2007–2008 agflation scare, droughts in Australia and Morocco and flooding in Argentina dealt major setbacks to wheat supply, while rice crop infestation in Vietnam and freezing conditions in China took large amounts of rice off the market.

Policy Choices

Both developed and developing countries often implement import barriers to protect domestic agriculture industries. Most experts agree that the removal of import tariffs is a sensible policy response to agflation because removal of these customs duties eases domestic shortages and thereby abates prices locally. Moreover, competition from imports pushes domestic farmers to achieve more efficient production.

The lowering of import barriers in recent years to address high food prices has some trade analysts suggesting a breakthrough in global trade talks is possible. The Doha round of WTO negotiations has been stalled in part by the reluctance of the West to cut agricultural subsidies. With developing countries now scrambling to supply their domestic markets, however, exports from these countries pose less of a threat. Nevertheless, high food prices are unlikely to reinvigorate the Doha trade talks. Most import tariff reductions are temporary measures designed to lessen food shortages in developing countries. So it seems unrealistic at this point that agflation could help bring about a multilateral trade agreement.

While removing import barriers helps moderate commodities prices considerably, countries such as Russia, Ukraine, India, Vietnam, and China have taken the added step in recent years of erecting export controls. In these countries, the political leadership uses export barriers as a short-term measure to address immediate concerns of soaring food prices. These barriers are likely to come down slowly as countries try to ramp up production. Export restrictions are detrimental to farmers by preventing them from earning higher prices on international markets. They also serve as a disincentive to farmers to expand output at exactly the time when more food is needed to ease shortages and bring supply in balance with structurally higher demand. Finally, they cause importing countries to question the reliability of global markers.

Efficient global agricultural trade flows offer a way to achieve global food security. Under optimal scenarios, lowest-cost producers would grow crops and export them to countries less suitable to producing at affordable costs. The historical bias toward ensuring domestic food self-sufficiency, however, has impeded progress toward achieving optimal trade in agriculture. Countries that lack land and/or water suitable for growing crops, such as Japan and Saudi Arabia, have poured subsidies into inefficient and costly production of grains, while the United States and the European Union have provided domestic farmers with subsidies allowing them to export surplus crops, sometimes at below market rates, eroding the business case for potentially lower-cost producers in Africa to boost local food production.

- Following the food-price inflation scare in 2008, import-dependent countries began to lose faith in the global agricultural market as numerous food producing countries restricted

exports. The import-dependent countries tried to control domestic prices and maintain domestic stocks in order to abate social unrest. Consequently, many importers began to question whether the global market in a period of crisis would be able to provide them with grain supply at any cost. In the face of this supply vulnerability, those governments with sufficient capital to make overseas investments began to view land acquisitions (and locking in associated agricultural production on that land) as the best way to ensure food security over the long term. Gulf countries have been the most active in this area, given their scarcity of arable land and water resources. But other countries, such as South Korea, China, and India, have engaged in similar ventures, despite self-sufficiency in grain production in the case of China and India.

- For so-called host countries, agricultural investments by foreigners can have sizable upsides, especially if these countries have suffered years of low food productivity. But such investments can also have significant downsides in light of their potential to exacerbate already unstable political situations and strain scarce water resources. Overall, crop investments have proven more contentious than biofuels projects, which tend to be smaller and run by private companies. By nature, these investments entail a delicate balancing act—there is a risk of igniting protest by exporting during a famine or flooding the market when there is already sufficient supply (in an agriculture-based economy). Incoming investors will be seen in many countries as cronies or proxies of the national government, which is likely distrusted. In countries where the leadership lacks legitimacy, the risk of backlash will grow, especially in regions where the government is out of favor, whether for historical, ethnic, or political reasons. Sudan and Ethiopia, the two largest recipients of this kind of investment, are home to such regions.

Overall, a stable supply of agricultural commodities to meet global food security needs can be assured through policies to boost food crop production, mitigate the harmful effects of adverse weather, and ensure stable trade flows. Even if this is achieved in the near term, there will be tighter markets, higher prices and increased price volatility, but not a fundamental shortage of food.

Long Term: Supply and Demand Challenges

B. In the long term, there is an even chance a number of supply and demand factors will undermine global food security. These factors include increasing extreme weather-related disruptions, prolonged periods of poor management of water and soil, inadequate use of modern agricultural technologies, land use for biofuels, and unforeseen stresses from population growth.

Supply Factors

The supply of agricultural products will depend upon four factors: climate change, water, fertilizer, and genetically modified (GM) technology.

Climate Change. The net impact of climate change alone is expected to be modest until 2050, resulting in a moderate rise in food prices. Still, climate change driven weather-related disruptions will lead to increased intermittent food shortages. These shortages will increase volatility in food markets through 2040 and beyond. The greater vulnerability to climate change is in the long term, from 2050 to 2100.

- In light of the growth in global greenhouse gas emissions, scientific consensus points to the growing incidence of variable weather

conditions such as droughts, flooding, heat waves, and severe storms as a result of climate change. At current rates, the average temperature is predicted to rise between 1.8 and 4 degrees Celsius by 2100. The Intergovernmental Panel on Climate Change has endorsed a goal of stabilizing the temperature rise at 2 degrees above pre-industrial levels by 2100, although recent estimates of current climate change mitigation policies suggest it will be difficult to keep the increase below 3.2 degrees.

Given the sensitivity of agricultural production to weather events, projected climate change will have an impact on global crop production. Among the effects of climate change on agriculture are higher temperatures; changes in rainfall; higher CO_2 concentrations; increased pollution; proliferation of weeds, pests, invasive species, and disease; and climatic variability and extreme weather events. Because these changes will have both positive and negative effects, accurate predictions about cumulative effects are hard to make.

- On the positive side, rising CO_2 concentrations will result in carbon fertilization, whereby CO_2 in the atmosphere can boost yields by acting as a fertilizer for certain crops. Offsetting this, however, will be variability in crop output caused by changes in temperature and precipitation. While higher temperatures could help boost production in colder areas such as Canada, Europe, and Russia, it will also create unfavorable growing conditions in already warm places such as South Asia, sub-Saharan Africa and Australia. Not only will it reduce crop yields in the latter areas, but it is also expected to lead to the growth of weeds and proliferation of pests that could further reduce production.

- Similarly, changing precipitation patterns could benefit drier parts of the globe by leading to higher levels of rainfall, but excessive rain would cause short-term disruptions to output. Over the longer run, severe floods and droughts will likely harm global food production.

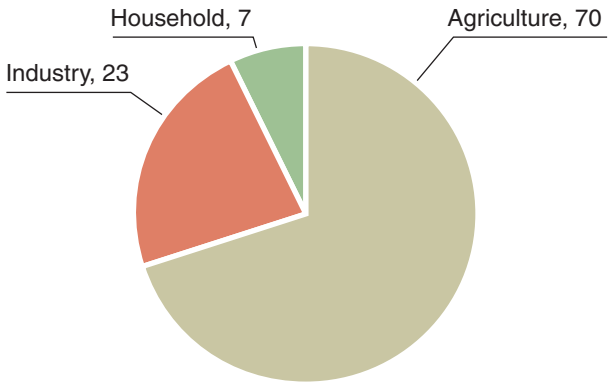
Water. Agriculture is by far the largest user of fresh water resources, accounting for an average 70 percent globally. The amount of water needed for crop production can vary considerably from locale to locale, as well as according to type of crop or food output. For example, meat production can require six to 20 times more water than grain production. In the future, the availability of fresh water will become increasingly scarce due to trends such as urbanization, pollution, and climate change. In addition, massive new demands on water resources from agricultural production amid global population growth will further elevate the importance of water resources to food security. Climate change will increase reliance on irrigation to provide predictable water supply when rainfall becomes more variable.

In many parts of the world, fresh water is already scarce and will become more so. Extreme water scarcity, defined as per capita consumption of less than 500 cubic meters per year, is especially severe in northern and eastern Africa, the Middle East, and South Asia. These regions will be forced to rely on energy-intensive water technologies and conveyance systems to meet direct human consumption and sanitation demands. The overuse of water is also affecting river basins that rely heavily on irrigated agriculture or are rapidly developing industrial production. Among the most severely constrained are the Indo-Gangetic Plain in South Asia, the North China Plain, and the Nile River basin. In addition, many models projecting the impact of climate change show that droughts will worsen in regions that are already water-constrained, particularly in subtropical regions around the Caribbean and the Mediterranean.

Food and Agriculture

Global Freshwater Usage

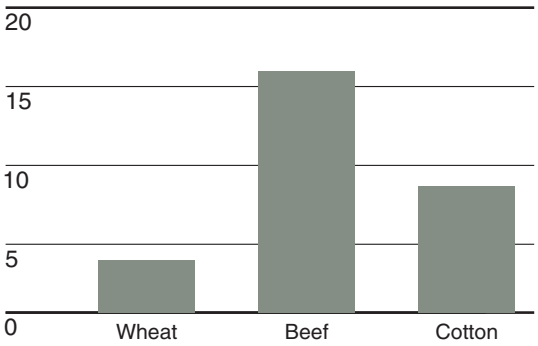
Percent



Source: World Economic Forum discussion document, "*Managing our Future Water Needs for Agriculture, Industry, Human Health and Environment*," 2008.

Water Requirements To Produce 1 Kilogram of Output

Thousand Liters



Source: World Economic Forum discussion document, "*Managing our Future Water Needs for Agriculture, Industry, Human Health and Environment*," 2008.

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The historical pattern of integrated agriculture and water policy is insufficient for the increasing challenge of fresh water scarcity. Authorities have struggled to coordinate such efforts for a number of political and economic reasons, but considering the rapid depletion of water in some areas, incorporating resource limitations into policymaking must begin soon if sudden water shortages are to be avoided. The primary challenge with water scarcity is that the policy steps needed to promote investment in the water sector for more efficient use of water—by increasing the price consumers pay—are politically difficult. Water is often viewed as a right rather than a commodity, and as such, efforts to raise water prices will almost always be met with vociferous opposition. Just as with the power sector, certain classes of consumers are more able to absorb higher water prices, including industrial, commercial, and larger residential customers. Smaller residential users will likely remain protected, as will agricultural users. But agriculture is the most water-intensive sector of the global economy and new water policies—encouraging technologies available that could reduce water consumption for farming—will have to be phased in over time.

- There is already some momentum for change. Southern California is addressing its water constraints by slowly increasing prices, and China is investigating various plans to encourage more efficient use. In countries that face water scarcity but are able to pass through higher costs to consumers, such as the United States, China, and Israel, there will be an advantage to the first countries that put innovative technology to use in their water sector. Countries such as Yemen and Pakistan face a much more uncertain future. Their water shortages are combined with a poor investment environment that will exacerbate the problem.

While much of the focus in the water sector will be on technologies on the supply side, such as improved desalination and recycling facilities, these solutions have a limited ability to meet the high water needs of agriculture. Desalination and recycling are better suited to support direct human consumption of water or industry. For agriculture,

the demand side and midstream water conveyance sectors must be addressed. More efficient use of existing water would provide the largest opportunity to reduce the risk of water as a limiting factor for agricultural production. Beyond efficiency improvements, one concept under development is the use of smart grids to deliver water. Like the electricity smart grid, water smart grids are designed to improve the efficiency of delivery with an end goal of decreasing the cost and energy needed for water movement.

Fertilizer. The limited availability of new agricultural land means that improving crop efficiency and infrastructure will become increasingly important to get crops to markets to meet global food needs. The nutrients in fertilizers are crucial to boosting crop yields as well improving the nutritional content of crops. In a number of countries, poor agricultural practices have eroded soil nutrients, thereby hurting crop yields, making fertilizer ever more important to future agricultural needs. In particular, high-growth economies in South and East Asia are expected to account for two-thirds of the increase in fertilizer use over the coming five years. The global biofuels drive has also caused a rise in demand for fertilizer, with the International Fertilizer Association estimating that 3.6 percent of global fertilizer consumption is used to grow biofuels crops.

For farmers, the decision to use fertilizer depends heavily on crop prices. While fertilizer usage is pervasive in wealthier countries with established agribusinesses, such as the United States and Australia, in developing countries farmers often buy fertilizer on credit that can only be paid off if crops are sold at an attractive price. If poor farmers choose to forgo fertilizer, however, that very likely will erode soil quality and imperil the sustainability of their crop production even if it results in immediate cost savings. Decades of low crop prices resulted in the overdrawing of soil nutrients in a number of countries, especially in Africa and Asia, which will require additional use of fertilizer to see sustainable future growth in crop yields. The fertilizer industry has seen a major increase in prices in the past four years, which has prompted significant new interest in fertilizer production. However, it will take time and capital to overcome the historical underinvestment in fertilizer production. A host of communication tools and technological strategies, which can help farmers optimize nutrient application and pick the ideal fertilizer mix, will likely improve soil management practices in developing countries.

Fertilizer resources are geographically dispersed, but certain types have unique risks associated with them. Potash, in particular, is highly concentrated in Russia, Belarus, and Canada, which account for around 75 percent of global potash exports. Potash Corp of Canada, the world's largest potash producer, has estimated that Chinese potash consumption could rise from less than 10 million metric tons (mmt) per year at present to 30 mmt by 2020, while Indian consumption could grow from less than 6 mmt to 15 mmt by 2020. Nitrogen and phosphate fertilizers are more geographically dispersed, and the price of nitrogen fertilizer is closely correlated with that of natural gas (which accounts for 70 to 90 percent of the cost of production). Variability in natural gas prices can have a major impact on fertilizer prices. Optimal crop management requires a specific cocktail of fertilizers to maximize crop yields and quality. Therefore, overuse of one type can result in severe long-term damage to cropland. Affordable availability of all three types of fertilizer will be critical to ensuring longer-term global food security.

In developing countries, the importance of fertilizer in the production of food will shape subsidy policies for the fertilizer sector. For instance, in India, food self-sufficiency concerns are guiding a policy that subsidizes and prioritizes natural gas supply to fertilizer producers; however, it would be cheaper for India to import fertilizer from countries that have cheaper access to natural gas. The government subsidizes 74

percent of the cost of fertilizer, and the bills for that subsidy are expected to rise significantly over the coming years. In China, fertilizer production is an important focus and support for the sector is expected to continue, as are acquisitions of fertilizer assets overseas.

GM Technology. Cultural and environmental opposition to genetically modified (GM) crops continues to slow down their deployment globally. The United States is currently the largest producer by far of genetically modified crops, although GM use has grown in other markets such as Argentina and Brazil. Despite India's success with GM cotton, the often hostile reception to GM food crops highlights the broader short-term challenges associated with expanding the planting of such crops globally. In developing countries, food security concerns will only escalate as populations and economies grow, putting strain on land and water resources. With limited access for GM crops, global agriculture markets are denied the benefits of increased supply thereby increasing the risk of food price increases.

- Over the longer term, food insecurity will likely become an overriding concern in a number of countries in Asia and Africa, and cultural opposition to biotech crops will almost certainly be surmounted with information campaigns and the implementation of more stringent standards for GM production. In the interim, however, GM crops can expect to face ongoing public resistance and fall victim to political posturing as agribusinesses attempt to penetrate developing country markets.

Demand Factors

There are two main structural drivers on the demand side of the agriculture market. The first is economic development and population growth and the second is the global trend to use agricultural land for the production of biofuels. The ongoing demands from population growth and, perhaps more significantly, economic growth and the shift to a meat-based diet will place strong upward pressure on food prices in the coming decades. Such economic and demographic shifts cannot be avoided or abated. Conversely, biofuel demand for crops largely stems from policy actions and can be removed. In the absence of an energy or biofuels technology breakthrough, biofuels' consumption of food crops will not subside, and extreme food price spikes could eventually prompt authorities to reconsider biofuels policy, potentially reducing crop prices.

Economic Development and Population Growth. Increasing populations in developing countries, coupled with the hundreds of millions of people who are coming out of poverty, are heightening demand for food products across the board, pushing up food prices and fueling investor interest in the agricultural sector. The world's population is expected to grow from 7 billion people today to 8.9 billion by 2040, according to United Nations population data. While the United Nations has issued a baseline estimate of 10.1 billion people by 2100, that number would reach 14 billion if current trends persist. China, already the world's second-largest grain consumer, is devouring 47 percent more corn than it did ten years ago, adding a demand pull that is larger than the entire corn crop of the world's third-largest producer, Brazil.

Population growth, along with the rapid urbanization taking place in many emerging economies, will also increase pressure on the land and water that are essential for food production, further elevating food security risks. The percentage of urban dwellers as a proportion of the total world population grew from 29 percent in 1950 to 50 percent in 2008, driven mainly by urbanization in developing countries, and is expected to continue to grow in coming decades. The McKinsey Global Institute forecasts that by 2025, China will add 400 million to its urban population, making up 64 percent of the country's total population. Similarly, India will add 215

million to its urban centers, accounting for 38 percent of its total population. From a supply perspective, the shift in labor away from rural farming areas to cities and the transfer of farm land to urban areas will set back food production. Moreover, from a demand perspective, this population shift will add a large new class of net food consumers to the world's cities.

- Even if the average global population growth rate stabilizes, regional disparities can have important implications for food security. In particular, a continued surge in population growth in low-income, food-insecure countries would exacerbate the incidence of food-related poverty and malnutrition in those countries, even if the average global supply and demand balance is more evenly distributed.

Land Use for Biofuels. Despite a growing backlash against land use for biofuels, support for ethanol in the United States is likely to remain strong over the long-run for a variety of reasons. First, while attacks on the industry have mounted in Washington and from parts of the country that do not rely on agriculture, ethanol is still an enormously popular program in politically powerful farm states. Second, even though subsidies are currently under threat from Congress, the tax credits the industry enjoys are not as critical to its survival as the Renewable Fuels Standard mandates. Present mandates require the incorporation of up to 15 billion gallons of corn ethanol in the transport fuel system and an additional 21 billion gallons of advanced and cellulosic biofuels by 2020. Third, billions of dollars in investment and subsidies have already been poured into the industry, and there are powerful vested interests working to preserve it and the jobs it has created. Fourth, there is concern that removing ethanol from the US fuel mix would drive up already high—by US standards—gasoline prices. In 2009, the US Department of Energy estimated that gasoline prices would be $0.20–$0.35 higher per gallon in the absence of biofuels.

The EU's biofuels mandate of 10 percent biofuel use for transportation by 2020 has also come under pressure for its contribution to food prices and food insecurity in less developed countries. Moreover, a stronger environmental backlash against biofuels has been building in the EU. In response, the European Commission in 2008 laid out a set of sustainability criteria for biofuels use. Notwithstanding the criticism biofuels has come under recently, there are also strong voices and backing for the EU biofuels program. The EU has spent large sums of money on biofuels subsidies to the benefit of European farmers and is unlikely to retract from the program quickly. During the 2008 crisis, EU representatives pointed out that just 1 percent of EU cereal production was being used for ethanol compared with the 30-40 percent of corn crop used in the United States. Although two-thirds of EU rapeseed crop is used for biodiesel, this represents just 2 percent of total global oilseed demand.

As concern for high food prices continues, biofuels will continue to come under pressure from the public and from policymakers. In addition to food security concerns, another major driver for investment in agricultural land has been the growth of biofuels mandates worldwide, although these investments have been made predominantly by the private sector rather than governments. Given the large investments that major biofuels producing areas such as the United States, the EU, and Brazil have already made in the industry, biofuels policies are unlikely to be abandoned by any of these regions. And in light of the overarching energy security concerns globally, particularly with high oil prices, policymakers are increasingly turning toward biofuels as a diversification strategy away from oil. The International Energy Agency has estimated that up to 75 percent of the net growth in non-OPEC oil could come from biofuels, highlighting the energy security considerations that are a key

driver of biofuels policy. As a result, aside from existing markets in the United States, the EU, and Brazil, other countries, such as Indonesia, Japan, South Africa, and India, are expanding their own biofuels programs, so the sector will continue to place upward demand pressure on global agricultural markets. Even though energy prices have always been correlated with agricultural commodities prices to the extent that energy is an input (in fertilizer, transportation, irrigation, etc.), there will be a stronger link between food and fuel prices—given the substitutability of biofuels and oil, and a greater risk of oil shocks disrupting food security.

Avoiding Global Food Insecurity

C. Despite the pressures of supply and demand, policies that support efficient global agricultural trade flows and increased deployment of existing technologies offer a path to global food security. With the aggressive application of existing technology—to include transportation infrastructure, fertilizers, and watering techniques—along with the development of new biofuels technology, the risk of price spikes and food insecurity will very likely decline.

Trade

Currently, major exporters of grain include the United States, EU, Australia, Brazil, Argentina, Ukraine, Russia, Kazakhstan, and Canada. Large importers include countries in the Middle East, North Africa, Southeast Asia, Japan, South Korea, and Egypt. Looking to 2040, the most significant shift in these trade patterns will be the possibility that China and India become structural net importers of food.

Export restrictions in major exporting countries drastically reduce the supply of grains on international markets, thereby sending prices higher, and cause food importing countries to question the reliability of global markets. When one country restricts exports, price pressure increases on countries that have not enacted barriers, causing a flow of exports and prompting other countries to impose restrictions of their own. As several countries have restricted grain exports recently, sending prices soaring, the United States has supplied a large portion of the export market. The country, happy to see windfall profits for its farmers, is unlikely to impose export restrictions of its own. That said, the US capacity to compensate for all of the shortfalls caused by trade controls has its limits, and higher exports have already driven US grain stockpiles to historical lows. While global stocks will not be depleted, tight supplies mean importing countries will have to pay more.

Russia, Kazakhstan, and Ukraine have the potential to greatly increase grain exports. Each may be able to expand production to unused farmland that was abandoned during the post-Soviet transition period. But they must confront policy and infrastructure constraints. In order to take advantage of unused land, countries must permanently refrain from export barriers to allow farmers to capitalize on the global commodities boom. Authorities must also invest in storage and transportation infrastructure and provide improved credit access for farmers. Such policies would not only help farmers in each of these countries, but would also alleviate global shortages of grains and thereby ease prices as well. Since export tariffs and quotas are likely to remain in play in the near term to stem domestic inflation, and since investment in infrastructure will take time, the export potential of these countries is likely to be fully realized only in the medium-to-long term.

Technology

The 20th century Green Revolution in agriculture was perhaps the single greatest factor enhancing global food security. The revolution consisted of a concerted R&D effort to improve crop yields that began in Mexico in the 1940s. Its success was

then disseminated globally and had its most pronounced effects in Asia. The greatest accomplishment of the Green Revolution was the development of new strains of seeds that, in combination with modernized irrigation technologies and fertilizer use, produced a higher amount of grain per acre of land. The FAO estimates that yield improvements have accounted for nearly 78 percent of the increase in crop production between 1961 and 1999, while additional cropping intensity contributed 7 percent, and the expansion of planted areas the remaining 15 percent. Funding for such research initiatives has fallen in the past two decades; it could come under continued funding pressure in the next five years while industrialized countries grapple with fiscal challenges.

- Historically, technology has not been globally deployed in an even manner. While much of the world benefited from the Green Revolution, sub-Saharan Africa largely missed out, mainly because the strains of seeds developed during the revolution were not suitable to conditions in that region and the multiple staples—beyond wheat and rice—used for food. Since the early 1960s, grain yields in the rest of the world have increased almost 2.5 percent annually, while in sub-Saharan Africa they grew only around 1 percent. Therefore, there is significant scope for expanding the Green Revolution to Africa by undertaking research efforts to develop grain strains that are matched to Africa's conditions and multiple staples.

In the long term, with the aggressive application of existing technology—to include transportation infrastructure, fertilizers, and watering techniques—along with the development of new biofuels technology, the risk of price spikes and food insecurity will very likely decline. Not only can crop technology boost yields, but prices could decline in coming decades with greater investments in irrigation, deployment of crop management best practices, more efficient use of fertilizer and water, and the wider dissemination of GM crops. Beyond the next decade, the development and deployment of technology enabling the production of biofuels with cellulose would also greatly reduce the risk of biofuel production adding to tight food markets with resulting price shocks and food insecurity.

Annex A
Case Studies

China

China's growing urbanization in coming years will lead to significant changes in the structure of its agricultural sector, as well as in consumption patterns of agricultural goods. As some 300 million people move from rural to urban areas and the population transitions to a diet with more meat, China's agricultural output will need to become more efficient. These developments are taking place at a time when the amount of arable land is shrinking and water supplies are increasingly constrained. The decline in rural labor, meanwhile, is reducing the potential for labor-intensive double-cropping (such as planting winter wheat and then corn as a summer crop in the north, or producing two rice crops per year in the south), a practice that has dramatically expanded the country's grain production.

China's ability to maintain "basic" self-sufficiency—defined by the government as the ability to internally produce 95 percent of the grain food production—is declining. Yet according to China's long- and medium-term strategic plan on grain security, issued in 2008, Beijing plans to maintain 95 percent grain sufficiency, retain 120 million hectares of farmland, and expand grain production capacity to 540 billion kilograms by 2020. Grain self-sufficiency will therefore remain a key goal for the foreseeable future for two main reasons. One, Beijing judges grain self-sufficiency is synonymous with the ability to control the prices of grains and thereby avoid social instability caused by food-price inflation. Second, for many of China's leaders who survived the Great Famine of 1959–1961, when some 30 million people died of starvation, food imports are a threat to national security. These leaders maintain that China has always fed itself, and it always will. Only a minority within the government currently espouse the view that China should focus on growing more value-added crops and import basic commodities.

So while Beijing recognizes that it must complement some of its demand through imports, it will continue to pursue hedging strategies to minimize vulnerabilities associated with import dependence. To this end, China has been developing internal trading markets that will align more closely with global markets as import dependence increases. China has become a net importer of soybeans and wheat, and accelerating demand for corn for both food and biofuel is almost certain to outstrip domestic output in the coming years. This trend will force China to resort to purchases from overseas, especially from Latin America and the United States. At the same time, Beijing maintains import quotas for essential food staples such as wheat, corn, and rice, which are licensed only to large state-owned traders, and has heavily restricted exports of commodities by canceling value added tax (VAT) rebates.

Authorities will also continue to maintain large state grain reserves. China uses reserves to buffer the effects of local production shortages and volatile grain prices on global markets, and to stabilize prices when inflation rises. The government will also aim to boost agricultural production through

increased mechanization and investments in R&D. The 12th Five Year Plan (FYP; 2011–2015) emphasizes the development of bio-agriculture—the use of modern agricultural technology and the promotion of a modern seed industry—and a more efficient and integrated agricultural logistics system. Substantial investments in research projects and pilot initiatives are likely, and these will accelerate the development of scientific innovation in agriculture. Bio-agriculture is part of one of the seven so-called strategic emerging industries identified in the plan as essential for China's long-term growth. Beijing has already adopted several key production-boosting measures, including a 40 percent rise in the grain support price paid to farmers, an increase in agricultural credit, and heavy investment in developing higher-yielding strains of wheat, rice, and corn—the country's leading crops.

Also as part of the 12th FYP, land consolidation will be a priority. Chinese farmers have an average planting area of 0.6 hectares (compared with 169 hectares in the United States). Encouraging land consolidation is a key component of the government's plan to modernize the sector and ramp up production. But in recent years, consolidation has made slow progress against a backdrop of unclear policies regarding land rights. While land consolidation is unlikely to accelerate dramatically—as the issue of land-reform and -ownership in China remains politically sensitive—a certain degree of consolidation is likely to occur naturally as a result of migration.

As China's rural population shrinks, farmland expropriation and land erosion will continue. Beijing will grapple with the need to keep food inexpensive for its urban population while allowing farmers to increase their revenues in order to introduce mechanization and move toward greater economies of scale. Authorities, however, will prefer to maintain heavily subsidized agriculture, and they will try to push its transition into a modern sector only gradually. As long as economic growth maintains a steady and healthy pace, the Chinese leadership will likely be able to pursue this strategy. The social challenges related to land expropriation will nonetheless be more difficult for Beijing to address as it attempts to rein in overzealous local cadres.

China has also actively sought to invest overseas, buying or leasing farmland as well as signing farming contracts in Southeast Asia, South America, and Africa to harvest palm oil, eucalyptus, teak, corn, cassava, sugar cane, and other crops. According to estimates, China has signed 30 agricultural co-operation agreements covering more than 2 million hectares since 2007. A recent example is one signed in December by Chinese state-owned company CAMC and companies under Venezuela's Ministry of Agriculture and Land for the construction of industrial parks, rural infrastructure and irrigation systems, and crop planting.

India

India made dramatic strides in expanding food production and boosting food security during the Green Revolution from the mid-1970s through the late 1980s, when crop yields grew by 65 percent, in large part because of biotechnology advances and the expansion of irrigation. Gross irrigated area doubled between 1970 and 1997, accounting for close to 40 percent of the country's cultivated land. Nonetheless, India's crop productivity growth saw a marked slowdown in the 1990s and continues to falter.

India has taken the basic technological steps to boost food security and is estimated to have already developed 76 percent of its irrigated potential. Further development of irrigation will require major

expansion of infrastructure, including technically challenging and environmentally controversial dam and canal projects. In addition, very generous subsidies granted to farmers have eroded the incentive to boost productivity, which has further contributed to crop yield declines. India will eventually have to reduce subsidies, but the topic is extremely sensitive and any meaningful shifts in subsidies policies for the farm sector are not likely over the next five to ten years.

Meanwhile, signs of strain from unsustainable farming practices are beginning to emerge. K. V. Thomas, the agriculture minister, announced in late 2010 that India was losing 5,334 million metric tons of soil each year (at a rate of 16.4 metric tons per hectare of land) to erosion from excessive use of fertilizers, insecticides, and pesticides. Heavily subsidized fertilizer provides farmers little incentive to control its use. Urea fertilizer in particular is overused. India's rice production per hectare is now lower than its less developed neighbors, Pakistan, Bangladesh, and Sri Lanka. In 2010, the government announced a new subsidy program to provide incentives for farmers to use a more efficient and sustainable combination of fertilizers, but because of lobbying by farmers and rural communities—a powerful constituency in India—the existing subsidies for urea were left intact. Urea fertilizer (21 percent imported) is used disproportionately because of the heavy dependence on imports of phosphorus (67 percent imported) and potash fertilizers (100 percent imported). As a result, in the state of Haryana, for example, farmers used 32 times more nitrogen than potassium fertilizer on soil in 2008–2009, compared with the recommended ratio of 4 to 1.

Indian farm output is also heavily correlated with the monsoon season. In past years, a growing occurrence of below average monsoon rains reduced farm output. Over the long term the impact of climate change is likely to exacerbate this trend. The country is already battling near double-digit food-price inflation. India is likely to use a combination of macroeconomic and monetary policy tools along with targeted price and regulatory actions in the agricultural sector to mitigate domestic food prices. So far, the government's macroeconomic policies have had limited success in curbing food-price inflation. And repeated efforts to crack down on hoarding of commodities have had little effect on the inflation rate. Authorities are now focusing on policies to heighten competition in food distribution by opening up channels for the purchase of food directly from retail outlets and farmers (rather than through the current government distribution system), as well as policies to increase the trading of food across states.

New Delhi has not shied away from export restrictions when domestic prices rise. It banned wheat exports in 2007 and extended the ban to rice (excluding basmati) the following year. India, however, must increasingly rely on global markets to close its supply shortfall. Following a particularly poor harvest in 2009, it imported record amounts of sugar, lentils, and cooking oil. If current trends in crop productivity are not reversed, India's call on global markets and its vulnerabilities to food-price inflation are likely to grow in the next few decades.

Sub-Saharan Africa

The areas of sub-Saharan Africa with the highest levels of food insecurity, notably the Horn of Africa and the Sahel, provide a chilling preview of the political and security stresses that might confront other regions of the world that face worsening food scarcity. In these regions of Africa, recurring famine and competition for scarce resources fuel instability at local, national, and sub-regional levels. Some notable examples are the crises in Darfur and Abyei, in Sudan. Demographic and environmental pressures including rapid population growth and desertification add to the strain. Most of these trends suggest an unsustainable food supply in regions where resources are already stretched scarce.

Despite these dire conditions, Africa also has the highest percentage of uncultivated arable land in the world, indicating the continent's untapped potential to bolster food security within its own borders and possibly beyond. Investors have started to access this opportunity in recent years by leasing huge tracts of land, but such investments might prove counterproductive for host countries if production is exported en masse or dumped locally in a way that undercuts local farmers. Such leasing arrangements, which are already contentious in affected and nearby communities, will become even more so under conditions in which land, food, and water resources are under greater strain. Agreements that look like a bargain today may end up being unfeasible—or magnets for future resource conflict—without strong buy-in from local communities.

The Horn of Africa presents a microcosm of the high humanitarian, geopolitical, and security costs associated with chronic food insecurity. At a time when other regions in Africa are moving toward peace and stability, the Horn remains mired in layers of conflict, many of which stem from, or are exacerbated by, competition for scarce resources. The trajectory of demographic and environmental pressures, together with poor governance (or lack of governance in the case of Somalia), suggest the problems will worsen. This is likely to fuel more conflicts at local levels, pitting pastoralist and agrarian communities against one another across the region, especially in Ethiopia, Sudan, and Somalia, where US security interests are already vulnerable.

The Darfur conflict in western Sudan could be a harbinger of things to come. While portrayed in the West as ethnic cleansing or even genocide perpetrated by Sudanese troops and Arab proxies to repress an insurgency, its roots are more closely tied to local competition between farming and pastoral communities for scarce resources. There is little doubt that Khartoum exploited these local tensions to justify a bloody crackdown on the restive province, but the spark in many ways grew out of land disputes tied to scarcity. A similar dynamic is at play in the disputed Abyei district that straddles north and south Sudan, with competing land claims centered on farming and grazing rights rather than oil, as is commonly assumed. The stakes are high; Sudan experts generally see Abyei as the most likely catalyst for a return to war between Khartoum and Juba.

Meanwhile, tensions over Nile water rights, which pit Egypt and Sudan against upstream riparian countries led by Ethiopia, underscore the precariousness of food security in Egypt. Officials there routinely warn that the abrogation of the colonial-era water-sharing rights that favor Egypt would be seen in Cairo as an act of war—a barely-veiled threat aimed at Ethiopia. Ethiopia, which struggles to feed a population that will soon exceed 100 million, is no longer willing to accept Egypt's veto power over its irrigation and hydropower plans. Addis Ababa and its upstream allies are moving to establish

an alternative Nile water-sharing commission that could put it on a collision course with Egypt, whose water needs are expected to outstrip supply by 2017.

The Sahel region is less associated with chronic food insecurity than the Horn, but it faces a comparable set of pressures. The World Food Program estimated in 2010 that more than 10 million people were at severe risk, a number that is expected to rise further as desertification, population growth, and urbanization proceed apace. The resulting food insecurity will overwhelm the limited capacity of governments and aid agencies to respond. As in the Horn, these trends have fueled land conflicts across the region, often between nomads such as the Tuaregs in Mali, Niger, and Chad and agrarian communities. Northern Nigeria is also highly vulnerable, especially in Jos and other hotspots where tensions between Fulani pastoralists and Berom farmers can quickly degenerate into broader ethnic and sectarian strife in a highly polarized country.

The Sahel and the Horn are also the two regions in Africa that face the greatest threat of terrorism. That threat does not stem from chronic food insecurity, but it does raise the stakes if conditions continue to deteriorate and overwhelm governments, turning weak states into failing states or safe havens for terrorists.

Middle East and North Africa

Countries in the Middle East and Africa appear particularly vulnerable to a sustained period of high food-price inflation, even though a new wave of regimes collapsing is unlikely. In the Middle East and North Africa, for example, it has become evident that there are significant differences among governments in their ability to contain social and political unrest—some of which was triggered by high food-price inflation. Gulf monarchies such as Saudi Arabia and the UAE have considerable financial resources to placate social discontent among their citizens, so the expectation that governments across the region would fall during the Arab Spring has proven to be unfounded. Nevertheless, sustained high food-price inflation could prove a tipping point in years to come in countries such as Syria and Algeria, where social discontent runs high.

While subsidizing food to keep prices low may prove to be of limited utility in the long term, it has been effective in the short term. In that context, the regimes most at risk are those that are largely unable to introduce massive spending programs to contain dissent. Yet countries experiencing unrest have varying levels of food security, although all share the challenge of limited resources. While the issue of food security was negligible in Tunisia, unrest in Egypt was influenced by rising food prices and the resulting hardship facing many Egyptians. Before the first revolt in the region, Egypt, Syria, and Yemen all had weak systems that were unable to maintain an appropriate level of food security.

Low income and poverty, limited domestic production, ineffective government incentives, and insufficient financial resources are the main challenges to regimes in the region. Poverty will continue to affect the ability of consumers to afford a broad array of goods. Because of shortages of water and fertile land, most Arab countries have limited food production capacity. And government programs to overcome these obstacles have been largely ineffective. Moreover, most countries that do not produce oil lack the funds to spend on expensive crop schemes.

Such countries will remain more susceptible to increases in global food prices. Families allocate a higher percentage of discretionary income for food, so any marginal uptick is substantial. Some governments, such as those in Syria and Egypt, subsidize a set of necessary food items such as bread, sugar, and oil. But fiscal pressures and shortages in global supplies of essential commodities have often led to domestic problems and could do so again.

In the aftermath of the unrest in the Middle East, many governments expanded their subsidy and social protection programs. And while GCC states can afford to ramp up spending with little effect on fiscal balances, the situation is much different in the other countries of the region. Ambitious subsidy programs, particularly for essential food items, will strain budgets. Yet maintaining these economically challenging programs in the short and medium term is essential for political stability. Markets will observe a rise in risk associated with many of these economies. As a result, their sovereign ratings will suffer and market interest rates will rise. This will put more pressure on fiscal balances and government policy in the medium term. Moreover, low-income households often pay prices that far surpass subsidized prices of bread and other basic foodstuffs, as occurred in Egypt. A run-up in global food prices tends to hike prices on the black market, which means that the threat of social unrest and riots remains a risk in the region's poorer countries.

Managing food-price inflation is a daunting challenge for many government bureaucracies and instability in global food markets exacerbates the problem. Exporting countries are likely to introduce export restrictions to limit inflationary pressures within their own economies. In 2010, Russia's wheat export ban harmed Egypt, the world biggest importer of wheat. Consequently, disruptions in global markets will also make it harder to manage public discontent.

Mexico

Mexico will find it increasingly difficult to meet the food demands of its growing population in the coming decades. The country's leaders must ensure food supply for an expanding middle class, which will consume greater amounts of meat. There is also pressure to improve the lives of a sizable number of Mexicans living in poverty, especially in rural areas. At the same time, the country will be vulnerable to higher global prices and the adverse effects of climate change on some of its most agriculturally productive regions.

Mexico's population is expected to reach 141 million in 2040, from 112 million in 2010. In the next few decades, the country will transition from a period characterized by a so-called demographic bonus—when population growth rates slowed and helped boost living standards—to a period when it must gradually confront the challenges of an aging population. Like the rest of the population, farmers are growing older. Younger Mexicans are already seeking employment opportunities in other sectors, either by migrating to urban areas, to the United States, or in some cases resorting to drug trafficking. Despite near-term slowing of migration to the United States, these trends are expected to intensify over the coming decades. It is estimated that 83 percent of the population will live in urban areas in 2040, and only 17 percent will remain in rural areas. As a result, more and more agricultural land could be abandoned, particularly in the less productive areas of the south.

The poorest half of the population remains highly sensitive to changes in food prices because they spend 43 percent of their income on food (compared to 23 percent for the average Mexican).

Moreover, 21.6 percent of the population lacks a suitable nutritional intake. Therefore, OECD-FAO predictions of price spikes in the coming decade are particularly worrisome. A scenario of high international prices spanning the next several decades will have a dual impact on the Mexican agricultural sector. On one hand, the government will have to hike social spending to insulate the poor from the impacts of food-price inflation. The 2008 agflation scare, during which 5 million Mexicans fell below the poverty line, demonstrated the vulnerability of poor communities to sudden jumps in food prices. The government will also attempt to encourage crop production through targeted subsidies that will put pressure on fiscal accounts and therefore social spending, which is already under significant stress from demographic changes. On the other hand, higher international prices will provide a boost to the sector, particularly in the north, where production is more profitable. And there will likely be sustained demand in the United States for certain agricultural products in which Mexico has comparative advantages.

Climate change, however, will likely affect some of the regions where these products are grown. It is widely expected that the magnitude of the impact on Mexico's agricultural sector will only increase in the coming decades. During the last decade, the country experienced increasingly costly and devastating extreme weather events: stronger hurricanes, less rain, increasing desertification, water shortages, unusual cold temperatures, and major flooding. According to the World Bank, the productivity of Mexican farms could diminish considerably. Losses are estimated between 12 percent in a mild climate change scenario and 50 percent in a more severe scenario.

The conditions described above will only exacerbate the sector's structural inefficiencies. The political factors that limit the potential for change will be challenged, but a constructive outcome is far from guaranteed. Powerful groups with vested interests in maintaining the status quo will ensure that reforms are slow and weakened. The so-called corporatist organizations that prevailed in the agricultural sector during the long rule of the Institutional Revolutionary Party (PRI) survive almost intact and will try to impede change by any means, including violent protests.

Overall, the prevalence of small-scale producers—80 percent of farmers own less than five hectares—suggests a future scenario with low productivity, particularly in the southern areas of Mexico where the poor rural population is largely concentrated. Climate change will only intensify this trend. Although farmers are able to rent their land, communal landownership structures in many regions with undefined property rights deter private investment, reduce access to credit, and inhibit the exploitation of economies of scale.

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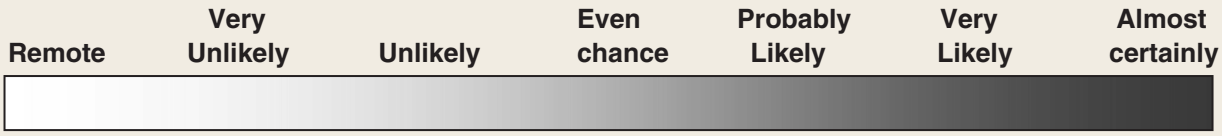
Annex B
Estimative Language

What We Mean When We Say: An Explanation of Estimative Language

We use phrases such as *we judge, we assess,* and *we estimate*—and probabilistic terms such as *probably* and *likely*—to convey analytical assessments and judgments. Such statements are not facts, proof, or knowledge. These assessments and judgments generally are based on collected information, which often is incomplete or fragmentary. Some assessments are built on previous judgments. In all cases, assessments and judgments are not intended to imply that we have "proof" that shows something to be a fact or that definitively links two items or issues.

In addition to conveying judgments rather than certainty, our estimative language also often conveys 1) our assessed likelihood or probability of an event; and 2) the level of confidence we ascribe to the judgment.

Estimates of Likelihood. Because analytical judgments are not certain, we use probabilistic language to reflect the Community's estimates of the likelihood of developments or events. Terms such as *probably*, *likely, very likely,* or *almost certainly* indicate a greater than even chance. The terms *unlikely* and *remote* indicate a less than even chance that an event will occur; they do not imply that an event will not occur. A term such as *might* reflects situations in which we are unable to assess the likelihood, generally because relevant information is unavailable, sketchy, or fragmented. Terms such as *we cannot dismiss, we cannot rule out,* or *we cannot discount* reflect an unlikely, improbable, or remote event whose consequences are such that it warrants mentioning. The chart provides a rough idea of the relationship of some of these terms to each other.



Confidence in Assessments. Our assessments and estimates are supported by information that varies in scope, quality and sourcing. Consequently, we ascribe *high*, *moderate*, or *low* levels of confidence to our assessments, as follows:

- *High confidence* generally indicates that our judgments are based on high-quality information, and/or that the nature of the issue makes it possible to render a solid judgment. A "high confidence" judgment is not a fact or a certainty, however, and such judgments still carry a risk of being wrong.

- *Moderate confidence* generally means that the information is credibly sourced and plausible but not of sufficient quality or corroborated sufficiently to warrant a higher level of confidence.

- *Low confidence* generally means that the information's credibility and/or plausibility is questionable, or that the information is too fragmented or poorly corroborated to make solid analytic inferences, or that we have significant concerns or problems with the sources.

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