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by Barry Jaruzelski, Volker Staack, and Tom Johnson

For farmers in rural India, gaining access to quality products, accurate information, and fair prices can be challenging. Pune-based startup AgroStar developed a mobile-commerce platform to help. AgroStar customers order supplies using a mobile app or through the "missed call" technique. (The customer dials a number to signal the recipient but disconnects before the call is picked up and charges are incurred.) Launched in 2012, AgroStar has partnered with more than 150 brands, including multinationals such as Syngenta, and has served 7 million farmers.

In recent years, agricultural innovation has resulted in promising new ways to boost productivity, from AgroStar's mobile solutions to drones that can analyze soil and monitor crop health. The urgent need for such R&D investment cannot be overstated. The United Nations estimates that by 2050, the world's population will reach 9.7 billion. Ensuring adequate supplies of food will require a 70 percent increase in agricultural production over the next 30 years. These numbers present the global agricultural sector with a daunting task, especially when they are combined with the effects of climate change and resource scarcity. Already today, in parts of Africa and the Middle East, millions of people are on the brink of famine.

Whereas the public sector represented the lion's share of past agricultural R&D investment, constrained fiscal policies in many countries have slowed public-sector R&D growth. Commercial R&D has increasingly filled the gap, especially in high-income countries. According to a 2016 study by the University of Minnesota of global agricultural R&D investment, the share of private-sector R&D rose from 35 percent in 1980 to 45 percent in 2011. In the U.S. alone, the private sector now accounts for 75 percent of agricultural R&D. These investments have resulted in innovations designed to strengthen yields, enhance the productivity of agricultural equipment, and promote sustainability. Developments in these three areas are essential to meeting the world's growing food needs. In the past, production growth largely came from increasing the amount of land and labor in use. But it is now clear that the amount of arable land available will not keep pace with demand. We need to be able to produce more with the land we have, while being mindful of resource scarcity and the potential for environmental degradation.

Illustration by Marc Rosenthal

Boosting Yields

Genetically modified crops (GMCs) that can resist environmental problems and thus increase crop production are already in wide use in some parts of the world. Genetically modified varieties make up more than 90 percent of the current planted area of soybeans, cotton, and corn in the United States. But their adoption has been controversial. In Europe, for example, health fears have limited GMCs' penetration.

The latest advances in genomics seek to avoid some of the features that have caused concern about GMCs. CRISPR (clustered regularly interspaced short palindromic repeats) technology, which is now being adapted for crop and animal science, uses the immune system of bacteria to edit specific genes in organisms. Unlike processes used for traditional GMCs, CRISPR does not introduce genes from other organisms into plants but instead edits the genome of the plant itself. Scientists believe CRISPR could improve the natural characteristics of crops to make them more resistant to drought, pests, and weeds, and could boost their photosynthetic efficiency to make them grow faster.

R&D in sensor technology, geopositioning, and big data will also enable significant yield increases. For example, Climate Corporation, a subsidiary of Monsanto, launched its Climate FieldView platform in 2015 to use sensors and satellite imagery to provide farmers with real-time data. It enables precision application of fertilizers and can also identify and prevent disease

vulnerability. FieldView is already in operation on more than 100 million acres in the U.S. and Brazil. Climate Corporation has recently expanded into Europe, and plans to offer the platform in South Africa, Australia, and Argentina over the next few years.

In May 2017, Virtus Nutrition and Dairy.com announced the joint venture My Dairy Dashboard. Virtus had previously acquired Farmeron, a Croatian startup that developed a cloud-based software platform for data management and agricultural production performance optimized for dairy farmers. My Dairy Dashboard will provide data aggregation for the dairy farm industry, to help enhance production and streamline operations.

Elsewhere, companies are adapting drones to produce precise three-dimensional maps for soil analysis and to optimize irrigation and nitrogen-level management. Drones with thermal sensors are well suited to monitoring crop health and growth. And drone systems are also being developed for planting; they will be able to shoot pods containing seeds and nutrients into the soil, and to spray crops far more efficiently than current tractor-based methods.

Smart Equipment

The latest models of tractors, planters, harvesters, and other equipment from companies such as Case IH, John Deere, and Kubota feature monitors, sensors, and software that generate detailed data to help farmers manage their operations more efficiently. Manufacturers have also been developing sophisticated autonomous tractors and other vehicles over the last several years, and have prototypes in operation today.

Case IH, for example, unveiled an autonomous concept vehicle in 2016 — a tractor built with an interactive interface that allows remote monitoring of its programmed operations. These operations include automatically accounting for implement widths, and plotting the most efficient paths in a field depending on terrain and other machines in use in the same field. Such vehicles can operate around the clock, and can provide the farmer with predictive information on maintenance needs.

Equipment manufacturers and third-party vendors are also offering software and GPS packages that can track and map an agricultural producer's mechanized equipment. This enables farmers to monitor their machines on a tablet or smartphone and direct them to where they are needed — when, for example, a storm is coming — as well as to reroute support vehicles carrying fuel, seed, and fertilizer. Similar tracking software is also available for livestock. Collars or tags placed on the animals can send data to farmers and ranchers on livestock location, health, and mating patterns.

Other companies are developing innovative technologies for offshore aquaculture operations that can grow and harvest different varieties of seafood, including smart floating farms and submersible cages that can be located near cities or out at sea. Ocean Farming, for example, a subsidiary of the Norwegian fish farming company SalMar, is adapting deepwater petroleum technology to develop offshore salmon farms that would anchor steel cages floating below the surface to the ocean floor and would adapt to the motion of waves and currents. The company estimates these could be eight times as productive as traditional inshore fish farms.

A Sustainable Focus

In recent decades, many innovations in sustainability have focused on irrigation. T-L Irrigation, for example, introduced a new system for arid farming areas in 2014. Drip hoses, spaced a few feet apart, apply water directly to crops, minimizing evaporation, and can reach water efficiency levels of 95 percent. Water use could be cut in half and yields could be increased by 10 percent or more by adding sensors to this type of irrigation equipment.

Access to fresh water is another priority, especially in arid climates. In 2012, the World Bank reported that 14 of the 20 most water-scarce countries in the world were located in the Middle East and North Africa (MENA) region. Desalination currently plays a critical role in supplying water to the populations of MENA countries, and will continue to do so as these populations grow. But traditional desalination plants consume intensive quantities of energy and resources. Many MENA countries are now investing in concentrating solar power (CSP) plants, which use large mirrors to generate the thermal energy required for desalination.

More and more players across the agricultural supply chain also hope to engender transparency and trust about their sustainability efforts. Land O'Lakes, a farmer-owned cooperative based in Minnesota, created a business unit named Sustain to align its sustainability efforts across its enterprise, which operates in all 50 U.S. states and more than 50 other countries. The program offers tracking, reporting, and aggregated results that enable farmers to communicate their sustainability record to their customers, and that enable retailers to document

and communicate the sustainability of their products to end consumers.

Feeding the World

Private-sector investment will continue to play a critical role in agricultural innovation. But the public sector will also need to increase its R&D spending, making investments in scientific research and supporting technologies.

Governments have another key role to play. They have the power to foster an attractive environment for corporate ventures focusing on agricultural innovation and to hasten and expand the proliferation of innovations into farms and fields, particularly in emerging markets, by eliminating barriers or creating incentives. For example, publicly funded agricultural extension efforts that disseminate knowledge about new technologies and that demonstrate their business case have been a key historical link between R&D and farmers and ranchers in high-income countries. Governments and supranational organizations should prioritize implementing such programs in low-income countries.

Governments can streamline regulation, which can reduce lag times. It is not unusual for the time between a successful R&D effort and the widespread adoption of a resulting agricultural innovation to be 15 to 25 years, and further lags can continue for decades. Governments can also provide targeted tax relief to enhance farmers' income and financial security, and offer preferential access to land and market support for promising agricultural techniques and technologies.

Finally, through the creation of public–private partnerships, governments can work with the private sector to make the most of public-sector investment, enhance private-sector involvement in agriculture infrastructure, and fill gaps in the delivery and adoption of innovation by public- and private-sector entities acting independently. The latter point underscores the complex nature of the food security challenge, and of its potential solutions. When it comes to feeding the world's people, we're all in it together. +

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