



Food and Agriculture
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United Nations

Agrifood chains in Asia and the Pacific

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BENEFITS AND CHALLENGES OF GOING DIGITAL

MAIN TOPICS

- Key messages
- What is digitalization in the context of agrifood chains?
- Where does digitalization happen along the agrifood chain?
- Digital innovations at the farm level
- Digital innovations in the extended value chain
- Digital innovations in food manufacturing
- Digital innovations in food retailing
- Digital innovations in meal delivery services
- Opportunities and benefits of digitalization
- Challenges and risks of digitalization
- Policy solutions to promote inclusive digitalization along the agrifood chain
- Recommendations
- References

KEY MESSAGES

- Digital transformation occurs at all stages of the agrifood chain: from production to consumption. In Asia and the Pacific, the ongoing food e-commerce revolution is happening at the same time that mobile-based business models are emerging to provide advisory, marketing and financial services at scale to smallholder farmers in the region. A parallel digital revolution is taking agro-industries to new levels of efficiency.
- Different agrifood chains, and actors within them, adopt digital technologies and business models at varying speeds and so require tailored digitalization strategies to leave no one behind.
- The COVID-19 pandemic has pushed the digital transformation agenda ahead, helping agrifood entrepreneurs to weather the crisis and opening new opportunities to build solutions for more resilient agrifood chains.
- Despite having great potential for improving the efficiency and sustainability of agrifood chains, there are several risks associated with digitalization, from potential job losses to environmental degradation and data governance concerns.
- Policymakers in the region need to facilitate the scaling up of digital innovations in an inclusive and sustainable manner to future-proof agrifood chains, and contribute to COVID-19 recovery.

WHAT IS DIGITALIZATION IN THE CONTEXT OF AGRIFOOD CHAINS?

Digitalization is the “fusion of advanced technologies and the integration of physical and digital systems, the predominance of innovative business models and new processes, and the creation of smart products and services” (EEA, 2020: p.3).

In Asia and the Pacific, all actors along the agrifood chain, from farmers to agro-industries and retailers, are increasingly using digital technologies to generate, store and process data and turn information into insights. These technologies range from the ubiquitous smartphone to the Internet of Things (IoT),

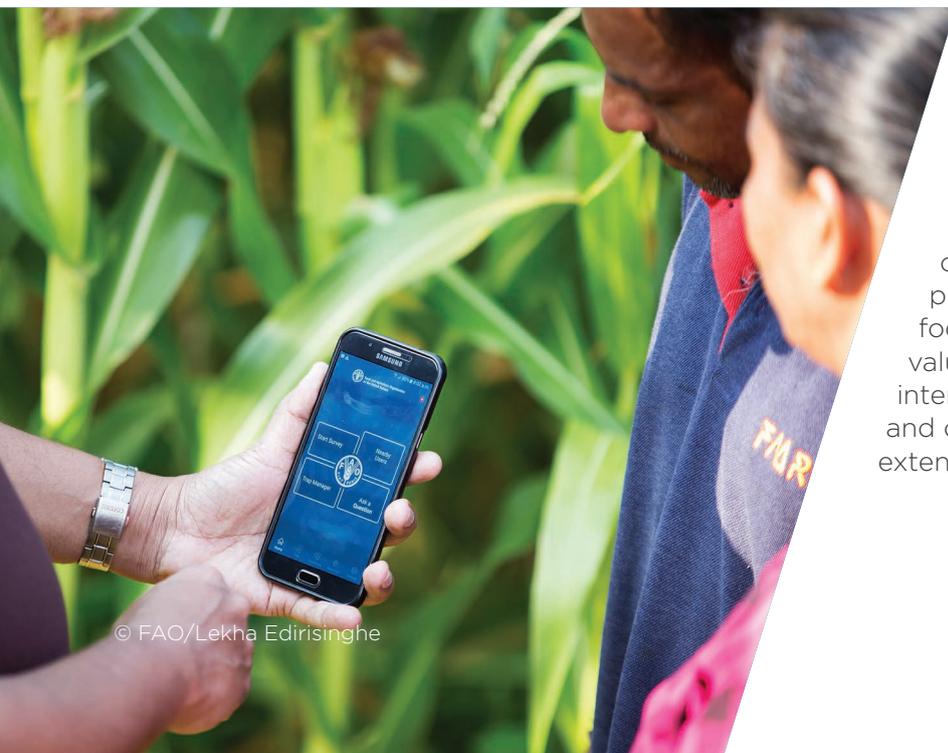
artificial intelligence (AI), blockchain and big data, among others. They often go hand in hand with intelligent automation, which applies robots and field devices on the farm, such as agricultural drones and sensor-equipped agricultural machinery. They are present in food processing facilities, distribution centres and logistics platforms. To properly work and reach scale, these technologies need to be delivered within a functioning business model, increasingly mobile-based.

By using a value-chain approach, it becomes evident for policymakers that not all agrifood chains digitalize at the same speed – which depends on their structure, commodity type and market orientation – and therefore require tailored digital policies and strategies. The approach also helps identify critical entry points along the value chain for promoting the digitalization of smallholders and small- and medium-size enterprises (SMEs). The value-chain lens also sheds light on what drives digital transformation: changes in consumer demographics, technological factors, behaviour and preferences, and changes in the broader environment, such as the COVID-19 pandemic, climate change, venture capital and increased pressure on natural resources.



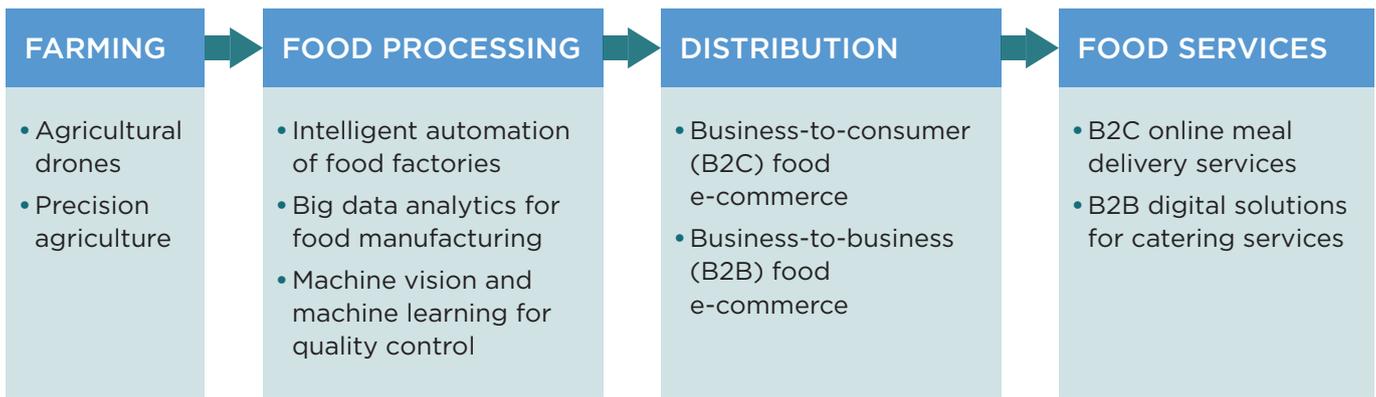
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WHERE DOES DIGITALIZATION HAPPEN ALONG THE AGRIFOOD CHAIN?



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A study conducted by Gálvez (2022) identified over a hundred examples of digital innovation that farmers, agribusinesses and governments have introduced in agrifood chains in Asia and the Pacific. The study revealed that digitalization occurs all along the supply chain: from production to processing, distribution and food services, as well as in the extended value chain. This phenomenon is more intense downstream (food e-commerce and online food delivery services) and in the extended value chain, as per the figure below.



EXTENDED VALUE CHAIN

Digital farming information and advisory services
 Digital marketplaces
 Blockchain solutions for food traceability and provenance

Fintech for farmers
 Supply chain management

Source: Gálvez, E. 2022. *Scaling up inclusive innovation in agrifood chains in Asia and the Pacific*. Bangkok, FAO.

DIGITAL INNOVATIONS AT THE FARM LEVEL

Agricultural drones and precision agriculture (PA) are two digital-based solutions reshaping farming in the region. These technologies help farmers produce more with less water, land, energy and labour, while protecting biodiversity and reducing carbon emissions. Digital services for farmers regarding finance, marketing and management are analysed in the next section.

AGRICULTURAL DRONES: Despite regulatory bottlenecks and pervasive land fragmentation, Asia and the Pacific is the fastest growing market for this technology. This is due to several factors such as the availability of domestic providers of drones and drone services; falling costs of the technology; a surge in venture funding to drone startups; pressure on the food supply from a growing population; and cost-efficiency improvements, especially in the wake of lower prices of agricultural commodities and rising labour costs, notably in China and Japan.

Governments in Asia and the Pacific use drones, often in combination with satellite imagery, for monitoring, mapping and food security strategic forecasting. The data informs forecasting staple crops such as rice, as well as for agricultural insurance services, climate forecasting and disaster management. Within the private sector, the main users are large agribusinesses that use drones for PA on plantations and for high-value crops, and spraying industrial crops such as rice and cereals for feed. There are also some smallholders that use drones for crop protection, particularly in the rice belts of China, India, Japan, Thailand and Viet Nam.





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PRECISION AGRICULTURE: This farm management strategy collects and uses data about soil, weather, crop yields and health, among others, to feed into a decision support system for optimizing farm returns on inputs while preserving resources. To capture and handle data, PA uses specific hardware, software and services in an integrated manner. The hardware it uses includes yield monitors, irrigation controllers, drones, satellite-remote sensing and tractor auto-guidance systems.

Depending on the technological intensity of the operation, PA can be classified as “soft” or “hard.” Hard PA is more suitable for large farms, as it involves applying complex technologies and big data analytic skills. Hard PA is still in the early stages of adoption in the region, except in Japan, nationally owned farms in China, and in some plantations and large farms producing high-value crops. Soft PA, on the other hand, relies on visual observation of crops and soils, and on low-cost tools such as digital soil testing kits and chlorophyll meters. Its services

are typically offered through apps or text messages, such as for weather forecasting. It is gradually becoming available for smallholders through innovative digital-enabled business models.

DIGITAL INNOVATIONS IN THE EXTENDED VALUE CHAIN

Through smartphone apps and other digital tools, farmers can have at their fingertips real-time data on soil, climate, irrigation, pests and diseases, and market prices. They can also get a loan, and connect with buyers and input suppliers. Not least, they can carry out commercial transactions online. Asia and the Pacific is one of the fastest-growing markets for these services, which can be divided into several categories (see figure below). These include digital farming information and advisory services, digital marketplaces, fintech solutions for farmers, and blockchain technologies for food traceability and provenance, and super platforms that offer a combination of these services.



Source: Gálvez, E. 2022. *Scaling up inclusive innovation in agrifood chains in Asia and the Pacific*. Bangkok, FAO.

DIGITAL FARMING INFORMATION AND ADVISORY SERVICES offer farmers timely and reliable information on topics such as production practices, pests and diseases, weather and market prices, among others. These services are delivered through apps, text messaging and websites. Depending on their level of sophistication, they can be divided into two categories:

- ⦿ Basic farmer information services that deliver non-personalized agricultural information and early warnings about weather events or pest and disease outbreaks, thus complementing extension services.
- ⦿ PA advisory services and farm management software (e.g. MimosasTEK in Viet Nam) that provide farmers more sophisticated and tailored agricultural advisory.

DIGITAL MARKETPLACES link farmers to other supply chain actors and facilitate the exchange of data and transactions between parties. Farmers can connect through them with:

- ⦿ Input providers. For example, the digital input marketplace Agrostar connects farmers with input providers in India.
- ⦿ Providers of mechanization services. Examples include Trringo, an Uber-like mobile-based application for tractors that Indian farmers can use to hire a tractor, and Myanmar-based Tun Yat's on-demand platform that connects farmers and renters of tractors and harvesters, and well-trained machine operators.
- ⦿ Off-take markets, such as wholesalers and retailers, or end-consumers through commodities trading platforms, such as Farmer Friend in India.

These digital marketplaces are evolving towards end-to-end integrated digital platforms that link farmers with both buyers and input providers. These marketplaces are mostly developed by the private sector, except for a few platforms driven by the public sector, such as India's National Agriculture Market, also known as eNAM, or established through public-private partnerships.

FINTECH SOLUTIONS FOR FARMERS typically involve generating digital profiles for farmers in combination with cashless tools such as virtual credit cards and digital wallets, and AI-enabled credit scoring systems. The most commonly found fintech solutions in the region are mobile money, mobile lending and data-enabled insurance, which are gradually bringing the unbanked into the financial system.

Digital crowdsourcing platforms for farming activities are a more recent development. Crowdsourcing allows smallholders to gather resources from a crowd of people, such as consumers and investors, through the use of digital platforms and storytelling techniques to fund their farming operations. Examples from the region are Cropital in the Philippines and Crowde and iGrow Asia in Indonesia.

SUPPLY CHAIN MANAGEMENT SOLUTIONS use a variety of applications, the most common of which use blockchain technologies for food traceability and provenance. Blockchain allows creating digital records to document the journey of a food from farm to table. The associated transactions and documentation can be shared with and monitored in real-time by each stakeholder in the system. By doing so, a food item can be traced back to the producer and its provenance can be guaranteed. This helps to combat food fraud or to get a price premium for quality linked to origin, as in the case of Geographical Indications.



Building on their blockchain know-how, big-tech and financial companies, such as IBM, MasterCard and SAP, along with a few startups, are piloting chain-wide food tracking solutions. However, the majority of these applications have been launched in the past couple of years, and in high-value supply chains in developed countries. In the region, there are a few exceptions, such as Traseable's digital platform for product traceability and provenance in seafood and agriculture value chains in Fiji, or Alibaba's tracking solutions for ensuring food safety and fighting fraud.

THE SUPER PLATFORM MODEL bundles together multiple digital services for agrifood supply chains. This model is exemplified by PacFarmer in Fiji, Ricult in Pakistan and Thailand, and Impact Terra and Greenovator in Myanmar. These super platforms target farmers and/or other small-scale value chain intermediaries, and typically integrate digital advisory services, market linkage services, and financial services, among others.

DIGITAL INNOVATIONS IN FOOD MANUFACTURING

Industry 4.0 technologies such as automation and data exchange are reshaping food manufacturing. In Asia and the Pacific, these technologies may prove essential for agro-industries to achieve the cumulative investment required to meet the challenges ahead. That investment is estimated to be US\$456 billion above existing levels during 2020 to 2030.

Automated food manufacturing processes generate large amounts of data that need to be stored and retrieved in real time to monitor and forecast processing functions. This requires investing in digital solutions such as the industrial Internet of Things, system integration to combine data from the processing plant with enterprise and value chain data, data storage systems on premises or in the cloud, cybersecurity solutions, and big data analytics to uncover information for decision-making.



Among the most common Industry 4.0 innovations deployed by agro-industries in the region are:

- ④ **INTELLIGENT AUTOMATION IN AND OUTSIDE OF FOOD PROCESSING FACILITIES:** In smart agro-industries, machines, smart sensors and robotic platforms generate data for monitoring, maintenance, and the basic management of the production line. Special computer systems at various hierarchical production and manufacturing levels are then required for controlling the robotic devices and systems, sensory feedback, and information processing.
- ④ **BIG DATA ANALYTICS FOR FOOD MANUFACTURING:** Big data analytics manages vast data sets for both operational and analytical purposes, such as improving business processes and outcomes through more effective decision-making and enhanced customer experiences. At its most basic, it can be used to understand what is happening in real-time or to analyse past performance to gain insight into what happened and why. It can also help predict what might happen, be it in terms of future sales, the availability of raw materials or when processing equipment may need maintenance. At its most sophisticated, big data analytics can identify actionable insights that represent the best course of action in a scenario given the available data. These insights can help decide which products to develop based on predicted consumer demand, while reducing the time to market. It can also offer insights into how to optimize inventory management, improve traceability and reduce food losses, or how to increase the uptime of the manufacturing plant and reduce equipment breakage.
- ④ **MACHINE VISION, EMPOWERED BY MACHINE LEARNING FOR SORTING FOOD AND QUALITY CONTROL:** Machine vision is an AI technology that provides imaging-based automatic inspection and analysis through sensors, robots, and other IoT technologies. Machine learning applies algorithms to big data in order to improve pattern recognition and identify more accurately what it is captured by machine vision. Agro-industries are using these technologies to:
 - Inspect food for product colour, ripeness, spoilage or damage, and proper cooking time.
 - Ensure that a food product is adequately contained and labelled by inspecting container integrity, labelling and fill levels to ensure consistency.
 - Track ingredients and finished, packaged food products through the production and distribution process, and compile a tracking history of each product for future reference.



Each agro-industry should design its own roadmap by identifying which areas and Industry 4.0 technologies to prioritize first, based on its size, digital readiness, commodity type and overall value chain dynamics. For some firms this would mean digitizing their business; for others, investing in pockets of automation such as automated weighing scales and packing equipment; and for some others, achieving plant-floor intelligent automation through equipment upgrades and connection to networks. This process requires not only sizeable investments, but also a change in mindset, workforce development and close collaboration with tech consulting firms and manufacturers of food processing and handling equipment.

The uptake of digital technologies and automation among agro-industries is fairly heterogeneous across Asia and the Pacific. Agro-industries characterized by large scale, standardized operations – such as dairy and sugar manufacturing – lead the race towards digitalization. Japan, China, South Korea, India and Indonesia have much higher levels of digitalization (around 20 to 40 percent) than the rest of the region. This relatively low uptake among agro-industries in Asia and the Pacific is rooted in the fact that 98 percent of them are SMEs that are less likely to be able to afford the required investments. Nevertheless, the digitalization rate of agro-industries is now on an upward trend driven by the falling cost of technologies, larger availability of local providers, increased public support and the growing pressure emanating from supply chain dynamics, such as shorter time-to-market requirements and the rise of e-commerce and omnichannel retailing.

DIGITAL INNOVATIONS IN FOOD RETAILING



Asia and the Pacific is the global leader in eGrocery shopping and is home to four out of five consumers worldwide who buy food online (Gálvez, 2022). China, Japan and the Republic of Korea are among the world's top five eGrocery markets, and China topped the ranking of venture capital recipients in this category in 2019. Less mature eGrocery markets, such as India, Indonesia and Thailand, will grow fastest over the next five years. Yet, online markets still represent a small share of total grocery sales: from 2.3 percent in India, to over 10 percent in China or 14 percent in the Republic of Korea (Gálvez, 2022). This reflects both supply challenges, such as perishable products and low net margins compared to other consumer goods, and demand deterrents, such as shoppers preferring to handpick food items themselves.

The large majority of Asia-Pacific consumers still purchase their food offline through street vendors, fresh markets and supermarkets. This does not detract, however, from the fact that, as eGrocery sales continue to outpace the growth of brick-and-mortar markets, food e-commerce is changing the way food is marketed, delivered, and paid for. This change occurs through two main pathways: a shift to digital business models and the emergence of an ecosystem of bundled digital technologies.

The shift from offline to online business models can take the form of:

- ④ **OMNICHANNEL FOOD GROCERS** combine digital and physical channels to entice customers, enabling them to gain an unprecedented visibility of food quality, price and service.
- ④ **ONLINE-ONLY GROCERS** rely on a digital shopfront and delivery-to-home service. Some examples from Asia and the Pacific are Miss Fresh in China, Grofers in India and RedMart in Singapore. These businesses focus on streamlining fragmented food value chains, while reducing their real estate requirements to office space and front-end warehouses – not stores.
- ④ **ONLINE MARKETPLACES** lead eGrocery in the region, despite the small share of this category in their overall business. Notwithstanding the high fees to set up and operate digital stores on these online marketplaces, they have become a must-have channel for food companies because they attract a great deal of traffic, have large shopper bases, established payment and delivery systems, and strong capability in analysing big data. China, Japan and the Republic of Korea are home to the leading digital marketplaces, including Alibaba, JD.com, Pinduoduo, Rakuten and Market Kurly. But Southeast Asia is experiencing increasing growth, especially in the wake of the COVID-19 crisis. Pacific countries are also in the midst of an emergence of local e-commerce platforms selling food among other products, such as Maua in Samoa and Vitikart in Fiji.
- ④ **SUPER APPS** are also drawing large numbers of Asia-Pacific consumers to buy their groceries, such as Go-Jek, Line or Grab. These apps are multi-functional mobile applications that offer on a single platform a broad range of options and services for consumers from mobile payment to food delivery and rideshare, messenger, games, and more.

To offer customers more convenient services, eGrocery relies on an ecosystem of bundled digital technologies that include:

- ④ **DIGITAL PAYMENTS:** More than half of all consumer purchases in the region are now handled through digital payment solutions, such as mobile wallet apps.
- ④ **DIGITAL MARKETING:** Digital marketing and social media enable eGrocers to engage in a two-way online communication with consumers for flash sales, feedback and customer service. This includes the use of live commerce and AI-facilitated customer relationship management programmes that allow grocers to track, analyse, and monetize consumer data. An innovative practice is social buying, whereby consumers can buy a product at a lower price by inviting their contacts through social networks to form a joint purchasing team.
- ④ **AI-ENHANCED LOGISTICS AND SUPPLY MANAGEMENT SOLUTIONS:** eGrocers have deployed AI-enhanced solutions to improve inventory performance, reduce food losses and obtain real-time data on delivery details and food safety compliance. They have also improved their “last mile” delivery capacity through the use of smart devices and AI software to determine drivers’ delivery itineraries, increase service quality, lower the cost to serve consumers, and make their operating model more agile and decentralized. In addition, they have used blockchain and machine learning to improve inventory performance so they can hold smaller and more manageable inventories, and have real-time data on delivery details and sanitation measures.



DIGITAL INNOVATIONS IN MEAL DELIVERY SERVICES

Three out of five consumers worldwide who purchase meals online are from the region. The food delivery market in the region – valued in excess of US\$100 billion – is led by China, India and Indonesia, with the Pacific Island Countries lagging behind despite new investments in the wake of the COVID-19 crisis (Gálvez, 2022). Online meal ordering and delivery services have emerged to connect restaurants and caterers with consumers through digital solutions (website and/or mobile app) using one of three business models:

- ④ **THE AGGREGATOR MODEL**, for example online tech platforms delivering food from a range of vendors, as exemplified by Singapore's GrabFood, India's Swiggy, Fiji Eats and Samoa's Seki Eats.
- ④ **THE OWNER MODEL**, whereby a restaurant, catering firm or food outlet develops its own digital solution (website and/or mobile app) to sell meals online directly to consumers.
- ④ **THE SUBSCRIPTION-BASED MODEL** of meal ordering and delivery.



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OPPORTUNITIES AND BENEFITS OF DIGITALIZATION

Digitalization has the potential to benefit all value-chain actors and more broadly, the region's agrifood systems.

BENEFITS FOR FARMERS: Farmers can optimize yields and obtain major cost savings, enhanced efficiency, and more profitability by using PA and drones. They can get data-driven farming solutions on their mobile phones to make more precise decisions, access information and finance, sell their products in online marketplaces or coordinate and monitor their contract farming arrangements. By the same token, digitalization has also opened up opportunities for agritech startups to develop innovative business models targeting smallholder farmers because of cutting-edge digital technologies that reduce transaction and discovery costs. These technologies can also create incentives for new business models with relatively less administrative burdens.

BENEFITS FOR AGRO-INDUSTRIES: By going digital, agro-industries can improve access to markets, enhance quality and safety control, reduce fixed costs and meet price competition, improve resilience, increase recipe agility and manufacturing flexibility to reduce time to market, minimize food losses, save energy and water, optimize equipment maintenance, and more. They can also access more affordable, efficient and secure payment and credit solutions that are enabled by digital technologies.

BENEFITS FOR RETAILERS AND FOOD DELIVERY COMPANIES: eGrocers and food delivery businesses can use data to better know their customers' preferences, which can ultimately lead to more purchases and deeper customer loyalty. Digitalization can also help them reduce costs and risks, optimize operational and supply management and last-mile delivery, save energy consumption, cut

down waste and reach higher levels of food safety and enhanced traceability. It can also significantly reduce the costs of linking small-scale food retailers with suppliers and consumers, thus skipping intermediaries, by decreasing transaction costs and more efficiently matching buyers and sellers. These innovations, though, entail substantial investments and the acquisition of new operational skills.

BENEFITS FOR SMES IN THE EXTENDED VALUE CHAIN: Digitalization has opened up opportunities for agritech startups to develop innovative business models that provide services to smallholder farmers because of cutting-edge digital technologies that reduce transaction and discovery costs.

BENEFITS FOR LENDERS: Digitalization also allows better-informed lenders to move away from land as collateral by reducing discovery, tracking and verification costs. Ultimately, this could expand credit access to smallholders.

BENEFITS FOR CONSUMERS: Digital technologies are also leading to better-informed and engaged consumers who are able to connect more directly with food producers. They also enjoy more tailored products and experiences, as retailers and agro-industries learn more about customers' needs and preferences from the data captured. Urban consumers, in particular, can enjoy fresher and more nutritious and convenient foods thanks to digital improvements in last-mile infrastructure and data-enabled indoor farms.

BENEFITS FOR THE ENTIRE AGRIFOOD CHAIN: The benefits of digital transformation can extend to the entire value chain, making it more efficient through accurate and real-time data analysis to support decision-making, intelligent automation and e-government services. It can also lead to shorter and more transparent value chains through enhanced access to finance and stronger value chain linkages, such as e-commerce, blockchain-enabled traceability and mobile service delivery. It has the potential to change the shape of demand towards more nutritious and environment-friendly foods and make value chains greener through reduced use of inputs, water, plastics and electricity along the supply chain, reduced food losses and waste, and increased resilience. More broadly, unlocking the potential of digitalization could help drive socio-economic growth, ensure food security and nutrition, alleviate poverty and improve resilience to climate change in the region.



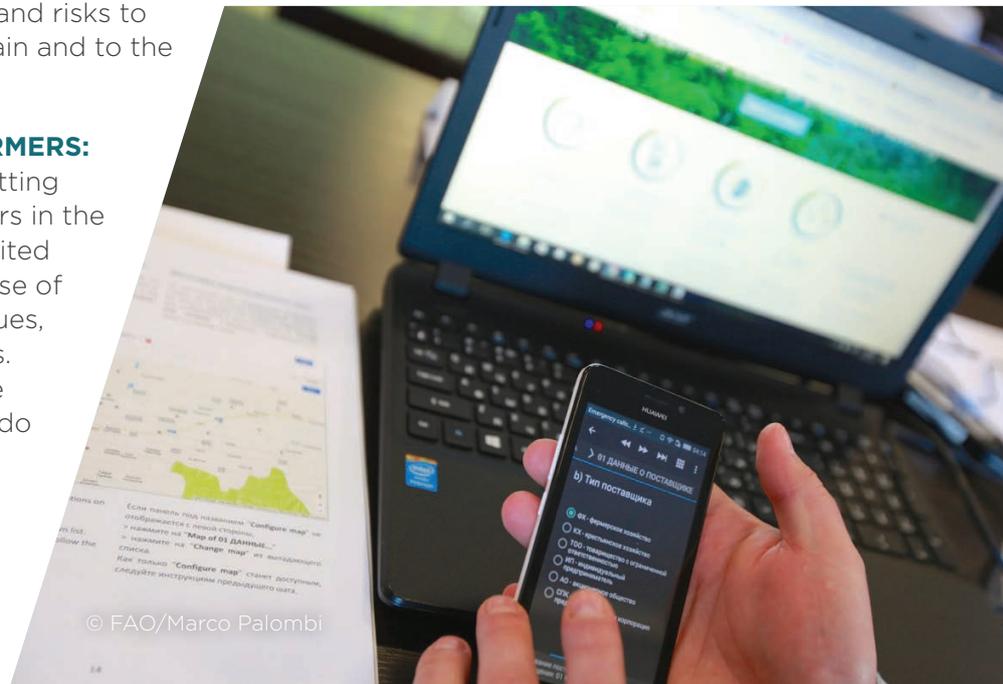
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CHALLENGES AND RISKS OF DIGITALIZATION

Digitalization also poses challenges and risks to different segments of the supply chain and to the entire agrifood system in the region.

CHALLENGES AND RISKS FOR FARMERS:

The digitalization of agriculture is setting higher hurdles for smallholder farmers in the region. Smallholder farmers have limited access to digital technologies because of structural problems, affordability issues, skill gaps and regulatory bottlenecks. Consequently, not many of them use digital technologies, and those who do are not very active or intense users, exactly the opposite of large-scale farmers. This widens the digital and efficiency gap between large and small farms, threatening the guiding principle of the SDGs to leave no one behind.



CHALLENGES AND RISKS FOR

SMALL-SCALE FOOD MANUFACTURERS: Large-scale Asian food manufacturers are eager adopters of digitalization in an effort to reshape their business processes and increase profitability. Conversely, small manufacturers are underinvesting in engineering innovation and the adoption of technology. This gives rise to a digital divide that keeps growing and adding to “traditional” gaps related to financing and human capital, among others.

The evolution of the digital divide separating small and large food manufacturers in the region will grow or shrink depending on the complex interplay of several factors. These include the cost of digital innovations, awareness levels about Industry 4.0 technologies among SMEs, public support to SME digitalization, and collaborative efforts between service providers of smart factory technologies and solutions, and small food manufacturers as the users and adopters.

CHALLENGES AND RISKS FOR SMALL-SCALE FOOD RETAILERS: Competition in food retailing is increasing as retailers deploy omnichannel strategies, which increase resilience, and integrated digital ecosystems that include mobilepay services and social media applications. Large eGrocers in the region have heavily invested in assets such as digital platforms, warehouse systems, and delivery fleets, to the detriment of traditional stores and brick-and-mortar supermarket chains that operate offline and incur more real estate, utility and personnel costs than their online competitors.

The results are noticeable across Asia and the Pacific, and notably in China, where there is a vast concentration of market power among just a few food retail giants and eGrocers that are visibly eating into the food sales of retailers with only a physical presence. There are, however, some efforts to help mom-and-pop shops go digital. For instance, the Indonesian startup Warung Pintar helps thousands of traditional small stalls (warung) to sell staple food items through its digital platform.

CHALLENGES AND RISKS FOR SMES IN THE EXTENDED VALUE CHAIN: Both agritech startups and corporations offer digital services to farmers and small entrepreneurs through mobile-based bottom-of-the-pyramid business models. Their capacity to scale up and reach a larger user base will depend on the viability of their business models in terms of their offerings, revenue models and growth strategies. While corporations bring substantial financial, human and technological resources to the sector, they need to adapt their business model – designed with large farms from industrialized countries in mind – to suit the needs of small-scale farmers in Asia and the Pacific. Conversely, startups often struggle with monetization and customer acquisition, and so require public support and financial backing from investors, but their solutions are attuned to the needs of local users.

Digital technologies could potentially increase the concentration of market power in the hands of corporations providing advisory, market and financial services to farmers to the detriment of agritech startups. This may lead to a widening digital divide and the risk of agritech startups being crowded out, as digital farming attracts big-tech, big-agri or fintech players from outside the region, but also from within the region, as in Japan and China.

CHALLENGES AND RISKS FACING CONSUMERS: Consumers may find themselves over-informed and tune out the digital world. They are increasingly struggling to control both the personal data they share with organizations and how these data are used given that the digitalization of food value chains increasingly depends on monopolistic or oligopolistic markets for big-data platforms. In addition, they are affected by the increased concentration of market power in the hands of a few digital marketplaces and service providers.

CHALLENGES AND RISKS FOR THE WHOLE AGRIFOOD CHAIN: These are manifold, including exclusion and over-concentration of service providers and market power. Other challenges refer to:

- **Impacts on employment.** Automation and digital technologies can result in potential job losses, displacing many current jobs along the value chain or necessitating new skills, and in poor quality jobs in grocery and meal delivery, the so-called gig economy.
- **Data governance concerns.** There are concerns surrounding who holds control and ownership of data within food systems, and how these data (on and about farms and consumers) acquired via digital technologies can be stored, accessed and used safely. A key challenge for policymakers lies in finding a balance between protecting the privacy and confidentiality of data, and the economic interests of farmers and consumers in those data, while making it possible to leverage their potential for the innovation and growth of agrifood systems.
- **Impacts on the environment.** Digitalization can have negative impacts on the environment associated with the carbon footprint of digital technologies, the surge of online grocery and meal delivery services, and the subsequent increase in carbon emissions and waste related to packaging materials. The share of digital technologies in global carbon emissions increased from 2.5 percent to 3.7 percent between 2013 and 2018. The production of every digital device potentially contributes to digital pollution and the demand of increasingly scarce raw materials, including lithium and heavy rare earths. The surge of food e-commerce is also associated with increased carbon emissions from the transport of goods, waste in the form of packaging materials, and intense use of resources such as soil and water.
- **Impacts on gender inequality.** Rural women face greater constraints than men in accessing productive resources, services, technologies, markets, financial assets and local institutions. In Asia and the Pacific, the Internet user gender gap has widened 7 percentage points since 2013, with 41.3 percent of women using the Internet in 2019, compared to 54.6 percent of men. This has made women more vulnerable to the socio-economic effects of the COVID-19 pandemic, which has deepened existing gender inequalities (FAO, 2020b).

POLICY SOLUTIONS TO PROMOTE INCLUSIVE DIGITALIZATION ALONG THE AGRIFOOD CHAIN

There is a need to scale up digitalization and reach a larger number of beneficiaries in a sustainable and inclusive way, taking into account the trade-offs between the benefits and risks. Consequently, countries in the region need to put in place policy and regulatory solutions that aim to upscale digital innovations in agrifood chains, while promoting inclusion and enhancing value-chain governance.

SCALING UP DIGITALIZATION IN AGRIFOOD CHAINS

Member countries need to put in place policy and regulatory solutions, investment programmes to scale up digitalization in agricultural value chains, and reach a larger number of beneficiaries. This will require addressing supply-side factors such as low rural network coverage, availability of digital applications and cybersecurity solutions. Demand side factors must also be addressed, including the need for better skills and knowledge, trust, affordability, and the absence of complementary investments. Therefore, governments in Asia and the Pacific need to invest in digital skills training and critical infrastructure, such as Internet and transport connectivity, value chain storage and cold facilities, collection centres and laboratories.

FOSTERING DIGITAL INCLUSION IN AGRIFOOD CHAINS

Scaling up digitalization is not enough. This process has to be inclusive and sustainable, while tackling related challenges and taking into account benefit-risk trade-offs. For example, some digital innovations may increase food security, but damage the environment, such as blockchain technologies for ensuring food traceability and provenance. Others may only benefit stockholders, but are harmful to consumers and farmers.

Making digitalization in agrifood chains more inclusive necessitates addressing existing market failures by enforcing competition laws to keep entry barriers at a reasonable level, and rolling out trading schemes and incentive systems. Digitalization-specific measures have to be accompanied by traditional measures to strengthen the capacity of farmers and entrepreneurs, such as subsidies, support to aggregate supply, adding value and ensuring compliance with food safety and hygiene measures, and improved access to finance and to public procurement contracts. These digitalization-specific measures include the following:

- **Expanding digital infrastructure and building digital capabilities.** The first step is to improve Internet connectivity in rural areas by expanding digital infrastructure, often through public-private partnerships (PPPs). The second is to build the digital capabilities of small farmers and entrepreneurs, youth, women, and other vulnerable groups. Setting up 'digital villages' accomplishes both things, as acknowledged by FAO's 1 000 Digital Villages Initiative. Other measures include:
 - Providing public extension services that combine physical and digital modalities to disseminate knowledge about new technologies, demonstrate their business case and build the digital skills of farmers and entrepreneurs.
 - Exposing farmers and SMEs to digital technologies and business models through exchange visits, digital exchanges and learning platforms.
 - Supporting the development of mobile apps, social media and network solutions targeting farmers.
 - Providing e-government services such as online subsidy applications and digital seed and fertilizer catalogues.
 - Funding public research programmes to help reduce barriers to widespread adoption of digital technologies by small-scale farmers and entrepreneurs.

- Increasing the space for private sector activity. Increasing the space for private sector activity and using public investments to help crowd-in private investment can also help improving digital services, infrastructure and skills in rural areas. This approach includes fostering public-private and corporate-startup collaboration, as well as with academia, to overcome the existing challenges to technology adoption at scale by smallholder producers and entrepreneurs in the region. This should include mainstreaming the delivery of tailored digital advisory, e-commerce and fintech services.

- **Facilitating access to e-commerce solutions.** Asia and the Pacific governments can adopt a range of measures to help farmers and SMEs operate e-commerce businesses, starting with improving Internet connectivity and digital capability, and investing in storage, cold chain and transportation. Other measures include:

- Providing financial and credit support for coping with e-commerce requirements.
- Developing public e-commerce platforms targeting these actors, such as India's National Agriculture Market or eNAM.
- Improving market regulations to generate an enabling environment for e-commerce and for building the trust of consumers in purchasing agrifood products online, including efforts to tighten regulations and develop dispute settlement mechanisms.
- Partnering with companies that source directly from local smallholder farmers through e-commerce platforms, as in the case of Taobao villages in China.

- **Encouraging the shift to digital fintech solutions to revitalize rural areas.** Availed with digital technologies, financial institutions can enter rural markets without establishing a costly physical presence, bringing financial inclusion to rural populations. This shift to fintech solutions can be further encouraged by:
 - Incentivizing the expansion of digital payments infrastructure and agent banking models.
 - Advocating for digital and financial literacy programmes.
 - Lifting the limits imposed on digital transactions and reducing the associated transaction fees.
 - Passing regulations to foster the use of mobile technology for financial services and to protect consumers.
 - Addressing the different standards and licensing requirements of each country.
- **Promoting entrepreneurship programmes.** Entrepreneurship programmes can help farmers and startups become competitive with large-scale businesses. Particularly impactful is the new generation of business incubators and accelerators, characterized by being increasingly virtual, private-driven and focused on agritech startups and, in some cases, on entrepreneurs from vulnerable groups, particularly women and youth.



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ENHANCING VALUE CHAIN GOVERNANCE

Efforts are ongoing in the region towards improving the governance of agrifood chains. These are centred on four major issues: better employment, data governance, gender equality, and environment and climate change.

Better employment. Asia-Pacific governments can promote better employment opportunities by providing training on digital technologies and addressing challenges related to gig-economy jobs through benefits, income-security measures, and training and credentials to make these jobs acceptable. Another solution would be to use smart employment contracts powered by blockchain technology, as they can help eradicate unfair practices in hiring agricultural and food workers.

Data governance. Policymakers need to strike a balance between protecting the privacy and confidentiality of data, and the economic interests of farmers and consumers in those data, while making it possible for businesses to leverage their potential. The region needs improved regulations for the independent generation, storage, use, dissemination, property rights and confidentiality of big data. Unclear and unequal data governance arrangements may weaken the willingness of smallholder farmers, SMEs and consumers to adopt digital solutions. To this end, governments in Asia and the Pacific need to:

- Assess how existing regulatory arrangements affect agrifood value chains.
- Determine whether there are persistent gaps in existing data governance arrangements and ensure that broader data policies are applied in a more tailored way to meet the specific needs of these chains.
- Improve communication around policy and regulatory frameworks for data governance to build confidence in the use of digital solutions, especially among farmers and consumers.
- Promote open data, data standards and data governance frameworks.

Inclusive digitalization in agrifood chains may benefit from strategic collaborations with large-scale initiatives such as the United Nations Digital Public Goods initiative and FAO's Hand in Hand geospatial platform for cost savings and SDG alignment. These external big data sources, known as blockchain oracles, increase the quality of the data within the value chain and facilitate digital innovations at policy and operational levels. The quality of the data also increases significantly with the adoption of data standards, data governance frameworks and data regulatory frameworks, which also ensure data protection (data privacy and data confidentiality) from a user perspective.

Gender equality. Governments in the region need to create an enabling environment that includes gender-responsive policies, strategies and initiatives to stimulate and accelerate digitalization. This requires mainstreaming a gender lens and promoting gender equality by empowering women to adopt and/or develop digital solutions throughout the agrifood value chain. Given that mobile phones are the most frequently used means of accessing the Internet, addressing the mobile-phone gender gap could help reduce the Internet-usage gender gap. Such efforts must be accompanied by digital and business skills training (notably e-commerce and financial literacy), financial support, the development of productive infrastructure required for e-commerce, and complementary initiatives that specifically target women.

Greener and climate-resilient agrifood chains. Governments in the region need to implement policies to internalize the hidden costs of digitalization-related environmental externalities and to foster digital innovations that make value chains greener and more resilient to climate change. Key measures include the promotion of digital technologies that track food loss and waste all throughout the value chain, allowing for devising specific reduction measures, and digitally enabled innovations to restore agro-ecosystems by reducing land and water degradation and carbon emissions.



Policymakers in Asia and the Pacific need to accelerate inclusive digitalization to future-proof the region's agrifood chains in the face of growing population numbers, urbanization, climate change, resource scarcity and the COVID-19 pandemic. This requires harnessing the power of digital technologies along agrifood chains to pilot, accelerate and scale innovative ideas through:

- ④ Expanding connectivity, specifically addressing the mobile gap that prevails among women, particularly in rural areas.
- ④ Building the digital skills needed to use digital tools among small-scale farmers, entrepreneurs, food-chain workers and consumers. Such efforts must be accompanied by skills training in digital- and business-related topics such as e-commerce and financial literacy, financial support and the development of productive infrastructure required for e-commerce, and complementary initiatives that specifically target vulnerable groups.
- ④ Supporting the development of digital business models that provide services to the bottom of the pyramid, be it farmers, SMEs or consumers. This can be done through PPPs and through direct support to agritech startups. This premise is based on the understanding that digital technologies only reach farmers and other value-chain actors at scale when they are delivered within a functioning business model.
- ④ Fostering greater collaboration between corporations, investors, accelerators, universities, and startups to build a more robust environment for digital solutions in agrifood chains.
- ④ Ensuring that digital technologies do not drive exclusion in agrifood chains, climate change, biodiversity loss or diet-related ill health.



- Overcoming regulatory issues related to data governance and cybersecurity, workers' rights and enforcing food safety in e-commerce, among others.
- Building back better to address the weaknesses in food supply chains laid bare by the COVID-19 pandemic. The crisis has put the spotlight on all the inequalities in the region's agrifood supply chains, as it has disproportionately affected smallholder producers – particularly those producing perishable, high-value commodities – SMEs, food-chain workers and low-income consumers (FAO, 2020a).

Consequently, there is an increased emphasis on the urgency of facilitating the sustainable transformation of agrifood chains in the region, particularly when it comes to investing in rural development linked with inequality and tied to the digitalization transformation, diversification and resilience of agrifood systems. These priority topics will not go away immediately after the pandemic is over. They will likely stay at the top of the agenda during the next decade.

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