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FAO REGIONAL CONFERENCE FOR ASIA AND THE PACIFIC

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Scaling up inclusive digitalization in agricultural value chains

Executive Summary

In Asia and the Pacific, digital transformation occurs at all stages of the value chains, from food production to consumption. 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. A parallel revolution in Industry 4.0 technologies is taking agro-industries to new levels of efficiency. Digitalization offers great potential for improving the efficiency and sustainability of value chains, and achieving Sustainable Development Goals (SDGs) 1, 2 and 13 (No Poverty, Zero Hunger and Climate Action). There are, however, several risks associated with digitalization, from potential job losses to environmental degradation and data governance concerns. Different value chains, and actors within them, digitalize at varying speeds and would therefore require tailored digitalization strategies to leave no one behind. Policymakers in the region need to facilitate the scaling up of digital innovations along agricultural value chains in an inclusive and sustainable manner, particularly in the wake of the COVID-19 pandemic. Members are invited to provide guidance on how FAO can best support them in fostering the inclusive digitalization of agricultural and food value chains.

Suggested action by the Regional Conference

The Regional Conference is invited to:

a. reflect on ways to promote the use of digital innovations at scale along the agricultural value chains;

b. increase awareness and understanding of the diverse benefits, challenges and support needed to improve the digitalization of smallholder farmers and small entrepreneurs, particularly women and youth, and support the development of digital business models that provide services to the bottom of the pyramid at scale;

c. foster greater collaboration between corporates, investors, accelerators, universities and start-ups in order to build a more robust environment for digital solutions in agricultural value chains;

d. help identify areas for increased analytical and policy work in order to contribute to scaling up inclusive digitalization from farm to fork;

e. create an enabling environment (e.g., policies, regulations, infrastructure, organizations, and socio-cultural changes) conducive to an inclusive and sustainable digitalization in agricultural value chains that helps overcome regulatory issues (e.g. data governance, cybersecurity and worker rights, and enforcing food safety in e-commerce) and build back better in the wake of the COVID-19 pandemic.

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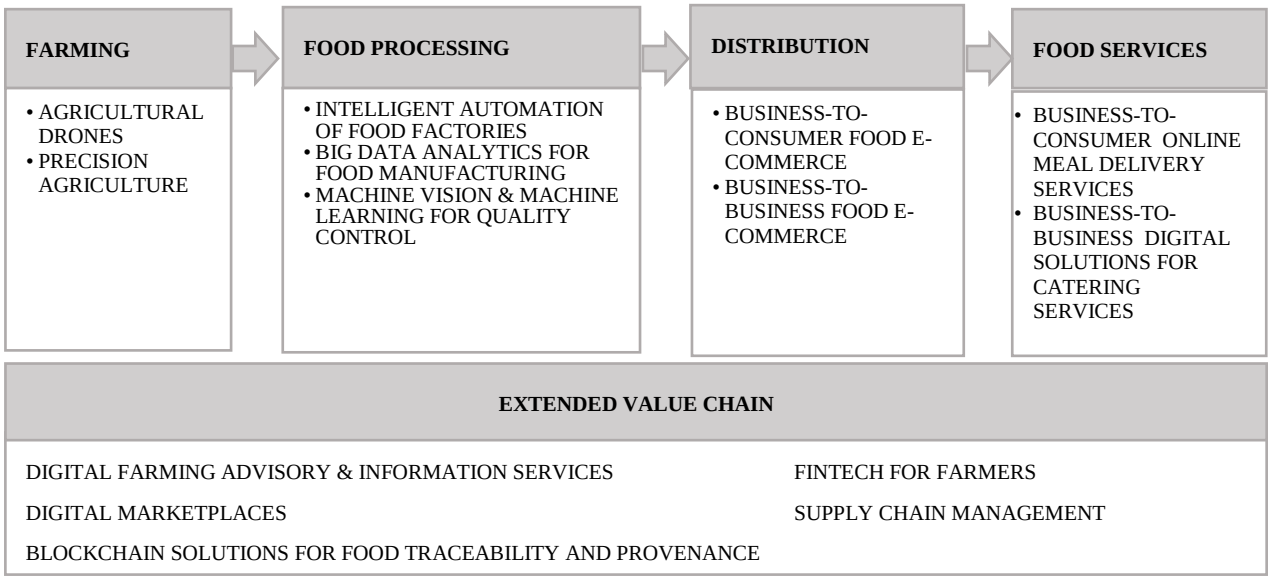
Introduction

1. 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"*.[1] In Asia and the Pacific, all actors along the agricultural value chains, from farmers to agro-industries and retailers, are increasingly using digital technologies to generate, store and process data and turn them into insights. These technologies encompass the Internet of things, artificial intelligence (AI), blockchain, big data and the ubiquitous smartphone, among others. They are often combined with intelligent automation, which applies robots and field devices on the farm (e.g. agricultural drones, sensor-equipped agricultural machinery) and in food processing facilities, distribution centres and logistics platforms. To properly work and reach scale, these digital innovations need to be delivered within a functioning business model, increasingly mobile-based.

2. The 35th Session of the FAO Regional Conference for Asia and the Pacific emphasized the imperative to build back better by leveraging digital innovations in the region's agrifood systems. This entails looking at how each value chain actor uses digital technologies and influences others to do so. Different value chains and actors within them digitalize at varying speed and would therefore require tailored digitalization strategies. Understanding the dynamics of digital innovations from farm to fork can help identify critical entry points for disseminating these innovations among smallholders and small and medium enterprises (SMEs).

3. The digitalization of agricultural value chains is being driven by changes in: (i) consumer demographics, behaviour and preferences; (ii) technological factors;[2] and (iii) the broader environment, such as climate change, venture capital, increased pressure on the environment and the COVID-19 pandemic.

4. Digitalization occurs all along the supply chain – from production to processing, distribution and food services – as well as in the extended value chain.[3] This phenomenon is more intense downstream (e.g. food e-commerce, online food delivery services) and in the extended value chain, as illustrated in the figure below.



[1] European Environment Agency. 2020. Digital waste management. *Eionet Report* - ETC/WMGE 2020/4; p. 3.
[2] Technological factors include falling data costs, increased connectivity, technological breakthroughs, the growing convergence of new digital solutions and their availability at local level, and increased flows of venture capital.
[3] The extended value chain includes input supply, financial services and agribusiness support services. FAO. 2021. *Scaling up inclusive innovations in agrifood chains in Asia and the Pacific.* Gálvez Nogales, E. Bangkok, FAO.

Digital innovations at the farm level

5. Precision agriculture (PA)[4] and agricultural drones are key digital-based solutions reshaping farming in the region. They help farmers produce more with less water, land, inputs, energy and labour, while protecting biodiversity and reducing carbon emissions.

6. PA is a farm management strategy that collects and uses data to feed into a decision support system for optimizing farm returns on inputs while preserving resources.[5] It involves the integrated use of specific hardware (e.g. yield monitors, irrigation controllers, drones, satellite remote-sensing, tractor auto-guidance systems), software and services to capture and handle data about the soil, weather, crop yields and health, among others. Depending on the technological intensity of the operation, PA can be classified as "soft" or "hard". The latter is more suitable for large farms, as it involves applying complex technologies and big data analytic skills. Although the global PA market grew threefold from 2014 to 2020,[6] hard PA is still in the early stage of adoption in the region, except in Japan, in nationally owned farms in China, and in some plantations and large farms producing high-value crops.[7] Soft PA relies on visual observation of crops and soils, and on low-cost tools (e.g. digital soil-testing kits and chlorophyll meters) and services typically offered via apps or text messages (e.g. weather forecasting).[8] It is gradually becoming available for smallholders through innovative digital-enabled business models, as shown in the "extended value chain" section.

7. Despite regulatory bottlenecks and pervasive land fragmentation, Asia and the Pacific region is the fastest-growing market for agricultural drones, owing to: (i) the availability of domestic providers of drones and drone services; (ii) the falling costs of the technology; (iii) the surge in venture funding into drone startups; (iv) pressure of the growing population on food supply; and (v) improvements in cost-efficiency, especially in the wake of lower prices of agricultural commodities and rising labour costs, notably in China and Japan.[9] Asia-Pacific governments use agricultural drones – often in combination with satellite imagery – for climate forecasting, disaster management and agricultural insurance services, as well as for monitoring, mapping and forecasting crops that are strategic for food security, mostly rice.[10] Private sector users are mainly large agribusinesses for PA (plantation and high-value crops) and spraying industrial crops (e.g., rice and cereals for feed). Smallholders are increasingly using drones for crop protection, particularly in the rice belts of China, India, Japan, Thailand and Viet Nam.

Digital innovations in the extended value chain

8. 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; obtain a loan; and connect with buyers and input suppliers to carry out commercial transactions.[11] Asia-Pacific is one of the fastest-growing markets for these services, which include digital farming information and advisory services, digital marketplaces, fintech solutions for farmers, and blockchain technologies for food traceability and provenance.[12]

9. 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 via

[4] Digital services for farmers (e.g. financial management) are analysed under the section on the extended value chain.
[5] InterAcademy Partnership. 2018. *Opportunities for future research and innovation on food and nutrition security and agriculture: The InterAcademy Partnership's global perspective.* Trieste and Washington, DC.
[6] www.marketsandmarkets.com
[7] FAO. 2021. See note 3.
[8] High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (HLPE). 2019. *Agro-ecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition.* Rome.
[9] https://www.grandviewresearch.com/industry-analysis/global-commercial-drones-market
[10] FAO & International Telecommunication Union (ITU). 2018. *E-agriculture in action: Drones for agriculture*. FAO, Bangkok. http://www.fao.org/3/I8494EN/i8494en.pdf
[11] FAO. 2019. *Digital Technologies in Agriculture and Rural Areas Briefing Paper*. Rome, FAO. http://www.fao.org/3/ca4887en/ca4887en.pdf
[12] www.marketsandmarkets.com

apps, text messaging and/or websites. They can be: (i) 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; and (ii) PA advisory services and farm management software that provide farmers more sophisticated and tailored agricultural advisories.[13]

10. Digital marketplaces link farmers to other supply chain actors and facilitate the exchange of data and transactions between parties. They can connect farmers with: (i) input providers; (ii) providers of mechanization services; (iii) off-take markets (e.g. wholesalers and retailers) or end-consumers through commodities trading platforms; and (iv) both buyers and input providers through end-to-end integrated digital platforms.[14]

11. Fintech solutions 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. In the region, mobile money, mobile lending and data-enabled insurance are gradually bringing the unbanked into the financial system. Crowdsourcing platforms for farming activities are also on the rise.[15]

12. These digital solutions for food and agricultural supply chains are evolving towards the so-called super platform model, which bundles together multiple services all in one platform. These super platforms target farmers or other smallholder value chains intermediaries, and typically integrate digital advisory services, market linkage services, and financial services, among others.

13. Startups, big-tech and financial companies are piloting chain-wide food tracking solutions that build on their blockchain know-how to provide participants with food traceability records and/or attest to the provenance of a food item in order to combat food fraud or obtain a price premium for quality linked to origin.[16] The majority of these applications have been launched in the past few years, and in high-value supply chains in developed countries, with some exceptions. FAO is developing a blockchain methodology for seafood value chains[17] through Key Data Elements.[18]

14. Both agritech startups and corporates offer these services 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.[19] While corporates bring substantial financial, human and technological resources to the sector, they need to adapt their business model – originally designed for large farms from industrialized countries – to suit the needs of small-scale farmers in Asia and the Pacific region. Conversely, startups often struggle with monetization and customer acquisition – thus requiring public support and financial backing from investors – but their solutions are attuned to the needs of local users.

[13] Technical Centre for Agricultural and Rural Cooperation. 2019. *The digitalisation of African agriculture report 2018–2019.* Wageningen; and Economist Intelligence Unit (EIU). 2018. *Food 4.0: The Future of Food Innovation in Asia.*
[14] https://corporate.agrostar.in/#home; https://tunyat.com/; www.farmerfriend.in
[15] Crowdsourcing platforms gather resources from a crowd of people (e.g. consumers and investors) through the use of digital platforms and storytelling techniques to fund farming operations. Deloitte. 2019. *Converge Cultivating Southeast Asia for the Future of Food.*
[16] Blockchain allows the creation of digital records to document the journey of a food from farm to table, and the associated transactions and documentation, which can be shared with and monitored in real-time by each stakeholder in the system. United Nations Development Programme (UNDP). 2020. *Blockchain for food traceability*. Singapore, UNDP.
[17] http://www.fao.org/fishery/nems/41300/en
[18] FAO. 2020. Blockchain application in seafood value chains. *FAO Fisheries and Aquaculture Circular No. 1207*. http://www.fao.org/publications/card/fr/c/CA8751EN/
[19] Offering refers to the company's product or service that fulfils the need of customers. Revenue model deals with the framework for generating financial income, while growth strategies pertain to the plan of action to achieve a higher level of users and market share.

Digital innovations in food manufacturing

15. Automation and data exchange, also known as Industry 4.0 technologies, can help the region's agro-industry meet the challenges ahead.[20] Automated food-manufacturing processes generate large amounts of data that need to be stored and retrieved in real time in order 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;[21] data storage systems on premises or on the cloud; cybersecurity solutions; and big data analytics to uncover information for decision-making. Each agro-industry should prepare its own roadmap by identifying which areas and Industry 4.0 technologies to prioritize, based on its size, digital readiness, commodity type and overall value chain dynamics. For some firms, this would mean digitizing their business;[22] for others, investing in pockets of automation like automated weighing scales and packing equipment; and for some others, achieving plant-floor intelligent automation through equipment upgrades and connection to networks. These processes require 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.

16. Asia-Pacific agro-industries are mainly deploying three Industry 4.0 technologies: (i) intelligent automation; (ii) big data analytics; and (iii) a combination of machine vision and machine learning.[23] First, leading agro-industries are using intelligent automation in and outside of the food processing facility in order to accommodate a wide range of raw materials, increase recipe agility, eliminate repetitive loads and tasks, and reduce fixed costs, among others.[24] Second, agro-industries are increasingly embracing big data analytics to manage vast data sets for improving decision-making and enhancing customer experience. By so doing, they can, for example: (i) understand what is happening in real time and use these insights to improve traceability and food safety, and reduce food losses; (ii) predict what might happen in terms of future sales and raw materials to optimize inventory management and equipment maintenance; and (iii) prescribe which products to develop based on estimated consumer demand, reducing the time-to-market and improving customer satisfaction.[25] Third, agro-industries are also investing in machine vision, empowered by machine learning, for sorting food, controlling quality (e.g. food quality, container integrity, labelling, fill levels), and tracking ingredients and finished food products.[26]

17. Given the sophistication of these technologies and the required investments, their use is relatively low among the region's agro-industries, 98 percent of which are SMEs.[27] In contrast, their uptake is higher (between 20 to 40 percent) among agro-industries characterized by large-scale, standardized operations – such as dairy and sugar manufacturing – and in some countries like China, Japan and the Republic of Korea.[28] Nevertheless, this uptake is expected to increase owing to the falling cost of technologies, growing availability of local providers, shorter time-to-market requirements, rise of e-commerce and omnichannel retailing, and increased public support to SME digitalization.[29]

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[20] Skinner, R., Chew P. & Maheshwari, A. 2019. *The Asia food challenge: Harvesting the Future.* Joint report launched by PwC, Rabobank and Temasec at the 2019 Asia-Pacific Agri-food Innovation Week in Singapore.
[21] Enterprise data include information on finances, employees, suppliers, customers, partners and assets.
[22] Digitization entails converting data from analogue to digital format.
[23] While machine vision provides imaging-based automatic inspection and analysis through sensors, robots, and other IoT technologies, machine learning uses AI to improve pattern recognition and identify more accurately what it is captured via machine vision. FAO, 2021. See note 3.
[24] Capgemini Research Institute (CRI). 2016. *Smart factories at scale*.
[25] FAO and ITU. 2019. *E-agriculture in Action: Big Data for Agriculture.* Bangkok. http://www.fao.org/3/ca5427en/ca5427en.pdf
[26] FAO. 2021. See note 3.
[27] FAO. 2018. *Dynamic development, shifting demographics, changing diets*. Bangkok, FAO. http://www.fao.org/3/I8499EN/i8499en.pdf
[28] CRI. 2016. See note 25.
[29] FAO. 2021. See note 3; McKinsey & Company. 2017. *The Future of Retail Grocery in a Digital World.*

Innovations in grocery retailing

18. Asia-Pacific is the global leader in e-grocery shopping and hosts four out of five consumers who buy food online worldwide.[30] China, Japan and the Republic of Korea are among the top five global e-grocery markets, and China topped the ranking of venture capital recipients in this category in 2019.[31] Less mature e-grocery markets such as India, Indonesia and Thailand will grow fastest over the next five years.[32] 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.[33] This reflects both supply challenges (e.g. perishable products, low net margins vis-à-vis other consumer goods) and demand deterrents (e.g. shoppers prefer to handpick food items themselves).

19. While the large majority of Asia-Pacific consumers still purchase their food offline (e.g. from street vendors, fresh markets and supermarkets), this does not detract from the fact that, as e-grocery sales continue to outpace the growth of brick-and-mortar grocers, 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.

20. The shift from offline to online business models can take the form of omnichannel food grocers, online-only grocers, online marketplaces and super-apps.[34] Omnichannel retailing combines digital and physical channels to entice customers, enabling them to gain an unprecedented visibility of food quality, price and service. Online-only grocers rely on a digital shopfront and delivery-to-home service. They focus on streamlining fragmented food value chains, while reducing their real estate requirements to office space and front-end warehouses – not stores.[35] Online marketplaces lead e-grocery 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 and 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, but South-East Asia is seeing increasing growth, especially in the wake of the COVID-19 pandemic.[36] Pacific countries are also seeing the emergence of local e-commerce platforms selling food among other products. Asia-Pacific consumers are also turning to "super apps" to buy their groceries.[37]

21. E-grocery relies on an ecosystem of bundled digital technologies composed of digital payments, digital marketing and AI-enhanced logistics and supply management solutions, to offer customers more convenient services.[38] More than half of all consumer purchases in the region are now handled through digital payment solutions, such as mobile wallet apps.[39] Digital marketing and social media enable the region's e-grocers to engage in a two-way online communication with consumers for flash sales, feedback and customer service. This includes the use of live commerce, social buying,[40] and AI-facilitated customer relationship management programmes that allow grocers to track, analyse, and monetize consumer data. Finally, AI-enhanced solutions for logistics and supply management

[30] www.marketsandmarkets.com
[31] AgFunder. 2020. *AgFunder Agri Food Tech: Investing report 2019*. San Francisco.
[32] https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation
[33] https://redseer.com/reports/online-grocery-what-brands-need-to-know/; https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation; https://www.statista.com/statistics/945335/china-penetration-rate-of-fmcg-and-grocery-in-e-commerce/
[34] FAO. 2021. See note 3.
[35] Food Industry Asia (FIA). 2020. *Food E-commerce across Asia: Risks and Opportunities.* Singapore; AgFunder, 2020. See note 33.
[36] FIA. 2020. See note 37.
[37] These super apps combine into a single mobile-based platform all aspects of a consumer's life from mobile payment to messenger, rideshare and food delivery, thus building up colossal user bases. McKinsey Global Institute. 2017. *China's digital economy a leading global force.*
[38] FAO. 2021. See note 3.
[39] McKinsey & Company. 2017. See note 31.
[40] Social buying is a practice whereby consumers can buy a product at a lower price by inviting their contacts through social networks to form a joint purchasing team.

have helped e-grocers to improve inventory performance, reduce food losses and have real-time data on delivery details and food safety compliance. E-grocers have also improved their "last mile" delivery capacity through the use of smart devices and AI software to determine drivers' delivery itineraries, while lowering the cost to serve consumers and making their operating model more agile and decentralized.[41]

Innovations in meal delivery services

22. Three out of five consumers who purchase meals online worldwide are from the region.[42] The food delivery market in the region – valued in excess of USD 100 billion – is headed by China, India and Indonesia, with the Pacific Islands lagging behind despite new investments in the wake of the COVID-19 pandemic.[43] Online meal ordering and delivery services have emerged to connect restaurants and caterers with consumers via digital solutions (website and/or mobile app) using one of three business models: (i) the aggregator model, i.e. online tech platforms delivering food from a range of vendors; (ii) the owner model, whereby a restaurant, catering firm or food outlet develops its own digital solution to sell meals online directly to consumers; and (iii) the subscription-based meal ordering and delivery model.[44]

Opportunities for and benefits of digitalization along the value chain

23. Digitalization has the potential to benefit all types of actors in the value chain. Farmers can optimize yields and obtain major cost savings, enhanced efficiency, and more profitability by using PA and drones.[45] They can obtain 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 on account of cutting-edge digital technologies that reduce transaction and discovery costs.

24. By going digital, agro-industries can improve access to markets and 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, and optimize equipment maintenance, among other benefits.[46] They can also access more affordable, convenient and secure digital payment and credit solutions.

25. E-grocers and food delivery businesses can use data to better know their customer preferences, which can ultimately lead to more purchases and deeper customer loyalty.[47] 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.[48] Digitalization can also significantly reduce the costs of linking small-scale food retailers with suppliers and consumers, thus skipping intermediaries, by decreasing transaction costs and matching buyers and sellers more efficiently.[49]

26. Digital technologies are leading to better informed and engaged consumers who are able to connect more directly with food producers. Consumers can enjoy more tailored products and

[41] https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation
[42] www.marketsandmarkets.com
[43] Skinner *et al.* 2019. See note 21.
[44] AgFunder. 2020. See note 33.
[45] HLPE. 2019. See note 10; EIU. 2018. See note 13.
[46] International Electrotechnical Commission. 2015. *Factory of the future*. White paper. Geneva.
[47] https://digital.hbs.edu/platform-digit/submission/kroger-doubling-down-on-data-in-the-face-of-hungry-competition/
[48] FAO. 2021. See note 3.
[49] World Bank. 2020. *Future of Food: Harnessing Digital Technologies to Improve Food System Outcomes.* Washington, DC.

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.

27. 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. Digital transformation can also lead to shorter and more transparent value chains via enhanced access to finance and stronger value chain linkages (e.g. e-commerce, blockchain-enabled traceability, mobile service delivery). It can potentially change the shape of demand towards more nutritious and environmentally friendly foods and make value chains more resilient and greener by reducing food loss and waste, and the use of inputs, water, plastics and electricity along the supply chain. More broadly, unlocking the potential of digitalization can help drive socio-economic growth, ensure food security and nutrition, alleviate poverty and improve resilience to climate change in the region.

Challenges and risks of digitalization along the value chain

28. Digitalization can also set hurdles for actors along the value chain. Asia-Pacific smallholders are faced with structural problems, affordability issues, skill gaps and regulatory bottlenecks that limit their access to digital technologies. Conversely, large-scale farmers are far more active and intense digital users. This widens the digital and efficiency gap between them, threatening the guiding principle of the SDGs to leave no one behind. The digital divide between small-scale agro-industries, which are under-investing in Industry 4.0 technologies, and large-scale agro-industries, which are eagerly adopting them, also keeps growing and adding to "traditional" gaps related to financing and human capital, among others. Consumers may find themselves over-informed and tune out the digital world.

29. Digitalization is not gender-neutral. Rural women face greater constraints than men in accessing productive resources, services, technologies, markets, financial assets and local institutions. In Asia and the Pacific region, 41.3 percent of women were using the Internet in 2019, compared to 54.6 percent of men,[50] and the Internet user gender gap[51] has widened 7 percentage points since 2013.[52] This has made women more vulnerable to the socio-economic effects of the COVID-19 pandemic,[53] which has deepened existing gender inequalities.

30. Competition in food retailing is increasing as retailers deploy omnichannel strategies, which increase resilience, and integrated digital ecosystems that include mobile pay services and social media applications. Large e-grocers in the region have invested heavily 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 incur. The results are noticeable across Asia and the Pacific, and notably in China, where there is vast concentration of market power by just a few food retail giants, and where e-grocers are visibly eating into the food sales of retailers with only physical presence.[54] There are, however, some efforts to help mom-and-pop shops go digital.

[50] The Internet gender gap is the difference between the Internet user penetration rates for males and females relative to the Internet user penetration rate for males, expressed as a percentage. ITU. 2021. Digital trends in Asia and the Pacific 2021 Information and communication technology trends and developments in the Asia-Pacific region, 2017-2020. https://www.itu.int/en/myitu/Publications/2021/03/08/09/13/Digital-Trends-in-Asia-Pacific-2021

[51] From 17.4 percent in 2013 up to 24.4 percent in 2019. GSMA. 2020. Connected Women. The Mobile Gender Gap Report 2020. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/05/GSMA-The-Mobile-Gender-Gap-Report-2020.pdf. (Note that GSMA stands for Groupe Speciale Mobile Association, but the spelled out version is rarely used).

[52] https://itu.foleon.com/itu/measuring-digital-development/gender-gap/

[53] FAO. 2020. Gendered impacts of COVID-19 and equitable policy responses in agriculture, food security and Nutrition. http://www.fao.org/3/ca9198en/CA9198EN.pdf

[54] McKinsey & Company. 2017. See note 31.

31. Similarly, digital technologies could potentially increase the concentration of market power in the hands of corporates providing advisory, market and financial services to farmers to the detriment of agritech start-ups. 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.

32. Consumers are increasingly struggling to control the personal data they share with organizations and how these data are used, given that the digitalization of agrifood value chains increasingly depends on monopolistic or oligopolistic markets for big-data platforms. They are affected as well by the increased concentration of market power in the hands of a few digital marketplaces and service providers.

33. Beyond the issues of exclusion and over-concentration of market power, there are other digitalization-related challenges that affect the entire value chain. For example, there are concerns surrounding who holds control and ownership of data within agrifood systems, and how these data (on and about farms and consumers) acquired via digital technologies can be stored, accessed and used safely. Moreover, 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.[55] Finally, digitalization can have negative impacts on the environment associated with the carbon footprint of digital technologies,[56] and the surge of online grocery and meal delivery services and the subsequent increase in carbon emissions and waste related to packaging materials.

Solutions to scale up inclusive and sustainable digitalization

34. Member Nations need to put in place policy and regulatory solutions, and investment programmes to scale up digitalization in agricultural value chains. This will require addressing supply-side factors such as low rural network coverage and availability of digital applications and cybersecurity solutions; and demand-side factors, including the need for better skills and knowledge, trust, affordability, and the absence of complementary investments such as value chain storage and cold facilities, collection centres and laboratories. Therefore, governments in the region need to invest in digital skills training and critical infrastructure, such as Internet and transport connectivity, and critical value chain infrastructure.

35. Scaling up digitalization is not enough. This process must 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 e-grocery. Others may only benefit stockholders but be harmful to consumers and farmers.

36. Making digitalization in agricultural value chains more inclusive requires addressing existing market failures by enforcing competition laws to keep entry barriers at a reasonable level, and rolling out trading schemes, incentive systems, and traditional measures to strengthen the capacity of farmers and entrepreneurs[57] as well as digitalization-specific measures.

37. The first step is to improve Internet connectivity in rural areas by expanding digital infrastructure, often through public-private partnerships. The second is to build the digital capabilities of small-scale farmers and entrepreneurs, women, youth, and other vulnerable groups. Setting up "digital villages" accomplishes both things, as acknowledged by FAO's 1 000 Digital Villages

[55] United Nations Industrial Development Organization (UNIDO). 2017. *Accelerating clean energy through Industry 4.0 Manufacturing the next revolution.* Vienna; Kalleberg, A. & Dunn, M. 2017. *Good Jobs, Bad Jobs in the Gig Economy.*
[56] The share of digital technologies in global carbon emissions increased from 2.5 to 3.7 percent between 2013 and 2018, and every digital device potentially contributes to digital pollution and the demand for increasingly scarce raw materials (e.g. lithium, heavy rare earths) for its original production. https://en.reset.org/knowledge/our-digital-carbon-footprint-whats-the-environmental-impact-online-world-12302019; UNIDO. 2017. See note 58.
[57] Traditional measures include improved access to finance and to public procurement contracts, and support to aggregate supply, add value and ensure food quality safety compliance.

Initiative.[58] Other measures include: (i) providing public extension services that combine physical and digital modalities to disseminate knowledge about new technologies and demonstrate their business case and build the digital skills of farmers and entrepreneurs;[59] (ii) exposing farmers and SMEs to digital technologies and business models through exchange visits, digital exchange and learning platforms; (iii) supporting the development of mobile apps, social media and network solutions targeting farmers; (iv) providing e-government services such as online subsidy applications and digital seed and fertilizer catalogues; and (v) funding public research programmes to help reduce barriers to widespread adoption of digital technologies by small-scale farmers and entrepreneurs.

38. Increasing the space for private sector activity and using public investments to leverage private investment can also help to improve digital services, infrastructure and skills in rural areas.[60] 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, including mainstreaming the delivery of tailored digital advisory, e-commerce and fintech services.

39. Asia-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: (i) providing financial and credit support to meet e-commerce requirements; (ii) developing public e-commerce platforms targeting these actors; and (iii) improving market regulations to generate an enabling environment for e-commerce and to build the trust of consumers in purchasing agrifood products online, including efforts to tighten regulations and develop dispute settlement mechanisms.[61] Some governments are partnering with companies that source directly from local smallholder farmers via e-commerce platforms.[62]

40. Availed with digital technologies, financial institutions can enter rural markets without establishing a costly physical presence, thus bringing financial inclusion to rural populations. This shift to fintech solutions can be further encouraged by: (i) incentivizing the expansion of digital payments infrastructure and agent banking models; (ii) advocating for digital and financial literacy programmes; (iii) lifting the limits imposed on digital transactions and reducing the associated transaction fees; (iv) passing regulations to foster the use of mobile technology for financial services and to protect consumers;[63] and (v) addressing the different standards and licensing requirements by each country.[64]

41. Entrepreneurship programmes can help farmers and start-ups become competitive with large-scale businesses. Particularly promising is the new generation of business incubators and accelerators, characterized by being increasingly virtual, private-driven and focused on agritech start-ups and, in some cases, on entrepreneurs from vulnerable groups, as well as women and youth.

42. There are ongoing efforts in the region to promote better employment opportunities by providing training on digital technologies and addressing challenges related to gig-economy jobs, via benefits, income-security measures, for these jobs to be acceptable. Another way to promote better employment is to eradicate unfair practices in hiring agricultural and food workers by using smart employment contracts powered by blockchain technology.[65]

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[58] This term refers to an internet-connected village where residents can receive various e-services from the government or private players, http://www.fao.org/director-general/news/news-article/en/c/1320506/

[59] Asian Development Bank (ADB) & the International Food Policy Research Institute (IFPRI). 2019. Information and Communication Technology for Agriculture in the People's Republic of China. Manila.

[60] FAO. 2020. *The State of the Agricultural Commodity Markets 2020. Agricultural Markets and Sustainable Development: Global Value Chains, Smallholder Farmers and Digital Innovations.* Rome, FAO. http://www.fao.org/3/cb0665en/CB0665EN.pdf

[61] Key regulations regard food safety, transparency and safety of digital transactions, ADB & IFPRI. 2019. See note 62.

[62] FAO. 2020. See note 63.

[63] For example, by clarifying what constitutes reasonable interest rates and removing predatory and hidden fees.

[64] ADB & Oliver Wyman. 2017. *Accelerating Financial Inclusion in South-East Asia with Digital Finance*.

[65] FAO. 2020. See note 63.

43. Policymakers need to strike a balance between protecting the privacy and confidentiality of data, and the economic interests of farmers and consumers, while making it possible for businesses to leverage the potential of the data.[66] The region needs to improve regulations for the independent generation, storage, use, dissemination, property rights and confidentiality of big data, as unclear and unequal data governance arrangements may weaken the willingness of smallholder farmers, SMEs and consumers to adopt digital solutions. To this end, Asia-Pacific governments need to: (i) assess how existing regulatory arrangements affect food and agriculture value chains; (ii) 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; (iii) improve communication around policy and regulatory frameworks for data governance to build confidence in the use of digital solutions, especially among farmers and consumers;[67] and (iv) promote open data, as well as data standards and data governance frameworks.[68] Inclusive digitalization in agricultural value chains may benefit from strategic collaborations with large- scale initiatives such as the United Nations' Digital Public Goods initiative[69] and FAO's Hand-in-Hand geospatial platform[70] for cost-savings and aligning SDGs. These external big data sources, known as blockchain oracles,[71] increase the quality of the data within the value chains 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.

44. Finally, 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 throughout the value chains, allowing for specific reduction measures to be devised, as well as digitally-enabled innovations to restore agro-ecosystems by reducing land and water degradation, and carbon emissions.

Recommendations

45. Policymakers in Asia and the Pacific region need to accelerate inclusive digitalization along agricultural value chains in the face of growing populations, urbanization, climate change, resource scarcity and the COVID-19 pandemic. This implies harnessing the power of digital technologies along value chains to pilot, accelerate and scale up innovative ideas through the following recommended actions:

a. expanding connectivity and building the digital skills of small-scale farmers, entrepreneurs, agricultural value chain workers and consumers to use digital tools;
b. supporting the development of digital business models that provide services to the bottom of the pyramid at scale, through public-private partnerships or direct support to start-ups;
c. fostering greater collaboration between corporates, investors, accelerators, universities and start-ups in order to build a more robust environment for digital solutions in agricultural value chains;
d. overcoming regulatory issues related to data governance, cybersecurity and worker rights, and enforcing food safety in e-commerce;
e. ensuring that digital technologies do not drive exclusion in agricultural value chains or exacerbate climate change, biodiversity loss or diet-related ill health; and

[66] World Bank. 2020 (see note 51); Jouanjean, M., Casalini, F., Wiseman, L. & Gray, E. 2020. Issues around data governance in the digital transformation of agriculture: The farmers' perspective, *OECD Food, Agriculture and Fisheries Papers*, 146, Paris.
[67] Jouanjean *et al.* 2020. See note 70.
[68] GS1 is an example of an industry data standard (https://www.gs1.org/). The EU General Data Protection Regulation is an example of a data regulatory framework (https://gdpr-info.eu/). DMBOK2 is an example of a data governance framework (https://damadach.org/dmbok2-dama-dmbok-version-2/).
[69] https://digitalpublicgoods.net/
[70] http://www.fao.org/hih-geospatial-platform/en/
[71] https://ieeexplore.ieee.org/abstract/document/9086815

f. building back better to address the weaknesses in food supply chains laid bare by the COVID-19 pandemic, which has disproportionally affected smallholder producers, SMEs, food chain workers and low-income consumers.[72]

[72] FAO. 2020. *COVID-19 and smallholder producers' access to markets.* Rome, FAO. http://www.fao.org/3/ca8657en/CA8657EN.pdf