FRESH IDEAS ABOUT BUSINESS IN EMERGING MARKETS

EM Compass

Artificial Intelligence in Agribusiness is Growing in Emerging Markets

By Peter Cook and Felicity O'Neill

Business models utilizing artificial intelligence can help meet rising global demand for food and support a more inclusive and sustainable food system by: (1) enhancing the resilience of farming methods; (2) reducing the cost of quality inputs and services to underserved farmers; and (3) improving market access to facilitate smallholder farmer integration into regional and global supply chains. Although nascent in emerging economies, applications for artificial intelligence in agribusiness will proliferate as farmers' access to the Internet and adoption of smart devices increases across low-income countries.

Meeting the food and agriculture related Sustainable Development Goals (SDGs) in a sustainable and inclusive manner is daunting. Progress toward these SDGs over the past decade has been hampered by an increase in global hunger, with 820 million people hungry today.[1] The challenge is to make food systems more efficient to meet the needs of the one-in-ten people who suffer from chronic hunger,[2] to meet the projected doubling of global food demand by 2050 (from 2009),[3] and to sustainably adjust to increased demand for animal-based products.[4] Yet current production practices in many food systems result in up to a third of food being wasted. Private sector investment is critical to addressing these pain points, with UNCTAD estimating that the food and agriculture SDG investment gap is almost $200 billion per year, through 2030.[5]

Investing in new technologies will be critical to meeting these challenges to agriculture. The term "agtech" describes the application of technology—especially software and connected hardware—to the agriculture value chain. Agtech innovations have significant development potential,

as they can help farmers use scarce resources such as water, and external inputs like agrichemicals, more efficiently, effectively, and sparingly. Agtech can also help farmers access the more advanced inputs they need to increase output, such as machinery and finance, and allow them to trace the origin and quality of their produce.

In recent years, artificial intelligence (AI) technologies—including machine learning, natural language processing, robotics, and computer vision—have been incorporated into agtech business models. Applications of AI—for use in alternative credit scoring or 'smart' farm equipment, for example—have the potential to reduce the cost of serving smallholder farmers across the agriculture ecosystem, improve the efficient and sustainable use of resources, and overcome market asymmetries that prevent farmers from accessing regional and global value chains. The use of AI technologies has become commercially feasible for agtech in recent years through advances in big-data analytics, increased computing power, and cloud-based storage, as well as cost reductions in satellite imagery, remote sensors,

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and other hardware (including smart phones), and the increased affordability and availability of mobile connectivity.

Despite these advantages, there are barriers to replicating and scaling AI technology, particularly in emerging markets. First, smallholder farmers often lack the skills and capital needed to utilize new technologies. Second, there are gaps in the agronomic data needed to teach AI systems, particularly given the diversity of farmland and crop varietals. Third, there are limits to the adoption of AI technology in markets where IT infrastructure is inadequate or the infrastructure needed to connect farmers to supply chains—including roads, cold storage, and freight capacity—suffers from underinvestment. Yet the potential of AI to help meet the critical challenges of hunger and climate change creates a clear incentive for development finance institutions (DFIs) such as IFC to invest in demonstrating the feasibility of these technologies in emerging markets.

FIGURE 1 Global Agtech VC Deals ($M) by Investor HQ

Source: Finistere Ventures, 2018 using Pitchbook data as of 31 October 2018.

What is AI?

AI is the science and engineering of making machines intelligent, especially intelligent computer programs (see EM Compass Note 69).[6] AI is, therefore, a series of approaches, methods, and technologies that display intelligent behavior by analyzing their environments and taking actions—with some degree of autonomy—to achieve specific objectives.[7] AI techniques have seen rapid progress over the past decade, supported by an evolution in machine learning, improvements in computing power and data storage,[8] and upgraded energy and communications infrastructure.

The use of AI in agriculture is nascent but expanding

As the distribution of venture capital into AI technologies closely tracks total venture capital flows, the latter can be used as a proxy for interest in AI (see EM Compass Note 71). Venture capital flows to agtech firms have increased rapidly in the past five years, with the majority received by firms headquartered in the United States (Figure 1). Agtech firms using AI make up a growing share of these flows, receiving $6.7 billion in venture capital flows over the past five years, including $1.9 billion in 2018 alone.[9] These flows illustrate that the feasibility of using AI in agtech has been demonstrated.
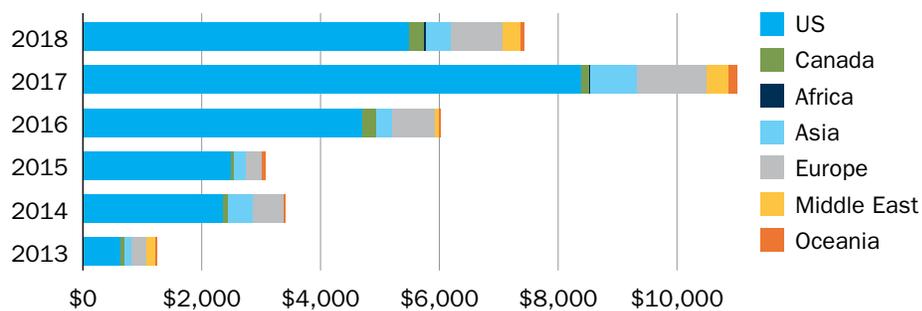
Although nascent, investors are showing interest in directing funds to emerging market businesses that use AI. China has seen around 200 agtech venture capital deals, and the number of deals in India and Brazil is growing.[10] In Asia and Africa, where smallholder farmers dominate the agricultural sector, agtech startups are focused on connecting farmers to larger buyers or cooperatives. Alternatively, markets like Brazil, where there are a number of significant larger holdings, are seeing more startups focused on precision farming.

AI technologies can improve food system performance

Improvements in the productivity and sustainability of the global agricultural system, as well as higher returns on investment for farmers, are critical to meeting the SDGs. In emerging markets, losses of food take place throughout the production, post-harvest handling, storage, and processing stages. The U.N.'s Food and Agriculture Organization estimates that annual food losses that occur from farm to fork are as much as one-third of annual global food production, or about 1.3 billion tons.[11] In addition, emerging market agriculture sectors suffer from low total factor productivity growth, as the main contributors to productivity in low-income countries since the 1960s have been increased agricultural inputs and land use (Figure 2). Currently, the yield gap—the difference between a crop's potential yield and actual yield—exceeds 50 percent in most low-income countries, and 76 percent in Sub-Saharan Africa.[12]

Another critical development challenge is that agriculture both contributes to and will be fundamentally affected by climate change. Land use, including agricultural practices, deforestation for arable land, and the forestry industry, account for 28 percent of net greenhouse gas emissions, while climate change affects the availability of, access to, and stability of the global food system.[13] The challenge
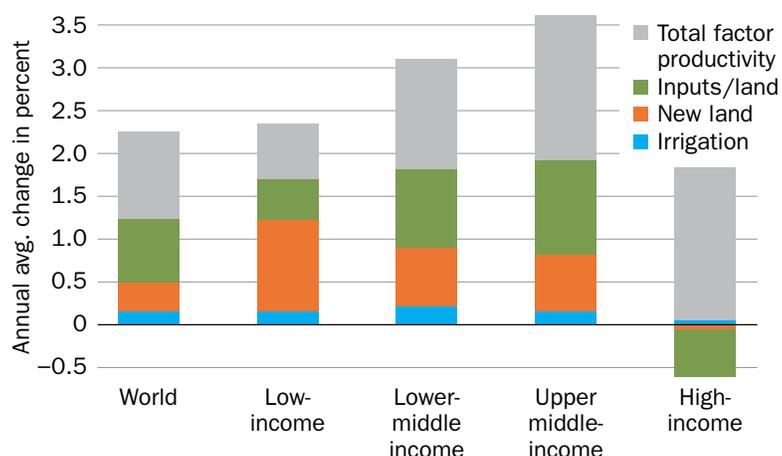
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FIGURE 2 Sources of Productivity Growth in Agriculture, 1961–2010

Source: Fuglie and Wang. 2012.

in meeting food demand and transporting food across markets sustainably cannot be solved through business-as-usual farming practices.

The adoption and diffusion of AI technology and precision agriculture into agtech business models holds promise for addressing these challenges (Table 1). For instance, AI applications in financial services, knowledge, and capital can help improve the cost efficiency of agribusinesses by using inputs "intelligently" and increasing the quality of outputs. AI applications also hold promise for improving the sustainability of farming practices by reducing fertilizer and pesticide use, enhancing the accuracy of pest and disease detection, and facilitating the automated grading of crops. Additionally, combining data on soil characteristics, weather, and other climactic factors and interpreting them through machine learning software helps planting, the management of farm operations, and harvesting. And AI technology can help enhance the transparency of global food supply chains, minimize food loss, and facilitate the monitoring of food quality standards.

AI technologies are transforming agtech business models

Extending products and services to underserved farmers. Farmers need access to credit and insurance to expand their businesses and manage risk, and to enhance the resilience of their operations. Many emerging market farmers lack access to affordable financial products because of the significant time and cost required to price their risk and collateral, as well as the difficulty of serving farmers in rural and remote areas. Technological advancements in satellite weather data collection and the wider adoption of mobile technology has dramatically reduced these costs, facilitating the extension of financial products to farmers in emerging economies.[14] Machine learning platforms are increasingly being employed by lenders to generate credit scores or price new products to help farmers access the microloans and insurance needed to upgrade their inputs to production, and this includes farmers without traditional collateral or bank accounts. In general, these platforms allow farmers to upload photos of crops and pests or disease, which are processed alongside satellite, geospatial, and other data sources, to estimate a farmer's collateral and/or to make estimates of the farmer's individual financial health and creditworthiness.

Decision support	On-farm analytical support and software for farm operations
Marketplaces	Online markets for purchasing farming inputs & for selling crops
Logistics & infrastructure	Digital management and optimization of farm produce to markets
Financial services	Credit scoring facilitating lending and insurance for farmers
Livestock solutions	Traceability, increased yield, management of nutrition, disease and breeding
Irrigation & water tech	Low-cost 'smart' irrigation through integrated sensor data
Robotics & Equipment	Using satellite and weather data and computer vision to optimize deployment of agrichemicals

TABLE 1 Applications of AI Technologies in Emerging Markets

Source: IFC.

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For example, financial services providers can leverage a greater number of new and existing data points to price new insurance contracts and potentially trigger a payout for a predefined event such as below-average rainfall.[15] Precision agriculture, alongside machine learning, has the potential to reduce agricultural insurance premiums by defining risks and improving risk assessment tools, and allows farms to move more quickly to prevent crop losses. WorldCover is an early example of an intermediary helping to connect farmers with insurance products. WorldCover uses AI to assess satellite, weather station, and agronomic data to determine the risk of weather events, and is working on smart contracts that use blockchain to trigger automatic payouts.[16] The automatic disbursement of payouts via nonbank payments providers like M-Pesa allows farmers without bank accounts to obtain insurance. Such automatic payouts through nonbank providers reduces the frictions involved with farmers adopting financial products like crop insurance, which they need to enhance their resilience to climate shocks.

Farmers in emerging markets often also lack timely, reliable, and sufficiently granular weather, pest, and market data to choose an appropriate crop to sow, and to realize the yields needed to service existing loans. Platforms using machine learning algorithms assess farm-level data against publicly available data sources to generate real-time business analytics that help farmers manage production risk, increase the effective use of inputs to generate cost savings, and optimize planting and harvest times to increase yields and farm-gate prices. The algorithm is refined as data is added through each crop cycle to improve the accuracy of farm-management recommendations.

In India, for example, B2B platform CropIn allows agri-businesses to upload unstructured data into a smartphone app (farmer information on planting, varietals used, photos of crops). Machine learning algorithms can combine unstructured data with a range of other data sources to generate real-time advice on risk management, sales, warehousing, and sustainable farm practices. The app can be used offline with analytics applied once the device is connected again. Data from the app can also be used to generate credit risk assessments for access to finance, and for farm-to-fork traceability and quality control for access to global value chains.[17] CropIn's weather algorithms currently provide course correction advisory services for 5,000 farmers' plots.

Increasing market access through the reduction of trade frictions and facilitated adoption of new technologies will help smallholder famers integrate into regional and global supply chains. In emerging markets, agricultural supply chains are often inefficient or incomplete, with many smallholder farmers excluded from regional markets due to complex regulatory arrangements, outsized market power of commission agents, a lack of access to quality inputs, and a lack of knowledge of available markets, prices, and standards.

AI can help address these market failures by improving traceability to prove the origin and quality of produce, which is needed to secure supply contracts and access markets. For example, Stellapps has developed a digital platform that collects data on cows and food safety and cooling equipment owned by small farmers in India; it uses the data to generate recommendations for the farmer on actions that will improve nutrition, growth, and milk production. The company also digitalizes the milk procurement process, including volume and quality measures, which can be done reliably onsite with Stellapps equipment. Stellapps monitors dairies' chillers to provide assurance that quality is maintained throughout the supply chain. Ultimately, dairies can provide traceability in their supply chain and access premium milk markets. The company enhances the value of these data monitoring applications through its machine learning algorithm to assign each farmer a credit score, or 'mooScore,' based on their personal data and cow data (health, nutrition, fraud proofing), which allows lenders to expand their financing of farmers. Stellapps' business model has been designed to scale, with the SmartMoo suite of apps currently touching over two billion liters of milk annually.[18]

AI-enabled platforms also give smallholder farmers the information they need to connect directly to buyers of their produce, reducing food waste and increasing farm income. IFC and TLcom Capital Partners invested $10 million in Kenyan company Twiga Foods in 2018. In 2019 the company raised an additional $30 million in a round led by Goldman Sachs. Twiga's platform aggregates market participants, facilitating a more efficient matching of buyers and sellers in Africa's large but fragmented fruit and vegetable market.[19] For farmers, the platform enables access to a fairly-priced, transparent, mobile marketplace. For vendors, the benefit is increased reliability in sourcing high-quality produce. Twiga's system has reduced post-harvest losses to 5 percent, compared to 30 percent in informal markets where farmers typically sell produce. Twiga is now increasing the value of its platform for users by integrating AI to expand its service offering, recently partnering with IBM to design a machine learning algorithm to provide small-scale vendors with a credit score to disburse loans. Through an eight-week pilot, more than 220 loans were processed with an average size of around $30, which allowed vendors to increase the size of the orders they

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handled by 30 percent and increased profits for each retailer by 6 percent, on average.[20]

Another example of how AI can help make the food and agricultural supply chain more transparent and efficient, as well as reduce food waste, is Indian company Intello Labs, which is digitalizing the process of grading and tracking the quality of agricultural produce. Intello Labs' technology system uses deep AI algorithms (convolutional neural networks) to identify produce defects and track the movement of produce across the supply chain. The company's data-driven system has been designed to improve customer-level quality of produce, reduce food loss along the supply chain, and achieve better prices for producers by removing human subjectivity from the grading process and moving that process further upstream and closer to the farmer. The company has also designed the system for implementation across delivery modes—mobile applications, fixed cameras on the processing line, cloud or edge computing—so that it is cost effective and can be scaled. Intello Labs is currently trialing their system with a few companies in India and the United States.

Enhancing the sustainability of agricultural farming methods. There are also a number of ways that businesses are using AI to improve agricultural sustainability, both in terms of environmental impact and return on investment at the farm gate.

First, AI can improve on-farm management of pests and diseases. Cameroon-based start-up Agrix Tech has developed an application that helps farmers with low levels of literacy manage these issues. Farmers can upload photos of infected crops on their phones. Machine learning and translation technology is then applied to the images to provide pest and disease management advice in the local dialect. Importantly, the app can be used offline, as the AI-technology does not require Internet connectivity, which is limited in parts of rural Cameroon.[21]

Second, applications using AI allow farmers to access more advanced or 'smart' machinery, which helps optimize the use of capital inputs. Hello Tractor operates in Nigeria, Kenya, Mozambique, Bangladesh, and Pakistan, offering tractor services between farmers so that owners of compact tractors can maximize their investment. The platform takes on the risk of payment, delivery, and asset security, creating an additional income stream for farmers.[22] The business recently partnered with IBM to use machine learning to help farmers predict crop yields that, combined with advanced analytics and blockchain technology, can be mined to develop a credit score for loans. Forecasted weather data from The Weather Company, an IBM

business, remote sensing data (e.g., satellite), and IoT data from tractors will also be incorporated into the app to help smallholder farmers know when to cultivate, the quality of their farm cultivation, what to plant, and the appropriate fertilizer using remote sensing and IoT data.[23] If successful on a large scale, applications like Hello Tractor could help farmers simultaneously access the equipment and knowledge needed to improve the efficiency of their farming practices and may facilitate the expansion of their area under cultivation.

Third, digital technologies including AI are being leveraged for so-called precision farming, in which intelligence from both farmers and public data sources is assessed by algorithms in order to use inputs to production— water, land, pesticides, fertilizer, and nutrition—more effectively and increase the farmer's return on investment. Intelinair is an American agtech business that gathers high-resolution aerial images, temperature readings, humidity measurements, rainfall, soil samples, terrain type, equipment utilized, planting rates, applications, and other datapoints, and applies hyperspectral analysis, computer vision, and deep learning to identify patterns and build a complete and precise situational representation of every monitored field for the entire growing season. As the machine learning system trains on new data, it becomes stronger, smarter, and more effective. The system can, for instance, identify abnormal crop conditions before the human eye can detect them. The intelligence generated by the system is delivered to farmers via smart alerts that allow them to make proactive, real-time decisions in their fields.[24] Minimizing the cost of inputs should improve the sustainability and resilience of farm-gate returns.

Although precision agriculture is dominant in higher-income economies like the United States, there are new applications by agtech businesses in emerging markets with large-scale production systems. For example, Agrosmart is a Brazilian company offering its technology platform to farmers in Latin America, the United States, and Israel. Agrosmart consolidates millions of data-points from field sensors and satellites, and applies machine learning and other AI technologies to improve farming performance, reduce environmental impact, and deliver intelligence across the agriculture value chain (Figure 3). The company offers several packages of services to producers of various sizes for an annual subscription fee. Each package delivers different information to the client, such as weather forecast, irrigation advice, and soil conditions. The system also eliminates the need for Internet or cellular coverage in the field to send the data to the Internet.[25] With the insights provided, producers can become more efficient, reducing

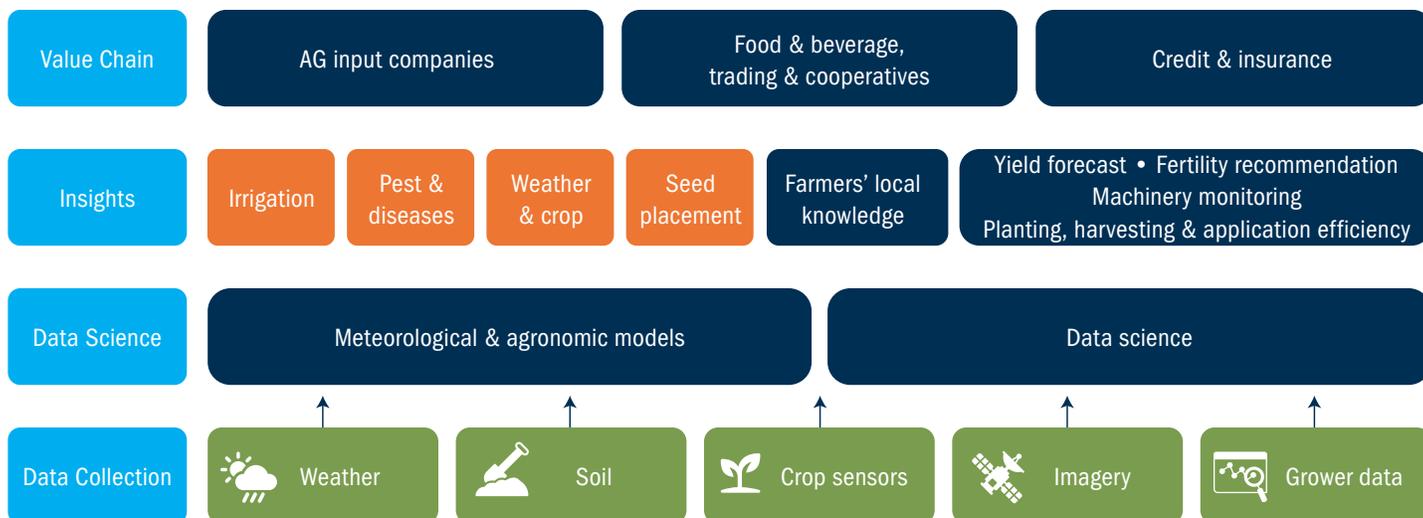IFC | International Finance Corporation | WORLD BANK GROUP

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How the Platform Works

| Value Chain | AG input companies | Food & beverage, trading & cooperatives | Credit & insurance |

| Insights | Irrigation | Pest & diseases | Weather & crop | Seed placement | Farmers' local knowledge | Yield forecast • Fertility recommendation / Machinery monitoring / Planting, harvesting & application efficiency |

| Data Science | Meteorological & agronomic models | Data science |

| Data Collection | Weather | Soil | Crop sensors | Imagery | Grower data |

FIGURE 3 Agrosmart's Data-Driven Insights

Source: Agrosmart.

labor time and water and energy consumption, while increasing yield. Users also benefit from a connected and monitorable supply chain.

Precision farming is now being extended, from applications that provide insights and information to farmers, to on-farm robotics equipment that acts autonomously. For example, India-based robotics company TartanSense is building a semiautonomous rover to traverse cotton farms with a downward facing camera capturing images of plants and weeds. When AI algorithms running on the system detect weeds, the rover automatically sprays them with agrichemicals through precision nozzles.[26] This can increase farm income by reducing labor required to pull weeds. It can also minimize chemical residue levels from broadcast spraying in the soil and reduce health risks to operators—traditionally women—from residue from traditional spraying methods. AI-enabled applications like TartanSense's spraying system are increasingly being trialed and rolled out in conjunction with pest and disease detection, pruning, harvesting, and crop grading.

Challenges in scaling AI across emerging markets

The focus of AI technology today is on larger farming operations with the aim of reducing input costs. Yet there are technical difficulties in building reliable AI systems that can be applied across different terrains. On-farm conditions are continuously changing, even across the same plot. For example, different crops vary in their physical characteristics due to differences in rainfall or soil quality

(among other factors), which makes it difficult for machine learning systems to identify and provide actionable advice, even for the same crops.[27] Additionally, the seasonality of the agricultural sector increases the time needed for machine learning algorithms to learn and prove their value, creating a time-lag to replication. Adoption will therefore be slow until the return-on-investment for applications using AI is proven in each market context.

At the smallholder level, agtech companies need to understand the needs, capacity, and constraints of emerging market smallholders in order to design and distribute appropriate solutions. This requires stakeholders like government, agtech companies, and other capacity building institutions to undertake hands-on training in the use of digital technology with farmers across emerging markets so that they are equipped to use AI applications as they become more cost-effective.

Barriers to adoption exist beyond the technology itself, with challenges in data supply, data use, and a lack of enabling infrastructure. Like companies in other industries that compile large data sets, agtech companies are increasingly ensuring that their data security practices and systems are ISO 27001 and EU Global Data Protection Regulation (GDPR) compliant, with supporting policies and data recovery plans in place. Empowerment of farmers who provide the data that the technology depends on is also critical and begins with obtaining the informed consent of farmers to collect their data, including any third-party use arrangements. Additionally, farmers

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cannot realize the benefits of digital technologies without improvements in complementary infrastructure, including the telecommunications, transport, and irrigation required to support AI innovations.

DFI's have a role to play in supporting agtech businesses

AI applications have yet to penetrate the poorest frontier countries. Agtech is now at an inflection point, however, with venture capital flows increasing to emerging markets in recent years. The cost of enabling technologies continues to fall, which allows scalable product and service companies to be built. This cycle leads to product adoption and further capital flows. DFIs like IFC have a role in demonstrating the feasibility of AI use in agtech to catalyze these flows, as well as in addressing enabling barriers such as farmer training.

IFC invests in and provides advisory support across the agribusiness supply chain—from farm to retail—to help boost production, increase liquidity, improve logistics and distribution, and expand access to credit for small farmers. Since 2014, IFC has invested over $60 million in agtech-related companies and has made more than 10 indirect agtech investments through accelerators, seed funds, and venture capital funds. Agtech is increasingly becoming a centerpiece of IFC's Manufacturing, Agribusiness & Services (MAS) advisory work with IFC clients. That includes supporting clients to deploy and effectively use farmer information service tools like CropIn and Farm Force that leverage local weather monitoring stations and unaccompanied aerial vehicles (UAVs) to capture appropriate spatial and temporal data. Application of these tools at various nodes in a client's production and distribution chains enables improved decision making, increased access to inputs, finance and markets, and improved visibility of production across the chain.

IFC is also working to reduce barriers companies face in adopting agricultural technologies.[28] In 2018, IFC held its inaugural Global Agribusiness Conference in Amsterdam, which focused on the challenges faced by smallholder farmers, as well as solutions to promote sustainable development, reflecting the need to ensure all stakeholders benefit as value chains become increasingly complex and global. The conference brought together companies whose supply chains rely on smallholder farmers, organizations offering products and services, investors, donors, and government officials from around the globe.

In addition, IFC and the World Bank held the first Digital Disruption in Agriculture Forum in Addis Ababa in May 2019. The purpose of the Forum was to help identify digital tools and service providers that can benefit the mainly smallholder farmers in Ethiopia, helping professionalize agribusiness and improve livelihoods. The use of digital technologies in agriculture remains limited in many low-income countries, and conferences like these provide an opportunity for learning, networking, and knowledge sharing that can help identify promising digital products and services to improve smallholder agriculture practices and yields. Building on interest in the first digital forum, IFC and the World Bank arranged a second forum in Ethiopia, scheduled for April 2020. This conference has been postponed due to the outbreak of coronavirus and will be held later this year.

Conclusion

Agribusinesses are leveraging AI to create new cost-effective business models and to provide the information they need to reach small farmers in emerging markets. Agtech firms using AI—for now mostly with large-scale farmers—have just begun to demonstrate their viability and are looking to scale their innovations. With growing deal activity and size, there will be plenty of opportunities for private sector investors to mobilize their capital toward meeting the agriculture-related SDGs. However, governments, investors, and industry will need to collaborate in addressing data, infrastructure, and human capital gaps before commercial AI integration is feasible at a larger scale.

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Please see the following additional reports and EM Compass Notes about the role of technology and AI in emerging markets:

Accelerating Digital Connectivity Through Infrastructure Sharing (Note 79, February 2020); *Artificial Intelligence and the Future for Smart Homes* (Note 78, February 2020); *Artificial Intelligence and 5G Mobile Technology Can Drive Investment Opportunities in Emerging Markets* (Note 76, December 2019); *How Artificial Intelligence is Making Transport Safer, Cleaner, More Reliable and Efficient in Emerging Markets* (Note 75, November 2019); *Artificial Intelligence: Investment Trends and Selected Industry Uses* (Note 71, September 2019), *The Role of Artificial Intelligence in Supporting Development in Emerging Markets* (Note 69, July 2019); *Disruptive Innovation in Agribusiness* (Chapter 8 in report *Reinventing Business Through Disruptive - Sector Trends and Investment Opportunities for Firms in Emerging Markets,* March 2019); *From Farm to Fork: Private Enterprise Can Reduce Food Loss Through Climate-Smart Agriculture* (Note 49, October, 2017); *Precision Farming Enables Climate-Smart Agribusiness* (Note 48, October 2017).

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[28] Further information on Bank agribusiness initiatives can be found at https://www.worldbank.org/en/topic/agribusiness.

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