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A note on Food Security: Challenges and Opportunities

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Food security “exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life,” according to the Food and Agricultural Organization (FAO) of the United Nations.[[1]](#endnote-1) Drought, shipping disruptions, fuel shortages, economic instability, and war have long been recognized as potentially disruptive threats to global food supplies.[[2]](#endnote-2) More recently, experts have warned about overpopulation, climate change, pollution, and biodiversity loss as additional risks.

Despite concerted efforts to eradicate world hunger under the United Nations’ 2000–2015 Millennium Goals, FAO estimated that 795 million people were undernourished in 2015.[[3]](#endnote-3) Skeptics fear the situation could become much worse. Optimists, on the other hand, point to farming and food-system innovations as the path to a future of continuing abundance and increasing health. Though experts agree that it will be possible to meet the nutritional needs of more than 9 billion people by 2050, there are heated debates about whether the innovations needed to reach the target can be achieved within reasonable boundaries of risk and cost. Hence, companies in the farming and food industries face the prospect of substantial change, and perhaps even disruption, to their traditional products and business models as society adjusts to the new realities of the market, political context, and natural environment.

Challenges to Food Security

Challenges to food security come from both the demand and supply sides: a growing population fuels the world’s demand for caloric intake at a time when global agriculture yields have stabilized, or even declined, and unexploited natural resources have become scarce.

Demand-Side Challenges

Population Growth

The United Nations estimates that the world population will reach 9.7 billion people by 2050 and 11.2 billion by 2100.[[4]](#endnote-4) Solutions for feeding over 9 billion people by 2050 are being carefully studied and documented. The World Resources Institute indicates that this will require an increase in the number of food calories available for human consumption by 2050 of 69 per cent in comparison to the 2006 baseline.[[5]](#endnote-5) When the food needed for cultivating livestock is taken into account, this demand surge is estimated at an even more staggering 100 per cent, or 6,000 trillion calories per year.[[6]](#endnote-6)

Shifting Diets

Global reductions in poverty have sharply increased the demand for calories, as newly emerging middle-class families shift their diets from vegetable-based protein sources to meat, dairy, and fish. Meat-based diets consume far more resources than vegetable-based diets because of the land needed to raise livestock and the food and water needed to grow animal feed. Livestock farming also contributes to climate change as a result of methane emissions from animals and land deforestation (i.e., the removal of vast tracts of trees that absorb carbon). For example, when cattle farmers switched their animals’ diets from meat by-products to plant products following the outbreak of meat-borne mad cow disease in the early 2000s, a boom in soybean demand prompted South American farmers to cut deeply into forest lands to clear fields for soy cultivation. The total toll on climate change from the combined effects of animal emissions and cultivation is substantial. Author James Cascio used energy data generated by Stockholm University and the Swiss Federal Institute of Technology to determine that, “the greenhouse gas emissions arising every year from the production and consumption of cheeseburgers in the United States is roughly the amount emitted by 6.5 million to 19.6 million SUVs [sport utility vehicles].”[[7]](#endnote-7) If diets continue to shift away from plants as global incomes continue to grow, the pressures on the climate, land, and water supply will continually increase.

Supply-Side Challenges

Food Waste and Loss

Nearly one-quarter of all calories produced for human consumption are lost or wasted. Food loss stems from spoilage and spillage in the pre-consumption stage; it emerges when prepared food is disposed due either to excess production or to eventual spoilage. Consumption-stage waste is a major problem in the developed economies of North America, Oceania, and Europe. In developing countries, by contrast, the biggest losses emerge at the stages of production, handling, and storage.[[8]](#endnote-8)

Natural Resource Limits and Degradation

Agricultural production uses 70 per cent of the earth’s accessible fresh water and 85 per cent of its arable land supply. The available resources are often overexploited and are sometimes destroyed in short-sighted attempts to boost farming profits, especially in low-income areas where smallholder farmers lack the education or the financial means to balance financial and environmental concerns for sustainable long-term outcomes.

Water scarcity is a large and growing problem for agriculture, and many crops are grown in areas of high water stress.[[9]](#endnote-9) Experts fear that we may see negative effects of water scarcity on global agricultural output in the near future, especially if problems such as overextraction and pollution of available groundwater supplies continue at current rates. Many small countries import a significant portion of their annual grain supplies, and there are worries that large countries like India and China could follow suit if unsustainable water pumping activities are not curtailed.[[10]](#endnote-10) China is enacting programs and policies to improve water management, but the risks to food security from poor water management remain strong.[[11]](#endnote-11) By 2030, the gap between expected global water demand and supply could reach as high as 40 per cent.[[12]](#endnote-12)

The outlook for land is similarly problematic. Unfarmed arable land lies primarily in forests—which are needed to control the greenhouse effect and preserve biodiversity—or in peat bogs—which release large amounts of carbon into the atmosphere when drained. Scientists warn of grave consequences from continuous exploitation of these lands. Although climate change is expected to release arable land from ice cover in some far northern regions, droughts, floods, and high temperatures are predicted to devastate some currently fertile southern farming zones. Russia, Canada, and northern European countries may see a net gain in agricultural land as a result of global warming.[[13]](#endnote-13) Iceland, for example, has been able to grow barley since the turn of the century as a result of the higher temperatures resulting from changing ocean currents.[[14]](#endnote-14) On the other hand, rising seas will threaten low-lying coastal farmland in countries like Bangladesh.[[15]](#endnote-15) The net effect of climate change on farmland availability is difficult to predict in the near term, but what seems certain is that change is coming—and with it, perhaps, come social and economic instability.

Pollution compounds the problem of a shrinking supply of resources. Farming is a major source of soil and water pollution, as overused pesticides and fertilizers seep into the ground and run into streams and oceans. At the same time, approximately 40 per cent of the world’s agricultural land is seriously degraded, and the loss of soil fertility leads to sharp declines in agricultural yields.[[16]](#endnote-16) Soil preservation and restoration will play an important role in assuring future food security.

Social Inequity and Labour Scarcity

A scarce supply of experienced and knowledgeable farm labour has emerged as an additional concern for future food security. In many low-income countries, farmers lack the knowledge and technology that would allow them to improve their crop yields. The small scale of their farms and their limited access to market information prevents them from negotiating better selling prices for their harvests. Poor systems for food preservation and transportation further reduce their profits, as crops spoil on the way to market. Moreover, safety and health risks result from low knowledge levels and lack of access to protective clothing and equipment, insurance, and organized labour. Cycles of poverty and hardship drive young people out of low-income farming communities in search of a better lifestyle. Even in high-income farming communities, few young people enter the industry, as most prefer careers with greater security and lower stress.

Food Security Opportunities

The bright side of any challenging situation is that it brings opportunity for change. Food and agribusiness form a $5 trillion[[17]](#footnote-1) global industry, and the trend of investing for future food security means the value of this industry will only grow. A McKinsey & Company report estimates that global investments in food and agribusiness companies tripled in 10 years, reaching a whopping $100 billion by 2013. High yields, exceeding even those of energy and information technology, assure that the trend will continue.[[18]](#endnote-17)

Solutions to global food security problems range from innovative seeds, crop protections, and farming methods to new products and business models intended to reduce food waste, shift dietary patterns, and manage risk. Big businesses typically strive to implement well-defined processes at scale rather than to adapt to the unique local requirements of agricultural systems. Global agribusiness companies focus on laboratory research, using tools like genomics, combinatorial chemistry, environmental science, toxicology, crop transformation, and nanotechnology. In contrast, entrepreneurs are often willing to focus on specific local needs that require low-tech solutions. They more readily accept and advocate for business model changes such as vertical farming and food redistribution or repurposing.

Technology-Based Solutions

Genetically Modified Crops

Using genetic modification technology, growers can genetically alter crops to boost their resistance to drought, pests, flooding, and other impending risks of climate change and environmental degradation. The public is widely divided about the long-term safety and wisdom of leveraging biotechnology in general, and genetically modified organisms (GMO) in particular, in the pursuit of food security. Advocates, including hundreds of researchers and government institutions, argue based on scientific evidence that GMO crops are safe and have not posed major environmental or health risks in regions where they are grown.[[19]](#endnote-18) Nevertheless, activists continue to warn of risks. Chief among their concerns is that GMO crops decrease biodiversity and place food security in the hands of a small number of high-tech agribusiness companies. Critics also argue that evidence to support the beneficial effects of GMO crops (e.g., higher crop yields and lower use of pesticides) is unsupportive or inconclusive[[20]](#endnote-19) and that other modern farming methods such as rotational cropping could be more effective than genetic modification technology in boosting crop yields without posing any of the feared GMO risks.[[21]](#endnote-20)

Laboratory-Produced Food

In recognition of natural resource limits, scientists have been working on growing meat in laboratories. Though researchers are not yet able to reproduce the taste and texture of a juicy, grilled steak, they have been successful in cultivating meat cells that receive favourable reviews for taste—especially when prepared with condiments or other flavour enhancers. A critical challenge for commercializing the meat at present is the high price. For example, in 2013, a Dutch lab-grown burger was offered at a price of more than $300,000; however, researchers in several so-called clean meat companies have been working to reduce the price since then.[[22]](#endnote-21) Many people are optimistic that lab-grown food will offer affordable and tasty alternatives to farm-grown meat in the near future. In another example of growing food in the lab, scientists are generating sugar as an intermediate product of cellulosic biofuel production. As land shortages drive the search for alternative growing spaces and climate change disrupts traditional growing geographies, the search for laboratory solutions to food production is likely to grow.

Precision Farming and Big Data

Advances in information technology can increasingly boost agricultural efficiency and profitability.[[23]](#endnote-22) For example, farmers are able to increase crop yields and optimize the application of fertilizers, crop protectors, and water using granular data (e.g., drone- or satellite-generated data for every 10 square metres of field) and sophisticated tools that integrate information about weather, soil, and market prices. The resulting resource efficiency also lowers costs. Mobile phone technology can be especially helpful to farmers in emerging markets, where data about production and demand is currently limited. Improving access to information about crop conditions and market prices can increase farmers’ productivity and give them greater power over the terms of trade.

Low-Tech and Business-Model Solutions

Improving Agricultural Productivity in Low-Income Areas

In many developing countries, the productivity of farming is low due to outdated techniques. In addition to high-tech solutions using drones and big data, low-income areas can benefit from low-tech solutions like improving soil fertility, expanding cropped areas, increasing irrigation efficiency, and reducing post-harvest losses. A major study led by the International Water Management Institute, for example, shows that hunger, poverty, and water are closely correlated. More efficient management of rain water combined with small-scale irrigation yields great gains for low-income communities.[[24]](#endnote-23)

Growing Differently, Eating Differently

Apart from improving productivity, farmers can focus on growing crops that provide the most calories while using the fewest resources. According to experts from the World Wildlife Fund, the amount of water required to produce 1,000 calories of beef is 10 times as much as it takes to produce 1,000 calories of bananas or plantains.[[25]](#endnote-24) Consumers can also do their part by reducing overconsumption of calories and limiting consumption of resource-intensive foods. Research conducted by the World Resources Institute shows that widespread implementation of three consumption-based solutions (reducing overconsumption of calories, reducing overconsumption of animal-based proteins in general, and reducing consumption of beef in particular) could close the food gap by as much as 30 per cent while simultaneously reducing the use of agricultural resources and resulting harmful environmental impacts.[[26]](#endnote-25)

Switching to an insect-based diet could be especially beneficial. According to research by the FAO, insects are already a part of the diets of around 2 billion people worldwide.[[27]](#endnote-26) Insects are nutritious and high in protein; moreover, compared to livestock, they can be raised with minimal environmental impact. At the very least, insects can be used to feed animals. For example, a start-up called Kulisha markets high-protein “Edibugs” as an alternative to conventional animal feeds. The bugs are actually black soldier fly larvae that feed on organic waste materials, some of which are donated by food companies seeking better means of waste disposal. The company’s founders claim that each bag of Edibugs diverts five pounds of food waste from landfills.[[28]](#endnote-27)

Changing the Farming Business Model

Farming can also move into urban warehouses or even into individual homes. Vertical farms use controlled-environment agricultural technology in which light, humidity, temperature, and gases are carefully balanced to grow food in vertically stacked layers inside warehouses, shipping containers, and other repurposed spaces. Since vertical farming is multi-seasonal, it can multiply the productivity of farmed surfaces by a factor of four to six, depending on the crop, while using fewer resources than traditional farms.[[29]](#endnote-28) At the household level, indoor farming can even be done in an apartment. PlantCube is a small appliance that looks like a smart-controlled refrigerator. It can be placed in a space-constrained kitchen to grow vegetables in the home, using technologies like those applied to large commercial vertical farms.[[30]](#endnote-29)

Reducing Food Loss and Waste

Much of the food loss that occurs in developing economies stems from pest infestations or bruising and compression during handling and storage. Researchers have found that plastic storage bags and small, airtight metal silos can prevent pests and other harmful elements like mould and moisture from damaging crops during handling and storage. Plastic storage crates have also been shown to have advantages for preventing bruising and crushing during transport. In developing markets, each of these potential solutions faces scaling challenges, such as high up-front costs or limited availability, but governments and support agents are working to close these gaps. If successful, these measures could greatly reduce the 48 per cent of global food loss and waste that occurs during production, handling, and storage.[[31]](#endnote-30)

Changes in food labels can reduce food waste in developed economies, where consumers or institutions might throw away food before it has really spoiled. Labels that typically read “sell-by,” “best if used by,” or “use-by,” refer to the quality or flavour of the food, but not to its safety (i.e., whether the food would cause someone to be sick).[[32]](#endnote-31) Food producers, retailers, and government regulatory bodies are acting together to seek solutions to simplify and clarify the differences in food safety and taste. Interventions to educate consumers and change their behaviour will ultimately be part of the overall solution.

Waste can also be reduced through food redistribution. A New York non-governmental organization, Transfernation, picks up extra, untouched food from events and corporate cafeterias on demand and takes it to the closest local feeding program. Using a mobile-phone application, it connects food donors with paid volunteer transporters, who deliver the food to charities that feed local people in need. Calling itself “the Uber of extra food,” this group had redistributed over 50,000 pounds of food to New York City shelters within two years.[[33]](#endnote-32) Services like this can make a dent in the high volume of food waste in the urban areas of developed economies. The basic requirements of ample food donors, transporters, and food bank locations are easily met in densely populated city centres. Government policies may also be needed to limit the liability of food donors in the event that food unintentionally causes harm to the recipients.[[34]](#endnote-33)

Food System Change and Disruption

It will take years, even decades, for our current food and agricultural ecosystems to transform to meet the needs of the future. Like all economic and social revolutions, there will be winners and losers. The winds of change are strong and seem poised to strengthen, as current trends of population growth and resource exploitation advance. Some of tomorrow’s winners are likely to be found among today’s innovators and adapters. Tomorrow’s losers are likely to be those who cling too tightly to the past without recognizing the opportunity of bringing much-needed solutions to market. Those who move will find many like-minded supporters and collaborators to accompany them on the way, for there are few more pressing problems in need of innovative solutions that that of global food security.

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