A.T. Kearney

Innovation in Agriculture: the Path Forward

Experts on the future of food from A.T. Kearney, FarmLink, WaterFX, and Monsanto weigh in on what future digital, biotech, and process innovation technologies should look like and how they should be managed.

Global agriculture is facing an unprecedented challenge. By 2050, the world's population is expected to swell by two billion people. Beyond the sheer number of mouths to feed, this growth will bring a fundamental shift in diets around the world as more prosperous populations seek more protein, demand higher-quality food, and eat more prepared foods. Food demand will double in the next three decades with a 50 percent increase in protein demand. At the same time, crops are being diverted for feed and fuel, land for agricultural expansion is scarce, and freshwater resources are dwindling. In fact, access to freshwater will be one of the greatest challenges in the next few decades.

The last time we faced such global issues was in the 1970s when the Club of Rome, a global think tank, published dire warnings about population explosion and starvation. Thanks to the great work of agricultural scientists such as Norman Borlaug, crop yields were increased dramatically.

Although farming techniques, fertilizer use, and crop protection are continuing to improve, the dramatic gains in crop yields have slowed. In a quarter to a third of today's most important cropland areas, many of which are in the world's top crop-producing nations, yields are flat or declining. Based on analysis of historical improvements, yields for corn, rice, wheat, and soy—the four crops that account for about two-thirds of globally harvested food calories—will fall short of the needed 2.4 percent annual improvement required to double crop production by 2050. Add environmental and sustainability issues and activists' demands for cage-free, antibiotic-free, and non-genetically modified foods, and combine that with the continuing need to provide food security to almost a billion people who are chronically undernourished. The result is that global agriculture will be severely challenged to meet the demands of nine billion hungry people.

Can the tech industry, which has forever changed the world's relationship to media, information processing, and communications, bring breakthrough innovation to agriculture? Venture capital funding supporting dynamic new approaches and disruptive technologies for food and agriculture-related start-ups has increased dramatically from $400 million in 2010 to an estimated $4.2 billion in 2015. According to industry experts who gathered earlier this year at a Chicago Council on Global Affairs (CCGA) event, there is reason to believe those are well-placed investments.

An Agricultural Revolution

Dave Donnan, A.T. Kearney partner in the Consumer Products & Retail Practice, moderated, "The Future of Food: Innovation, Technology, and Agriculture," a panel discussion hosted by the Chicago Council on Global Affairs in January 2016. The dialogue engaged industry experts, including Randall Barker, FarmLink's managing director of business development; Aaron Mandell, WaterFX and HydroRevolution co-founder and chairman; and Virginia Ursin, Monsanto Company's biotechnology prospecting lead. These leaders shared their views on what breakthrough innovations in the future of food should look like and, perhaps more importantly, how to manage the development and acceptance of digital, biotech, and process innovation technologies (see figure 1 on page 2).

Digital innovation capitalizes on the latest advancements in hardware and software, creating a radically new system of farming that relies on computing power and connectivity. Soil sensors measure how much moisture is in the ground. Drones collect data and imagery providing crop

Figure 1

Technological advances could transform agriculture

Varying outcomes in the next global economic order

Area	Description	Breakthrough innovations
Digital	Parallel development of hardware and software to create a radically new system of farming that relies on computing power and connectivity	• Sensors • Drones • Big data • Automation
Biotech	Scientific techniques including genetic engineering used to improve plants, animals, and microorganisms	• Genetic modifications • In-vitro meat • Animal protein substitutes
Process	Innovative farming processes to help sidestep constraints on farming productivity and environmental sustainability	• Vertical farming • Hydroponics and aquaponics • Drip irrigation • No-till farming • Perennial agriculture

Source: A.T. Kearney analysis

analytics. Cloud-based advanced analytical solutions process data for growers and manufacturers. Predictive analytics and the ability to analyze data is fundamentally changing farming. Farmers can buy seeds that have been bred for specific types of soil, and tractors, which are outpacing self-driving cars in terms of technology, know which seeds to plant based on current conditions. "There's an obvious convergence of all these technologies that can be connected in a data-science approach," Barker said. "It's all about taking the complexity of biology, weather, and math and making it work." FarmLink's advanced analytics puts sophisticated industry data at farmers' fingertips, allowing growers to validate their practices and decisions and plan their investments to maximize yields.

Biotech innovation incorporates scientific techniques to improve plants, animals, and microorganisms, including a broad array of solutions from genetically engineered plants and animals to improved tools such as microbial technologies that target bacteria and clustered regularly interspaced short palindromic repeats (CRISPR), a radically improved genome editing technique with vast potential in ecology and conservation. "Eighteen million farmers globally are growing biotech crops," Ursin said. "Ninety percent are smallholder farmers in the developing world. This technology has made agriculture profitable and has decreased problems with pesticide poisoning. We cannot go back to agricultural practices that will increase the footprint of agriculture. We have to decrease the footprint. Sustainable intensification and genetic

optimization are essential parts of that." For example, she said, every year when corn is harvested, the U.S. Department of Agriculture publishes the highest yield for corn. The opportunity to bring every seed of corn that is planted to its theoretical maximum is available to us now, Ursin said. "It's not magic. It's what FarmLink and Monsanto are doing. It's matching the genotype to the type of soil and giving that seed every opportunity to maximize its potential," she said. "Genetics is one solution, just one of many solutions. Ultimately, everyone benefits from sustainable agriculture and global food security."

Process innovation introduces new farming techniques designed to address constraints on farmers' productivity and environmental sustainability. Vertical farming combined with hydroponics and aquaponics allows agriculture to flourish in areas where there is no natural soil. Drip irrigation technology uses sub-surface low-pressure piping to deliver water directly to crop roots, resulting in both better yields and preserved water resources. Desalination removes salts and minerals from saline water for freshwater uses. Israel, for example, has used efficient technologies such as drip irrigation and desalination to produce 20 percent more water than it consumes, proving that solar desalination can create an affordable, sustainable water source in water-scarce regions. "We need to focus on redesigning the entire sustainable water model from the ground up," Mandell said. "WaterFX focuses on leveraging what is happening in the energy industry and applying it to water. Water is just a form of energy. If we have a sustainable, affordable, scalable source of energy, we can produce as much water as we need."

Managing the Headwinds

While these technological innovations have the potential to make a positive impact on agribusiness, the challenge is to find common ground between the significant social, political, and environmental concerns and the business interests surrounding these disruptive changes (see figure 2 on page 4). The situation is so complex and interdependent that one group cannot resolve it. A concerted effort from large businesses, governments, non-governmental organizations (NGOs), and the high-tech community is required.

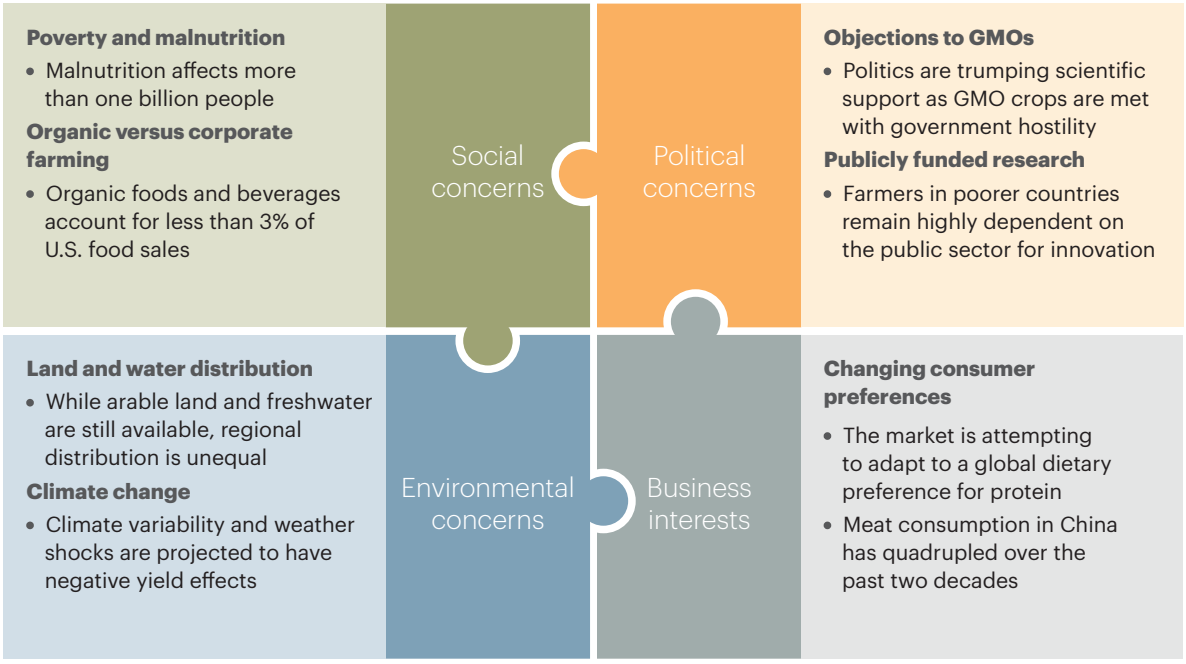
In the United States and Europe, for example, the idea of food with genetically modified organisms (GMOs) has been accompanied by a storm of media, consumer, and political backlash. Scientific organizations such as the National Research Council, the American Association for the Advancement of Science, and the American Medical Association have issued studies and statements saying there is no evidence that GMOs present unique safety risks compared with conventionally bred products. Despite the evidence, 93 percent of respondents in a 2013 poll favored mandatory labeling, and three-fourths of Americans expressed concerns about GMOs in food.[1] All 28 European Union countries have strict GMO labeling, and as of October 2015, 19 of them have opted out of growing GMO crops in their territories. The U.S. Federal Aviation Administration highly regulates the commercial use of drones, and new legislation that might encourage agricultural uses has been pushed back to 2017. Even with these regulations, legal and political issues associated with data standardization, data privacy, and data access are holding back promising innovations.

In the developing world, where more than a billion people suffer from malnutrition, agricultural productivity is critical. Smallholder farmers are particularly susceptible to climate variability,

[1] *"Restrictions on Genetically Modified Organisms: United States,"* Library of Congress, 9 June 2015; "Strong Support for Labeling Modified Foods," *The New York Times*, 27 July 2013

Figure 2

A variety of interacting forces are transforming agriculture



Note: GMOs are genetically modified organisms.

Source: A.T. Kearney analysis

weather shocks, and inconsistent road access and water supplies. In many cases, businesses, NGOs, and governments are developing innovative solutions to provide the initial capital, technology, and training to make farming more profitable. But improving food security and reducing poverty will require ongoing investments and sustainable commitments from all participants.

"There are economic headwinds all the time in agriculture. I've seen lots of technologies come into agriculture," Randall said. "Is there a clear economic benefit, is it repeatable and reliable, and is it simple to use? In agriculture, you have a really fragmented group of people geographically as well as on the technology spectrum," he said. "While some farmers are content with current methods, the younger farmers are totally tech-focused. The industry needs to get beyond its focus solely on farmers farming to a food system."

Mandell addressed the cost hurdle with technology such as solar desalination by drawing an analogy to the energy sector. "When rooftop solar first came out, it was very expensive. Even today, it's more money than many people want to pay," he said. "But what has happened is that companies have stepped in with new business models where you no longer have to own the equipment. You don't have to operate it yourself," he noted, saying users can simply sign up with energy providers such as California's SolarCity to receive cheaper, more sustainable energy. And WaterFX subsidiary HydroRevolution aims to do for water what other companies have done for energy, with farmers not being required to put up any of the costs (see sidebar: WaterFX Plans to Build Solar Desalination Plant on page 5).

WaterFX Plans to Build Solar Desalination Plant

California's Central Valley is home to soil that is rich in naturally occurring salts and minerals. But when irrigated, crops soak up freshwater and leave behind salts and minerals, creating a briny discharge that affects local water systems. In 2014 and 2015, farmers who buy water from the federal Central Valley Project received no water because of the state's ongoing drought. As a result, 30 to 50 percent of the land lay fallow. The alternative solution—drilling wells for freshwater—decreases water reserves and is unsustainable.

WaterFX says it has a solution. The company's HydroRevolution subsidiary aims to put fallow land back into production at an economical price by using solar energy to purify salt-impaired water. HydroRevolution plans to build a commercial solar desalination plant in the Central Valley. The plant, which is being partially financed through a direct public offering, will capture freshwater from irrigation and create a sustainable water supply to complement the current water system. The company says the plant will be able to produce up to 1.6 billion gallons of freshwater each year.

The flashpoints are biotechnology and GMOs, Ursin said, addressing the issue of consumer acceptance and fundamental philosophical concerns about the technology. For example, she noted, some activist groups oppose golden rice, which is produced through genetic engineering. "Food is sacred, and their issues, fears, and concerns are very real," she said. However, these foods can save many lives. "A huge amount of greenhouse gases comes from agriculture," she said. "No-till agriculture allows carbon to be sequestered in the soil instead of being released. This is enabled, fundamentally, by herbicide-resistant crops" such as GMOs, she said, adding that the industry's challenge will be to shift the conversation.

The Path Forward

Meeting the challenge to increase agricultural productivity and feed a growing population with shrinking resources will require a concerted effort from agribusiness companies as well as the technology and venture capital community, NGOs, and governments. Going forward, solutions must address the transfer of technology to users worldwide, the transparency of scientific solutions, and the necessity of collaboration and cooperation between the private and public sectors.

Several moves can pave the way:

Global transfer of knowledge will help speed development and acceptance of new tech solutions. Mandell favors an open sourcing approach that makes technology available to entrepreneurs in developing countries to speed dissemination. In developing countries, connectivity via mobile technology is already allowing data science to bring information and solutions to a growing number of smallholder farmers (see sidebar: Mobile Phones a Powerful Tool for the World's Poorest Farmers on page 6). In these countries, it's about leapfrogging, Randall said. "It's not just communications, but behavior, images, and infrastructure and using them to solve problems," he said. "Data science and connectivity has been a greater lift. While it may be hard for a large farmer to improve from 300 to 500 bushels an acre, it is much simpler for a farmer in the developing world to move from 20 to 100 bushels."

Transparency and the democratization of data can speed adoption. Understanding how the data is collected and then sharing that data benefits everyone. Much of the energy in the food

Mobile Phones a Powerful Tool for the World's Poorest Farmers

In Sub-Saharan Africa, mobile phones are helping farmers grow more food. More common in developing nations than paved roads or electricity, wireless technology is giving farmers in Tanzania access to information about weather, rainfall, market demand, and seed prices, allowing them to harvest more food.[2] This also ensures that agricultural advances in the developed world reach small farmers in the most remote regions of the developing world. For example, the Ethiopia Commodity Exchange allows farmers to use their mobile phones to trade coffee and find the best prices and markets for their crops. This access to information is making the difference between a bountiful harvest and a poor one.

processing industry is focused on making data collection passive and using the Internet to share information. To deliver sustainable results, the technology toolbox should be full and available to everyone. With climate change and resource constraints, the future is unpredictable. Every tool, including genetics, should be available to address all of the opportunities.

Collaboration and cooperation between agribusiness, government, and NGOs must accelerate. Engagement is necessary to understand the opportunities and to address the issues of data ownership, data privacy, GMO food safety, and sustainability of new farming methods. Like climate change, only a collective effort from multiple groups can solve the looming crisis of food security. Meeting the future needs of our global population will require an accelerated and sustained focus of government working with the industry.

[2] "How Cell Phones Can Help End World Hunger," *National Geographic*, 10 June 2015

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