

## SEVEN

# How AgriTech Is Transforming Traditional Agriculture in Emerging Markets

*“Think Big, Act Fast, Start Small”*

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**A**griculture is a significant contributor to the economic growth of most developing economies. It provides food security, reduces poverty, and generates a significant portion of employment. As of 2018, agriculture accounted for more than 25 percent of GDP in developing countries, and it is estimated that 65 percent of the poor working adults depend on agriculture for their livelihoods.<sup>1</sup> Agriculture also plays an essential role in driving job creation, and it is one of the most important sources of employment in low- and middle-income countries. In the ASEAN region, the agriculture sector contributes to about 35 percent of the region’s employment, of which 60 percent are small-holder farmers.<sup>2</sup> Women hold important roles in all parts of agriculture value chains, and account for nearly half of the world’s smallholder farmers. Equally important, agriculture will be critical to eliminating extreme poverty, and recent evidence shows that a 1 percent increase in agriculture GDP reduces poverty, on average, by more than 1 percent—this is especially true in the poorest countries.<sup>3</sup>

However, the agriculture sector in emerging markets continues to rely on tools

1. See World Bank website “Agriculture and Food,” [www.worldbank.org/en/topic/agriculture/overview](http://www.worldbank.org/en/topic/agriculture/overview).

2. PwC and FIA, p. 3.

3. Christiaensen and Martin.

and methods from the nineteenth century. The sector remains largely underdeveloped due to numerous challenges and constraints faced by smallholder farmers, such as high labor-intensity with limited access to modern equipment; lack of access to data; lack of access to markets, which leaves farmers highly dependent on intermediaries; limited access to formal finance due to lack of collateral to secure financing and lack of data to appropriately assess their credit risk; limited or no interest from young generations to become farmers, due to low income levels; and extreme weather events due to climate change, which affects crop productivity. Female smallholder farmers experience additional challenges, such as laws in many emerging-market countries that discriminate against women, limiting their land and property rights,<sup>4</sup> as well as lack of access to training, information, and market services, compared to male smallholder farmers. The FAO declared that eliminating the gender gap in agriculture would increase production in emerging markets by 2.5 percent to 4 percent.<sup>5</sup>

The COVID-19 pandemic has added to the challenges by significantly affecting the supply and demand factors of the agriculture value chain and exacerbating the issues related to the lack of food security and increasing poverty levels. Labor shortages at firms, logistics disruptions of food, and input supply chains have constrained the availability and access to food for consumers, and in some situations, have also led to local shortages and price hikes.<sup>6</sup> The U.N. World Food Programme has warned that an additional 130 million people could face acute food insecurity by the end of 2020, on top of the 135 million people who were already under severe threat of hunger before the crisis, because of income and remittance losses.<sup>7</sup> On the demand side, the pandemic is reinforcing changing consumer habits toward convenience and safety, increasing the reliance of packaged foods and e-commerce for a more direct sourcing and delivery of food.

Against this backdrop, there is potential for a breakthrough in how food crops are produced and marketed, which can dramatically improve living standards of producers and food nutrition value for consumers. The pandemic has accelerated the adoption of digital technologies and innovative solutions across all sectors, giving rise to new AgriTech models. Governments around the world are prioritizing needed investments in internet connectivity, and consumers are increasingly adopting digital payments and the use of e-commerce to shop for goods and services, including in emerging markets. The readiness of digital technologies is a key catalyst in the transformation of the agriculture sector. It enables the emergence of new business models to solve the main constraints and barriers in

4. Abass.

5. Agung.

6. PwC and FIA, p. 6.

7. Anthem.

a low-cost and efficient manner, which results in higher food productivity, food security, and financial inclusion. Innovations such as biotechnology, Internet of Things (IoT), e-commerce, precision farming, and climate-smart agriculture have demonstrated great potential to improve the sector's overall sustainability and resilience to external shocks, as well as to reduce food loss and waste (FLW) and greenhouse gases (GHG).

The combination of a broad range of old-tech and new-tech solutions in agriculture is creating a new mindset and dynamism in agriculture, a sector that has remained stagnant for a long time in emerging markets. These innovative methods and new business models can deliver significant benefits to smallholder farmers, encouraging young people to become farmers, providing a pathway to the formal economy and helping them become more resilient to the effects of climate change and the pandemic. Well-established old technologies, such as the mobile phone, are essential to connect farmers to information needed to manage their crops. In the past, reaching out to farmers was challenging, due to last-mile logistics from poor infrastructure and physical remoteness; the mobile phone has led to a paradigm shift, making it possible to reach smallholder farmers at scale. The pandemic has also underscored the critical role of the mobile phone, which has become the primary way most people access the internet. At the same time, new-tech business models, such as e-commerce platforms, can help smallholder farmers achieve higher income by connecting them directly to consumers' demands. These digital platforms provide farmers with higher price-transparency, match supply and demand, and increase farmers' access to market. The introduction of digital technologies also makes it possible to collect and track essential agricultural data, which can be used for the evaluation of farming conditions, and provides access to needed financing for smallholder farmers. To scale up these tech solutions in emerging markets, the responsible use of data and setting up partnerships between the public and private sector are essential.

Digital technologies in agriculture also play an important role in addressing five of the seventeen Sustainable Development Goals (SDGs), namely:

- No Poverty—by helping smallholder farmers increase crop yield and access to finance
- Zero Hunger—by improving crop yield and agriculture processes, which results in stronger food security
- Good Health and Well-Being—by focusing “smart” agriculture, a subset of agriculture technology, on food and nutrition quality
- Responsible Consumption and Production—by lowering costs in post-harvest, which reduces food wastage

- Climate Action—by helping reduce emissions and introduce sustainable farming techniques through innovations in climate smart agriculture

This chapter focuses on the themes of “think big, act fast, and start small.” The traditional agriculture sector, which represents a significant portion of global GDP and is the livelihood for the poor in emerging markets, is being dynamically transformed by the application of digital technologies and innovative business models that enable smallholder farmers to increase their productivity, efficiency, and competitiveness. The dynamism and transformation of the agriculture sector in emerging markets is quickly taking place through the emergence of agriculture technology—or AgriTech—startups. These small, young companies are developing innovative business models and using a wide variety of old and new technology solutions, similar to the way that fintech startups are transforming the financial services sector. In this chapter, we first look at how general-purpose technology innovations are being used in ways that benefit farmers and describe five new AgriTech business models that are being used to solve specific problems. We then highlight case studies of AgriTech companies and technology providers from different parts of the world, showcasing key innovations and lessons learned. Two critical components for the success of AgriTech solutions are (1) the effective and responsible use of data and analytics and (2) the establishment of partnerships between the public and private sector. Finally, we examine the possibilities for digital agriculture in Indonesia—where agriculture is a significant contributor of the economy, with approximately 27 million farmers or 30 percent of the workforce—as an example of how a breakthrough can be scaled up across an entire country.<sup>8</sup> Specifically, we focus on Indonesian AgriTech and highlight the key challenges they face in transforming the agriculture sector. We argue in favor of setting up an Agriculture Innovation Hub in Indonesia, which would consist of an agriculture data exchange platform designed with data governance and would bring together multiple stakeholders such as government agencies, technology providers, venture capital firms, and AgriTech startups. Ultimately, the combination of AgriTech business models, data and analytics, and public-private partnerships can help unlock the full potential of digital technologies in agriculture and create significant breakthroughs in achieving food security in emerging markets.

8. BPS-Statistics Indonesia, p. 22.

## Digital Technology Is Transforming the Agriculture Sector: “Think Big”




Key advances in technology are transforming the agriculture sector. These technologies are mitigating the main challenges farmers face and address the pain points of value chain actors in the agricultural last mile. Some of the key benefits of digital technology in agriculture are:

- *Elimination of information asymmetry* by increasing access to data to all stakeholders, which, in turn, increases transparency and results in effective communication among value-chain players at lower cost. More transparency can result in higher productivity and less food wastage
- *Lowering of operational and transaction costs* by using digital tools to reduce manual and paper processing or data entry errors
- *Improvement of crop yields* through the use of data analytics, artificial intelligence (AI), and machine learning (ML)
- *Improvement of access to markets* by connecting farmers directly to consumers, thereby eliminating the middlemen and resulting in better pricing for their produce and savings to consumers
- *Enabling of access to finance* by using alternative data to evaluate the credit-worthiness of farmers who did not have access to finance in the past
- *Increase in the ability to perform sustainable farming techniques* that ultimately help the environment

Table 7-1 provides a summary of the key technology innovations emerging in the agriculture sector, and the main benefits each of them offers. One of the most essential technology innovations is the mobile phone, which helps to connect farmers at the last mile, making it easier to share data and serve as the main distribution channel for vital information about crop prices and weather forecasts to manage their crops. Although many smallholder farmers in emerging markets lack electricity and modern farm equipment, the majority have a mobile phone, even in the poorest areas. Therefore, the mobile phone has made it possible to reach almost all smallholder farmers, which was difficult in the past due to poor infrastructure and remote locations. Moreover, the mobile phone has become a key tool to access financial products for smallholder farmers.

In many instances, technology innovations overlap each other, which makes them mutually reinforcing. For instance, IoT sensors are able to monitor and measure soil moisture in the field, which can then automatically send a signal to the robotic irrigation system to turn on when it is too dry. The data generated

**Table 7-1. Summary of Technology Innovations Serving as the Foundation for New Business Models in Agriculture**

Technology Innovation	Description	Potential Benefits to Farmers
 Biotechnology	<p>Wider range of tools, including traditional breeding techniques that alter living organisms, or parts of organisms, to make or modify products; improve plants or animals, or develop microorganisms for specific agriculture uses. Some examples include pest resistant crops, genetics, nutrient supplements, antibiotics, vaccines</p> <p>Designed to allow people to communicate wirelessly almost everywhere at all times and are transforming how individuals conduct business and interact socially. Mobile phones serve as a key distribution channel for information and financial services</p>	<p>Improved crop yields, reduced vulnerability to environmental issues, increased nutritional qualities of food crops and reduced dependence on fertilizers</p>
 Mobile Phones	<p>Refers to the different ways to connect to the Internet – mobile phones, tablets, Internet of Things (IoT) or computers. Also includes the latest connectivity standards such as 5G.</p> <p>Refers to the analysis of exponential amount of structured and unstructured data by using different techniques / methods such as AI and ML. AI refers to the analysis of data to model some aspect of the world by using computers and models that learn from the data in order to respond intelligently to new data and adapt their outputs accordingly</p>	<p>Allow farmers to gain access to vital information about prices of crops and instant weather information to properly manage crops. They also serve as the main distribution channel for financial products such as loans, insurance, savings and a means to make payments</p> <p>Brings new information resources and can open new communication channels for rural communities. Other benefits include increased efficiency, less duplication of activities, and global access to information</p>
 Internet / Connectivity	<p>Refers to the analysis of exponential amount of structured and unstructured data by using different techniques / methods such as AI and ML. AI refers to the analysis of data to model some aspect of the world by using computers and models that learn from the data in order to respond intelligently to new data and adapt their outputs accordingly</p>	<p>Enables farmers to manage key resources including seed and fertilizers, while increasing productivity. The tremendous amount of data generated can also be used with AI / ML techniques to make informed decisions and predictions.</p>
 Data Analytics & AI / ML	<p>Refers to the global network of billions of internet-enabled devices and machines that are connected to the internet, collecting, generating and sharing data. IoT sensors are used to monitor different characteristics in the field such as soil moisture, rainfall, and other aspects of the production cycle</p>	<p>Introduces efficiency, precision and automation at various stages of the agriculture production cycle. IoT also enables the creation of real-time monitoring systems, which allows farmers to quickly respond to any significant changes in weather, light, humidity, as well as the health of each crop or soil in the field. IoT sensors and devices generate data that can help farmers make well informed decisions related to the crops' growth</p>
 IoT Software & Hardware	<p>Refers to the use of drones, satellite imaging, robots and other machines that help automate and improve the farming process such as weed control, harvesting and picking, sensing, imaging and monitoring of fields and sorting and packing</p>	<p>Robots automate slow, repetitive tasks for farmers, allowing them to focus more on improving overall production yields</p>
 Automation	<p>Blockchain, a form of distributed ledger technology (DLT), is a decentralized, distributed digital ledger that records ownership and transactions across a network of computers and relies on consensus algorithms and cryptographic methods to add transactions to the ledger in sequential, time-stamped immutable blocks.</p>	<p>Can be used to improve the traceability of crops across the agriculture supply chain, thereby providing transparency throughout the process and potentially reducing transaction costs. Blockchain / DLT promises increased efficiencies through enhanced data management, lower transaction costs, optimized logistics, and enhanced food safety protocols</p>
 Blockchain / DLT		

Source: Author.

from these IoT sensors can be analyzed by using AI/ML to ultimately develop a predictive tool for watering the field. The strong complementarities between these various innovations reinforce their disruption potential.

Digital technologies are affecting all stakeholders in the agriculture value chain, generating direct and indirect benefits. Table 7-2 shows suppliers benefit from biotechnology solutions that improve seed quality, while farmers are able to increase production yield and improve product quality, which leads to higher incomes. The food processors, in turn, will see improved product quality from the farmers and have reduced wastage. The distributors can experience improved linkages and less complexity along the farmer's value chain, while retailers and consumers will benefit from higher food quality and safety, improved food traceability, and faster time to market from the farms. In addition to the stakeholder impacts, there are economic impacts, such as economies of scale and greater efficiencies. Finally, technology innovations can better monitor deforestation and reduce GHG emissions.

## **The Rapid Emergence of Agriculture Technology (AgriTech) Business Models: "Act Fast"**

Agriculture technology, or AgriTech, holds the promise to revolutionize farming quickly, especially for smallholder farmers in emerging markets. There are five main AgriTech business models that have emerged to address the numerous challenges that smallholder farmers face in the region. Table 7-3 provides an overview of each model, key technologies used, and their value proposition to farmers.<sup>9</sup> Examples of the different business models are discussed in more detail through three case studies from different parts of the world.

Southeast Asia, a region that is home to more than 70 million smallholder farmers, is an example of the rapid growth of AgriTech startups in the developing world. The majority of people own a mobile phone, with an estimated mobile phone penetration rate of 135 percent.<sup>10</sup> In addition, the population is becoming more connected to the internet, with more than 65 percent penetration, and 90 percent of the total internet users are using smartphones.<sup>11</sup> The AgriTech landscape features more than 130 different companies. Farm advisory AgriTech companies are the largest group, representing more than 40 percent of the total, followed by digital marketplace and traceability AgriTech startups.<sup>12</sup> Indonesia







9. Grow Asia, p. 5.

10. This phenomenon may be due to the fact that mobile penetration is counted by the number of SIM cards, and some individuals may own multiple SIM cards.

11. Grow Asia, p. 2.

12. Ibid., p. 11.






Table 7-2. The Role of Digital Technologies in the Agriculture Value Chain

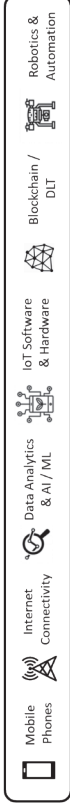
	Suppliers 	Farmers 	Processors 	Distributors 	Retailers 	Consumers 
<b>Stakeholder-Level Impacts</b>	<ul style="list-style-type: none"> <li>• Biotech solutions improve seed quality</li> <li>• Increased access to finance and insurance</li> </ul>	<ul style="list-style-type: none"> <li>• Better yield and quality</li> <li>• Less intense use of water and land</li> <li>• Optimal farm inputs and less wastage</li> <li>• Digital platforms for credit, payments</li> </ul>	<ul style="list-style-type: none"> <li>• Improved produce quality</li> <li>• Reduced wastage</li> <li>• Better anticipation of inputs</li> </ul>	<ul style="list-style-type: none"> <li>• Decreasing complexity in value chain</li> <li>• Improved traceability and produce quality</li> </ul>	<ul style="list-style-type: none"> <li>• Higher quality and safety of food</li> <li>• Stronger linkages with supply chain</li> </ul>	<ul style="list-style-type: none"> <li>• Improved food traceability</li> <li>• Better digital literacy and knowledge base</li> </ul>
<b>Economy-Level Impacts</b>	<ul style="list-style-type: none"> <li>• Reallocation of labor from farms to more productive sectors downstream</li> <li>• Stronger linkages along the value chain and increased potential for value addition</li> <li>• Economies of scale and greater efficiencies</li> </ul>					
<b>Environmental Impacts</b>	<ul style="list-style-type: none"> <li>• Reduced use and better management of water and land; lower use of fertilizer and pesticide, and reduced pollution</li> <li>• Smaller CO2 footprint of agriculture and reduced GHG emissions</li> <li>• Better monitoring of deforestation</li> </ul>					
<b>Equity through Inclusive Markets</b>	<ul style="list-style-type: none"> <li>• Spillover effects from increased agribusiness competitiveness</li> <li>• Stronger farmer and processor integration into regional and global value chain, including through inclusion of smallholders</li> <li>• Dissemination and adoption of more sustainable farming practices and improved resilience to shocks</li> </ul>					

Source: World Bank Group.



Table 7-3. Summary of AgriTech Business Models

Business Model	Key Technologies Used	Description	Key Challenges / Problems Addressed	Examples (Case Studies)
Farmer Advisory		Provide advice and information to farmers such as agricultural best practices, market prices, weather forecast through mobile phones / internet. By using mobile phones as a productivity tool, smallholder farmers can enhance their knowledge and skills, improve yields and income	Lack access to information	Twiga Foods (Kenya) Pinduoduo (China)
Peer-to-Peer Lending		Peer-to-peer (P2P) lending platforms serve as intermediaries bringing farmers which need capital to finance inputs and working capital with investors/lenders which want to invest. Loans are mainly done through mobile devices using alternative data such as mobile phone call data records and others to evaluate the credit risk of farmers	Lack access to financial services	TaniHub Group (Indonesia)
Traceability		First mile data collection using IoT sensors and blockchain / DLT to enable traceability of food across the supply chain. Traceability is important since it allows non-compliant (unsafe or off-specification) shipments to be traced back to their source, which can provide incentives throughout the chain to supply improved quality farm produce	Lack of information Lack access to markets Lack access to quality inputs	Twiga Foods (Kenya) Pinduoduo (China) Microsoft FarmBeats (USA)
Digital Marketplaces		Builds direct connections between farmers and consumers through online marketplaces. The result is significantly lower transaction costs as middlemen are removed from the value chain. In addition to efficiency gains, digital marketplaces have allowed smallholder farmers to enter a range of previously inaccessible markets, thus improving competition	Lack access to markets Lack access to quality inputs High search and transaction costs	Twiga Foods (Kenya) Pinduoduo (China)
Mechanization		A range of equipment is available to replace labor on farms and provide important information, from tractors to drones and satellite imagery and IoT sensors. Mechanization platforms have emerged which allow equipment owners to offer the temporary use of agricultural machinery on a digital portal, matching them with farmer customers. Using digital portals improves efficiency as it avoids the ad hoc placement of multiple phone calls and allows more effective scheduling around demand clusters	Lack access to machines and labor Inefficiencies in production	Pinduoduo (China) Microsoft FarmBeats (USA)



Source: Grow Asia, Author.

represents the largest market for AgriTech startups, with more than fifty of them identified across the five different business models. Figure 7-1 provides an overview of some of the main AgriTech companies in Southeast Asia.<sup>13</sup>

The digital marketplace platform business model offers substantial opportunities for smallholder farmers by providing more transparency, opening access to new markets, and improving the efficiency of producing and selling products to customers. This business model has attracted significant interest from investors, raising more than twice the amount of capital in Southeast Asia when compared to the other business models combined. By enabling the buying and selling of agricultural produce online, farmers can bypass intermediaries and gain access to new markets, giving them more choice and a higher margin of what consumers pay.<sup>14</sup> In addition, farmers can sell their agriculture products, purchase goods online, make online payments, and pick up purchased goods at the service facilities without leaving their respective villages.

The sustainability and scalability of AgriTech e-commerce platforms depend on a country’s infrastructure (mobile internet penetration and connectivity), logistics networks, and financial services, including the digital payment solutions

Figure 7-1. The AgriTech Startup Landscape in Southeast Asia: Selected Companies by Business Model

SEA countries with large smallholder population					
Business Models	Indonesia	Philippines	Vietnam	Thailand	Myanmar
Farmer Advisory					
Peer to Peer Lending					
Traceability					
Digital Marketplaces					
Mechanization Platforms					

Source: Grow Asia.

13. Ibid., p. 13.

14. GSMA (2020), p. 63.

available.<sup>15</sup> These factors have contributed to rapid growth of agriculture e-commerce platforms in China, such as Pinduoduo, Meichai, Meituan, and others, expanding their services to offer fresh produce from farmers directly to consumers. The COVID-19 pandemic has accelerated the adoption of agriculture e-commerce, as consumers limit their shopping in person. The emergence of more innovative business models is expected in the future, which may combine lending and advisory together with e-commerce to drive a holistic solution for farmers.

### **AgriTech Sector in Practice: "Start Small"**

AgriTechs are making inroads in reshaping the agriculture value chain, much in the same way that fintech firms are transforming the financial services sector. These AgriTechs may hold the key to attract more young people to the agriculture sector, which is essential to ensure food security in the future.

The digital transformation of various agriculture systems (such as invoicing, supply chain, crop receipt) and the harmonization of the data architecture that supports the agriculture sector is another important factor for the scale-up and growth of AgriTechs. For instance, the digitization of farm registries could lead to better governance and transparency for public subsidies, with significant reduction in inefficiency and leakages.

### *Case Studies of Transformative AgriTech Companies*

There are several lessons to be learned from established AgriTech players that can help other startups to scale up and succeed. The case studies below provide an overview of three AgriTech companies by summarizing their business models, digital technologies used, and key factors that led to their success.

#### *Pinduoduo (China)*

Pinduoduo (PDD) is the fastest-growing e-commerce platform in China, which has attracted more than 700 million users in five years with its unique interactive team purchase and social e-commerce model. Through team purchase, users are able to enjoy lower prices by forming teams of two with their friends to make purchases. Users simply send an invitation to join their team purchase to selected contacts in their social network through popular in China platforms like WeChat or QQ. This helps aggregate large volumes of orders in a short time for PDD's merchants, which enables them to offer products to its

15. GSMA (2019), pp. 16–18.

users at competitive prices. Another important feature of the business model is the consumer-to-manufacturer (C2M) approach, which connects manufacturers directly with consumers. Provided with insights on consumer preferences, manufacturers can reduce production costs and upgrade their inventory management by focusing on selling more of the products consumers want, while pick-up and delivery planning for logistics can be streamlined.<sup>16</sup>

The company, which started out selling fresh produce, is now the largest online marketplace for agriculture products in China. The company's vision is to help accelerate the digitization of the agriculture industry and share the efficiency gains with farmers and the platform's users. PDD has applied its innovative model of aggregating demand through team purchases to make it possible for more farmers to tap into the online market. By removing intermediaries and providing transparent pricing, PDD allows farmers to capture better economics in the value chain while saving consumers money compared to traditional offline retail channels. The company can also actively push agriculture produce on the relevant users' recommendation feeds, so that users can easily discover fresh and affordable produce. By sharing these finds with their friends to form team purchases, they, in turn, help drive more volume with greater visibility to the farmers. This is especially useful for produce in over-supply or that needs to be sold quickly to maintain its freshness.

PDD is also shaping supply to meet the demands from consumers by guiding farmers on what they should plant, when they should plant, and how they should market to consumers more effectively. For instance, PDD partnered with tea producers from Anxi, Fujian, to provide consumer insights and help them build their brand. From the data that PDD has collected, it can provide suggestions on preferred packaging, price points, and product development based on the preferences of different target audiences (for example, young/old, family/single buyer).<sup>17</sup>

Another way that PDD helps farmers is through its Duo Duo University New Farmer training, a collaboration with China Agricultural University, whereby the former provides free agronomist guidance and training to farmers, with PDD providing inputs on consumers' product preferences and business management tips. This better equips farmers to transition into being agricultural entrepreneurs online. As of 2020, PDD has nurtured over a hundred thousand new farmers, with over 12 million smallholder farmers selling produce through their platform.

Technology has played an essential role in the company's significant expansion and growth. The company has leveraged technology to optimize its operations and design customer-centric products/services, as well as teach farmers how

16. Jao.

17. World Bank webinar.

to use agriculture technology to improve their livelihoods and lift themselves out of poverty. In October 2020, the company announced a strategic partnership with the National Engineering Research Center for Information Technology in Agriculture (NERCITA) to develop smart agriculture solutions to alleviate rural poverty.<sup>18</sup> As part of the partnership, PDD and NERCITA will explore the use of AI and 5G for precision farming and build a smart agriculture innovation center to develop data-driven production and boost sales through brand-building. Overall, PDD has been successful in leveraging agriculture technology for farmers in China by engaging them through its e-commerce platform and establishing different programs to help farmers in rural areas adopt innovative techniques that will ultimately lift them out of poverty.

PDD's success as one of the world's top online marketplaces for agriculture products can be attributed to several key factors:

- Favorable preconditions for e-commerce in China—The country has a well-established and reliable logistics infrastructure (95 percent coverage of rural areas) and internet connectivity is widespread in rural areas. Moreover, the digital payment system is one of the most advanced in the world, facilitating quick and efficient transactions that are free and widely accessible.
- Compelling value proposition and easy to use platform—PDD has made its e-commerce platform very simple and easy for farmers to use, with low transaction fees.
- Focus on user insights to inform product design and advise farmers—PDD has built up a deep understanding of its user base and their needs over the past five years, which it can use to advise farmers to make decisions that benefit them.

By addressing farmer pain points from the perspective of what to sell (through product insights), where to sell (market access via PDD online platform), and how to sell (from training farmers to run a business), PDD has created a comprehensive and compelling offering that addresses both farmers' and consumers' needs. This “handholding” approach could be applicable to other developing countries to increase adoption in the long run.

#### *Twiga Foods (Kenya)*

Founded in 2014 and based in Kenya, Twiga Foods is a fast-growing B2B, mobile-based e-commerce marketplace platform, focused on solving the major inefficiencies of the food production and distribution system in Kenya. An

18. Pinduoduo website.

inefficient supply chain, where almost 90 percent of the food produce sold is through the informal sector, is a major challenge, which results in high food prices. In Nairobi, 6.5 million people purchase food through 180,000 small retailers. The retail food marketplace is highly fragmented and inefficient, consisting of various layers of middlemen, which invariably leads to increased costs.

To address these inefficiencies, Twiga delivers food produce to the mass market by digitizing the supply chain, cutting out layers of middlemen, eliminating waste, and reducing food prices. The company aggregates produce from farmers and delivers it to retail vendors in the informal sector in Nairobi through its comprehensive distribution infrastructure. As a result, farmers and food manufacturers have guaranteed access to a fairly priced, transparent, mobile marketplace, and retailers can consistently source lower-cost, higher-quality produce, which is conveniently delivered to their doorstep within eighteen hours of their ordering it.<sup>19</sup> Since its founding, Twiga has reduced typical post-harvest losses in Kenya from 30 percent to 4 percent for produce brought to market on its network.<sup>20</sup>

Twiga collects produce from more than 700 farmers and distributes it to over 35,000 vendors every month. Over the last few years, the company has diversified to a fast-growing range of agriculture products and processed foods, including bananas, rice, maize flour, cooking oil, milk, juices, table sugar, and snacks. The company has been instrumental in the development of efficient commercial farming ecosystem that is geared toward the domestic food market. In November 2020, the company announced a US\$30M IFC-backed debt facility that will be geared toward helping farmers develop irrigation and other modern agronomy infrastructure to improve yields and efficiency.

Twiga's business model offers significant value to farmers, vendors, and mass market consumers. Through Twiga, farmers can get a guaranteed market for their products, with fair, transparent, and reliable pricing; payment within twenty-four hours; and no intermediaries involved. For vendors, Twiga provides convenience, since products are delivered on site, and offers a stable, on-demand supply of high quality, well-priced products, with no middlemen involved. The result is that mass market consumers are able to enjoy a lower purchase price for high-quality products.

Twiga is digitizing the agriculture value chain by aggregating supply and demand, disintermediating brokers, and unifying vendors in Kenya on a single platform. The company has created a tech-enabled digital platform, minimizing supply-and-demand inefficiencies for farmers and vendors along the value chain. The platform relies on the use of mobile money, such as M-Pesa, to manage and

19. Twiga.

20. Bright.

streamline its payment processes for vendors and farmers. Moreover, the company has integrated mobile payments in its supply chain platform, whereby the majority of farmers receive their payments through mobile money and information is recorded in real time in the field, to enable timely settlement of payments.<sup>21</sup>

At its core, Twiga is a data-driven AgriTech company collecting and analyzing all market-driven data while simultaneously tracking farmers and vendor data through its platform. Through the use of data analytics, the company is able to record and analyze the activities of farmers, vendors, and logistics in order to better optimize the supply chain of products.

Leveraging an array of digital technologies has been a critical component for the growth, scale-up, and success of Twiga. The digital platform business model simplifies the supply chain process by connecting the farmers directly with the vendors, thereby eliminating the intermediaries. In addition, Twiga is able to address the inefficiencies in the market by serving as an aggregator of the informal food retailers, resulting in significant cost savings to consumers and vendors. The amount of data captured on Twiga's platform is highly valuable, since it can be used to optimize the logistics, broaden the company's product base, and help vendors access financial services, including working capital loans from financial service providers that partner with Twiga.

#### *Microsoft FarmBeats (USA)*

Launched to the public in 2019 by Microsoft's research arm, FarmBeats is a project that combines IoT sensors, data analysis, and ML to augment farmers' knowledge about their own farm with data and data-driven insights. The idea behind FarmBeats is to take in data from a wide variety of sources, including sensors, satellites, drones, and weather stations, and then turn that into actionable intelligence for farmers, using AI and ML,<sup>22</sup> which results in higher agriculture productivity, reducing losses and cutting down input costs. The rapid advances in technology, such as cloud computing, IoT sensors, and AI, are helping to make affordable digital agriculture solutions for farmers. Transparency in food is becoming a big issue globally, and thus data is becoming increasingly important to farming, since consumers want to know where their food is coming from and whether conservation and environmentally oriented practices were used when cultivating the crops.

FarmBeats aggregates massive amounts of agriculture data from different sources and develops AI models by fusing the datasets. Using satellite imagery combined with IoT sensors in the field, FarmBeats creates a farm map and assesses

21. Ibid.

22. Lardinois.

farm health using vegetation and water index. FarmBeats tracks and visualizes the farm conditions through the collection of data from different sensors, aerial imagery from partner drone companies, and soil moisture maps from the combination of sensors and satellite data.<sup>23</sup>

Given the lack of internet connectivity in most rural areas, the agriculture sensors used by FarmBeats leverage unoccupied slices of the UHF and VHF radio frequencies used for TV broadcasts, slotting data between channels. Often referred to as “TV white space,” many developing and developed economies are experimenting with this innovation to unlock extra bandwidth for mobile phones.<sup>24</sup> Using the TV white space for internet connectivity is a game changer that significantly reduces the cost, which makes it extremely affordable to use IoT sensors to collect data.

FarmBeats provides a groundbreaking, cloud-enabled software platform that is able to democratize the use of data for farmers so that they can gain better insights into ways to improve their crop yields, as well as predict performance. The partnerships established with different providers (drone and satellite imagery companies, IoT sensor providers, and so on) are vital for the success of FarmBeats, and having an open-source software stack that connects through APIs makes it easy to use and connect with the different partners. Finally, innovative solutions, such as the use of TV white space for internet connectivity in rural areas with limited access, make it possible to collect large amounts of data at an affordable price.

## Challenges in the Adoption of Digital Technologies in Agriculture

While digital technologies offer many benefits in the agriculture sector, technology adoption is highly dependent on economic, regulatory, and social factors. From an economic perspective, some of the technology innovations outlined above are expensive, especially in emerging economies with poor infrastructure and internet connectivity. For instance, it is difficult to deploy IoT devices at scale, due to the fact that emerging market countries may not have licensed mobile IoT networks deployed by mobile network operators (MNO).<sup>25</sup> Digital literacy is also a major challenge, which has made it difficult for smallholder farmers to adopt these new technologies.

Access to data together with digital technologies provides transparency in the value chain. However, it is important to recognize two potential issues: power

23. Microsoft Azure website.

24. Ibid.

25. GSMA (2020), p. 70.



concentration and data governance. Digital technologies can increase market power and concentration that reduces competition. With access to processing high volume of data to fine-tune the AI algorithm, digital technologies could increase power and vertical consolidation in the entire food supply chain, with harmful effects leading to market concentration from the monopoly of the digital platforms and super apps. In addition, the lack of contestability and oversight for data governance could be an issue for personal data protection and could erode trust from the consumers and citizens.

### **Agriculture Innovation Hub for Indonesia: Overview**

The government of Indonesia considers the agriculture sector a major priority for the economy. Specifically, the Strategic Agricultural Program focuses on the development of high value agriculture, export markets, nutrition, food supply, rural incomes, and entrepreneurship.

Indonesia already has an active ecosystem of AgriTech companies. Currently, there are more than fifty startups that can disrupt the agriculture and aquaculture sectors in Indonesia. Firms like TaniHub are using technology to bridge the large gap between farmers and consumers by allowing consumers to buy fresh produce directly from the farmers, which results in higher income for farmers by eliminating the middlemen. In addition, TaniHub's peer-to-peer (P2P) lending platform, TaniFund, connects retail investors with money to lend with farmers that need debt capital. AgriTechs such as e-Fishery are using AI and ML, as well as IoT sensors to better track production yields and provide essential data to banks in order to better evaluate the credit risk of farmers.

The adoption of digital technologies will be essential in order to implement the government's program; however, technology adoption in the agriculture sector varies significantly across 17,508 islands in the country. Complementary policy actions, including encouraging more private sector involvement through improving the policy and regulatory environment, are critical to accelerating the countrywide adoption of digital technologies in agriculture. Furthermore, infrastructure investments are also needed to address the other constraints that farmers face, such as roads, energy, post-harvest storage, and logistics. A combination of these investments and policy improvements has the potential to increase the adoption of digital technologies and bring in new generation of farmers in Indonesia.

### *Objectives of the Innovation Hub*

Establishing an innovation hub would catalyze agricultural innovation and investment for the development of the agriculture sector in Indonesia. The hub could be structured by a neutral convening broker, such as the World Bank Group, as a public-private partnership (PPP) digital platform where government intervention would foster an enabling environment for the growth of the sector, crowding in private sector for investment capital to become the driving force for sustaining an innovation culture that cultivates a growth mindset to disrupt the sector. The Agriculture Innovation Hub will have the following objectives:

- Foster innovation ecosystem from multi-stakeholders in the agriculture value chain (government agencies, academia, and technology providers) to share insights and key learnings on the use of digital technologies
- Invest in data platform accessible to all, providing a wide variety of public and private data to increase market intelligence and have better information on how to best scale up agricultural businesses
- Provide capacity building for the new generation of farmers so that they are able to quickly learn and deploy these technology innovations
- Link enterprise with e-commerce platform to increase market insights, connecting smallholder farmers directly to consumers

Furthermore, there are key characteristics of the Innovation Hub that would be essential to offer a positive environment for the development and growth of AgriTech startups and encourage the adoption of digital technologies across the agriculture value chain:

- Presence and support of large agri-food businesses—cross-pollination from the established businesses with the AgriTech, leading to new strategic partnership and business models
- Government initiatives supporting innovation and investment—to provide incentives for AgriTech innovations and direct connection with policymakers
- AgriTech start-up ecosystem and entrepreneurial culture—AgriTechs are leading the way with the introduction of digital technologies
- Mentoring from accelerators—to scale up AgriTech innovations with mentors to support the business model

- Digital talent development—knowledge-sharing from agronomists and big technology using challenges and hackathons as a way to crowdsource expertise
- Quality research with academic institutions—gain better understanding of the local market dynamics, key innovations, and factors affecting agriculture
- Engagement and presence of venture capital and private equity firms—to provide the investment capital needed to fund the growth of digital agriculture

Many factors contribute to the market failure for smallholder farmers. Two main causes are the lack of market access and limited access to finance to fund working capital. The data platform could address information asymmetry for smallholder farmers and gain market insights from the e-commerce platform.

The agriculture digital transformation could benefit from the learnings in the vibrant growth of fintechs in Indonesia by building the collective strength of the AgriTech community, similar to the Indonesia FinTech Association (AFTECH), which is now the self-regulating organization for the financial authority. Currently, AgriTechs in Indonesia do not have direct access to the policy makers; therefore, organizing into AgriTech groups with similar functions could have better advocacy for the well-being of the smallholder farmers and offer direct communication channels for policy matters.

The Innovation Hub is envisioned to support action-oriented policy dialogue for cross-sector collaboration (for example, agriculture and fintech) through technical assistance, studies, consultations, and learning events with agriculture experts from industry and academia, Big Techs with agriculture experience, and fintech entrepreneurs to promote, develop, and adopt digital solutions for smallholder farmers. Other thought leaders, such as World Economic Forum, have put forth Agriculture Innovation Hub concepts,<sup>26</sup> and thus it is important to join forces to amplify the strength of the multi-stakeholder partnerships, operationalizing the concept in specific countries.

### *Creating a Data-Sharing Platform—The Heart of the Agriculture Innovation Hub*

Data holds great promise for digital technologies, and open data could generate large benefits for society, but there are risks that need to be addressed. To maximize the benefits, governments could encourage the private sector to share

26. Bora, Kowatsch, and Desai.

data that are of public interest, monitoring and increasing the impact of public data, and improving the governance of data sharing. To mitigate the data risks, governments could improve data protection and clarify data ownership, address unfair data practices in agricultural policies, and reduce imbalances in the value chain—related information asymmetries.

The data platform will focus on the optimal use of data that empowers small-holder farmers and agribusiness entrepreneurs to increase their productivity, efficiency, and competitiveness, thereby facilitating access to market intelligence, improving nutritional outcomes, and enhancing resilience to climate change. An agriculture data exchange platform designed with data governance could unlock the full potential of digital technologies and maximize data benefits between private and public sector.

The Innovation Hub will be designed for agriculture data sharing, harmonizing the granular data types and coordination with government data, to provide real time data access on simple user interface to help smallholder farmers make better decision for the crop yields, beyond the traditional data sharing for academic research. Having access to market intelligence could improve the efficiency of farms and agribusinesses in the value chain. Firms can learn about customer preferences and tailor their products accordingly, and can also forecast more accurately, improving their profitability.

Data integrated with tracing systems can also increase transparency and accountability in food systems. Tracing systems integrated with public systems alert consumers over digital platforms and speed product recalls when food hazards are discovered. Traceability, as a part of food safety systems, limits costly outbreaks of foodborne illnesses and reduces the financial and reputational risks posed to grocery stores and fast-food restaurants by tainted food.

Having access to the transactional and operational data is a virtuous cycle that fuels greater innovation and entrepreneurship. When combined with data from weather, commodity prices, and agronomic research data, it could reduce production costs and mitigate risk for the smallholder farmers.

### *Data Governance—A Major Challenge that Needs to Be Addressed*

Data is not a zero-sum game. Policymakers need to recognize that data is a “public good”—it is not a finite good, and the usage of it by one actor in the economy does not prevent others from using it. Therefore, good data governance from the collection and processing of data is critical for building trust. Data security by design and data use agreement will be established as part of the Innovation Hub and must be enforced and implemented consistently for both public and private institutions that are part of the hub. A successful data protection regime will

embed consumer education as a key objective focusing on the human dimension. This needs to include measures to inform users of their rights, the benefits as well as risks, and what avenues they have to lodge complaints and seek redress.

## Conclusion

If there ever was a silver lining in the COVID-19 crisis, it would be the readiness of digital technology to change the way we work and the way to adapt to online and contactless buying experience to reduce the risk of spreading the pathogen. The pandemic confirms that AgriTechs have an incredible potential to change the agriculture value chain.

The COVID-19 pandemic is already disrupting food systems and supply chains and affecting the economic life of farmers. Our world is also confronting a climate crisis, not only with higher temperatures and rising seas, but also intensifying food shortages. There are many promising agricultural innovations, including advances in irrigation, new types of seeds and fertilizer, and digital technologies that provide close-to-real-time data about growing conditions. To realize the promise of these innovations, however, farmers need access to capital and digital financial services, such as payments, savings, and insurance.

Technology offers new business expansions, such as GoJek transformation from ride sharing to food delivery and digital financial services. The growth of cross industry partnerships powered by digital transformation is enabling a wide range of new and traditional finance providers to join forces with agribusinesses and other Big Tech platforms that work in rural areas to provide credit and other capacity-building services to farmers.

Various AgriTech business models have emerged globally to address the main challenges smallholder farmers face. We look at Indonesia as an example of what developing countries can hope to achieve. There is growing momentum in Indonesia, with more than fifty AgriTechs founded over the last five years. Together with enabling regulations and increased investments in infrastructure, digital technologies will be the main contributor to food security, reduction in food wastage, and sustainable farming, addressing the Sustainable Development Goals to end poverty and hunger, and promote responsible consumption and climate action. The establishment of the Agriculture Innovation Hub in Indonesia can enhance these benefits by bringing together multiple stakeholders of the agriculture value chain to share data; foster innovation; and provide investment, mentoring, and capacity building for young startups. The hub's success will be dependent on building partnerships between the public and private sector and making sure that regulations can foster innovation while mitigating potential risks. The February 2021 MOU between Ministry of Agriculture and

Microsoft,<sup>27</sup> together with the establishment of the new data center to empower Indonesia's digital economy,<sup>28</sup> is the first among multiple partners to scale out the innovation ecosystem in Indonesia.

More technological innovation in agriculture is needed today. This is a global challenge, and the time to act is now. In the spirit of Lean Startup mindset: let us think big, start small, and act fast.

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