Rural and structural transformation for accelerating SDG progress:

the role of new technologies

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Executive Summary

- Digital and alternative technologies have become more prominent in the development world in the last decade or two thanks to the rise of mobile phones and advancements in science. They are threatening to disrupt the existing ecosystem and potentially transform economic development. Promising technologies revolve around mobile phone apps, ag tech innovations, data analytics, 3D printing, and precision technology.

- Since many of these interventions are recent, the evidence of their longer-term impact is not fully known. However, promising work using micro-evidence and randomized control trials in several African and Asian countries suggests promising results, including increases in farmer productivity. Evidence from China and India shows a catalytic effect on the rural non-farm sector.

- Three transformative areas for digital technology are becoming increasingly evident: support of farm and non-farm development; provision of price information to farmers and connecting to consumers; facilitation of access to funds through virtual digital payments; and provision of quality control on food supply; and lowering transaction costs for government services. There are a range of interesting case studies in India, Kenya, and several other countries.

- Mobile banking has shown strong empirically demonstrable results, allowing the unbanked to access funds and also providing technical and financial support for farmers. More than two-thirds of world's population has a digital phone, including many poor farmers. Fabregas and Kremer (2019) find that since the cost of information transmission are low, mobile phones are used by smallholder farmers in low-income countries to optimize markets.

- The experience of ANT and MYBANK in China, M-PESA in Kenya, and various others in South Asia and sub-Saharan Africa indicate strong impact on rural communities.

- There are five policy areas where government can support structural transformation through digital work: skills training and startups for youth; government incentives for ag-tech startup ecosystem; direct and indirect support for farmers; funding of science parks and ag zones; development of agricultural research units

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I.   Introduction

Digital and alternative technologies have become more prominent in the development world in the last decade or two thanks to the rise of mobile phones and advancements in science. They are threatening to disrupt the existing ecosystem and potentially transform economic development. These technologies range from technologies like drones and software analytics to mobile payment solutions and crowdfunding. The tech space is becoming increasingly saturated with new products. This is becoming even more widespread due to the covid-19 pandemic, which has been the biggest public health and economic crisis since the Great Depression. Rising death tolls of more than a million people, coupled with widespread impact on global GDP has resulted in the largest economic shock in decades.

These technologies have the potential for significant changes. Heralded as potential game-changers, these technologies can lead to major improvements in agricultural production and distribution. In parallel, they have a strong potential to improve the rural non-farm sector – the web of manufacturing, commerce, and services – that complements the farm sector. Both farm income from agriculture and other income from non-farm employment and wages can help poor rural households emerge from poverty. These technologies are still at an early stage in many countries, but they are rapidly expanding in scope and influence. These new technologies are unique in that they are based on technologies and data that can help a farmer increase productivity and can also help all parts of the agriculture value chain.

The empirics are impressive. Ag Funder (2019) notes a big increase in technological investments and finds that during 2018, global total venture capital investment in the Ag tech sector was USD 16.9 billion, and the largest deals were from Asia. There are eleven deals worth more than $200 million from China and India. Ag tech investments, though more concentrated in developed countries, have been spreading to sub-Saharan Africa and Southeast Asia. There is also a small but growing ag tech ecosystem in Latin America and the Caribbean. On top of this, more than two-thirds of the people in the planet own mobile phones now, many of which are used in different knowledge-seeking apps. There is strong investment in mobile technology, with many private operators emerging in the last decade.

As the covid-19 pandemic is still unfolding with a potential recovery envisioned in 2021, the world economy is still facing shockwaves, and there have been many disruptions to existing supply chains. One of the riskier ones has been a disruption to world food systems due to the lockdowns. Many poor people have lost incomes and face hunger, and many farmers face supply chain disruptions for their products. This has been a global phenomenon, adversely affecting the poor and the vulnerable the most. World Food Program estimates at the peak of the pandemic was close to 1 million hungry people. In light of this, the post-pandemic world may be a different world, where there is an evolution of existing paradigms, and there could be an accelerated pace of digital transformation, robotics, and telehealth.

The international policy world and development practitioners are taking increasing note of these developments. Food and Agriculture Organization (FAO) of the United Nations is taking a role in using mobile and digital technologies to help countries combat invasive species and deforestation, optimize water management and land use patterns and disseminate knowledge on food safety standards and e-commerce opportunities. In a recent conference sponsored by FAO, Nobel laureate Michael Kremer said "digital agriculture has allowed governments to support smallholders during this pandemic, and it should also be a path to creating a better system for the future," while the new Director General of FAO

argued that "digital technology is not only about economics, but digital governance, digital society and a digital world."[1]

From the seminal work with M-PESA in Kenya to innovative work in India, mobile technologies have grown by leaps and bounds in recent years. Innovative experiments in countries, especially in sub-Saharan Africa, South Asia, and Latin America have the potential to address development gaps. Given that more than 70 percent of the poorest one-fourth of people in developing countries have mobile phones, there is a large potential to harness these technologies for development goals. Smartphones and other technologies can be used to boost the productivity and livelihood of poor people in developing countries. In several countries, the United Nations International Fund for Agriculture Development is supporting the deployment of remote sensors to help farmers optimize water and fertilizer levels for their crops.

A range of new technologies can change the development landscape. The rise of 3 D printing, which allows manufacturing processes to be more flexible, can help catalyze manufacturing in developing countries by lowering costs and creating economies of scale. The supply chains can be supported by new technologies. Many ICT innovations can help famers obtain more cropping information and market intelligence and better connect smaller producers with markets. Digital technologies can help in improving the provision of public services in urban and rural areas with one-stop online platforms allowing the public to access a range of public services.

Digital technologies are beneficial in many ways. They are creating new opportunities to integrate smallholders in a digitally driven agri-food system (USAID, 2018). According to a recent FAO report, digitalization will change every part of the agri-food chain and optimize management of resources throughout the system, and it can make value chains more traceable and coordinated (FAO, 2018). Innovations in digital agriculture can help farmers increase their yields and incomes by adopting locally suited seeds and fertilizer and prevent crop disease.

Mobile phone usage and mobile banking is increasing in many countries, including many in sub-Saharan Africa (Table 1). The penetration to smallholder farmers in developing countries, especially in South Asia and sub-Saharan Africa, has the potential of being very disruptive. New technologies can be used at very low marginal cost to make agricultural knowledge and extension practices accessible to farmers. At least fifty percent of the population in Botswana, Kenya, Uganda, Tanzania, and Zimbabwe are using mobile banking suggesting that mobile banking can do well in countries with little infrastructure, especially in remote and rural areas. There are similar trends in South Asia. From 2018 to 2020, the total VC inflow into Indian fintech startups has more than doubled to 117 percent, whereas the fintech adoption rate for India has surged to 87 percent in 2019 from 52 percent in 2018. [2] More than 1000 startups globally have entered the ag tech world and the numbers are growing.

The goal of this paper is to provide the analytical framework, empirical information, and concrete case studies that are necessary to discuss ways in which technologies can amplify the role of rural development in the next decade (2021-2030) to help in achieving the SDGs. There are several SDG's that are involved. The most important goals that are linked to agriculture and rural transformation are SDG2

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[1] http://www.fao.org/news/story/en/item/1314651/icode/

[2] https://www.moneycontrol.com/news/business/fintech-how-fintech-startups-are-bridging-the-digital-gap-in-rural-india-4947441.html

- end hunger, achieve food security and improved nutrition and promote sustainable agriculture and SDG5 – achieve gender equality since women are a key contributor of the labor force. Success in achieving the SDG's will involve coordination of public actors and private entrepreneurs as well as the support of the international development community.

Figure 1: Mobile Banking Accounts by Country in 2017 (%)
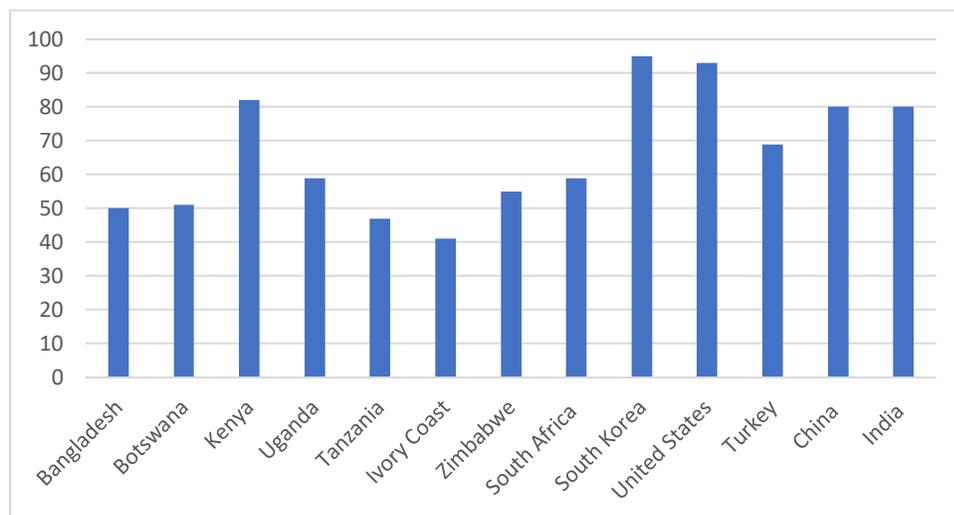
World Bank Findex Report (2020)

Central to the development of mobile technologies is to develop a public policy regime and set of incentives that allows these tools to help farmers. The institutional arrangements in governments, together with appropriate division of responsibility between public entities and entrepreneurial firms should be established. Since this is a nascent field, there is still considerable policy uncertainty about the best way for governments to support this. In a world of increasing urbanization accompanied with stagnant rural poverty, it will be important to marshal new technologies to help the rural poor. The diffusion of new technologies, and the progress in making many technologies more affordable and accessible, has the potential to transform the geography of economic activity. Technologies can help to bring new economic opportunities and services to rural sectors, where the vast majority of the development needs are concentrated.

The main questions that the proposed background paper is expected to address are as follows: What is the role of technologies in connecting urban with non-urban communities of different sizes? How can technologies reduce the geographic gaps that exist and bring opportunities where development is most needed? How can new digital technologies expand innovation, entrepreneurship, and the potential for economic activities in rural communities, including in agri-food, in services, in manufacturing, and other sectors? What is the role of digital technologies in providing opportunities for youth employment in non-urban communities, including in agri-food, in services, in manufacturing, and other sectors?   What are the priority policies and interventions required to accelerate the diffusion and use of technology for rural development? Which technologies are more promising and which are less promising?

II. Digital Technologies: Basics

Definitions

Digital technologies refer to any of a set of mobile or other technologies that use digital innovation to help improve human knowledge and communication. Spanning a wide range of technologies, these technologies revolve around mobile phone apps, ag tech innovations, data analytics, 3D printing, precision technology, genetic innovation, and other technologies. 3D printing consists of technologies that enable companies to lower the barriers to manufacturing leapfrogging. [3] Precision agriculture (robots, sensors, drones, satellite imagery) are adopted by farmers to optimize their use of resources. technology[4]. Precision farming capabilities include data collection, data interpretation, and data analysis. One particular technology, variable-rate application (VRA) technologies, can apply precise amounts of water, fertilizer, and pesticide. In recent work, the OECD (2019) finds that digital technologies are changing agriculture and the food system:

> "Farm machinery automation allows fine-tuning of inputs and reduces demand for manual labor; remote satellite data and in-situ sensors improve the accuracy and reduce the cost of monitoring crop growth and quality of land or water; and traceability technologies and digital logistics services offer the potential to streamline agri-food supply chains, while also providing trusted information for consumers." [5]

Many of these technologies have developed in the last decade or two in response to a growing gap in the market. Some have been first developed in the US and Western Europe, and they have been slowly spreading to emerging markets. After the Green Revolution in the 1960s, which allowed farmers to have higher yields, this represents some of the most innovative and interesting technology. The landscape is still filled with many different players in different sectors, and they are mostly small in size but with some scale-up potential. The basic idea behind these technologies is to help farmers handle their operations in a better way and optimize use of water, fertilizer, and pesticides. These technologies can allow farmers to be able to monitor movements in crops and livestock and plan accordingly. Most important, the new technologies can be used for all kinds of processes, including inventory management, communications, and crop supervision.

Over the next years, these technologies will help boost agricultural productivity growth and use data analytics to increase yields and reduce costs. There will a growing digitization process to address specific challenges such as growing populations and climate change. Some experts find that the while the foundation was set over the past decade, the next decade can witness greater adoption of innovative practices and technology enabled by the digitization of the ag industrial complex, potentially accelerated by the impact of COVID-19.[6]

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[3] Farmers in Myanmar use 3D printing to create tools, while 3D printer in Togo startup helps local farmer to prototype their own tools.

[4] Precision technology related to agriculture refers to any set of new technologies, such as GPS devices or lasers, that famers can use to increase crop yields and profitability and lowering the dependence on traditional inputs that are used to grow crops, such as land, water, and fertilizer. The idea of precision technology is to save time and labor for the farmer.

[5] http://www.oecd.org/agriculture/topics/technology-and-digital-agriculture/

[6] https://www.williamblair.com/en/News-Items/2020/October/02/AgTech-Revolution.aspx

III.   Conceptual Framework and Policy Implications

Macroeconomics of rural development and micro links

Macroeconomic policy in developing countries relates to the fiscal, monetary, trade and exchange rate policy that affect the commercial viability and the opportunities for agriculture. In a review of the relationship between macroeconomic policies and agricultural and rural sectors in Latin America and the Caribbean, Bonilla (2019) finds several important patterns, that also seem applicable to other parts of the emerging markets. First, all major downturns in the region's GDP show parallel declines in Latin America and the Caribbean's agricultural growth. Second, the variations in macroeconomic prices (such as exchange rate, interest rates and wages) define the relative incentives between agricultural and nonagricultural activities. Third, macroeconomic policies affect the prices and availability of factors or production and inputs, affecting the supply side of primary agriculture and value chains. Fourth, the work of farmers and agricultural value chains require public productive services and quality infrastructure. Fifth, farmer productivity benefits from social services in the rural areas, such as health and education, and depends on the quality of infrastructure. Finally, macroeconomic policies help avoid economic crises since macroeconomic volatility can help cause poverty traps. In sum, macroeconomic policies affect the rural sector in many ways, especially through influencing the enabling environment for productive

This macro-micro link is especially important for emerging economies. Achieving the Sustainable Development Goals (SDGs) by 2030, will require increased policy focus on rural development. In most developing countries, more than a three-fourths of the poor live in rural areas. In some countries, poverty rates are more than three of four times as high in rural areas as in urban areas. Most of the rural poor have weak human capital assets and are engaged in low-productivity subsistence farming. The poor households rely on farm labor income and often, supplement the income with some non-farm activity. They can provide a great opportunity to catalyze production.

Digital technologies and agricultural transformation

In this context, ag tech and digital technologies can help improve the rural sector. Microeconomic reform can lead to macroeconomic changes. Greater farmer productivity leads to greater farmer incomes and increases non-farm activity. When this is expanded to a larger scale, the microeconomic effects multiply to affect macroeconomic variables. The rise of ag tech, the intersection of financial services and technology, and the development of new technological approaches to boost rural productivity promises to disrupt existing models and practices.

While there are a multiplicity of approaches and technologies, a basic map is emerging. From an analytical perspective, there are two elements of structural transformation. The "structural change challenge" is focused on moving resources from traditional low-productivity activities into modern, more productive industries. (McMillan, Rodrik, and Sepulveda, 2017).
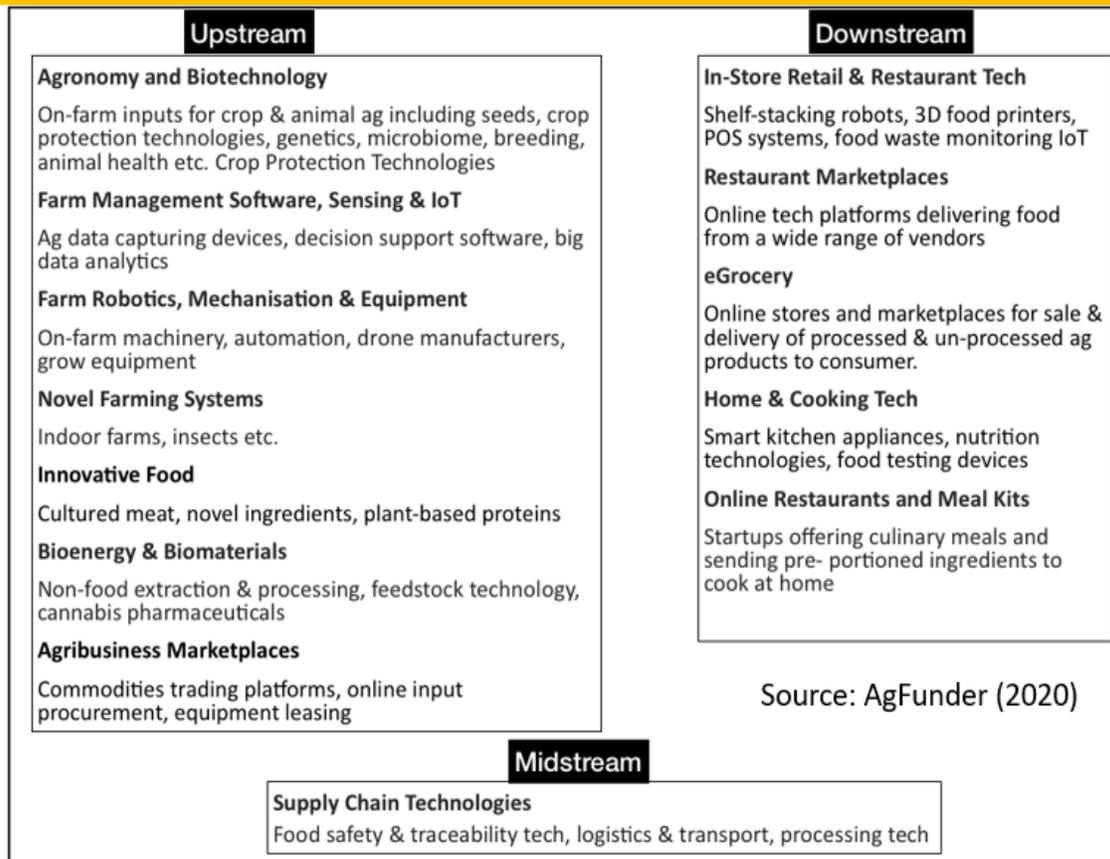
- First, within agriculture sector itself, there is the technological change and transformation that can increase the productivity.

- Secondly, as people leave agriculture, they join more productive manufacturing and services sectors in the urban areas. [7] The experience with structural change has been quite diverse around the world, with Asia being the stronger performer.

The new technologies are disruptive in one sense but can help connect rural markets with urban and global consumers in another sense and speed up rural transformation. There are several interventions that can have a potentially strong positive impact on the rural economy. Figure 2 presents a schematic approach to show how ag tech can transform and modernize existing elements of the agricultural ecosystem, such as agronomy, robotics, and farm management, and have an impact on retail and downstream consumers. There are clear links between upstream technologies and downstream impact and the key midstream channel is the supply chain technology.

Figure 2: Agtech and Rural Economy

AGTECH has potential to *disrupt* the rural economy and link it to the urban and global economy

Upstream

Agronomy and Biotechnology

On-farm inputs for crop & animal ag including seeds, crop protection technologies, genetics, microbiome, breeding, animal health etc. Crop Protection Technologies

Farm Management Software, Sensing & IoT

Ag data capturing devices, decision support software, big data analytics

Farm Robotics, Mechanisation & Equipment

On-farm machinery, automation, drone manufacturers, grow equipment

Novel Farming Systems

Indoor farms, insects etc.

Innovative Food

Cultured meat, novel ingredients, plant-based proteins

Bioenergy & Biomaterials

Non-food extraction & processing, feedstock technology, cannabis pharmaceuticals

Agribusiness Marketplaces

Commodities trading platforms, online input procurement, equipment leasing

Downstream

In-Store Retail & Restaurant Tech

Shelf-stacking robots, 3D food printers, POS systems, food waste monitoring IoT

Restaurant Marketplaces

Online tech platforms delivering food from a wide range of vendors

eGrocery

Online stores and marketplaces for sale & delivery of processed & un-processed ag products to consumer.

Home & Cooking Tech

Smart kitchen appliances, nutrition technologies, food testing devices

Online Restaurants and Meal Kits

Startups offering culinary meals and sending pre- portioned ingredients to cook at home

Source: AgFunder (2020)

Midstream

Supply Chain Technologies

Food safety & traceability tech, logistics & transport, processing tech

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[7] From a technical standpoint, according to the Rodrik definition, the first part—the "within-sector" component—captures how much of overall labor productivity growth can be attributed to changes within sectors. It is the weighted sum of productivity growth within individual sectors, where the weights are the employment share of each sector at the beginning of the time period. The second term—the "structural change" component—captures how much of overall labor productivity growth can be attributed to movements of workers across sectors.

Policy implications of the new digital technologies

The rise of this new technologies will have implications on the regulatory and policy framework for the economy. Different countries will have different approaches, depending on their political economy, their geography, their institutional strength, and the mindset of the policymakers. The spectrum will range from tight control to laissez-faire approaches. The early experience shows countries like Kenya and Philippines to have more laissez-faire approaches, while India and the CFA zone in West and Central Africa to have a more controlled and dirigiste approach to regulating new technologies. The regulatory approach will depend also on the mindset of the regulators and the potential reward/risk payoff. In a post-COVID-19 environment, where there is urgency for job creation, the regulators may provide light regulation for ag tech and fin tech firms.

- **Nature of regulatory authority**. These tech disruptions will lead to regulatory changes. Currently, there are no central authorities that regulate these new technologies. For fintech, it is unclear if the regulatory space should be controlled by the central bank or the telecommunications authority, or a mixture. Over-regulation is risky as it hampers innovation and prevents the emergence of a dynamic ecosystem. Different countries have adopted diverse approaches to this. For example, Brazil's central bank and the country's National Monetary Council have established operation guidelines for a regulatory sandbox to encourage financial and payments technology innovation. Kenya's Central Bank established guidelines to encourage the development of M-PESA. The key issue revolves around ensuring that economic efficiency is enhanced while malpractice is controlled. Regulation should be prudential but not protectionist and should be done in a way to increase economic competition and create markets. The cross-regulation approach by multiple regulators also should be considered.

- **Fintech regulation.** Existing regulatory approaches for fintech should be modernized to address changes in the financial landscape. Financial supervision and principles of corporate governance can be amended to address risks from financial innovation. Also, since traditional banks make money from interest and fees, fintech firms obtain revenue through monetization of data, a different regulatory approach is needed to deal with a different revenue model. In many ways, fintech owes its existence to smoother regulatory requirements and differences from traditional banks and financial institutions. The fintech world is a disruptive world of seamless interaction with customers and selling different products than traditional banks.

- **Public/private interface**. The relationship between public sector and private sector will also have to be understood. It is key to have the public sector "crowd in" the private sector rather than duplicate or "crowd out" the private sector. Government involvement should be linked to clear market failures and public goods provision.

- **Quality control**. Regulators will have to set standards of quality control to ensure that the new technologies comply with basic norms. The product quality can also be strengthened via consumer reviews. In relation to ag tech, there will need to be stronger regulation of agricultural biotechnology products, genetically engineered organisms, and research and development activities.

- **Consumer protection.** It will be important to ensure that consumers are protected. A prominent example relates to food supply. Regulating a startup means ensuring that the startup follows accepted hygiene practices and complies with safety norms. Many developing countries do not

have a strong regulatory system that protects consumers from fraud. For example, Pakistan and Bangladesh and several African countries do not have secure online payment systems, leading to credit card fraud. With regard to fintech and mobile banking, the appropriate question is the degree of oversight over the company owners and financiers of digital lending apps to the interface between borrowers and lenders. For online financial payments to work well, consumer credit history and reporting is needed to avoid malpractice or credit delinquency.

- **Data security.** It is important to preserve personal information in the digital world. Many surveys show that farmers have concerns about who can access their data. The regulatory regime to ensure that consumer data and privacy as well as data transfer through payment systems, needs to be set up. Given the risks of security breaches, software will need to be put in place in fintech products to ensure data integrity. Contractual arrangements can also be put in place between consumer and businesses. It will be important to clarify who owns the data.

- **Cross border flows.** Central banks can ensure that cross-border financial flows be monitored to ensure that there is not undue risk to the financial system. For example, remittances providers have to deal with banking regulations that vary across countries as well as limits to volume of flows. In an environment of money-laundering the authorities will have to remain vigilant to ensure that flows are properly monitored.

IV.   Transformative Role of New Digital Technologies

Digital transformation can effect structural transformation in many ways. The ramifications of the adoption of new technologies can be significant and alter the dynamics of the rural economy. The precise magnitudes of the impact will depend on the technologies adopted, the scale, the country context, and the local rural environment. Since these technologies are relatively recent, one will have to wait a longer time for a more cumulative impact on farmer incomes. This study will look at five main channels of transmissions. These are summarized in Table 2, which presents a comparison between the different technologies and their respective impacts.

- First, most ag tech, especially **drone, data analytics, and e-platforms,** can support both farm and non-farm development.
- Second, **drones, mobile apps, and platforms** can provide information to farmers and help match rural producers with urban consumers**.**
- Third, **fintech** can facilitate access to funds through virtual digital payments.
- Fourth, **mobile apps and blockchain** can provide quality control on food supply.
- Fifth, **mobile payments** are able to lower transaction costs for government services.

Supporting both farm and non-farm development

These new technologies can have multiple effects on farmers. The work has not had much evaluation but there is now some early evidence through RCT trials.

Fabregas and Kremer (2019) find that since the cost of information transmission are low, mobile phones are used by smallholder farmers in low-income countries to optimize markets. The authors find that mobile phones can not only deliver market information but also more sophisticated agricultural extension advice, as well as locally relevant weather and pest information and video-based farming advice. Practices recommended through digital extension are adopted at rates that compare well with those adopted through the course of traditional in-person extension practices and at significantly lower cost. Other related work by the authors, using randomized control trials (RCT) find that farmers in Kenya and Rwanda were experimenting with agricultural lime, an input that can reduce soil acidity and increase yields, and with certain types of fertilizer. In such a circumstance, supporting digital extension services makes economic sense.

FAO and Microsoft in collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), have developed an artificial intelligence-based sowing app that enables smallholder subsistence farmers to receive precision agro-advisory services based on the weather and other parameters. In 2017, the service was used by 3 000 farmers during the rainy season for several crops, including groundnut, maize, rice and cotton. The increase in yields ranged from 10 to 30 per cent across crops.

Digital technology has not just empowered individual farmers, but it has made the whole ecosystem more efficient and more sustainable. This is very helpful for the non-farm sector, defined to include value chain activities, such as agro-processing, transport, distribution, marketing, and retail, as well as tourism, manufacturing, construction and mining, plus self-employment activities. [8] World Bank

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[8] Growing the Rural Non-Farm Economy to Alleviate Poverty | Independent Evaluation Group (worldbankgroup.org)

research shows that the rural nonfarm sector contributes to economic growth, household income diversification, rural employment, poverty reduction, and a more spatially balanced population distribution in most developing countries.

In terms of the impact of digital technologies on the rural non-farm sector, there are three trends. First, it is too early to see a strong impact, although the potential is massive. Second, by helping support farmer income, digital technologies will indirectly help the rural non-farm economy, which tends to absorb farmer surplus. Third, e-commerce is the area which is having the most impact on the rural non-farm sector. In many countries, especially China and India, ecommerce is helping to revitalize rural industry by helping smaller firms integrate in global supply chains.

Evidence from company case studies, RCTs, and anecdotes suggests an improvement in labor and factor allocations in rural markets due to these new technologies and the beginning of a reshaping of patterns of investment and productivity growth both in farm and in non-farm activities.

- Pinduoduo, currently one of the largest e-commerce platforms in terms of sales in China, is a dynamic firm that helps farmers to sell products online via a platform/marketplace. According to the Pinduoduo Annual Report, as of the end of December, 2019, the company has generated over $150 billion and had close to 600 million active buyers. More than 10,000 rural industries have been involved in the supply chain, together with farmers.
- Since 2010, Ant Financial has a business lending subsidiary, which has provided financing to 180,000 rural SMEs through an Internet-based loan program that gives poor rural merchants access to Alibaba's platforms, many of them selling farm produce or handicrafts.
- Technology is being developed to give students in rural China more access to education via online learning platforms, with many rural Chinese having skills development.
- In India, Reliance Retail, the biggest brick-and-mortar retailer, is expanding access into the rural non-farm sector by utilizing its over 6,000-plus smaller Jio Point stores in more than 5,000 cities and towns as the last mile connection point for its e-commerce venture to reach consumers without internet access or who have never shopped online. The idea is innovative and involves integrating the smaller local stores into a bigger supply chain. This is expected to create a big improvement in productivity and investment and a significant boom in employment.

Provide information to farmers and help match rural producers with urban consumers

One important use of technology is to connect farmers with consumers and to foster closer integration between urban and rural communities. The development of trading platform for agricultural products that connect farmers to markets allows these farmers to be better connected to dense urban consumer agglomerations with high demand for their produce. Given geographic distance and the asymmetric information between consumers and farmers, many innovative startups are trying to overcome the divide. In many developing countries, especially in sub-Saharan Africa and South Asia, the farmers are the largest employees but have tended to be fragmented. Since many of them are poor and illiterate, they also do not get updated market information on the prices of their products.

One technique that is being used to collect information is through drones. These are being used by both developed and developing country governments alike. Some analysis suggests that the food and

agriculture sector will be the second largest user of drones in the world in the next five years. Drones are being used for general surveillance and to scan agricultural land and identify potential challenges that are linked to natural disasters or crop failures.

Another powerful tool to help farmers is to use early warning systems to support farmers facing challenges. The best example of this is the FEWS NET, the Famine Early Warning Systems Network, that has been a leading provider of early warning and analysis on acute food insecurity. It was created in the mid-1980s in response to African famines and no is widely used by USAID and other development partners. It helps to alert people to food production trends and alert farmers and policymakers to growing famine challenges.

An important area where digital technologies can help is to provide price information to farmers. This can reduce market distortions and help farmers to plan production processes. Farmers are able to use their phones to identify a pest or disease and get customized weather information. In India, a study by the International Maize and Wheat Improvement Center (CIMMYT) in 2011 found that about 67 per cent of the smallholders and marginal farmers were using mobile phones for market price alerts and about 71 per cent of the smallholders and 63 per cent of the marginal farmers, who were using mobile phones, reported to have obtained a better price for their product.

- Akers and Fafchamps (2015) find that the introduction of mobile phone coverage in Niger reduced spatial price dispersion for agri-food products, especially for remote markets and perishable goods.
- Parmeeda is a Bangladeshi company that brings organic farm produce to the consumer through an effective supply chain management system and a sophisticated mobile application, while Mandi Trades, a Bangalore-based mobile app, helps connect Indian farmers to markets (Box 1).
- The M-Farm application in Kenya led to farmers changing their cropping patterns and some reported receiving higher prices at market as a result (Baumüller, 2015).
- In Kenya, Apollo Agriculture is an innovative, tech-based business model that helps farmers maximize their profits with a combination of financing, farming products, and insurance.
- Small scale farmer organizations from Uganda has launched an online agricultural marketing using ICT that will support farmers to access information related to farm produce in the two countries).
- In India, RML Ag tech has a multi-function, online agtech platform and provides information for farmers using SMS texts. A farmer can get crop, weather, and commodity price data for $1.50 a month.
- Ghanaian firm Esoko sends market information (prices for specific commodities, market locations, etc.) to agents and farmers, connecting them to commodity buyers.
- Agri Marketplace is a Portuguese digital e-commerce that enables farmers to obtain better information about suppliers for raw material purchases, marketplaces to sell their products and market prices. It helps to accommodate direct transactions between buyers and sellers, covering all intermediate supply chain stages.[9]

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[9] https://agrimp.com/

Box 1: Parmeeda in Bangladesh and Mandi Trades in India

Bangladesh is another development success story, with a rising middle class (more than 30 million) and an innovative ag and fintech startup world, with ecommerce growing at more than 50 percent a month. Enjoying growth rates averaging more than 5 percent per year in the last decade, the country has grown based on ready-made garments, remittances, microfinance, and agro-industrial strength. It exports more than $30 billion a year.

Registered as a joint stock company in 2017, Parmeeda is a company that helps brings organic farm produce directly to the consumer through supply chain management and mobile application. It has a vast collaborative network with famer organizations and uses a technologically sophisticated mobile application. Its products include meats, vegetables, and oils. It has a reputation in the country of enforcing ecological farming practice in a sustainable business manner and ensuring competitive value chains. Its e-commerce platform currently connects more than 100 farmers and more than 10000 customers.

Similar to Bangladesh, India is an emerging economy with an agricultural sector that has been challenged during the COVID-19 pandemic. It is a country where agricultural is hampered by post-harvest lots and the plethora of middlemen between farmers and consumers. In this context, there has been a recent startup called Mandi Trades, a Bangalore-based mobile app designed for farmers residing in rural areas of India. Founded by Indian entrepreneur Edvin Varghese, it has a trading platform for agricultural products that connects Indian farmers to markets and allows these farmers to sell their produce at attractive prices. The app allows farmers to view the current prices of commodities in trade, the demand for products, and the weather patterns. The app is sophisticated and a farmer can post details of his crops from his or her smartphone. The early evidence shows a decline in wastage and transportation costs due to this smarter and lower cost food supply system.
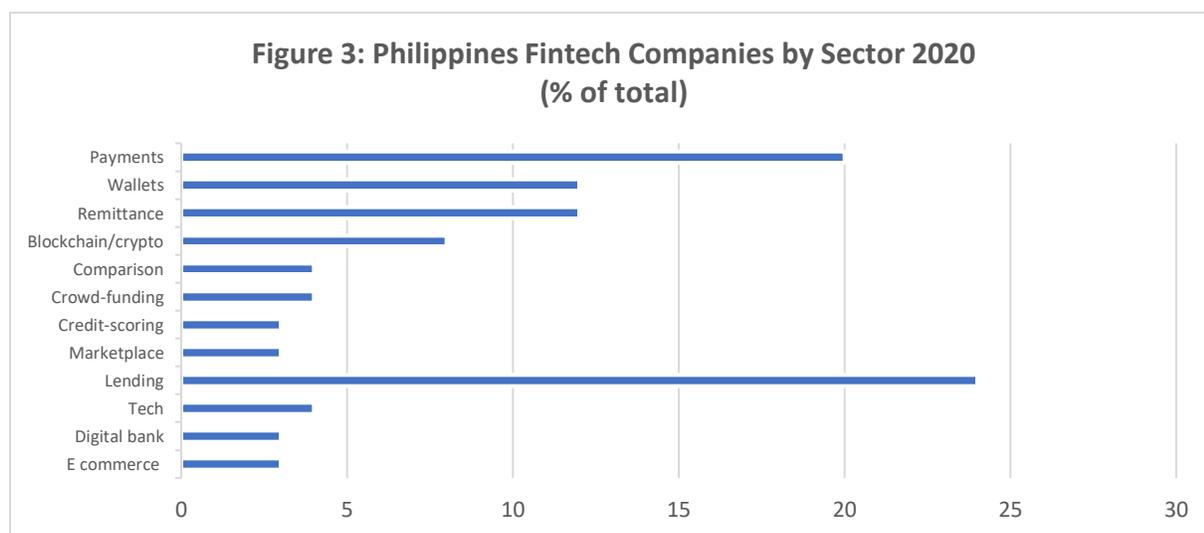
Facilitate access to funds through virtual digital payments

Another potential transformative role for fintech is through providing rural finance. Currently, much rural credit does not reach small farmers, and smallholder farmers tend to have poorer networks and inadequate access to funding. Credit costs for farmers remain very high, and there are only a few bank branches in rural areas. Despite a few successful cases of farmer cooperatives, the farmers have tended to remain unorganized. In order to address their growing needs, financial institutions have adapted their digital products to support rural consumers. The world of microfinance has developed to meet the market failures of conventional financial modalities.

In a recent study, the World Bank (2020) finds that Digital Financial Services (DFS), enabled by fintech, has the potential to lower costs, increase speed, and transparency and allow for more tailored financial services. According to the analysis, the low marginal costs and greater transparency in DFS allows a quick response to supply-side barriers to access to financial services, such as high operating costs, limited competition, as well as demand-side barriers, including low incomes for the poor, lack of ID, and geographical barriers. Given that there are over 850 million registered mobile money accounts across 90 countries, with USD $1.3 billion transacted via these accounts per day, there is a huge possibility for a fintech revolution. Access to digital financial services, such as mobile money, has had welfare benefits

from households, with many examples of such technologies in developing countries. By merging technology, finance, and development, the experience of ANT and MY Bank in China has revolutionized digital finance and helped millions of farmers and SME's (Box 2). There are many other examples.

- Farm Drive, a startup in Kenya connects smallholder farmers to loans and financial management tools through their mobile phones and apps.
- In India, Grameen Foundation is supporting local rural women by training them on digital financial literacy and enabling them to act as agents for both public and private sector financial service providers (FSPs).[10] Over 200 skilled agents have empowered almost 270,000 low-income individuals – mostly women – with access to digital financial services and have already facilitated transactions worth more than 21 million Indian rupees. This has also reduced the gender gap in access to credit considerably.
- Credible India is an innovative firm that focuses on agricultural entrepreneurs by identifying financing gaps and designing AI-driven crop monitoring and local market demand forecasting tools.
- In Philippines, a digital ecosystem is emerging with the rise of many fintech companies (Figure 3). Recently, PearlPay has signed a pilot program agreement with BHF Rural Bank, Inc. (BHF), based in Dagupan City, marking the first time a Philippine rural bank will utilize cloud-based technologies such as core banking solutions (CBS), agent banking solutions (ABS) and white-label eWallet solutions. [11]
- In Kenya, Agri-wallet, is a disruptive fintech that provides supply chain finance to ensure that all actors in the value chain – farmers, buyers and suppliers – can access the resources they need to grow and scale. The Kenyan company M-Shwari uses customers' phone and mobile money records to assess creditworthiness

Figure 3: Philippines Fintech Companies by Sector 2020 (% of total)

Source: Fintech Philippines (2020)

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[10] https://nextbillion.net/women-digital-finance-empowerment/#:~:text=Digital%20finance%20has%20made%20great%20strides%20in%20India%2C,thousands%20of%20women%20with%20access%20to%20financial%20services.

[11] https://mb.com.ph/2019/08/04/fintech-targets-underserved-rural-banking-sector/

Box 2: China – ANT and MY Bank

One of the emerging countries with the most innovative ecosystem in recent years has been China. China has had a track record of more than 8 percent GDP annual growth over the last two decades and has become the second largest economy in the world. Two of the new Chinese companies are behemoths in the fintech/ag tech space. Ant Group, which was formerly known as Ant Financial and Alipay, is an affiliate company of the Chinese Alibaba Group. It has the distinction of being the world's highest valued Fintech company. It is now one of the biggest technology firms in the world and the biggest online payments platform in China. It has now diversified into many sectors, from online payments to consumer lending to microfinance. Alipay has over 700M active users and completed over $8 trillion in transactions in 2017. My Bank, which is an online private commercial bank, has developed a niche and focus on SME financing. As of June 2019, leveraging Alipay's AI, computing and risk management technologies, MY Bank has performed well and worked with over 400 financial partners to provide business loans of over RMB 2 trillion (USD 290 billion) to a total of 15.74 million SMEs in China.

The success of MY Bank is due to its sophisticated algorithms, which crunch real-time payments and other data to evaluate borrowers that often lack collateral and credit histories. The system is able to predict default payments by also tracking online payment history. Ant Group is able to provide small loans to millions of farmers with a combination of online collateral-free financial and use of satellite technology. Ant Group created the 310 online lending model (three minutes to apply, one second to approve, and zero human intervention), serving 29 million small and medium-size enterprises (SMEs) in China, the number has nearly tripled since 2018. It is a very unique data-driven lending model that has kept the nonperforming loans (NPL) rate under 2%, even during the COVID-19 period. [12] ANT is planning to expand this model to other Asian countries.

The secret of ANT's success is that the technology drives the finance. By evaluating a borrower's social and consumer footprint, and without examining the borrower project, the model is able to generate high volumes of loans and low transaction costs and at an interest rate of between 3 and 5 percent. It is interesting that using proprietary AI and risk management technologies, the non-performing loan (NPL) ratio for MY Bank's SME business loans has consistently been at around 1%, which is very impressive. As of March 2018, the average NPL for SME loans in China was 2.75%, according to the Chinese central bank.[13] Even during COVID-19 times, the SME's have been repaying loans with very low NPLs. In October 2020, it was set to raise US$34.5 billion in the world's largest IPO at the time, valuing the company at US$313 billion. However, regulatory differences with the Chinese authorities have delayed the IPO. Given that fintech companies are different from traditional banks, the debate relates to whether one-size-fits-all regulatory model works.

The company also uses satellite technology. These satellites are used to monitor farmers' assets, including size of farm and cropping characteristics, in remote rural regions in order to reduce the difficulty of granting loans in these areas. Farmers can send information via smartphone. A sophisticated algorithm can estimate the value of a farmer's future harvest based on industry prices, climate projections and through the use of dozens of risk control models, and then structure loans accordingly.

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[12] https://www.zdnet.com/article/ant-groups-next-move/
[13] https://www.businesswire.com/news/home/20190623005055/en/MYbank-Works-Financial-Institution-Partners-Serve-15

Provide quality control on food supply

Another area that is seeing growing interest for digital technology is food supply. Already pre-pandemic, there is a significant loss of food from post-harvest loss and poor distribution systems. FAO estimates worldwide that farmers lose about $750 billion from crop losses every year, which represents about a third of all food grown. Food waste in developing countries is much higher compared to the developed ones (Joardder and Masud, 2019). Some estimates show that India loses more than 20 million tons of wheat every year, and parts of Vietnam waste as much as 80% of the rice harvest. [14] The pandemic has exacerbated the disparities and threatened the supply chains. Covid-19 is leading to chain reactions along the food supply chain from production to consumption, and many fresh products like fruits and vegetables are being lost. It is also having a negative impact among many low-income households, especially slum dwellers.

Mobile apps have been successfully used to detect poor quality food in food chains allowing early and effective responses. They are able to trace the weaknesses along the supply chain. Blockchain has also been used to understand logistics and transport networks. According to some estimates, blockchain can facilitate $31 billion in "food fraud savings" by the year 2024. [15] The research shows the blockchain can drive down the cost for retailers through the streamlining of supply chains, but there has not been clear evidence of blockchain so far. FDA Commissioner Scott Gottlieb has said food suppliers can experiment with blockchain because it could link outbreaks "to a specific grower, specific farm and a specific distributor." [16]

There are several good examples. E- Farmers' Hub - a digital platform created by Syngenta Foundation (based in Basel, Switzerland but with agents and representatives in most emerging economies) to help farmers and entrepreneurs keep track of agricultural inputs and outputs in real time. As of 2018, the project is working across 45 Farmers' Hubs (FH) and has benefitted around 30,000 farming households so far. These hubs are close to farming zones and transport infrastructure, but normally far from formal markets, serving up to 1000 farmers and linking them to 10-20 buyers, including medium to large traders, processors and export companies. These Hubs are owned by rural entrepreneurs, agribusiness suppliers or farmers' cooperatives, with fees for the services providing a regular flow of income. It is important to note that buyers benefit from product aggregation and reliable supply. [17] Two other interesting companies to watch are Plantix in India, which provides advisory apps for farmers and extension workers, and Sokowatch, an innovative ecommerce platform connecting merchants to suppliers (Box 3). These are all part of a shifting and growing ecosystem.

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[14] According to one estimate, India produces 28 percent of the world's bananas yet represents just 0.3 percent of all internationally traded bananas. Having an improved cold chain, the number of bananas exported could grow from 4,000 to 190,000 containers, providing an additional 95,000 jobs and benefiting as many as 34,600 smallholder farms.
https://www.npr.org/sections/goatsandsoda/2015/09/28/444188475/even-poor-countries-end-up-wasting-tons-of-food

[15] https://www.cnbc.com/2019/11/27/blockchain-to-save-food-industry-31-billion-new-research-says.html

[16]

[17] Farmers' Hub | Syngenta (syngentafoundation.org)

Box 3: Plantix in India and Sokowatch in Kenya

Plantix is one of the innovative and dynamic mobile crop advisory app for farmers and extension workers. It is now the largest ag tech app in the world. Developed by PEAT GmbH, a Berlin-based AI startup, it can diagnose pest damage, plant disease and nutrient deficiencies affecting crops and can offer corresponding treatment measures. [18] The innovative feature of Plantix is that it uses artificial intelligence to help identify diseases in crops. Farmers are able to upload the app and get a diagnosis and treatment plan. Recently, it has used its geo-tagging software to create a live tracking map of verified cases of the fall armyworm in India. It also provides advice on the use of pesticides.

Its website is a glossy and user-friendly site. It also has a strong interface with users who can discuss with scientists and plant experts plant health issues. The empirics are striking. It has had about 25 million downloads in India, and about 80 percent of the 1.1 million monthly active users are in India. The company has been able to develop a trust network with many individual farmers. Currently, it is able to identify more than 450 diseases in around 50 different crops, and those numbers are growing rapidly in the presence of farmer demand.

Plantix is evolving in recent years, and it has been dubbed an interactive plant doctor. It is benefiting from greater cooperation with governments and private organization. It is drawing increasing attention of many state governments in India, and it cooperates with international research institutes and inter-governmental organizations such as ICRISAT.

Another interesting company to watch is Sokowatch. It is a Kenya - based B2B e-commerce startup, and has raised more than $15 million in funding from venture capitalists to improve supply-chain markets for Africa's informal retailers. The company has created a platform connecting merchants directly to local and multinational suppliers, such as Unilever. Its overall business is to digitizes orders, payments and delivery-logistics. It has developed a quick, verifiable and effective way to bring food security to vulnerable families in Kibera, Nairobi. The company runs an e-commerce platform that enables these SMEs to order products (via SMS or mobile app) directly from fast-moving consumer goods suppliers, and receive free same-day delivery. [19] Thus, the transaction costs for shopkeepers to source goods is eased.

The startup is quite innovative and is able to leverage SMEs' purchasing data and provide them with rotating inventory credit, as well as product mix recommendations to maximize their earnings. The results are quite positive. The startup now serves more than 15,000 retail SMEs in Eastern Africa - Kenya, Rwanda, Tanzania and Uganda. Some evidence suggests a reduction in payment delays and more efficiency along the supply chain. The company is planning to expand and has piloted an innovative e-voucher program. Given the growing size of the East African middle - class consumer market and the supportive ecosystem, the company is only bound to grow.

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[18] https://plantix.net/en/
[19] https://bfaglobal.com/catalyst-fund/insights/fintech-startups-food-insecurity-covid19-crisis/

Lowering transaction costs for government services

Another area where digital technologies show big potential is in the area of digital government services, which can leverage emerging technology and government data to better serve citizens and promote efficiency and welfare. In a world of high transactions costs and excess bureaucracy, the ability to streamline processes and systems is very welcome. Another use of digital technology is to help facilitate collaboration between different government entities and to improve programs. A third use of these technologies is to provide information to consumers. From the payment of taxes to the processing of registration forms to start a business to the provision of information on public health, there is a wide range of digital government services that allow speedier processing.

There are many benefits from digital government services. Some of the main areas are: better online user experiences for citizens. increased public participation, improved internal efficiency and productivity, less burden on IT, better collaboration among departments, reduced labor costs, and greater innovation. [20] Moreover, for developing countries, given the poor levels of state and administrative capacity, the payoff from digital services may be even greater, especially in rural areas. There are many country examples where digital payments can help with government services in rural areas.

- In Nigeria, the Government has set up an electronic payments system - using e-wallets on mobile phones - that uses vouchers for the purchase and distribution of agricultural inputs. Under the system, the government tracks the recipients of fertilizer, the timing and the cost. Under the GES program, the Federal Government was expected to provide 25 per cent, the state also provided 25 per cent, while the farmer paid 50 per cent for each bag of the product supplied to them. [21] According to the National Association of Nigerian Traders (NANTS) in 2015, with the GES, via the e-wallet at 50 per cent subsidy, 1.2 million farmers reportedly bought a maximum of two bags of fertilizer in 120 days.
- In India, the Public Distribution System (PDS), the largest food grain distribution system in the world involving a network of over more than 500,000 Fair Price Shops (FPSs), is now getting more digitized due to the Modi government. The digitization of 230 million ration cards, more than half are strengthened with a universal ID and Aadhaar. Several states have now installed electronic point-of-sale devices at FPSs to track sales of food grains to cardholders on a real-time basis. [22]
- In Kenya, the Ministry of Agriculture has been reforming agricultural extension services by using technology to create E-Extension services, aimed at reaching out to over 7 million farmers, which is 5 million more than the current system of agricultural extension officers. Given Kenya's agricultural population, a new ICT-based system is based on an E-Extension program designed to help foster food security through adoption of smart modes of mass communication to reach to the farmers. [23] The project has been quite successful and seen more than 650 E-Extension agents trained and equipped with the necessary technological gadgets and communicating with farmers via the mobile phone apps.

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[20] Digital Government Services: Modern Definition + Examples | Granicus

[21] Whither the e-wallet scheme? | The Guardian Nigeria News - Nigeria and World News Features — The Guardian Nigeria News – Nigeria and World News

[22] https://www.weforum.org/agenda/2017/10/india-fourth-industrial-revolution-farming/

[23] Kenya rolls out e-extension to improve agriculture | Government News in Kenya (biztechafrica.com)

Table 2: Technology Impact on Rural Sector

Type of technology	Key Features	Advantages	Challenges	Impact
Ag tech 1/Drones, robots, sensors, mechanization, 3D printing	• Encompasses a range of technologies that are relatively new and small-scale • Focus of ag tech innovations is on water management, crop yields, weather prediction, and new machinery. • Many venture capital firms interested in investing in these innovations. • More sophisticated in advanced countries compared to the less developed economies.	• Helps improve farmer knowledge and labor productivity • Minimize inputs for a certain yield • Helps farmer productivity and ensures more food sustainably • Alert problems to crop diseases • More benefits to larger farmers (due to high cost) • Mostly used in Asia and sub-Saharan Africa	• Difficulty in scaling up multiple micro-experiments • Hard to ensure relevant technology is adopted • Very poor farmers may not have finance to benefit from this • Geography varies according to country – leading to lack of "one size fits all"	• **Can support both farm and non-farm development** • RCT studies show early impact • precision agriculture can increase yields by 15 to 20 percent • However, jury still out on longer term impact on productivity
Ag tech 2/data analytics, software/artificial data intelligence apps	• Potential to support both small scale farmers and larger farmers • New and interesting technologies	• Lowers transaction costs for farmer • Allows farmers to move products faster through the supply chain • Helps farmers make better decisions	• Difficult to adapt technology to needs of developing country farmers • Fiscal cost of new technologies	• **Can support agriculture and non-farm development** • Can RCT analysis shows some early wins in South Asia and sub-Saharan Africa • Some farmer beneficiary studies
Fintech/ mobile banking/ remittances services/world of new tech	• Dynamic and usable model • In emerging markets, fintech can help create a stronger interface between governments, businesses and	• Provides tailored financial services to poorer farmers at low cost	• Regulatory challenges and central bank policy response	• **Can facilitate access to funds through virtual digital payments** • **Can lower transaction costs for government services**

	consumers to increase financial inclusion. • With mobile phone and sophisticated algorithms, fintech can help foster financial intermediation	• Allows access to credit and financial information • Reduces informational asymmetries • Can reach small and mid-sized farmers, although not poorest farmers	• Merging tech with finance difficult • Ensuring consumer protection • Training consumers in using app effectively	• A large body of empirical evidence shows dramatic increases in farmer credit and incomes
E-commerce/ Platforms linking producers to consumers/ commodities trading	• Developed in the last two decades • Uses a business model that allows firms and individuals to buy and sell things over the internet • Allow greater consumer flexibility. • Operates in: business to business; business to consumer; consumer to consumer; consumer to business.	• Matches buyers and sellers • Allows rural farmers, both small and larger, to be connected to urban consumers • Reduces transactions costs • Helps internet intermediaries facilitate transactions between third parties (OECD, 2010)	• Generating sufficient and targeted traffic • Maintaining food quality and safety standards • Complexity due to platform intermediaries spanning a wide range of digital business activities	• **Can provide information to farmers and help match rural producers with urban consumers** • **Can support farm and non-farm development** • E-commerce has helped farmers bypass intermediaries, increase incomes and reduce wastage • Quantitative and qualitative evidence is abundant from many micro studies
Blockchain	• Shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network.	• Useful potential for data sharing and supply chain monitoring • Decentralized and can protect asset	• Unclear evidence of blockchain additionality • Mobile app may be more relevant	• **Can provide quality control on food supply** • Lack of clear demonstrable impact so far • Lack of rigor in assessments
Crowd funding	• One of latest development in technology and finance space	• Potentially innovative funding model	• Scalability challenges	• Helps nascent firms but early to assess impact • Not large impact

V. Interventions for Technology Diffusion in Rural Development

There are many interventions that can help diffuse technologies. Digital technologies can create new roles or responsibilities for governments, to enable the digital infrastructure and also support private sector interventions to develop the ecosystem. Depending on the country, the particular technology, and the policy objective, the government can either support the private sector or liberate the private sector to work closely with farmers. Depending on the skill set of the particular government and whether there is a public good element (public infrastructure, ag research, etc), the intervention can be tailored to the particular needs of the situation.

Skills training and startups for youth

Governments can team up with companies to help provide skills training for youth entrepreneurs. Governments in many countries have set up programs to support youth startups. In South Africa, the Small Enterprise Development Agency (SEDA) is working to set up incubation centers for young digital entrepreneurs. In aquaculture, communities are trained to farm indigenous fish as a business and receive technology in terms of infrastructure (production cages) and training to manage a fish farm, including diseases and harvesting.

In other cases, companies and organizations do it directly. Recently, Microsoft has launched a new initiative to help 25 million people worldwide to acquire new skills for a COVID-19 economy. In June, 2017 Google announced plans to train 10 million Africans in online skills over the next five years, while Jordan has an ambitious program to develop digital skills of young people and public-school students. In 2019, the African Development Bank partnered with Microsoft and launched the 'Coding for Employment' digital training platform, an online tool to provide digital skills to African youth, wherever they are across the continent. There is personalized learning for a large-scale mobile-based community. In 2018, the World Bank, together with the Kaduna State Government, launched the Click-On Kaduna program to help youth affected by conflict to leverage new opportunities in the digital space, with more than 1,000 youth trained in accessing remote online work. Another example of partnership between companies and local youth comes from South Africa, where Samsung has been working with universities and colleges to bring market relevant training and development to unemployed youth.

Government incentives for ag-tech startup ecosystem

One of the best ways for developing country governments to support innovative ag-tech firms is to provide policy support and to help contribute to building the ecosystem for startup firms. This approach can involve the government supporting the startups by providing early-stage financing, fiscal or tax incentives, training, and market intelligence. This can also include regulatory support, as was done in the case of M-PESA in Kenya (Box 4).

By supporting firms and improving regulations, governments will help overcome the high barriers to entry for many tech startups as well as help them overcome their isolation. In some countries like Vietnam, government helps partner with private firms to create associations that allow firms to share ideas and experiences. An alternative approach is to develop potential public-private partnership (PPP) ventures where the government contributes some of the seed capital and partners with ambitious

private firms. A third option is to facilitate mergers with local startups to disseminate technology. A fourth option is for the government to directly get involved in subsidizing manufacturers of equipment. In China, in 2018, XAG, the leading drone manufacturer in China received support from the government and developed crop protection drones that can cover an area of 35 acres in as little as an hour, a task that would have taken farmers far longer. In India, with Government support, tech companies such as Skymet, are using drones to provide agriculture survey services to insurance companies and the state governments of Maharashtra, Gujarat, Rajasthan, and Madhya Pradesh.

Box 4: MPESA, Central Bank of Kenya, and M-Farm

Combining a dynamic private sector solution with strong Government of Kenya and Central Bank regulatory support, M-Pesa has been one of the most successful and innovative companies in Kenya and has altered the landscape of mobile money not only in sub-Saharan Africa, but also globally. Launched in 2007 by Vodaphone Group and Safaricom, it one the first mobile phone-based money transfer service, payments and micro-financing service in Africa. Supported by incentives and policies of the Central Bank of Kenya, the company had strong regulatory support. It was allowed to operate as a telecom provider in a banking environment.

Originally facing competition from the banks, it is now used by more than 95 percent of households. It was based on an entrepreneurial vision of using mobile technology to overcome financial obstacles and constraints. Since there were few very banks in rural areas in Kenya, M-Pesa allows remittances to be sent from urban areas to rural farmers without high transaction costs. The mechanics of M-Pesa are simple. It allows a person to create an account and deposit, transfer money, and pay for services – all from a mobile device.

Recently, M-Pesa has partnered with M-Farm, a pioneer agribusiness technology firm that has revolutionized the digital agriculture space in Kenya since it started in 2011. The goal is to support agribusiness to increase transparency in the agricultural crop market and ensure best practices in agriculture using web and mobile, share crop prices throughout the country, train farmers and exchange platform for commodities. MFarm solves a niche in the market by providing up-to-date market prices via an app or SMS, directly to farmers and thus also connects farmers with buyers directly, removing the middlemen. It solved a problem in the market by aggregating farmers. Many farmers were producing in low volume and that many buyers in big cities don't want the hassle of getting the volume they need from multiple different farmers. [24] Thus, farmers have access to the latest market intelligence courtesy of this mobile technology.

The initial evaluation of M Pesa impact has been very positive. Suri and Billy Jack (2016) find that M-Pesa estimate that the expansion of M-Pesa lifted 194,000 households, or two percent of households in the country, above the poverty line. Most of these households are in rural areas and many of them are led by females. The authors also noted that M-Pesa users were able to maintain normal consumption levels in the event of unexpected setbacks. Also, MFarm application in Kenya led to farmers changing their cropping patterns and some reported receiving higher prices at market as a result (Baumüller, 2015).

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[24] https://www.wired.co.uk/article/mfarm

Government support for farmers

Governments can also help famers in many ways, especially by providing financial support. One approach can be for government to help lower the cost of capital for rural entrepreneurs. Rural credit cooperative, with government offerings of lines of credit and guarantees can be helpful ways to strengthen the financing for rural entrepreneurs. Uganda has an interesting and innovative program of joint government-farmer coordination (Box 5). Other approaches revolve around providing mobile technologies to help farmer yields.

Box 5 Uganda Commodity Production and Marketing by USAID

One interesting program of joint aid-government-farmer coordination in Uganda is the USAID Commodity Production and Marketing (CPM) Activity, where mobile technology is used to collect information on smallholder farmers in Uganda and connect the farmers to a range of digital financial services, bundling crop insurance and production loans to increase client value.[25] The goal of the project is to increase the production of high-quality maize, coffee, and beans in Uganda. The project engages buyers and government agents to establish relationships that helps mentor intermediaries in technologies. The project uses mobile tools to help farmers to understand weather forecasts. Also, the activity helps support adoption of weather-indexed crop insurance, which protects farmer incomes when adverse weather conditions cause harvest losses. The insurance serves a financial purpose as it allows farmers to access credit because the policy provides collateral. Adoption of these technologies has helped increase farmer's yields in maize by 24%, beans by 13% and coffee by 173% and led to the reduction in post-harvest losses by 9% in maize, 10% in beans and 6% in coffee in the last four years.

Funding of science parks and ag zones

Another way government policy can help the structural transformation through digital technology is through the creation of special economic zones devoted to agriculture. These zones can be public or private, or a synthesis of both. These zones, consisting of demarcated land and duty-free enclave, benefit from a special policy regime and "plug and play" infrastructure. The zones tend to depart from the country's normal regulatory approval processes and have a streamlined regime to ensure faster service to investors. Many countries, such as China, Vietnam, and Bangladesh, have succeeded in making vibrant economic zones, although the focus has been on labor-intensive manufacturing. Only a few countries have focused on agricultural zones, but there is potential to expand these zones. China has had a few ag zones focused on agricultural biotechnology, but they have not been at large scale. In the early 1980s, the Thai government introduced these zones (AEZs) to mitigate risks for farmers from variations in crop price stability and increase production productivity.

Not all special economic zones have been a success, but the governance of the zones, the level of infrastructure development, and the location are all important determinants of success. Success in economic zones has to do with the competitiveness of particular value chains. Transport costs and the

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[25]

https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID_CCIS%20integration%20case%20study-FTF%20Uganda%20CPM_0.pdf

cost competitiveness of agricultural products, compared to the neighbors, are important factors determining success of an agro-oriented economic zone. Zones in East Asia have generally done better, zones in South Asia have had a mixed record, and African zones have not generally been successful. There do exist opportunities for governments to help develop digital tech economic zones favoring ag technologies or more realistically, allocating a special area.

Development of agricultural research units

Another policy to support digital technology is for governments to fund agricultural research. Globally, agriculture R and D is an important determinant of agricultural productivity and production and indirectly, of poverty. This is even more so in developing countries, where the returns of agricultural investment can be considerable. To take a famous example, the Green Revolution in South Asian agriculture revolutionized the sector, leading to dramatically increased yields. The high-yielding seeds had been developed by research institute in Mexico. Another good example is Embrapa in Brazil, which is the Brazilian Agricultural Research Corporation, a state-owned research corporation affiliated with the Brazilian Ministry of Agriculture. It has been an international pioneer in developing knowledge to help grow Brazilian agriculture. The best output has been the "Revolution in the Brazilian *cerrado*, where 770,000 square miles of acidic, aluminum-rich soils were successfully transformed by Embrapa using lime and fertilizer.

The World Bank (2019) finds a trend that suggests there is underinvestment in agriculture. In developed countries, investment in agricultural R&D was equivalent to 3.25 percent of agricultural GDP in 2011, compared with 0.5 percent in developing counties. Among the emerging economies, Brazil and China stand out as having invested relatively high amounts into agricultural R&D, while Africa and South Asia had the lowest spending relative to agricultural GDP. The study notes that in half of African countries, R&D spending is actually declining.

Government investment in agricultural research can be complemented with private company work. Research about weather, crop patterns, and soil conditions can then be fed into digital technologies and help modern farmers optimize harvest yields. The goal is to utilize research to ensure strong productivity increases in agriculture.

VI. Conclusion and Implications

The use of digital technologies is potentially transformative for developing country agriculture and can lead to productivity gains and structural transformation. This is a rising field, although there has yet to be much rigorous evaluation of many of the methods and approaches, besides a few successful randomized control trials (RCTs). During the post-pandemic recovery, it is expected that there will be an increased rollout of these new approaches. The use of these technologies can help small holder farmers in developing countries. Over the next decade, the ag tech innovations will hopefully lead to greater farmer productivity and welfare gains.

However, the significance of these technologies should not be overstated as they will need to be complemented with other policy approaches – fiscal policy and public investment, infrastructure development, pricing policy, fertilizer subsidy- to help farmers and support the non-farm economy.

The report has several key conclusions.

- Ag tech embraces a heterogeneity of technologies with potentially significant impact on rural farmers and producers.
- A significant potential lies in mobile technology being used by famers for financing and for crop knowledge.
- Early RCT studies and company case studies have documented signs of impact, which are projected to multiply as the technologies take shape.
- E-commerce platforms are helping foster connectivity between farmers and urban residents and also supporting the development of the non-farm sector.
- The most advanced fintech company in the world is ANT and MyBank. This is revolutionizing rural finance in China and having strong transformative effects on the economy.
- The remittance space is particularly promising, as has been seen in the case of M-Pesa in Kenya.
- Government can support this rising ecosystem with regulatory and policy support, the financing support for ag tech startups, and the investing in research and public infrastructure.

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