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Challenges Facing Global Food Supplies

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"Unprecedented challenges require unprecedented solutions."

— Amin Maalouf

The global economic development that has occurred over the past 50 years has substantially improved human well being, but it has also created unprecedented social, economic and environmental problems. Furthermore, interdependencies among nations and economies have created new risks and vulnerabilities, as demonstrated by the recent food and financial crises.

Today's world is undergoing a major transformation characterized by increased globalization, fundamental shifts in economic and political power, growing global environmental problems, and potentially explosive social conflicts. The past decade alone has reversed a 100-year decline in resource prices as demand for commodities has surged.[1] The volatility of resource prices today is at an all-time high; the era of cheap food is over. Indeed, the price and volatility of different resources have developed increasingly tight links over the past ten years. Shortages and price changes in one resource can rapidly impact other resources. In this context the correlation between food prices and energy prices is now higher than at any point in the past century because of biofuels, fertilizer and transport costs.[2]

The world has also experienced several, sometimes unexpected shocks. These include the rise in energy prices in 2008 and 2010, and concerns about energy security; related food and commodity price rises; worries about water and food security and how to feed 9 billion people by 2050; declining ecosystem services and the global economic recession. Climate change is yet another dark cloud on the horizon which may bring the prospect of more extreme and unpredictable floods and droughts to those parts of the world that are already struggling to cope with climate uncertainties.

These problems are becoming increasingly interconnected. They cannot be solved by individual countries acting in isolation. On the contrary, they can sometimes be exacerbated when countries act alone.[3] This can be illustrated by the 2007–2008 food crisis. The year 2008 was one of extreme variability for international food prices. In the first half of the year, prices increased for nearly every agricultural commodity. For instance at their peaks in the second quarter of 2008, world prices of wheat, and maize were two times higher than at the beginning of 2003 and the price of rice was three times higher. Oil prices also rose sharply.

Uncoordinated government responses to rising prices led to enormous efficiency losses within the global food system. When food prices were particularly high, major producers imposed restrictions on agricultural commodities in order to minimize upward pressure on domestic prices. Although these export restrictions may have reduced food shortage risks in the short term, they made the global market smaller and more volatile. Furthermore, these export bans provoked panic buying in the international markets which in turn deepened the food crisis. This distrust in markets has led many countries to reexamine the "merits" of self-sufficiency and start rebuilding their national stocks and investing in agriculture in other countries to secure supplies. Large-scale acquisitions of farmland (termed "land-grabs") in Africa, Latin America, Central Asia and South East Asia have made headlines in a flurry of media reports across the world. For people in recipient countries this new context may create opportunities for economic development and improvements in livelihood in rural areas; but in the absence of a code of conduct, it may also result in local people losing access to the resources on which they depend for their food security.

Social protests and unrest have occurred in a number of countries and cities around the world. The seriousness of these incidents is suggestive of what might occur – possibly on much larger scale – in the event that future food shortages become exacerbated. This crisis should, therefore, be treated as an early warning sign of what is to come. If the world is having difficulty meeting global food security now, the challenges in the future loom large. We have indeed reached the age of consequences.

Heads of states and governments have listed food security as a major global risk, and consensus on a global food security agenda has emerged. It calls for: (1) increasing investments in agriculture, rural infrastructure and market access for farmers, and especially smallholders; (2) expanding social protection for the poorest in urban and rural areas; (3) enhancing the efficiencies of agricultural markets through greater transparency and equity in global trade; and (4) facilitating agriculture production responses via scientific and technological solutions.

Food Security at a Crossroads

There is growing evidence of a fundamental structural change in the global balance between food supply and demand, and this is increasingly being reflected in rising world food prices. The declaration of the UN Food and Agriculture Organization (FAO) World Summit on Food Security, held in November 2009, stated that: "to feed a world population expected to surpass 9 billion in 2050, it is estimated that agricultural output will have to increase by 70 percent between now and then." This 70 percent figure is now the most commonly used figure when estimating how much food production must increase in the next three to four decades. It is projected based on current trends in consumption and population growth.

The global system of agriculture today is very much driven by the demand side. With income growth, globalization, and urbanization, demand for agricultural products will continue to grow and shift towards high-value commodities. Up to three billion more middle class consumers will emerge in the next 20 years. The projections of the International Food Policy Research Institute (IFPRI) show that by 2050 cereal demand will globally increase by more than one-third.[4] These trends will be accompanied by very strong growth in meat consumption—especially poultry and beef. Demand for milk is also likely to increase quickly. In India, calorie intake per person is expected to rise by 20 percent over the next 20 years, and China's per capita meat consumption could increase by 40 percent.

Considering the high agricultural demand, rising prices, and other emerging challenges, the global production response has been slow. The overall productivity growth in agriculture is simply too low to cope with the pace of demand. Total factor productivity – that is, aggregate productivity, not just yields per unit of land or animals – grows by about 1.3 percent per annum in most regions and by about two percent in China. Its growth is dependent on technological progress. Between 2000 and 2006, cereal supply increased by a mere eight percent. The production response to high prices is impaired because of land and water constraints and because of neglect in agriculture innovation investments in many countries in past years. Yields grow very slowly in most regions today that have already reached high levels of production in the past. Africa actually shows the highest agricultural growth compared to other world regions, but starting from low levels. Increased production driven by higher yields (and not by area expansion) and increased productivity in the livestock sector require substantial investments in research and development, services, and input supply systems. The need for more agricultural science and technology investment is further increasing as a result of climate change and continuing population growth, and must embrace the entire value chain including enhanced food quality and safety.[5]

Different regions are facing different challenges. Long term regional perspectives indicate that: (1) Asia and Near East/North Africa will be major food importers; (2) sub-Saharan Africa could feed itself but with a low increase of per capita food ratio; (3) Latin America will be a major exporter (Brazil, Argentina) but with important ecological risks; (4) Canada and Russia could increase their export capacity; and (5) the USA and EU could also increase exports but in lower proportions.[6]

World agriculture is facing new challenges for which it is not well-prepared. The implications are that food security for the chronically poor will deteriorate in all four of its main dimensions: (1) availability of food will decrease owing to scarcity arising from declining water resources, global population increase, worsening climatic conditions, changing food demands and a shift from food to biofuel production; (2) poor people's access to food will decline owing to worsening terms of trade between wages and food costs; (3) stability of supply will be threatened as a result of the increasing prevalence of natural disasters, uncertainty regarding food prices, and national protectionism; and (4) the safe and healthy use of food will deteriorate as the poor switch to diets lacking essential micronutrients, thereby increasing child malnutrition. Increasing food insecurity might lead to more competition over water resources, migration, difficulties of supplying cities and ultimately state failures and international conflicts.[7]

Key Drivers of Global Food Supply

In responding to growing demand, global food supplies will be impaired by: (1) land and water constraints; (2) biofuels production with its strong links to markets and resources use patterns; (3) climate change acting as a threat multiplier; and (4) declining agricultural productivity. These factors could add up to an uncertain future for global food security.

Growing Scarcity of Water and Land

Feeding the world's growing population and finding the land and water required continues to be a basic yet sizeable challenge. It is an enormous task, as many countries lack the luxury of unused resources. Indeed, some regions face severe and increasing resource scarcity. South Asia and the Near East/North Africa regions have exhausted much of their rain-fed land potential and depleted a significant share of their renewable water resources. More than 1.2 billion people today live in river basins where absolute water scarcity or a trend of increasing shortages are serious concerns. Expanding land under cultivation is possible in sub-Saharan Africa and Latin America but will require adequate farming practices, increased investments and sustainable management of natural resources.[8]

The world's agricultural production has grown between 2.5 and 3 times over the last 50 years while total cultivated area has grown by 12 percent. More than 40 percent of the increase in food production came from irrigated areas, which have doubled in size.[9]

Demand for the world's increasingly scarce water supply is rising rapidly, challenging its availability for food production. Two-thirds of the world's population lives in areas that receive a quarter of the world's annual rainfall. Agriculture accounts for 70 percent (2,700 cubic kilometers) of total global withdrawals from rivers and aquifers available to humankind, with huge variations across and within countries. To produce enough food to satisfy a person's daily dietary needs takes about 3,000 liters of water, which represents approximately 1 liter per calorie.[10] Already some 30 developing countries are facing water shortages and by 2050 this number may increase to over 50 countries, a majority of which are in the developing world. This water scarcity could become a very serious obstacle to increasing food production.

Water availability for agriculture is a growing constraint in areas where a high proportion of renewable water resources are already being used, or where trans-boundary water cannot be negotiated. Increasing water scarcity threatens irrigated production in some of the world's most important agricultural areas. In low and medium income countries with fast population growth, the demand for water is outstripping supply. Rising demand from both agriculture and other sectors is leading to environmental stress, socio-economic tension and competition over water. Where rainfall is inadequate and new water capacity development is not feasible, agricultural production is expected to be constrained more by water scarcity than land availability.

Groundwater has provided an invaluable source of water for irrigation and other purposes, but has proved almost impossible to regulate. As a result, locally intensive groundwater withdrawals are exceeding rates of natural replenishment in key cereal producing locations. Excessive water pumping has rendered groundwater levels in China, India, Iran, Mexico, the Middle East, North Africa, Saudi Arabia and the USA critically low. Because of the dependence of many key food production areas on groundwater, declining aquifer levels and continued abstraction of non-renewable groundwater present growing risks to local and global food production. In Yemen, for example, groundwater withdrawals exceed recharge by 400 percent, threatening the fundamental wellbeing of its citizens.[11] With 25–27 million irrigation wells, groundwater irrigators in South Asia extract over 300 cubic kilometers of groundwater every year, which provides supplemental irrigation to 70–75 million hectares (ha) of land. Private investments in groundwater wells have added more irrigated area to South Asia in the past 40 years than public investments in dams and canals added in the previous 200 years. A booming groundwater irrigation economy is a unique aspect of South Asia's waterscape. It has become so central to South Asia's food security and agrarian livelihoods that its governments cannot afford to dismantle it. On the other hand, its environmental impacts are potentially so pernicious that they cannot afford to allow the groundwater boom to keep continue unchecked, as it has in recent decades.

In regions where natural resources are stretched, agricultural production must compete with growing needs for water from other users. Expanding cities, industries and services have priority in terms of water supply. Locally, this translates into a reduction in the share of water available to agriculture. Municipal and industrial water demands are growing much faster than those of agriculture, and can be expected to sap from allocations to agriculture and ultimately threaten natural groundwater sources. Demand for fresh water for cities and industry has doubled over the past 20 years, and is projected to increase by a factor of 2.2 from 900 cubic kilometers (km^3) in the year 2000 to 1,963 km^3 by 2050.

In other places, it is land – not water – which is the limiting factor for agricultural production. Agriculture currently uses 11 percent of the world's land surface. Global cultivated land per person has gradually declined from 0.42 ha to less than 0.21 ha during the last five decades.[12] Cultivated land per person in low income countries is less than half that of high income countries and its suitability for agriculture is generally lower. In large areas of Eastern and Southern Asia, including parts of India and China, demographics and demand for agricultural products are putting unprecedented pressure on limited resources. In parts of sub-Saharan Africa, in particular in Nigeria and Eastern Africa, land fragmentation has reached unsustainable levels, leaving farmers with crop areas much below what is necessary to ensure self-sufficiency. The expansion of urban areas and land required for infrastructure and other non-agricultural purposes is expected to continue, as we live in an increasingly urbanizing world. In China, for example, if in 2050 the entire population enjoyed a level of automobile ownership equivalent to that of the United States in the 2000s, it would require 13 million hectares of good farmland for roads corresponding to about half of the 29 million hectares currently producing 120 million tons of rice to nourish the Chinese people.

The Fate of Biofuels

The allocation of crops to non-food uses, including animal feed, seed, bio-energy and other industrial products, affects the amount of food available to the world. Globally, only 62 percent of crop production (on a mass basis) is allocated to human food, versus 35 percent to animal feed (which produces food indirectly as meat and dairy products) and three percent for bio-energy, seed and other industrial crops. A striking disparity exists between regions that primarily grow crops for direct human consumption and those that produce crops for other uses. North America and Europe devote only about 40 percent of their croplands to direct food production, whereas Africa and Asia typically allocate over 80 percent of their crop land to food crops.

Originally promoted as a way of decreasing dependence on fossil fuels and avoiding the carbon emissions generated by them, biofuel production has now been recognized as having strong links to agricultural markets and land and water use patterns. The first generation of biofuels currently in commercial use – biodiesel made from vegetable oil and ethanol made from sugar cane or maize – raise major concerns with regard to their increasing competition with food crops for land and water, as well as their role in food price volatility. According to the United Nations Environment Program (UNEP), about 118 to 501 million hectares "would be required to provide 10% of the global transport fuel demand with first generation biofuels in 2030. This would equal 8% to 36% of current crop land, including permanent culture."[13] In the long run current first generation biofuels production on cultivated land is not tenable, as the world's limited arable land resources are essential to meet future food demand.

Worldwide, there is rapid expansion of corn and vegetable use for fuel.[14] Many governments have set fixed mandates specifying the amount of biofuels to be produced, regardless of food and fuel prices. According to the FAO, biofuel production is projected to more than double from 2007–09 to 2019 and biofuel demand is expected to grow fourfold from 2008 to 2035.[15] In addition, biofuel support is predicted to increase from $20 billion in 2009 to $45 billion by 2020 and to $65 billion by 2035. Biofuel production has absorbed a rapidly increasing share of the US maize crop—today close to 35 percent of US maize production is used for biofuels. The US National Academy of Sciences found that even if all the maize and soybeans produced in the USA in 2005 had been used for bio-ethanol production, it only would have replaced 12 percent of the country's gasoline demand and six percent of its diesel demand[16]

The second major demand growth category has been the use of oilseeds—including vegetable oils for biodiesel production, oilseed meals for livestock production and vegetable oils for human consumption. The percent of total world use attributed to industrial and biodiesel usage has increased sharply since the mid-2000s. Rapeseed has been used extensively for biodiesel in Europe. Worldwide, nearly 33 percent of total rapeseed is now used for industrial purposes, compared to 17 percent in 2004–05. Industrial uses of soybean oil expanded to 16 percent of the world total by 2010–11 from just four percent in 2004–05.

From the late 1970s to the early 1990s, world food prices gradually declined by almost half and then stagnated until 2002. During the period 2002–2007, world food prices increased by some 140 percent owing to a number of factors including increased demand for biofuel feedstock and rising fuel and fertilizer prices. Estimates indicate that agricultural prices will rise by 30 percent by 2020 as a result of biofuel targets. The High Level Panel of Experts on Food Security and Nutrition, established by the UN Secretary General in the aftermath of the 2007–08 food price crisis, recommended that governments abolish biofuels targets, subsidies and tariffs. The G20 countries recognized the need to adjust biofuel mandates when market situations warrant interventions. They did not, however, make more definitive statements about biofuels and their links because of disagreement between large producers (like Brazil) and net food importers (like China) on the importance of these links. Given the trajectory of the biofuel debate so far, food and energy markets will continue to interact in the future, creating fast-changing market opportunities for producers of feedstock crops like sugar cane and maize, regardless of whether they are supplying the food, feed or fuel sectors.[17]

Threats to Agriculture from Climate Change

Climate change acts as a threat multiplier, making the challenges of food security much more difficult. It will affect all facets of society and the environment, both directly and indirectly, with strong implications for water and agriculture today and in the future.

The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) has shown that climate is changing at an alarming rate, causing temperature rise, shifting patterns of precipitation and more extreme events (droughts and floods). Climate models project substantial regional changes in runoff and stream flow – and hence in water availability – for the 21st century. Robust projections of these models imply decreasing water availability in southwestern North America, the Mediterranean region, and southern Africa, and increasing water availability in high-latitude North America and Eurasia, the La Plata Basin of South America, eastern equatorial Africa, and Indonesia. In general, regions of projected decreasing water supply tend to be the regions of contemporary water-supply stress, and regions of projected increasing supply tend to be those where water shortage is not a major issue for water managers.

Ongoing climate change will also affect the frequency of droughts. It is expected that an increase in drought frequency will occur in many regions—such as the Mediterranean region, where drought has been a problem historically. Additionally, we have reason to watch for increased frequency of floods, particularly in humid regions (although not necessarily only in those regions).

In addition, the AR4 has gathered scientific evidence and expert opinion on the expected impacts of climate change on agricultural systems.[18] The report notes that climate change is already having an impact, for instance, through changes in patterns of variability and associated changes in rainfall distribution. It anticipates with high confidence that projected changes in the frequency and severity of extreme climate events, together with increases in outbreaks of pests and diseases, will have significant consequences for food security. Climate also affects food production through rises in sea level that risk inundating coastal agriculture, and via reductions in glacier cover that might drastically change the hydrology of rivers critical for irrigating large agricultural areas.

The AR4 finds that Africa is highly vulnerable to climate change, because of multiple stresses and low adaptive capacity. Projections indicate an increase in arid and semi-arid land in some countries while others will become wetter but with changes in seasonal patterns. In Asia, potential changes in the monsoon and in glacier and snowmelt are perhaps the greatest threats. Sea-level rise is also of great concern as coastal and deltaic areas are often heavily populated and intensively cultivated.

Recent research strongly suggests that rising temperatures in the second half of the 20th century and early years of the 21st century, and accompanying changes in precipitation, have already had observable effects on agriculture. Under optimal management, when the mean temperature is less than 22°C, a 1°C change in temperature has a small but positive impact on yields; but as the average temperature exceeds 25°C, the effect becomes negative, causing declines of roughly 30 percent in yields.[19] During a drought, the yield declines begin at lower temperatures and can be greater than 40 percent. Although growing season temperature changed only slightly in North America from 1980 to 2008, it increased dramatically in other parts of the world—particularly in China and Europe. For maize, for example, climate change had essentially no effect on US yield trends, whereas it substantially slowed yield growth in Brazil, China and France. The growing area has shifted northward for maize in the United States, rice in China and wheat in Russia.

Overall, research suggest that calorie availability will not only be lower than in the no-climate-change scenario- it will actually decline relative to 2000 levels throughout the developing world. Climate change will also result in additional price increases for key crops - rice, wheat, maize and soybeans.

Declining Agricultural Productivity

Over the past five decades growth in world food production has been dependent primarily on increasing crop yields, firstly in the developed world and then, with the onset of the "green revolution," in the developing world. Much of this increase has come about as a result of expanding irrigation and fertilizer use, complemented by improved genetic potential as well as expansion of double and triple cropping in irrigated rice production systems.

However, decades of underinvestment in agriculture and agricultural research and innovation have slowed productivity growth. Over the last decade there has been evidence of a clear slowing in cereal yield growth, particularly of rice and wheat, a leveling in fertilizer use, and constraints on expansion in water use. Annual growth in cereal yields worldwide has declined from about three percent in the 1960s and 1970s to less than 1 percent since 2000. Sustaining yield growth of the three principal cereals under increasing resource constraints will be essential to meeting growing world food demand over the next four decades.

Intensifying crop management, together with bred-seed and efficient use of inputs such as fertilizer and water, will be needed to provide enough food for the growing population of the 21st century. Further and more sustainable gains in crop yield levels require improvements in soil quality, as well as precision management of other factors. Global food security will depend on gaining greater insight into the physiological basis of crop yield potential, analyzing the processes involved in the relationship between soil quality and crop productivity, and understanding the interacting environmental factors that affect crop yields.[20] The last decade has seen huge gains in our knowledge of how plants grow and synthesize useful products, and in our ability to use this information. Genome sequences of major crop species are now available or close to completion, while functional genomics is providing critical information on the role of genes and their products. Generic markers have enabled scientists to detect previously hidden genetic variability, and genetic engineering is expanding the ways in which microorganisms, plants and animals can be used for human and environment benefits. These advances are allowing researchers to improve plant breeding methods, construct safer and more effective pest control strategies, and develop plants with improved agronomic traits and nutritional characteristics. They also provide the basis for breaking through present yield barriers.

Food Self-sufficiency: An Elusive Target

Food security, as a concept, originated only in the mid-1970s. The initial focus, reflecting the global concern leading to the World Food Conference in 1974, was on the volume and stability of food supplies. Food security was then defined as "availability of adequate food supplies of food stuffs to sustain a steady expansion of food consumption and to offset fluctuations and prices." Until almost the mid-1980s most countries sought to meet their food needs from domestic supplies. This quest for food self-sufficiency was the result of the following factors:[21]

- The food crises and famines that raged in several parts of the world, particularly in Asia before the Green Revolution of the early 1970s.
- The hopes entertained by the Green Revolution; thanks to increased production and productivity, some countries significantly reduced undernourishment, or even enjoyed a food surplus.
- The number of people suffering from undernourishment was reduced from about 870 million people in the 1960s to about 770 million in 1995/96 when it again began to increase.
- The inherent risks of dependence on international trade in agricultural products, given the volatility of prices and the effects of protectionism.
- The Cold War and threats related to food embargos; when looking to gain political independence countries were concerned about their food self-sufficiency.

Given that water and land resources are unevenly distributed, food self-sufficiency is an elusive target in countries facing growing scarcity of these resources. Furthermore, as incomes grow and dietary regimes diversify most countries inevitably become net importers of agricultural products when domestic production can no longer meet demand.

The expansion of globalization and international agricultural trade in the 1980s led many countries to move away from the food self-sufficiency objective and rely more on the international market to cover their food needs. Thus, domestic production, combined with international trade flows, determine domestic food availability, whilst per capita income and domestic prices determine the ability of consumers to pay for that food.

Ideally, the liberalization of agricultural trade widens the entire spectrum of economic possibilities, offering countries the potential to efficiently allocate their water resources and to make the most of their comparative advantages. In addition, international trade is supposed to help diversify risk, as agricultural production varies quite a lot from year to year in a single location, but overall world production tends to vary much less. In reality, these aspects of trade do not work as well as they could. Indeed, today's agricultural markets exhibit the following three characteristics that affect their reliability:[22]

- First, export markets for the main staple commodities – rice, maize, wheat and soybeans – are highly concentrated in a few countries (or are very "thin"). Nine countries account for 90 percent of the world's wheat exports and just five countries account for 85 percent of the world's exports of rice. In fact, together Thailand, India and Vietnam produce 66 percent of all milled rice. This high concentration puts importing countries at risk and limits the world's capacity to cope with shocks. Any incidence of poor weather or other events causing production shocks will immediately affect global prices and price volatility. Similarly, any policy changes in any of the top exporters – such as trade bans or other restrictions on exports – will significantly affect the levels and volatility of prices. Research suggests that such policies explained almost 40 percent of the increase in the world market price for rice during the 2007–2008 food price crisis.

- Second, the world's stocks of cereals are now at historically low levels. This situation leaves the world vulnerable to food price spikes and threatens the proper functioning of markets.

- Third, appropriate and timely information on food production, stock levels, and price forecasting is sorely lacking. When information deficits lead to overreactions by policy makers, the result can be soaring prices. In the 2007–2008 and 2010–11 food price crises, many countries responded by cutting exports or boosting imports in ways that worsened price increases.

In the contentious debate over countries' food policies, one conclusion garners support from all sides: the need to boost agricultural productivity to both smooth food prices and strengthen global trade by increasing the number of food exporting countries. More productive farming in more countries would not eliminate the need for other measures to ensure a healthy global system of food trade, but it could help export bans become a measure of last resort instead of a panicked first reaction. The issue is not only one of prices increasing too quickly, but also of risky volatility and of inappropriate policy responses around the world posing threats to free trade and possibly even to political stability in some countries.

Conclusion

The long term prospects of the global food supply situation show that:

- Agricultural production needs to almost double by 2050.
- Long-term abundance of agricultural commodities is not guaranteed, but there is no reason to be Malthusian and predict famines.
- The constraints related to the scarcity of basic resources (soil and water), biofuels, climate change and declining agricultural productivity involve potential risks of shortages.
- Food self-self sufficiency is not an option.

This confluence of pressures raises uncertainties about our ability to produce and distribute enough food to feed nine billion people in 2050.

Is it even possible to feed nine billion people? There is certainly no lack of authoritative global assessments of global food security challenges. Most of them respond that it is indeed possible to produce enough food to feed nine billion in 2050, but only if we are able to produce more food and more variety, mainly through higher yields in an environmentally friendly manner, with higher prices on inputs and better prices and fair access for consumers. Furthermore, these objectives must be accomplished under climate change conditions.

It is a truism to state that this can only be achieved by mobilizing all kinds of agriculture and utilizing all sources of water, with much better coordination and partnerships between the major actors involved: farmers, market operators, authorities and consumers. The political and economic governance of the food system must be improved to increase productivity and sustainability.

Increasing food production is a necessary, but not the sole condition. The globalization of markets has been a major factor shaping the food system over recent decades and the extent to which this continues will have substantial effect on global food security.