



Food and Agriculture  
Organization of the  
United Nations



Scaling up inclusive  
**INNOVATION  
IN AGRIFOOD  
CHAINS**  
in Asia and the Pacific



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Eva Gálvez Nogales

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS  
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# ABSTRACT

The publication looks at innovations happening at all stages of the food value chain: from production to manufacturing and retailing. This also includes the extended value chain, for example input supply, financial services and agribusiness support services. Yields are improving and primary production is becoming more resilient as a result of digital technologies such as precision agriculture, agricultural drones, and digital farming services and marketplaces; and novel business models such as plant factories, crowdsourcing for farmers. Data and robotics help lift productivity and food safety in the manufacturing process. Online grocery commerce and food delivery services are revolutionizing the way consumers purchase food. Distributed ledger technology, such as blockchain, allows making payments and tracing back food products along the chain in order to increase transparency and trust. New business models are springing up to shorten the chain by removing or shifting stages and to make it fairer and greener, stimulated by enabling technologies and changing customer behaviours. Innovations such as these are discussed and illustrated by almost 200 practical examples from 21 countries in the Asia-Pacific region, across various types of firms and commodities.

By observing emerging trends and providing concrete examples, the book discusses the nature of these innovations, how they are affecting food systems and value chains, positively or negatively, and how to deal with trade-offs. It concludes with a reflection on the impacts of these innovations, the policy solutions identified, and lessons learned to future-proof the region's food systems, particularly in the wake of the COVID-19 pandemic.

# ACRONYMS

ADB	Asian Development Bank
AFA	Asian Farmer’s Association for Sustainable Rural Development
AI	artificial intelligence
AMR	antimicrobial resistance
APAC	Asia Pacific
ASEAN	Association of Southeast Asian Nations
B2B	business-to-business
B2C	business-to-consumer
BDS	business development services
CAGR	compounded annual growth rate
CEO	chief executive officer
CFDA	China Food and Drug Administration
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
CRM	consumer relationship management
CSA	community-supported agriculture
ERP	enterprise resource planning
ESG	environmental, social and governance
F2B	farmer to business
F2C	farmer to consumer
FP&H	food processing and handling equipment
FSP	Farmer Services Platform
FSSAI	Food Safety and Standards Authority of India
GDP	gross domestic product
GHG	greenhouse gas
GIS	geographic information system
GMP	good manufacturing practices
GNSS	global navigation satellite system
GPS	global positioning system
HMI	human machine interface
HORECA	hotels, restaurants and cafes
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	information and communications technology
IoT	Internet of Things
ITT	innovation and technology transfer
ITU	International Telecommunication Union
KPI	key performance indicator
LIDAR	laser imaging detection and ranging
LPDR	Lao People’s Democratic Republic
MES	manufacturing execution systems
MIC25	Made in China 2025

NGO	non-governmental organization
O2O	online-to-offline
PLC	programmable logic controller
PPP	public-private partnership [and 4P or public-private-producer partnership]
QR	quick response [code]
R&D	research and development
SaaS	software as a service [company]
SCADA	supervisory control and data acquisition
SDG	Sustainable Development Goals
SFACH	Small Farmers Agri-business consortium Haryana [India]
SMAE	small- and medium- agro-based enterprise
SME	small- and medium- enterprise
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
VRA	variable-rate application
WEF	World Economic Forum
WTO	World Trade Organization

### **Units and currencies**

m <sup>2</sup>	square metre
ha	hectare
USD	dollar of the United States of America

# EXECUTIVE SUMMARY

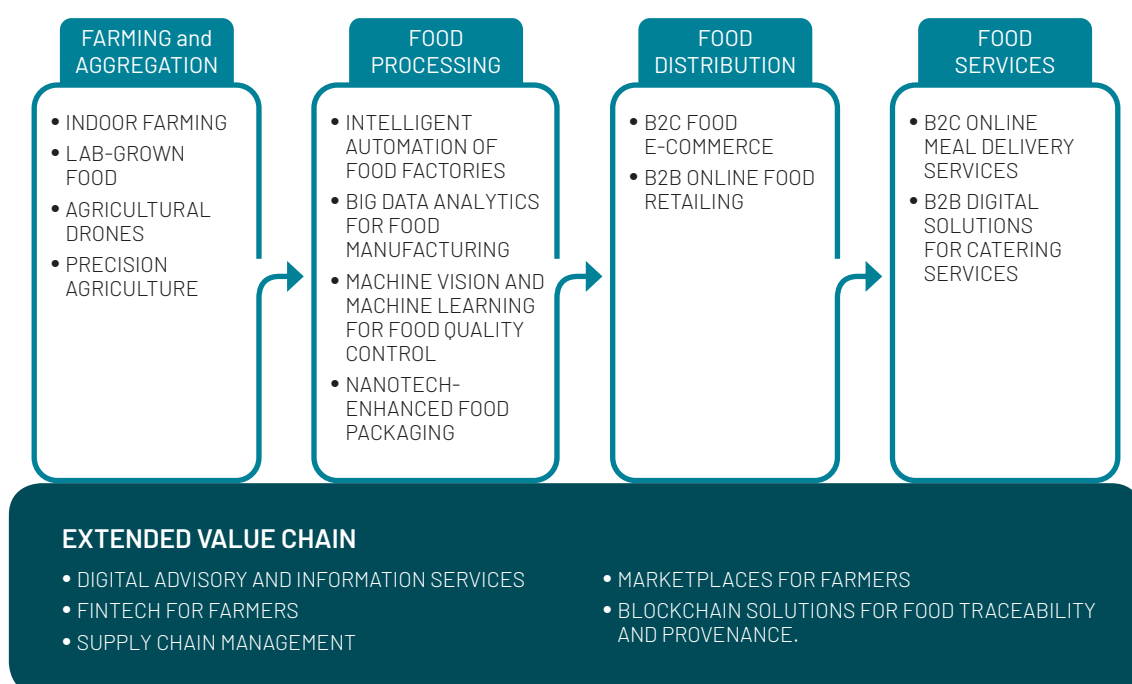
## WHERE DOES INNOVATION IN FOOD VALUE CHAINS OCCUR?

Innovation is all around us, from the fields where our food is grown to online applications that deliver ready-meals to our door. This publication examines various innovations occurring in food systems in the Asia-Pacific (APAC) region, in an effort to understand their scope, patterns, underlying mechanisms and impacts. The study also underlines key factors driving these innovations, such as changes in demographics and consumer behaviour, increased pressure on the environment, climate change, increased connectivity and technological breakthroughs such as artificial intelligence, big data, the Internet of Things and blockchain.

Given the incalculable number of innovations taking place, the scope of this

publication has been narrowed to focus on business model and technological innovations such as digital technologies, automation, robotics and nanotechnology. These have the most potential for reshaping the region's food systems, according to industry leaders and supported by investment flows.

The study identified nearly 200 examples of innovations introduced by farmers, agribusinesses and the public sector in 21 countries in the region, across various types of firms and commodities. These cases have been mapped out along the value chain: from production and aggregation, to processing, distribution and food services, as well as the extended value chain (e.g. input supply, financial services and agribusiness support services), as summarized in the figure below.



The large majority of the innovations identified take place in two areas: downstream, as evidenced by the soaring rise of food e-commerce and online food delivery services; and in the extended value chain, such as digital farming services, agricultural marketplaces, financial technology (fintech) solutions, and supply chain management applications, including blockchain for food traceability and provenance. Other innovations have been documented at the processing level related to Industry 4.0 technologies, and at the production stage, namely: agricultural drones, precision farming, novel food production systems such as vertical farms and indoor aquaculture, and innovative foods, including lab-grown meat.

These major fields of innovation have in common two elements: digitalization and the adoption of new business models.

## **DIGITAL TRANSFORMATION IN AGRICULTURE AND FOOD SYSTEMS**

Data are the foundation of the digital revolution sweeping across APAC's food systems. Thanks to the digitalization process, the agriculture and food sectors – traditionally considered low technology – are becoming cognitive businesses that turn data into insights for farmers, processors and food retailers, among others. Through digital solutions, smart farmers can not only access real-time data on soil, climate, irrigation, pests and diseases, and market prices, but also connect with buyers and input suppliers, and learn about available commercial loans and government subsidies (van Es and Woodard, 2017). Digitalization also allows better-informed lenders to move away from land as collateral, and contributes to reducing discovery, tracking and verification costs. Ultimately, this could expand credit access to smallholders and improve their welfare. E-grocers and food delivery businesses use data to better know their customer preferences in order to deliver tailored food products and experiences. Moreover, they rely

on data to optimize supply management and last-mile delivery, reduce food loss and waste, etc. Likewise, by going digital, food processors can improve quality control and maintenance, increase recipe agility so they can quickly react to customer needs, reduce fixed costs and food losses, and save energy and water, among other things.

Digitalization is often combined with “intelligent automation,” which involves an increased use of technology including robots and field devices on the farm such as agricultural drones, sensor-equipped agricultural machinery, and automated irrigation/fertigation systems. The combination is also found in food processing facilities, collection and distribution centres.

## **THE BUSINESS MODEL REVOLUTION**

The effects of innovation are found in improved business models, processes and services along the agricultural value chain, and not only in novel technologies. The digital revolution needs new business models to reap its fruits. Companies in the APAC's food space are changing their business models to maximize returns in an evolving scenario characterized by the rise of the digital economy and of sustainability criteria. The digital economy implies migrating towards a stage in which digital technologies become the backbone of the products or services of a company. Examples include farming apps and platforms, for example climate apps, precision-farming apps, and agricultural machinery rental apps. Digital economies include online marketplaces such as farmer-consumer, farmer-buyer apps, and e-commerce platforms, as well as online meal delivery applications, and fintech solutions for farmers. Digital and sustainability trends are closely interrelated. For example, digital-based short-chain models have their *raison d'être* in materializing a greater alignment with sustainability principles, but use e-commerce and other digital technologies as the means to attain it.

This publication highlights several categories of innovative business models, including models for the provision of digital agribusiness services for farmers, fintech for farmers, food e-commerce and online meal delivery services.

The global market for **digital-based farming services** will reach \$9.53 billion by 2023, with APAC being one of the fastest-growing regions (AgFunder, 2020). These business models offer digital solutions for technology-driven smallholder farmers to increase productivity and better utilize farm resources. Such solutions can be divided into three main categories: i) farm management software, sensing and IoT (e.g. agricultural data capturing devices, decision support software, big data analytics); ii) farm robotics, mechanization and equipment including drone manufacturers; and iii) digital marketplaces, including commodities trading platforms, online input procurement and equipment leasing.

These services are provided by both agritech startups and established firms, which have adapted their business models to serve bottom-of-the-pyramid users, such as the over 400 million smallholder farms in APAC countries. Although hundreds of startups have sprung up in the region to make data-driven farming (e.g. market, meteorological, financial, geographical and agronomic) a possibility for smallholder farmers, they struggle with monetization (services provided at no cost for farmers) and customer acquisition. Consequently, they are forced to find alternative monetization strategies, such as: i) ensuring that third-parties pay for or subsidize these services, e.g. buyers engaged in contract farming with said farmers, government or donor initiatives or incubator and accelerator programmes; ii) advertising on the platform; iii) bundling the information and advisory services into an online marketplace that generates profits from the sale of agricultural inputs, outputs and/or farm equipment rental; and iv) selling data collected through the mobile app to interested parties.

Multinational companies are developing two different models to serve large farmers in industrialized countries (i.e. hard precision farming using subscription or pay-as-you-go models), and smallholder farmers in developing APAC. In the latter case, business models involve the provision of soft precision farming services at no cost for producers, mostly through public-private partnerships for trialling and adapting their digital tools for use in various value chains. As these established firms join the game, they can potentially crowd-out startups that cannot compete in terms of financial, human and technological resources. Moreover, these companies are developing blockchain solutions to trace food safety and provenance. Blockchain technologies applied to the food industry will help save \$31 billion by 2024 in food fraud globally and reduce compliance costs by 30 percent by immutably tracking food across the supply chain (Juniper Research, 2019).

The success of these startups depends on several factors: from the founder's vision and perseverance, to their ability to collaborate with the government and/or the development community, and most notably, the financial backing from investors (e.g. venture capital firms, impact investors and incubator/accelerator programmes). Agritech startups in China and India have been very successful in this field, managing to attract altogether \$6 billion of venture capital investments in 2019, or 30 percent of total funds globally (AgFunder, 2020). There is also a tight correlation between the health of a country's startup ecosystem and its overall performance in terms of innovation (Cornell University, INSEAD and WIPO, 2020).

**Fintech business models for farmers** include solutions such as mobile money, digital lending and insurance services, as well as digital peer-to-peer lending and crowdsourcing for farming activities – connecting farmers with a crowd of small investors through the use of digital platforms and storytelling techniques (ADB and Oliver Wyman, 2017; McIntosh and Mansini, 2018; Minet *et al.*, 2017).

Mobile money and mobile lending services create opportunities to bring unbanked farmers into the financial system. These fintech solutions could fulfil 40 percent of the unmet need for payment services and 20 percent of the need for credit (ADB and Oliver Wyman, 2017). Widespread implementation of digital financial services, particularly in rural areas, could increase GDP growth in Indonesia and the Philippines by 2 to 3 percent per year, and in Cambodia by as much as 6 percent (ADB and Oliver Wyman, 2017). Mobile payments can revolutionize the way that agricultural transactions take place in countries such as China, India, Indonesia, Viet Nam, and the Philippines, which have the world's largest concentrations of unbanked individuals, and where receiving agricultural payments in cash is the norm (McIntosh and Mansini, 2018). Even for farmers in China, India or Thailand who have access to financial accounts, McIntosh and Mansini add, 80 percent still receive some of their agricultural payments in cash, and between 5 and 20 percent receive all of their payments in cash. Promoting the use of mobile payments in such contexts is critical to help farmers reduce their dependency on cash transactions and physical agents, build their financial scores and improve safety.

Similarly, digital insurance solutions can reach millions of APAC smallholder farmers, many of who were previously considered uninsurable, as in the example of India. Big data-enabled insurance solutions could provide crop insurance to an additional 200 to 300 million farmers worldwide, generating 40 to 150 million tonnes of additional food valued at \$15 to \$70 billion (FAO, 2020b; WEF and McKinsey, 2018).

**Asia has emerged as the global leader of e-grocery shopping.** Approximately 80 percent of consumers who buy food and beverages worldwide are from APAC and 61 percent of global revenue in the food and beverage e-commerce segment in 2021 will also originate in the region.<sup>1</sup> China, with e-commerce giants such as Alibaba, JD.com and Pinduoduo,

followed by Japan and South Korea are among the top five global online grocery markets. India will be the fastest-growing e-grocery market over the next five years, followed by Indonesia and Thailand.<sup>2</sup>

Despite growing fairly quickly, e-grocery represents only a small fraction of the total market: from 2.3 percent in India, to 6.6 percent in China and 14 percent in South Korea. This somehow reflects supply challenges such as perishable products, low net margins vis-à-vis other consumer goods, and demand deterrents such as shoppers preferring to handpick food items themselves. In fact, the large majority of Asian consumers are still purchasing their food from a broad range of off-line markets and outlets, including traditional markets and street vendors as well as modern retail sources, such as supermarkets, convenience stores and hypermarkets (FAO, 2018d).

Online food commerce should not be disregarded as a niche market either. As the growth of e-grocery sales continues to outpace brick-and-mortar, it is undeniable that the times are changing. More specifically, these economic activities are deeply impacting food systems *in the region* along multiple pathways: from reshaping marketing channels towards omnichannel food retailing to mainstreaming transformative technologies such as digital payments, digital marketing and AI-enhanced solutions for logistics and supply management. All are changing the way food is marketed, delivered, and paid for. In tandem, a plethora of new actors and business models is emerging, pushed forward by the opportunities available on the digital frontier.

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<sup>1</sup> For more information, please see <https://www.statista.com/outlook/253/216/food-beverages>; <https://www.foodnavigator-asia.com/Article/2019/07/25/>

<sup>2</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation>



A few e-commerce players dominate the market in the region. In China, the top three online retailers accounted for nearly 80 percent of total online retail sales in 2019,<sup>3</sup> and the top five companies in the fresh food e-commerce market had a combined market share of over 63 percent.<sup>4</sup> These companies have the resources to drive competitors out of the market – from foreign-invested supermarket chains to at least 150 online grocery delivery startups – through pricing strategies, self-owned mobile-pay and social media applications, and powerful AI-supported logistical networks. All of the above means that they can dictate almost unilaterally the terms of engagement with other supply chain actors, including small- and medium-size enterprises (SMEs). Moreover, the effects of this concentrated market power are also felt in the rest of the region, as these companies are also funding dozens of new unicorns in this segment across APAC. On the other hand, these e-commerce companies have opened up opportunities for SMEs within food systems by connecting them directly to consumers or recruiting them as agents in digital villages and similar programmes.

**Asia is also leading the global market for online meal delivery services.** The region is home to 60 percent of consumers who use meal delivery services worldwide, and generates more than half of global revenue in this segment.<sup>5</sup> China, India and Indonesia are driving growth in this market, followed by other countries in the region.

## OPPORTUNITIES AND BENEFITS PRESENTED BY THESE INNOVATIONS

The innovations showcased earlier have the potential to benefit all value chain actors and the region's food systems, more broadly.

<sup>3</sup> For more information, please see <https://www.statista.com/statistics/880212/sales-share-of-the-leading-e-commerce-retailers-in-china/>

<sup>4</sup> For more information, please see [http://www.iresearchchina.com/content/details7\\_56071.html](http://www.iresearchchina.com/content/details7_56071.html)

<sup>5</sup> For more information, please see <https://www.statista.com/outlook/374/296/online-food-delivery>

**Benefits for farmers.** The use of precision agriculture and drones offers farmers major cost savings, enhanced efficiency, and more profitability. Agricultural drones can report on crop health, improve spraying accuracy, and monitor livestock and irrigation systems in a fast and cost-efficient manner. Precision farming allows farmers to optimize yields and reduce their costs by tailoring input applications to the real needs of specific locations at the right time (Kendall *et al.*, 2017). It can also reduce environmental impacts by facilitating integrated pest and weed management, soil amelioration, and improve water and yield productivity by adopting management practices optimally matched to crop genotypes (HLPE, 2019). It can also create incentives for sustainable production and new business models with relatively less administrative burdens (EIU, 2018).

In addition, bottom-of-the-pyramid business models have emerged in the region to make data-driven farming (e.g. market, meteorological, financial, geographical and agronomic) possible for small-scale farmers. It can help them make more precise decisions, reduce costs, increase access to information, knowledge, markets, finance and data-enabled insurance solutions. 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 agro-industries.** By going digital, agro-industries can improve quality and safety control, maintenance, meet price competition and reduce fixed costs, while increasing recipe agility and manufacturing flexibility so that they can quickly react to customer needs and access markets. It can reduce food losses, and save energy and water (IEC, 2015). Agro-industries can also access more affordable, efficient and secure payment and credit solutions that are enabled by digital technologies.

**Benefits for retailers.** E-grocers and food delivery businesses use data to better know customer preferences so they can deliver tailored food products and experiences, and optimize supply management and last-mile delivery. The innovations analysed can help food retailers and wholesalers reach high levels of food safety, improve traceability, cut down waste, reduce costs and risks, save energy consumption, improve smooth operation and supply chain management, and lead to efficient logistics performance (FAO, 2021). Although these innovations entail substantial investments and the acquisition of new operational skills, adopters can benefit from more purchases, deeper customer loyalty and a positive loop in data capture that ultimately makes their systems smarter and more attuned to consumer needs.<sup>6</sup> Digitalization can also potentially reduce the costs of linking small-scale food retailers with suppliers and consumers by decreasing transaction costs and matching buyers and sellers more efficiently (World Bank, 2020).

**Benefits for consumers.** Digital technologies, automation and associated business models in food value chains are already leading to better informed and engaged consumers who are able to connect more directly with producers. These innovations improve the ability of retailers and agro-industries to meet consumers' needs and preferences through enhanced ability to comply with requirements pertaining to food quality, safety, traceability, convenience, better understanding of consumer preferences through big data and less time needed for developing new products. Urban consumers, in particular, can enjoy fresher, more nutritious and convenient foods thanks to indoor farming and improvements in last-mile infrastructure.

**Benefits for SMEs in the extended value chain.**

Digitalization has opened up opportunities for agritech startups to develop innovative business models that provide advisory, marketing and finance services to smallholder farmers because of cutting-edge digital technologies that reduce transaction and discovery costs.

**Benefits for the region's food system.**

Unlocking the potential of these innovations can help drive socio-economic growth, ensure food and nutrition security, alleviate poverty and improve resilience to climate change. Digital transformation can make value chains more efficient thanks to accurate and real-time data analysis to support decision-making, intelligent automation and improved public services. It can also lead to shorter and more transparent value chains through enhanced access to finance and strong value chain linkages such as e-commerce, blockchain-enabled traceability and mobile service delivery. Finally, it can guide demand towards more nutritious and environment-friendly foods (WEF and McKinsey, 2018). Digital technologies can have a positive environmental impact on the value chain through yield optimization, reduced use of inputs, water, plastics and electricity along the supply chain, reduced food losses and waste, and increased resilience. Finally, there are opportunities for more localized production and shorter supply chains through indoor agriculture, urban aquaculture systems and cellular agriculture. These can make APAC's cities more food-secure.

There is a need to scale up these innovations and reach a larger number of beneficiaries in a sustainable and inclusive way, taking into account the trade-offs between the benefits and risks of any given innovation on food systems. Some innovations may only benefit stockholders, yet be detrimental to consumers, farmers and broader segments of society. Others may generate positive social outcomes such as increased food security,

<sup>6</sup> For more information, please see <https://digital.hbs.edu/platform-digit/submission/kroger-doubling-down-on-data-in-the-face-of-hungry-competition/>

while damaging the environment. Some social and environmental challenges are mutually interdependent,<sup>7</sup> so their impacts will likely be multiplied, exerting even more pressure to innovate along the entire food system.

## CHALLENGES AND RISKS POSED BY INNOVATION IN AGRICULTURAL VALUE CHAINS

The innovations studied along food value chains in the region also pose the following challenges and risks to different segments of the supply chain and to the entire food system:

**Challenges and risks for farmers:** The digitalization of agriculture is creating higher hurdles for APAC smallholder farmers, who are faced with structural problems, affordability issues, skill gaps and regulatory bottlenecks that limit their access to digital technologies. Consequently, not many producers use digital technologies, and those who are subscribers of digital solutions use them to some extent, but not necessarily to an active or intensive level. Conversely, large-scale farmers tend to be highly active and intense users of digital farming technologies. As a result, the digital and efficiency gap between larger corporate firms or plantations, and smallholder farmers seems to be widening (World Bank, 2020). The result is growing inequalities of income and opportunity within the governance of food systems in the region that may threaten the guiding principle of the SDGs to leave no one behind.

**Challenges and risks for small-scale agro-industries:** Large-scale Asian food manufacturers are eager adopters of industrial automation, digitalization and process control

in an effort to reshape their business processes and increase profitability. At the same time, small-scale agro-industries are underinvesting in engineering innovation and the adoption of technology. The uptake of digital technologies and automation is highly heterogeneous across food manufacturing subsectors, with those characterized by large scale, standardized operations, such as dairy and sugar manufacturing, leading the race towards digitalization. The evolution of the digital divide separating small and large agro-industries in the region will depend on the complex interplay of several factors. These include the cost of digital innovations, the level of awareness about Industry 4.0 technologies among SMEs, public support to promote SME digitalization and overall competitiveness, collaborative efforts between service providers of smart factory technologies and solutions, and small agro-industries as the users and adopters (IEC, 2015).

**Challenges and risks for small-scale food retailers:** The food retail revolution and its underlying dynamics may also lead to excluding small-scale food retailers and traditional marketing agents that operate mostly offline.<sup>8</sup> Large food e-tailers in the region have heavily invested in establishing e-grocery business models that are asset-heavy, including digital platforms, warehouse systems, and delivery fleets. Moreover, e-grocery operations are intensive in terms of labour and marketing as steep competition erodes market share and customers flitter among many similar offerings. Omnichannel marketing is increasing competition among food retailers even further, favouring organized, formal food retailers that deploy O2O strategies thanks to fully integrated

<sup>7</sup> For example, climate change is a major “hunger-risk multiplier”: by 2050, climate change may put at risk of undernourishment an additional 120 million people.

<sup>8</sup> For more information, please see <https://digital.hbs.edu/platform-digit/submission/would-you-rather-lead-a-light-or-a-heavy-company/>

digital ecosystems that include mobilepay services and social media applications. This is happening to the detriment of traditional stores and brick-and-mortar supermarket chains that have not jumped on the digital bandwagon. They incur more real estate, utility and personnel costs than their online competitors. There are, however, a few startups that enable the digitalization of mom-and-pop shops, such as the Indonesian Warung Pintar,<sup>9</sup> which allows thousands of traditional small stalls known as 'warung' to sell staple food items at their digitally enhanced kiosks. 'Pintar' means smart.

Some changes are already visible across APAC, and notably in China, where there is a great concentration of market power by just a few food retail giants. The hypermarket format is disappearing, replaced by high-end, physically close and online stores. Food e-tailers are visibly eating into the food sales of retailers with only physical presence. Some foreign-invested supermarket chains that failed to transition into an O2O model have already exited the APAC market (McKinsey & Company, 2017b).

#### **Challenges and risks facing consumers:**

Consumers are affected by the increased concentration of market power in the hands of a few digital marketplaces and service providers, as well as by uncertain long-term impacts of new technologies on their health. They are also increasingly struggling to control both the personal data they share with organizations and how organizations use that data, given that the digitalization of production and marketing processes within food value chains increasingly depends on monopolistic or oligopolistic markets for big-data platforms.

#### **Challenges and risks for SMEs in the**

**extended value chain:** Digital technologies could potentially increase the concentration of market power in the hands of large global, regional and local agribusinesses providing advisory, market and financial services to the detriment of SMEs (World Bank, 2016a). The interplay between these forces may lead to a widening digital divide that contributes to the exclusion of SMEs from the extended value chain. Such a question is particularly pertinent in the APAC region; one of the world's most dynamic markets when it comes to the provision of digitally enabled agribusiness and financial services to farmers. Local agritech startups may be in danger of being crowded out, as data-driven farming attracts large players from not only the USA and Europe, but also from Asia, notably Japanese and Chinese tech companies that are expanding their operations in other countries of the region.

#### **Challenges and risks for the region's food systems:**

The region's food systems face manifold risks and challenges including exclusion, an over-concentration of service providers and potential over-concentration of market power. Other negative impacts deal with potential job losses for some activities, data governance concerns including lack of data privacy and cyber security breaches, and a negative environmental footprint.

- **Impacts on employment.** Efficiency increases generated by digital technologies can result in potential job losses (UNIDO, 2017a). Many jobs along the value chain may be displaced or necessitate new skills to adapt to automation and AI (World Bank Group and DRC, 2019). Hard questions are also being raised about the quality of jobs in the so-called gig economy, such as grocery and meal delivery, which can leave workers open to exploitation and low wages (Hill, 2015; Sundararajan, 2016; Kalleberg and Dunn, 2017). Additional concerns stem

<sup>9</sup> For more information, please see <https://warungpintar.co.id/>

from the fact that the weight of labour costs gets diluted as agro-industries adopt automation, advanced robotics, and increase their proximity to consumer markets.

Access to resources, workforce skills, and infrastructure quality are assuming more importance, which might lead to a decision to relocate (MGI, 2019a).

- **Data governance concerns.** Concerns surround who holds control and ownership of data within food systems, and how data on and about farms and consumers acquired by digital technologies can be stored, accessed and used safely (World Bank, 2020). A key challenge for policy-makers 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 food systems (Jouanjean *et al.*, 2020).
- **Impacts on the environment.** A large numbers of technologies currently applied in food and agricultural systems degrade natural resources. They rely on intensive production systems that focus exclusively on productivity while ignoring environmental aspects. In addition, digital technologies have their own carbon footprint. The share of digital technologies in global carbon emissions increased from 2.5 to 3.7 percent between 2013 and 2018,<sup>10</sup> and every digital device potentially contributes to digital pollution and the demand of increasingly scarce raw materials for its original production (UNIDO, 2017a). The surge in food e-commerce is also associated with increased carbon emissions from transporting goods, waste in the form of packaging materials, and intense use of precious resources such as soil and water.

To sum up, there is a need to scale up these innovations in agricultural value chains, and to do it in a way that is inclusive, sustainable and tackles the challenges and risks.

## POLICY SOLUTIONS TO PROMOTE INCLUSIVE INNOVATIONS ALONG THE VALUE CHAIN

The adoption of digital technologies varies significantly across the region, with lower current adoption rates in low-income countries. Consequently, it is necessary to scale up ongoing efforts to reach more value chain actors. APAC countries are putting in place policy and regulatory solutions that aim to upscale innovations in agricultural value chains, while promoting inclusion.

**Scaling up innovations in food and agricultural value chains** will require addressing supply side factors such as low rural network coverage and the availability of digital applications. There are also demand side factors, including the need for better skills and knowledge, trust, affordability, and the absence of complementary investments. APAC governments need to invest in critical infrastructure, such as Internet and transport connectivity, value chain storage and cold facilities, collection centres and laboratories.

**Making innovation in agricultural chains more inclusive** will necessitate addressing existing market failures such as exclusion, job losses, data concerns and negative environmental impacts, by implementing incentive systems, trading schemes, and other measures that strengthen the capacity of farmers, entrepreneurs and communities to innovate. This requires a combination of traditional support to smallholder farmers and agro-based SMEs,<sup>11</sup> and innovative measures that aim to strike a fairer balance in food chains.

<sup>10</sup> For more information, please see <https://en.reset.org/knowledge/our-digital-carbon-footprint-whats-the-environmental-impact-online-world-12302019>

<sup>11</sup> Traditional support measures include the following: aggregate supply, add value, ensure compliance with food safety and hygiene measures, subsidies, better access to appropriate financial products and access to public procurement contracts)

- Improve Internet connectivity and build digital capability.** The first step involves expanding and strengthening digital infrastructure, often in partnership with the private sector, as highlighted in national e-agriculture strategies, in for example Bhutan and Sri Lanka (FAO, 2019). An innovative measure to this end is the establishment of ‘digital village’ programmes. These are Internet-connected villages where residents can receive various e-services from government or private players. FAO acknowledged the importance of this topic in its 1 000 Digital Villages Initiative.<sup>12</sup> The second step is to build digital capability and broader skill development, ensuring targeted support to smallholder farmers, small entrepreneurs, youth, women, and other vulnerable groups. Education and building trust among the naturally risk-averse smallholder growing communities are essential for the success of such programmes (ADB and IFPRI, 2019). Agricultural extension efforts, using physical and digital modalities, to disseminate knowledge about new technologies and to demonstrate their business case, are of immense importance. These services should also include training in agricultural techniques, marketing, finance managerial skills, and the diffusion of information such as meteorological and market data. A practical measure that is usually successful is to increase exposure of farmers and SMEs to innovative technologies and business models through exchange visits, digital exchange and learning platforms. In addition, it is essential to launch programmes aimed at supporting and leading research in agriculture technologies to help reduce barriers to widespread technology adoption on-farm, such as enhancing the provision of e-agriculture services such as digital seed and fertiliser catalogues, and online subsidies applications. Developing mobile apps, social media and network solutions targeting farmers are also important (FAO, 2019).
- Increase the space for private sector activity.** Engaging with the private sector and using public investments to help crowd-in private sector investment are key measures for improving digital services, infrastructure and skills in rural areas (FAO, 2020a; World Bank, 2020). Increased private-public collaboration can help infuse excellence and innovative attitudes along the food value chain, and unlock value for the grassroots in areas such as mobile payments and credit, and e-commerce. This approach includes fostering public-private and corporate-startup collaboration to overcome the existing challenges to technology adoption at scale by smallholder producers in the region. This should include mainstreaming the delivery of tailored digital advisory, e-commerce and fintech services at scale to smallholder producers (Rankin *et al.*, 2018; World Bank, 2020).
- Facilitate access to e-commerce.** There are several means to facilitate the access of farmers and agro-based SMEs to e-commerce solutions. They include building the skills of farmers and SMEs to operate and manage e-commerce businesses, and developing public e-commerce platforms for connecting farmers to markets. They encompass providing financial and credit support to smallholder farmers to help them cope with e-commerce requirements in terms of working capital and of investments needed in storage and transportation of agriculture products. Investing in storage and transportation for the development of e-commerce in agriculture is essential. Improve market regulations to generate an environment conducive to the development of agricultural e-commerce, including efforts to tighten regulations on food safety,

<sup>12</sup> For more information, please see <http://www.fao.org/director-general/news/news-article/en/c/1320506/>

transparency and the safety of transactions, and develop dispute settlement mechanisms to build consumer trust in purchasing agrifood products online. Lastly, engage in public-private-producer partnerships to move direct e-commerce initiatives forward (ADB and IFPRI, 2019).

- **Encourage fintech.** Supporting the shift to digital fintech solutions helps revitalize rural areas, providing financial inclusion, insurance and jobs. Key actions identified on the policy front include incentivizing the expansion of digital payments infrastructure and agent banking models, advocating for digital and financial literacy programmes, and increasing limits imposed on digital transactions. They also involve reducing the associated transaction fees, and passing regulations to foster the use of mobile technology for financial services, which should include protect consumers by clarifying what constitutes “reasonable” interest rates and removing predatory and hidden fees. Finally, addressing the different standards and licensing requirements by each country is important (ADB and Oliver Wyman, 2017).
- **Promote entrepreneurship programmes.** Government support is needed to help farmers and startups become competitive with large-scale players, while at the same time fostering collaboration and partnership-based models to accelerate innovation. These programmes include business incubators and accelerators to support agro- and food-based firms.
- **Improve value chain governance.** There are different ways of enhancing governance, from keeping service provider entry barriers low to providing good data governance, as unclear and unequal data governance arrangements may weaken the willingness of smallholder farmers and of consumers to adopt digital solutions (Jouanjean *et al.*, 2020). This can also be achieved by promoting the digitalization of inclusive contract farming schemes to reduce

transaction costs related to searching for partners, bargaining and monitoring contracts, and enjoy better transparency (FAO, 2020a).

**Solutions for coping with employment issues in agricultural value chains and food systems.** Ongoing efforts are underway in the region to promote better employment opportunities by providing training on digital technologies, and addressing challenges related to jobs in the gig-economy, such as benefits, income-security measures, and training and credentials for these jobs to be acceptable. Another solution is eradicating unfair practices in hiring workers in agricultural and food value chains by using smart employment contracts, which are both immutable and public owing to blockchain technology, and can help improve the conditions of agricultural and food workers across the region (FAO, 2020a).

**Solutions for the betterment of data governance.** Improved regulations are required for the independent generation, storage, use, dissemination, property rights and confidentiality of big data in the region’s food systems. To do so, APAC governments need to assess how existing regulatory arrangements affect food systems and ensure that broader data policies are applied in a more tailored way to meet the specific needs of food systems. They must determine whether there are persistent gaps in existing data governance arrangements for agriculture and food systems, and improve communications around policy and regulatory frameworks for data governance so they can build confidence in the use of digital solutions, especially among farmers and consumers (Jouanjean *et al.*, 2020).

**Policy solutions for building healthier, cleaner and climate-resilient food value chains. Governments in the region are progressively implementing policies for greening food value chains, making them healthier, cleaner and more resilient to climate change.** The underlying principle that engenders these innovative policies is

internalizing the hidden costs of environmental externalities. Key measures in this sense 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 GHG emissions. Not to be forgotten are cellular agriculture and other innovations that increase the supply of cleaner, improved traditional and alternative proteins (FIA, 2018; UNEP and FIA, 2020).

## KEY INSIGHTS FOR APAC POLICYMAKERS TO ACCELERATE SUSTAINABLE INNOVATION IN FOOD VALUE CHAINS

**There is a pressing need for accelerating innovation to develop high-impact, sustainable and socially just solutions to future-proof APAC's food systems.** The need for innovation is ever more urgent in the face of growing population numbers, urbanization, climate change and resource scarcity. This future-proofing exercise implies rebuilding food systems that are able to feed a growing human population, while meeting the expectations of the new Asian consumer and avoiding diet-related ill health and placing cities at the front and centre of the regional food policy agenda. Moreover, it is critical to put smallholder farmers and SMEs first, and to promote sustainable production and consumption models that do not drive climate change, biodiversity loss or destruction of employment.

APAC Governments should focus on **creating a strong agrifood innovation ecosystem** that infuses innovation, entrepreneurship and investment into food value chains in the region. There are several ways in which they can accomplish this.

**Foster greater collaboration between corporations, investors, accelerators, universities, and startups** to build a more robust environment for agrifood technology innovation and commercialization.

**Support 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 direct support to startups working in this field. This premise is based on the understanding that new technologies only reach farmers and other value chain actors at scale when they are delivered within a functioning business model. This new generation of business models uses digital technologies to generate value by operating at a scale, while delivering far lower transaction costs (GrowAsia, 2020).

**Harness the power of digital technologies** to pilot, accelerate and scale innovative ideas with high potential for impact in food and agriculture, transforming digital solutions and services into global public goods.

**Build the capacities of actors in food value chains.** APAC policy-makers need to create more opportunities for training and education for the development of new technologies, and also for enabling the current workforce along the food value chain to use digital tools.<sup>13</sup>

**Overcome regulatory challenges and build consumer trust.** Regulatory costs have increased and much pressure has been put on regulators, who are struggling to keep up with the pace and scope of changes in food systems. These changes include worker rights (food distribution), food safety, alternative financial channels and systems,

<sup>13</sup> For more information, please see <https://www.newfoodmagazine.com/news/98666/report-identifies-next-steps-for-food-manufacturing-digital-technologies/>





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and data governance. APAC regulators are finding it a challenge to cope with the pace and breadth of innovations in food value chains.

[Rethink food value chains in Asia and the Pacific after COVID-19](#). The pandemic has fundamentally altered the dynamics of innovation in APAC food systems, and public priorities in the policy agenda of the “new normal.” The pandemic has placed increased emphasis on the urgency of facilitating the sustainable transformation of food

systems (FAO, 2020), particularly when it comes to investing in rural development linked with inequality and tied to the digital transformation, diversification and resilience of food systems. These priority topics will not just disappear after the pandemic is over, but will likely remain at the top of the agenda over the next decade.

FAO and other organizations are helping facilitate the emergence of such ecosystems and unleash sustainable innovations within food chains in the region.



# PART I

## INTRODUCTION

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Part I delves into the concept and different types of agricultural or food system innovation, and discusses the main drivers behind it.

It examines innovation mainly through the lens of the value chain, but also takes into account the influence of the innovation and entrepreneurial ecosystems.

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# 1. INTRODUCTION

## 1.1.

### ABOUT THIS PUBLICATION

Food systems are built on a complex web of upstream, midstream, and downstream markets where consumers, farmers, agricultural input providers, aggregators, food processors and sellers interact. These markets are currently undergoing deep transformations fostered by the digital revolution and other innovations. Digital and bioscience technologies are improving yields and resilience in primary production. Data and robotics are helping lift productivity and food safety in the manufacturing process. Online commerce and delivery services are revolutionizing the way consumers purchase food. Blockchain technology allows tracing back food products along the chain, increasing overall transparency and trust. Moreover, new business models are springing up to shorten the food value chain by removing or shifting stages, stimulated by enabling technologies and changing customer behaviours. In a nutshell, innovation is occurring at all stages of the value chain, from food production to manufacturing and retailing, and within the extended value chain (input, finance and service provision).

The **purpose** of this publication is to shed light on innovations taking place in the food value chains of Asia and the Pacific (APAC). By observing emerging trends and providing concrete examples, the authors discuss the nature of these innovations, how they are positively or negatively affecting food systems and value chains, and how to deal with trade-offs.

**Using a value chain approach has several benefits.** A value chain approach facilitates an understanding of the dynamics of innovation by navigating the complex networks of

interrelations among value chain actors from farm to fork. It prevents overlooking key value chain segments, such as food processing and the extended value chain, for example input suppliers, financial providers and extension services. These segments represent critical entry points for disseminating innovation among smallholder farmers and small and medium agro-based enterprise (SMAEs). This approach recognizes that not all value chains are equal, as they pivot around different types of commodities, such as high-value agricultural products and staple crops, which are structured differently and target different markets. Policies and strategies to foster innovation and digitalization need to take into account these specificities.

The publication is **structured** in three parts.

- The first part is an introduction that delves into the definition of innovation in the context of food value chains, the different types of innovations and their main drivers.
- The second part deals with “Food Systems 4.0” technologies (i.e. technological innovations at the farm, and food processing and retailing levels, as well as in the extended value chain) and associated business models.
- The third part is a reflection on the opportunities and challenges presented by these innovations, the policy solutions identified to tackle those challenges, and lessons learned.

The **methodology** used includes a literature and business practice review on the subject of innovation in food systems and value chains. Based on the framework and guiding

principles for value chain analysis illustrated by FAO (2014a), nearly 200 cases of innovations in 21 APAC countries have been mapped out along the supply value chain. Although the geographical scope of the publication covers the entire region, the availability and quality of data and information are considerably greater in Asia than in the Pacific subregion. The mapping exercise exposed the main traits of these innovations and their relevance in the regional context, particularly for small-scale actors and developing economies. Further information on specific cases was obtained from interviews with key informants, as well as from current and past projects by FAO and others.

This publication does not provide a comprehensive overview of all innovations currently taking place in food value chains in the region. That would be a self-defeating task given the sheer number of innovations. To give an idea of the magnitude of the task, Prause *et al.*, (2020) have identified 280 digital innovations currently being applied across the entire food value chain, and IFPRI (2016) has documented 12 social and organizational innovations in food chains around the world, including some in the APAC region. The innovation landscape is in a constant state of flux, with consumer demands continually changing, and technological applications developing fairly quickly.

Rather, the aim of the publication is to give an overview of some of the key technological innovations and associated business models that are reshaping food chains and to discuss their impacts on food systems, the economy and the environment. For the analysis, the innovations have been sorted according to their typology and their place in the food value chain, as well as who is innovating (farmers, companies, governmental institutions), and their size and subsector. A general sense of the importance of the individual innovations highlighted has been drawn from participation in regional and global fora on different aspects of innovation and food systems, supplemented by secondary data on market dynamics (size and growth rate) of key technologies in

the region and globally. Data from this assessment have been triangulated with data on flows of venture capital going into different innovative technologies and their associated business models globally and in the region, as well as anecdotal evidence of investments made by multinational companies in this arena.

The author has tried to focus on providing policymakers and practitioners with an easily referenced overview of key themes and innovation cases that will facilitate their consideration of the policies and tools that can be adopted. Public sector planners, policy analysts and decision-makers will find guidance to foster innovation in food systems at all levels, including among smallholder producers and small and medium agro-based enterprises (SMAEs). Furthermore, development practitioners and advisors will benefit from the lessons and examples described.

## 1.2. CLARIFYING CONCEPTS

Innovation has become the mantra of our age. Its importance for future-proofing food systems has escalated in recent years. Innovation presents a major opportunity to accelerate food systems transformation and to cope with the daunting challenges they face. Global food systems must feed 7.8 billion people,<sup>1</sup> and do so while protecting the environment and ensuring inclusive livelihoods, particularly in rural areas. Achieving this at the required speed and scale entails changing the way food is produced – including the practices of 570 million smallholder farmers – accessed, valued and consumed (FAO, 2019b). In other words, systemic transformation calls for systemic innovation.

<sup>1</sup> For more information, please see [https://population.un.org/wpp/Estimated world population in 2020](https://population.un.org/wpp/Estimated%20world%20population%20in%202020), last visited on 9 September 2020.

Novel ways of thinking, producing, behaving and interacting are needed all along food and agricultural value chains and across sectors to foster and sustain the changes required to meet the needs and demands of expanding populations. And nowhere is this more important than in the APAC region, where the demographic pressure on food and agricultural systems is highest. Thankfully, Asian countries – not so much those in the Pacific (FAO, 2021) – show a particularly remarkable potential for innovation in the field of agriculture, which has historically been their stronghold.

Against this background, food system innovation, and digital transformation in particular, has unsurprisingly risen to the top of the agenda of both policymakers and the food industry. For the former, innovation is needed to cope with ongoing demographic and environmental pressures in order to achieve the Sustainable Development Goals (SDGs) by 2030. For the latter, innovation is the key to staying competitive. Yet, all of them share an

understanding that business-as-usual is not an option anymore, and that accelerating and scaling up innovation throughout agriculture and food systems is crucial for today and future generations.

Despite often being praised as a panacea for resolving many of the issues affecting food systems and value chains, innovation is a poorly understood concept. A rather partial comprehension is prevalent about the scope, patterns, underlying mechanisms and impacts of innovation on food systems. This situation prevents policymakers and other stakeholders from understanding the innovation and digital transformation processes and their implications for food system policies.

Part of the problem stems from the absence in the literature of a widely accepted definition of innovation, particularly in the context of food systems and value chains. For this very reason, in 2018 FAO convened a symposium on the topic and came up with the definition of food system innovation provided in Box 1.

## BOX 1. KEY CONCEPTS

- **Food systems** encompass the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products that originate from agriculture, forestry or fisheries, and food industries, and the broader economic, societal and natural environments in which they are embedded (FAO, 2018g).
- **Sustainable food value chains** refer to “the full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and transform them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, has broad-based benefits for society and does not permanently deplete natural resources” (FAO, 2014a).
- **Innovation**, in the context of food systems and value chains, is the “process whereby individuals or organizations bring new or existing products, processes or ways of organization into use for the first time in a specific context in order to increase effectiveness, competitiveness, resilience to shocks or environmental sustainability and thereby contribute to food security and nutrition, economic development or sustainable natural resource management” (FAO, 2018a; 2018b).
- **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). Not to be confused with digitization, the “conversion of information or data from analogue to digital format” (EEA, 2020).

This definition of food system innovation runs counter to the strong emphasis frequently given to technological features and applications, overlooking the fact that innovations in the agriculture and food realms go well beyond transformative technologies. Innovative business models, novel policies and regulations, are equally important, as Chapters 6 and 8 will show. It also points toward the economics of food system innovation, which is often insufficiently analysed and addressed. Critical issues such as affordability and cost-benefit considerations of such innovations, financing, associated business models and sustainability impacts of innovations, among others, should be at the forefront of the debate.

The above definition encourages the adoption of a systemic, holistic approach that attempts to give a full picture of all the innovations happening at each node of the value chain and how they are interacting with and impacting each other. Indeed innovations cut across all subsystems – from crop, forestry, fishery or livestock production – and along the entire value chain – from input suppliers and farmers, to food manufacturers, retailers and service providers to consumers.

**Value chain innovations are nested within innovation ecosystems**, including larger R&D and innovation regimes and socio-technical landscapes (Pigford *et al.*, 2018). An innovation ecosystem encompasses governments, private companies, producers, civil society, and R&D institutions. It is essential to generate solutions and influence innovation uptake in the agricultural sector (FAO, 2017a; IICA, 2014). The key to developing food innovation ecosystems is to identify their key development and business bottlenecks, and the enabling conditions that need to be met to address them. Key enablers to creating such a conducive environment include policies and regulations, infrastructure, access to capital from startup<sup>2</sup> to scale, managerial and technical talent, and business support services, among others (WEF and McKinsey, 2018).

Efforts to strengthen food innovation ecosystems ideally pursue the triple goal of providing support to develop technology and business model innovation for food value chains (further detailed in Chapters 2 through 5), scaling up ideas, and expanding to multiple markets. The capacity of an innovation ecosystem to undertake these functions depends on the level of economic development of the country or region where it is embedded.

### 1.3. DRIVERS OF INNOVATION IN FOOD VALUE CHAINS

Economic growth has been widespread in APAC over recent decades, driving structural, agricultural and food system transformation. This transformative growth has led to some of the most rapid reductions of poverty in history, with 1.1 billion people lifted out of extreme poverty since 1990 (UN, 2019). But it has also been accompanied by other trends that lead to both challenges and opportunities for achieving the SDGs. These trends include the rise of the digital economy; urbanization, migration and growing inequality, together with ageing of the population in general and the farm population in particular; pressure on natural resources, environmental degradation, climate change and an increased frequency of natural disasters. These emerging technologies and demographic trends, along with changes in consumer behaviour, and social and environmental dynamics, are considered key drivers of innovations in the region's food systems.

<sup>2</sup> Startups are for-profit businesses that are generally aimed at high growth, and centre on an innovative product, service or business model (SFI, 2019).

### 1.3.1. Emerging technologies

Digitalization is changing the organization of APAC's agrifood system (FAO, 2019b; Prause *et al.*, 2020), driven by several technological and economic factors.

**Falling data costs:** Digital technologies are based on data and have benefitted from a number of technological advancements that have increased computing power by 32 times and reduced the cost of data storage by 97 percent in the last decade. The past four years have seen a 75 percent drop in wireless data transfer prices.<sup>3</sup>

**Deeper penetration of smartphones, particularly in rural areas:** The smartphone adoption rate in APAC reached 64 percent in 2019, whereas the mobile Internet user penetration was estimated at 40 percent, according to GSMA (2020), or 48 percent with about two billion mobile Internet users in the APAC region, according to Statista.<sup>4</sup> The majority of these Internet users are from China (850 million as of 2019), where more than half of the population possesses a smartphone.<sup>5</sup> As the number of mobile and Internet users goes up, penetration in rural areas also increases. Before the era of mobile telephones, many farmers in the region had only limited access to landline telephones, with many households having to wait years for installation.

**The growing availability and convergence of new digital industrial solutions:** New solutions include big data, the Internet of Things (IoT), artificial intelligence (AI) and cloud computing that are enabling food value chain actors to advance on the road to digitalization.

**Increased flows of venture capital investments into food system-related digital and physical technological innovations quicken the pace of technology advancement in food systems:** Agritech startups attracted \$14 billion of venture capital investments from 2010 to 2017 (WEF and McKinsey, 2018) and \$19.8 billion in 2019 (AgFunder, 2020). Of this amount, \$7.6 billion was invested upstream and midstream in agribiotech, farm robotics and equipment, agribusiness marketplaces and alternative protein startups. The remaining \$12.2 billion was invested downstream in online restaurants, e-grocery, and restaurant marketplaces (AgFunder, 2020). This trend is not only expected to continue, but to accelerate.

**The availability of local suppliers of these technologies:** China and Japan have been spearheading digitalization in APAC. China has one of the most active digital investment and startup ecosystems in the world, ranking in the global top three for venture capital investment in types of digital technology, such as AI, big data, robotics, drones, autonomous vehicles, 3D printing and virtual reality (MGI, 2017a). It also leads the e-commerce revolution, which will transform food systems in their entirety.

### 1.3.2. Demographic trends

Innovation also comes from understanding and trying to meet and share consumer needs, as well as from demographic changes such as people moving to cities, getting educated and earning more. Today's agrifood systems face an unprecedented rise in global food demand while at the same time competition for limited natural resources is at an all-time high. This issue is particularly pressing in the APAC region, where the demographics of consumers are changing substantially (HLB, 2018). Several demographic trends are driving innovations in food systems.

**Population growth:** By 2030, there will be 700 million more consumers in the world, predominantly urban and middle-class (UN, 2019). All things being equal, this demographic

<sup>3</sup> For more information, please see [https://unctad.org/system/files/non-official-document/cstd2016\\_p21\\_MartinRand\\_en.pdf](https://unctad.org/system/files/non-official-document/cstd2016_p21_MartinRand_en.pdf)

<sup>4</sup> For more information, please see <https://www.statista.com/statistics/201218/forecast-of-mobile-internet-users-in-asia-pacific/>

<sup>5</sup> For more information, please see <https://www.statista.com/statistics/201218/forecast-of-mobile-internet-users-in-asia-pacific/>



growth will generate an additional demand for food, water and energy of approximately 35, 40 and 50 percent, respectively (National Intelligence Council, 2012). The increasing demand for food associated with the skyrocketing world population will likely exacerbate the existing tensions brought by the triple burden of hunger, obesity and malnutrition. According to Skinner *et al.*, (2019), Asia will spend over \$8 trillion on food by 2030, up from \$4 trillion in 2019.

**Urbanization and the demographic transition are leading to ageing of the population:** These trends are generating profound shifts in food systems in the region. The rural-to-urban transition will continue and accelerate, particularly in APAC, where by 2030 more than 55 percent of the population will be living in cities (UN, 2019), including 27 megacities<sup>6</sup> (Skinner *et al.*, 2019). Besides putting more pressure on resources, this fast pace of urbanization will not only reshape consumer demand and foster e-commerce and online food delivery solutions, but also pose a major logistical and social challenge for food systems. Against this backdrop, new urban food systems are arising, with different characteristics and problems than those in rural areas, and are in need of unique solutions.

**Income growth:** With rising incomes and urbanization, dietary patterns are changing, for better and for worse. The rise in the annual disposable income of Asian consumers has fostered increasing demand for high-quality proteins such as dairy, chicken, beef and fish. Increased consumption of animal source foods and fruits and vegetables has contributed to improved nutritional status and a substantial reduction in the prevalence of stunting in many APAC countries. These trends put pressure not only on these value chains, but also on crops needed to feed livestock. These pressures are

fuelling a “protein revolution” leading to the development of alternative proteins, including cultured meat. Concurrently, urbanization and the demand for convenience that accompanies a more hectic pace of life have also led to increased consumption of foods high in fat, salt and sugar, which along with more sedentary lifestyles is contributing to increased obesity and a rising burden of non-communicable diseases. At the same time, additional efforts will have to be dedicated to finding innovative ways of addressing the persistent pockets of hunger and malnutrition, through reformulation and fortification (i.e. preserving or adding micronutrients into foods during processing), and new food banking solutions for reducing food insecurity at the community level, among others.

### 1.3.3. Changes in consumer behaviour

In recent years, a paradigm shift has been taking place in consumer behaviour and preferences towards healthier food choices and demanding high standards of sustainability around Environmental, Social, and Governance (ESG) issues.<sup>7</sup> Consequently, APAC consumers are now more tech-savvy, socially informed, health-conscious and interested in personalization and customization. The focus on health and wellbeing translates into a growing demand for a variety of new or different types of food.

**Fresher, minimally processed and more nutritious food:** This includes a preference for organic, clean foods and “free-from” products. “Free-from” products are those that remove ingredients such as gluten, lactose or sugar to address consumers’ needs such as weight loss, allergies and intolerances (Mintel, 2019a).

<sup>6</sup> Megacities are metropolitan areas with a population of more than 10 million people.

<sup>7</sup> In the domain of food systems, governance refers to formal and informal interactions between public and/or private entities ultimately aspiring to the realization of food availability, access, and utilization (Candel, 2014).

**Functional foods:** These are foods containing supplements or ingredients that are intended to improve health by aiding specific bodily functions in addition to being nutritious. This category is becoming an attractive market in the region (Lang, 2007), with APAC leading, for example, new food product introductions with a gut-health claim, and with India, China, and Vietnam as the largest markets (Mintel, 2019a).

**Rising protein consumption and alternative proteins:** By 2050, meat and seafood consumption in Asia will go up by 78 percent (McCarron, Tan and Giunti, 2018), triggering investments in new forms of production, such as cultured or lab-grown proteins and urban aquaculture systems. New lines of meat-free products are being developed to keep up with the ascent of vegetarianism<sup>8</sup> and veganism and the rising concerns surrounding animal welfare and the impact of livestock farming on the environment. APAC is the region that offers most opportunities (IPSOS, 2019; ABB, 2020).

**Specialty foods and drinks:** These have moved up in ranking to become the third fastest-growing luxury category worldwide, with global sales of specialty foods and drinks expected to reach 28 percent of the luxury category by 2023.<sup>9</sup> For example, the Chinese market, which has been traditionally dominated by commodity sales, is now demanding premium food products, with an emphasis on provenance, quality, health and sustainability. The Japanese market offers great opportunities for high-quality packaged foods. In India, where the food

and drink industry was worth \$624.1 billion in 2020, consumers with increasing discretionary incomes are also buying more high-quality food products.<sup>10</sup>

**The focus on ESG issues,** or ethical or sustainable living, brought by “Generation X,” is the fastest-spreading megatrend in food (Euromonitor, 2019). It denotes a sense of awakening among APAC consumers about the unsustainability of the business-as-usual attitude in the food and agriculture industry. This is partly a reaction to often finding themselves navigating the murky waters of conflicting messages about dietary guidelines, aggressive marketing of convenience food of poor nutritional value, food labels that aren’t user friendly, greenwashing accusations, increasing news reports of food contamination outbreaks and food recalls, and many more. Ethical living emphasizes four main attributes:

**Eco-consciousness:** This involves concerns about energy saving, recycling, waste management, and sustainable food packaging (e.g. green alternatives to plastic, paper and polystyrene foam) in food systems.

**Transparency:** APAC consumers are now more demanding in terms of clear labelling and more discerning when choosing the brands that embody their personal values. This is causing companies to invest in traceability (Chapter 5) and to share information about their environmental impact, work culture, inclusion and other social measures. Some authors (Peters *et al.*, 2018; MDPI, 2019) see in this social movement a call for putting the needs of end-consumers at the core of all value chain interactions.

<sup>8</sup> There are 628 million vegetarians worldwide with over half stemming from India (Bagul *et al.*, 2020).

<sup>9</sup> For more information, please see <https://www.ift.org/news-and-publications/food-technology-magazine/issues/2019/october/features/global-migration-emerging-opportunities-in-food-and-drink>

<sup>10</sup> For more information, please see <https://www.ift.org/news-and-publications/food-technology-magazine/issues/2019/october/features/global-migration-emerging-opportunities-in-food-and-drink>



**Social fairness:** This translates into the pursuit of suitable forms of governance aligned with democratization and broader inclusion. It covers fairer treatment of smallholder farmers, workers and SMAEs in food systems, often with a focus on youth and female empowerment, and to some extent about structural problems, such as concentration of input-output markets. This issue is particularly important in the APAC region where, unlike in many other parts of the world, smallholders dominate farming. In response to these demands, inclusive business models are emerging to avoid excluding small-scale actors along the food value chain, such as responsible contract farming and enhanced cooperative models that combine business-oriented approaches with participatory governance elements. Some of these models focus on shortening the supply chain as a way to promote sustainable production and consumption of local food (Chapter 6). This can be achieved through more direct producer-consumer connections through community-supported agriculture (CSA), and local food markets, including farmers' markets, farm shops and veggie box subscriptions.

**Authenticity:** In this context, authenticity means that consumers demand traditional flavours and recipes, and food products from farmers who are from a certain geographical area and who comply with sustainable business practices.

With increased awareness and heightened expectations for sustainability, transparency and accountability, APAC consumers have modified their purchasing decisions accordingly. They look for brands that display consistent values aligned with their ethos, including social fairness and transparency. Consumers are also looking for ways to pressure governments to put the right policies in place, and to motivate food manufacturers and retailers to bring new products to market

that meet their health and nutritional needs, while caring for the environment and being fair to employees.

Against this background, food processors and retailers are progressively embracing ESG issues, from social responsibility and green business practices. A recent study by Mintel showed that 17 percent of new global foods and drinks launched in 2018 made an environmentally friendly claim, followed by 14 percent that made a recycling claim, 9 percent a sustainability claim, 4 percent an ethical human claim, 2 percent an ethical animal claim, and so on.<sup>11</sup> The extent to which food businesses meet ESG criteria has an impact on the way they are perceived not only by consumers but also by other stakeholders. Among those stakeholders are shareholders and potential investors, regulators and other government officials, and increasingly, NGOs powered by social media.<sup>12</sup> Although these trends are global, they are taking place especially rapidly in APAC. Skinner *et al.*, (2019) foresee an acceleration of the ethical living trend in the coming years, so that by 2030, media-savvy APAC consumers will be even more aware of issues associated with transparency and sustainability.

The above changes point to a transition towards internalizing all ecological and social externalities in the price of food – often supported by government policy and regulation. Nonetheless, there is still a considerable inertia among agribusinesses, governments and education systems leading them to remain with the current dominant food system model, where externalities are not properly considered. An exception to the rule is the proliferation of impact funds and other sustainability-oriented funders seeking to direct global capital flows into food systems

<sup>11</sup> For more information, please see <https://bit.ly/3bQeL0>

<sup>12</sup> For more information, please see <https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/why-esg-is-here-to-stay>

to regenerate them (Negra *et al.*, 2018). Another step in the right direction are initiatives such as the Sedex platform.<sup>13</sup> Sedex facilitates access to responsible sourcing data for nearly 60 000 member companies – of which roughly half are from the agrifood sector – from over 180 countries, including the majority of Asia and some in the Pacific (Sedex, 2020). Members self-report their sustainability practices regarding the environment, health and safety, labour standards, supply chain management and business ethics. Negra *et al.*, (2020) affirm that this type of initiative could benefit from third-party monitoring systems that verify the actual achievement of reported sustainability goals and targets using science-based indicators.

#### 1.3.4. Soaring environmental pressure and climate change

Agriculture and food systems account for 70 percent of freshwater withdrawals, 70 percent of biodiversity loss, 20 to 30 percent of global GHG emissions, and 30 percent of the world's available energy, mostly from fossil fuels (WEF and McKinsey, 2018). Pressure on natural resources, environmental degradation, climate change and an increased frequency of disasters pose existential threats to our food systems and to our survival. Key concerns include:

##### Asian demographic trends and dietary shifts:

These will intensify the pressure on natural resources. They include population increase, urbanization, industrialization and rising animal protein consumption. By 2050, meat and seafood consumption in Asia will increase by 78 percent (McCarron, Tan and Giunti, 2018), putting additional pressure on natural resources, unless innovations such as cultured proteins and urban aquaculture systems deliver on their promises.

**Declining arable land:** Arable land will fall from 0.4 ha per person in 1961 to 0.13 ha in 2050.<sup>14</sup>

**Declining water availability:** Globally, agriculture accounts for 70 percent of water withdrawals and irrigation demands will increase by up to 100 percent by 2025 (IAP, 2018). Current water use for irrigation already depends on groundwater sources that are unsustainable in some areas. Over 40 percent of cultivated area in Asia is reliant on irrigation systems, a much larger percentage than any other continent (2018d). An estimated 80 to 90 percent of all wastewater produced in the APAC region is released untreated, polluting ground and surface water resources (FAO, 2018d).

**Growing food waste:** Asia is predicted to be the world's largest generator of wasted food by 2030, contributing around 500 million tonnes a year (Skinner *et al.*, 2019).

**Increasing impacts of climate change:** In the region, climate change is leading to shifting and unpredictable monsoons and slow-onset disasters such as drought, desertification and aquifer salinization, with the corresponding harmful impacts on food systems (IPBES, 2018). In 2018, about 140 natural disasters struck APAC, causing economic losses amounting to 2.4 percent of the region's GDP or \$675 billion (UNESCAP, 2019). Climate change threatens to cut crop yields by 25 percent in the coming years (WEF and McKinsey, 2018), and FAO predicts a 17 percent increase in harvest losses from climate change (FAO, 2017b). In addition to shocks caused by climate change, the region must guard against others as well, such as from transboundary pests and diseases, including the possible emergence of new zoonotic diseases.

<sup>13</sup> For more information, please see <https://www.sedex.com>

<sup>14</sup> For more information, please see <http://www.fao.org/faostat/en/#data>

### 1.3.5. Regulatory compliance in the food industry

Food value chains in the region have undergone a spate of changes owing to a more stringent regulatory landscape that requires all players to adhere to ever-changing norms (Peter *et al.*, 2017). These norms pertain to food quality and safety and end-to-end traceability, the launch of healthy products, food labels containing nutritional content, allergen presence and increasing demand for differentiated stock-keeping units, among others.<sup>15</sup> They also include animal welfare and environmental concerns such as enforcement of plastic bans in many countries, and standards-based factors such as ISO compliance.

As part of regulatory efforts to discourage unhealthy diets, many APAC countries have passed the so-called “sugar taxes.” They have adopted innovative food-labelling and advertising laws requiring foods that exceed specified limits of sodium, sugar, and saturated fats to be labelled transparently as such, so consumers can make their choices based on real information. These policies have led to a wave of product reformulations among food processors. Similarly, this regulatory push is largely behind the increased adoption of blockchain technologies for provenance and food traceability. Peter *et al.*, (2017) warn, however, that regulations can also represent barriers to food system innovation in certain contexts.

### 1.3.6. The COVID-19 pandemic as a major driver of innovations in the region’s food systems

The COVID-19 outbreak has had profound impacts on the APAC region that will be felt for some time to come. The pandemic has changed what and how APAC consumers eat in multiple ways: from a surge in home cooking,

online grocery shopping and meal delivery to an increased interest in foods that build health and immunity, as well as in sustainable living in the hope of preventing future pandemics. For less fortunate consumers, the pandemic-caused economic downturn has forced them into making poor dietary choices or becoming food insecure, joining the ranks of the more than 1.9 billion people in the region that were unable to afford healthy diets before COVID-19 (FAO *et al.*, 2020).

The pandemic has tested the resilience and flexibility of food supply chains across APAC. COVID-19 could pose longer-term effects on food security and nutrition through multiple disruptions in food systems that affect food production, health of farmers, access to agricultural inputs, access to markets, rural jobs and livelihoods, and a decrease in both rural and urban demand of food due to a loss of jobs and incomes, among others (FAO *et al.*, 2020). Some countries reacted in a rather self-centred manner during the early stages of the pandemic, focusing exclusively on their own food self-sufficiency and banning food exports. This brought renewed attention to the geopolitics of food. It highlighted the need to strike a balance between relying on imports and locally produced food, and to ensure collaboration in times of crisis to prevent the Balkanization of food systems in the region.<sup>16</sup>

Going forward in the “new normal,” farmers will collectively need to diversify their production in order to meet changes in market demand and make nutritious food more affordable for the poor. Meeting these demands may prove challenging in the context of an ageing farm population and decreasing farm sizes, which undercut incentives for innovation in the absence of new policies and institutional structures. Consumers’ access to diverse and nutritional diets has also been affected across the region, but more so in countries with

<sup>15</sup> A stock-keeping unit is a scannable bar code seen printed on product labels that allows vendors to automatically track inventory movements

<sup>16</sup> For more information, please see <http://www.fao.org/2019-ncov/analysis/en/>

pre-existing high levels of food insecurity and malnutrition. Greater opportunities must be provided through innovative policies, business models and technologies to vulnerable groups, including women, youth, migrants and indigenous peoples, so that they can contribute fully to, and benefit from food system transformation. On the other hand, affluent consumers are buying more and more food online, and increasingly prefer nutritious foods with health benefits that support immunity. The changes in consumer behaviour, coupled with digital acceleration, have created opportunities for the private sector to invest in APAC, particularly in farm productivity, indoor farming and aquaculture systems to strengthen local food production.<sup>17</sup>

But the social distancing and lockdowns associated with the COVID-19 pandemic has also significantly driven forward the use and adoption of digital applications. This increased the reliance by farmers, agribusinesses and consumers on digitally enabled commercial interactions, and information and extension services, among others (McKinsey & Company, 2020e). This has triggered many creative and entrepreneurial responses and innovations by governments and communities to address the disruptions. Many of the solutions and creative initiatives will likely survive and be scaled up to help in the broader transformation toward nutritious and healthy food systems. Many experts concur that this trend will unlikely diminish when the outbreak ends, as the acute disruption brought on by the pandemic has shown companies that digital channels are vital to supplement and further strengthen value chain relationships, while greatly reducing their resistance to experimenting and taking risks.<sup>18</sup>

<sup>17</sup> For more information, please see <https://agrifoodinnovation.com/>

<sup>18</sup> For more information, please see <https://home.kpmg/xx/en/blogs/home/posts/2020/08/accelerating-digital-transformation.html>; <https://www2.deloitte.com/us/en/insights/topics/digital-transformation/digital-transformation-COVID-19.html>; <https://www2.deloitte.com/nl/nl/pages/consumer/articles/food-covid-19-accelerating-food-transformation.html>

## 1.4.

### TYPES OF AGRICULTURAL OR FOOD SYSTEM INNOVATIONS

There are different types of food systems innovations. They can be classified according to their market impact, newness, object, and the challenges they address.

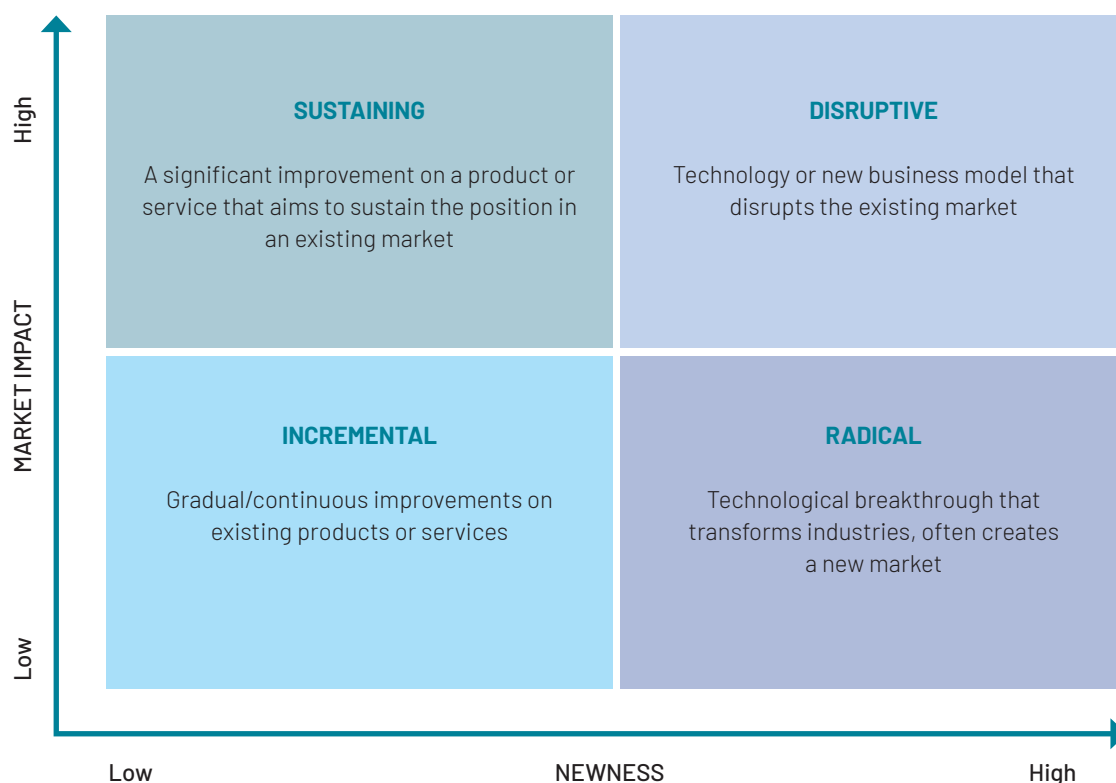
#### 1.4.1. Types of innovations according to their newness and impact on the market

Innovations can be classified as sustaining or disruptive, depending on how they affect the markets concerned. Christensen *et al.*, (2015) define “sustaining innovations” as the process of incorporating improvements to products of services that can be incremental advances or major breakthroughs, but enable companies to better reach their core customers. On the other hand, they see “disruption” as a process, rather than referring to a product or service at one fixed point, which often involves building business models that are very different from those of established businesses.

All innovations can be placed in a newness spectrum that goes from incremental (i.e. the optimization and further development of existing products, services or processes) to radical (i.e. new products, services or processes that involve significant change and may even lead to the creation of new markets), as shown in Figure 1.

Radical innovation is not necessarily superior to incremental innovation. In his article “Creation Myth,” Gladwell (2011) dispels the notion that innovation must per force equal new ideas and ‘aha’ moments. The skills and circumstances (including market-readiness) countries and companies can draw upon when it comes to innovation are as important as the act of invention itself, especially in relation to food systems.

Agriculture is naturally inclined towards incremental innovations, given that it is a commodity-based industry that operates with thin margins on large volumes. Incremental innovations also dominate the food

**Figure 1.** Types of innovations according to their newness and market impact

**Source:** [www.viima.com/blog/types-of-innovation](http://www.viima.com/blog/types-of-innovation)

manufacturing industry (Yoshioka-Kobayashi *et al.*, 2020). Consequently, incremental innovations that generate modest gains in productivity and/or efficiency can generate tremendous overall value in the supply chain. Obviously, this tendency does not preclude the emergence of disruptive innovations in food systems, such as gene editing. There is a gap, Gladwell posits, between invention and adoption. Leaders and early adopters are needed. Moreover, new ideas can take a long time to take hold, even if the technology is mature, because they need to match the prevailing paradigm and social norms. Small-scale farmers are known for their reluctance to adopt modern technologies because of their traditional mindsets and the perceived risks associated with new ideas, methods and technologies (Crentsil *et al.*, 2020).

#### 1.4.2. Types of innovations according to what they affect

Innovations can be classified by what they affect. In the context of food systems, Innovations can impact products, processes, marketing and organizations (OECD/EUROSTAT, 2005).

This publication will discuss key organizational innovations such as novel business models and partnerships (North, 1995). The business model concept describes “an architecture for how a firm creates and delivers value to customers and the mechanisms employed to capture a share of that value” (Teece, 2018). In food systems, it explains the position of a company in the food value chain, which is determined precisely by the value offered and delivered. A business



## BOX 2. INNOVATIONS ACCORDING TO THEIR OBJECT

- **Product innovation:** changes or additions to goods produced or services delivered.
- **Process innovation:** changes to the way goods are produced or services are delivered.
- **Marketing innovation:** changes in the method or conditions for marketing the good, or changes in the placement or target of the good or service.
- **Organizational innovation:** changes in an organization's structure, activities or services, in its processes or methods, or in its relationship with other stakeholders.

**Source:** OECD/EUROSTAT, 2005, and IICA, 2014.

model innovation entails consciously changing the existing business model or creating a new one to generate and/or capture more value (Chesbrough, 2007). In the context of food systems, it may involve good practices, examples and knowledge products that highlight how businesses in agricultural value chains can become more efficient, inclusive and sustainable (Nosratabadi *et al.*, 2020). Chapter 6 underlines notable examples of business model innovations in APAC food systems.

### 1.4.3. Types of innovations according to the challenges they seek to address

Innovations can also be classified into social, institutional and technological according to the challenges they seek to address (OECD, 2011; IICA, 2014).

**Social innovations** concern the development or substantial improvement of strategies, concepts, ideas, organizations, goods or services, to bring positive changes in the way of meeting or responding to social needs or serving social purposes. Social innovations are constructed jointly by several different stakeholders for the well-being of individuals and communities. They may generate employment, consumption, participation, or introduce some other change to improve the quality of life for individuals (IICA, 2014).

**Institutional innovations** embrace novel policy and regulatory frameworks, standards, institutional practices or relationships with other organizations that encourage improvements in the performance of an institution or system to make it more competitive and sustainable (IICA, 2014). The definition of institution is a body of norms, rules, habits, etc., recognized by most, if not all, parties in a society, broadly intended (North, 1995). Food systems institutions are defined here as “durable systems of established and embedded social rules that structure social interactions” involving the production, processing, transport, and consumption of food (Hodgson, 2007). These rules include policy and legal frameworks, which need to be redesigned in order to adapt to the myriad challenges posed by demographic trends and environmental pressures. This process of redesign or re-architecture is known as institutional innovation.

This publication highlights two subcategories of institutional innovations: novel policy solutions related to food systems and multistakeholder partnerships,

including public-private and corporate-startup collaboration. Particular attention is given to public-private partnerships (PPPs) in agricultural and food systems or agriPPPs for short. These can be defined as a “formalized partnership between public institutions and private partners (agribusiness firms and farmers) designed to address sustainable agricultural development objectives, where the public benefits anticipated from the partnership are clearly defined, investment contributions and risks are shared, and active roles exist for all partners at various stages throughout the PPP project lifecycle” (FAO, 2016a). Sometimes, these partnerships are referred to as public-private-producer partnerships (4Ps) to explicitly emphasize that smallholder producers are partners and an integral part of the PPP process (IFAD, 2016).

Institutional innovations often trump technological ones in terms of value creation potential, as they enable food system actors to become more adept at innovating at other levels, including products, services, processes

and technologies (Hagel and Brown, 2013). Nonetheless, these innovations remain largely invisible in the existing literature on the topic (Lundvall, 2010).

**Technological innovations** involve the “application of new ideas, scientific knowhow or technological practices to develop, produce and market new or improved goods or services, reorganize or improve production processes or substantially improve a service” in order to satisfy a known or suspected consumer need (IICA, 2014). The emphasis is placed on the technological characteristics of the new products or processes brought to market, and which are significantly different from before (FAO, 2006). The above definition also clarifies that technological innovations can also be applied to marketing processes or forms of organization by either producers or firms, although generally associated with changes in goods or productive processes. Technological innovations in food value chains are happening on three fronts: digital, physical and advancements in science (Box 3).

### BOX 3. TYPES OF TECHNOLOGICAL INNOVATIONS RESHAPING FOOD VALUE CHAINS

- **Digital innovations** encompass several building blocks ranging from new computing technologies to artificial intelligence (AI), Internet of Things (IoT), blockchain, big data and advanced analytics, machine learning, virtual reality and augmented reality, among others.
- **Physical innovations** include autonomous and near-autonomous vehicles; advanced, smart robotics; additive manufacturing and multidimensional printing, including of food; and advanced materials and nanotechnologies.<sup>19</sup>
- **Advances in science** comprise next-generation biotechnologies (e.g. cellular agriculture and synthetic foods) and genomics, as well as energy creation, capture, storage and transmission.

**Sources:** UNCTAD, 2017; FAO, 2018b; FAO, 2019b; Pesce *et al.*, 2019.

<sup>19</sup> Nanotechnology is the branch of science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers (Lindquist *et al.*, 2010).

Today's technological developments are swift, transformational and subject to rapid cost reductions, with digital technologies being hailed as the epoch-making innovation of our times. For many years, technological innovation in agriculture referred to crop science, particularly the development of high-yield crop varieties, in association with chemical fertilizers and pesticides, mechanization and irrigation.<sup>20</sup> These technologies underpinned the "Green Revolution" in the 1950s that brought about substantial production increases, which took millions out of hunger, but also put considerable pressure on the environment (Cornell University, INSEAD and WIPO, 2017). Next came advanced breeding and biotechnology innovations that further improved yields and reduced risk in the 1980s and beyond. Nowadays, the digital agricultural revolution is well under way propelled by Agriculture 4.0 technologies, instigating a shift from input-based technology to information and knowledge-sharing tools (EIU, 2018). As a result, the pace of innovation in agricultural and food systems has increased over the past decade, owing to the spillover of innovations from other sectors (Cornell University, INSEAD and WIPO, 2017). This pace quickening is partly due to the data revolution that is powering smart farming, the food e-commerce revolution, and fintech solutions in agriculture and food systems.

## 1.5. AN OVERVIEW OF THE INNOVATIONS HIGHLIGHTED IN THIS PUBLICATION

The scope of the current publication has been narrowed down to focus on **technological and business model innovations** within food value chains in the APAC region. These two kinds of innovations are often interrelated. For example,

deploying a technological innovation is part of a business model decision regarding openness and user engagement (Baden-Fuller and Haefliger, 2013). Conversely, new technologies can give rise to new business models, such as when the advent of digital financial technologies results in the creation of startups specialized in crowdsourcing for farmers.

Only one key advance in biotechnology, cellular agriculture, has been portrayed in this study. This is a reflection of the relatively limited significance of innovations associated with emerging technologies for APAC economies and small-scale actors within the region's food system. Moreover, advances in areas such as genetics and nano- and biotechnologies have proven their ability to be a source of higher yields and better nutrient content, but their health and environmental impacts have yet to be fully understood. This is why, for example, biotech crops (i.e. crops enhanced using biotechnologies to make them more nutritious, tolerant to herbicides and droughts, or resistant to pest and diseases) and gene-editing technology for food enhancement (e.g. CRISPR or clustered regularly interspaced short palindromic repeats), although undeniably important, have been excluded from the study (Cornell University, INSEAD and WIPO, 2017). The global report by IAP (2018) on future research and innovation on food and agriculture offers a comprehensive coverage of these issues.

Other notable exclusions are key organizational innovations such as new generation cooperatives and multi-stakeholder platforms, which deserve to be studied on their own and may be the subject of a separate publication in the near future. In the meantime, Torero, Donovan and Horton portrayed many examples of such innovations in IFPRI (2016).

<sup>20</sup> Something similar can be said about livestock and aquaculture, and the use of antibiotics and hormones.

### 1.5.1. Focus on digital technologies and automation

The publication zeroes in on digital and physical technologies. Within the latter category, automation and nanotechnologies are highlighted. Automation and digital technologies are leading into Agriculture 4.0, also known as the Fourth Agriculture Revolution (FAO, 2020b), as well as into Industry 4.0 and Retail 4.0 (FAO, 2019b).

- **Automation** is the automatic execution of tasks to reduce human intervention and increase the efficiency of processes. The automation of a system or process implies the use of robotic devices.
- **Digital technologies** are electronic tools, systems, devices and resources that generate, store or process data. Agrifood chain actors are leveraging digital technologies and digitized data turned into intelligence and actionable knowledge to meet evolving consumer needs (Figure 2)

(Ritter and Pedersen, 2020). They do so by adopting digital processes that rely on IT infrastructure, digital applications and networked systems and data.

Digital technologies and automation used in combination erase the boundary between the physical and the virtual worlds. Although there can be digitalization without automation and vice versa, the line between these two phenomena is becoming blurred as most current automation is driven by software, and both automation and digitization strategies are delivered on computing platforms. Digitalization and smart automation are expected to contribute roughly 14 percent to global gross domestic product (GDP) gains by 2030, equivalent to about \$15 trillion in today's value, a significant part of which will be directly related to the agrifood sector, a \$7.8 trillion industry that employs over 40 percent of the global population (FAO, 2019b).

## BOX 4. DIGITAL TECHNOLOGIES: KEY CONCEPTS

- **Additive manufacturing:** Additive manufacturing is 3D printing or a computer controlled process that creates three-dimensional objects by depositing materials, usually in layers. Additive manufacturing is advancing with the use of advanced materials opening new possibilities for massive customization in the food industry. These advanced include materials with engineered properties created through the development of specialized processing and synthesis technology, such as ceramics, composites, polymers, and biomaterials.
- **Artificial intelligence:** Any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals.
- **Augmented reality:** This is technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view. Applications include the delivery of information and training, such as providing instructions to staff in the field.
- **Big data:** This term describes the use of techniques to capture, process, analyse and visualize potentially large data sets in a reasonable timeframe for enhanced insight, decision making, and process automation. Big data analytics is the management of data for both operational and analytical uses and the analysis of data to drive business processes and improve business outcomes through more effective decision-making and enhanced customer experiences.

- **Blockchain technology:** Blockchain is a distributed database of records or shared public/private ledgers of all digital events (e.g. records of individuals, land, and financial transactions) that have been executed and shared among blockchain participating agents. It is a useful tool for bringing transparency and accountability throughout the food value chain, given that each player along the chain can potentially generate and securely share data points to create an accountable and traceable system.
- **Broadband networks:** Broadband is a network with wide bandwidth for data transmission and can transport multiple signals and traffic types via a medium. Broadband networks are an essential technology that provides online connection.
- **Cloud computing:** Cloud computing provides on-demand access, anytime and anywhere, to a shared pool of configurable computing, especially data storage (cloud storage) and computing power, without direct active management by the user. With cloud computing, many digital technologies can be made available to even small-scale firms as a utility with minimal upfront capital investment.
- **Digital Twin:** This is a virtual replica of a physical entity, and the data connections in between. It implies creating a digital replica of the physical twin composed of assets, processes, people, places, systems and devices that can be used for various purposes.
- **Distributed ledger:** A database that does not have a central data store, unlike traditional databases, but it is consensually shared and synchronized across multiple sites, and accessible by multiple participants. Accordingly, distributed ledger technology is a digital system for recording transactions and their details in multiple places at the same time, which can be shared and synchronized across multiple sites, by multiple participants.
- **Global navigation satellite system:** technology used in many applications to determine the position of an asset based on satellite data.
- **Information and communication technologies:** ICT is an enabling commodity technology for creation and/or uptake of more complex technologies such as cloud computing, satellites, remote sensing and smartphones.
- **Internet of Things:** This consists of networks of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment. It refers to the trend that more and more devices are connected to the Internet or other networks to help gather, manage and store data.
- **Machine learning:** An AI application that gives systems the ability to automatically learn and improve from experience without being explicitly programmed.
- **Platforms for e-business:** Software technology solutions that are used as a base for other applications, processes or technologies, mainly digital commerce.
- **Virtual reality:** This technology creates an interactive experience of a real-world environment.

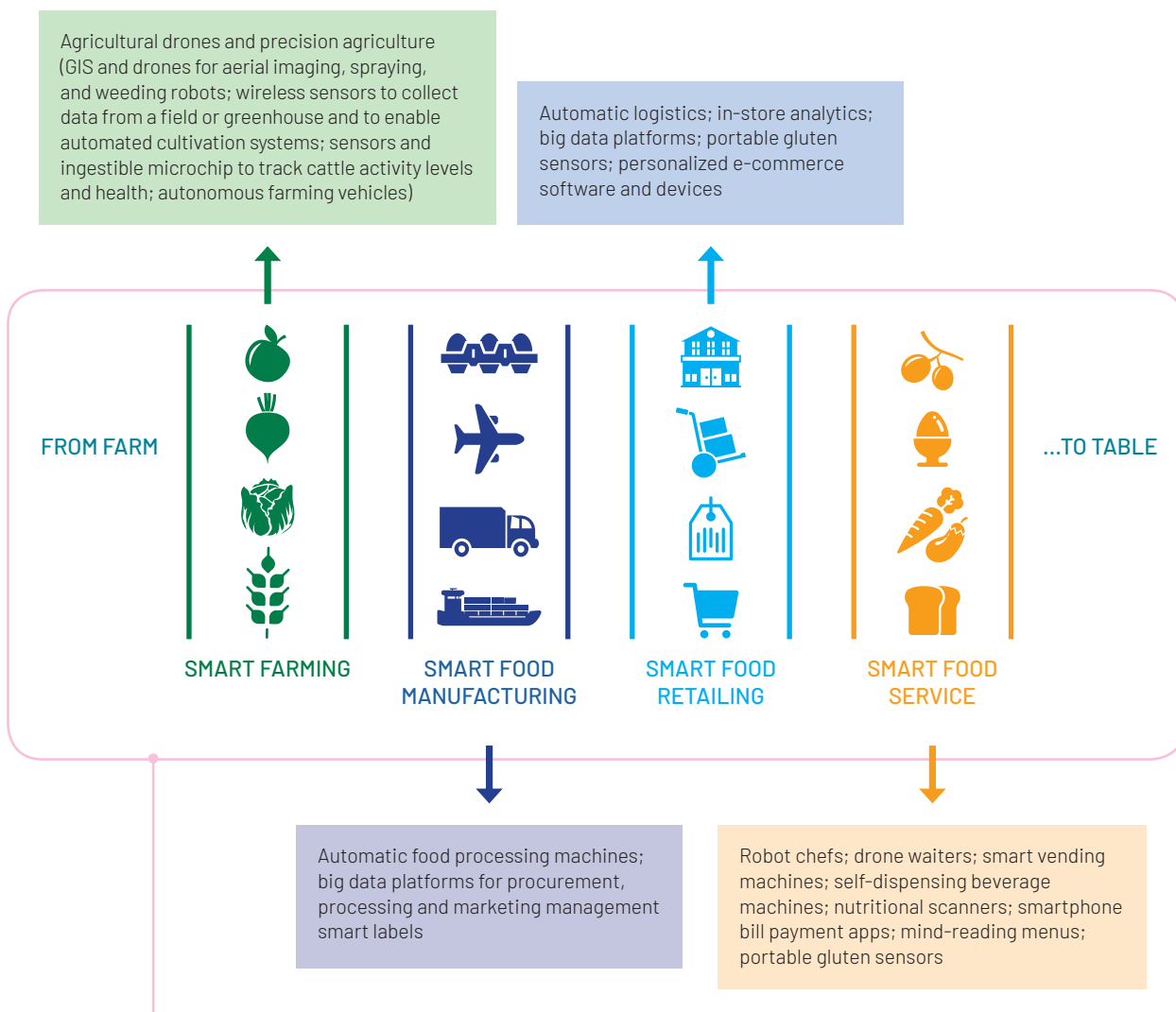
**Sources:** Crosby *et al.*, [www.tandfonline.com/doi/full/10.1080/00207543.2018.1533261](http://www.tandfonline.com/doi/full/10.1080/00207543.2018.1533261) ; EEA, 2020 ; IAP, 2018 ; Jones *et al.*, 2020 ; Mitchell, 1997 ; MITI, 2018; Pesce *et al.*, 2019; <https://www.gartner.com/>

**These digital and physical technologies are being applied all along the value chain**, from food retailing and services to farming or food manufacturing, with different purposes (Figure 2).

Figure 2 shows the different technological innovations in terms of digital and automation developments currently adopted at different stages of the value chain, from farm to

food services. It illustrates how the digital revolution has changed how food is grown (e.g. field monitoring and precision agriculture) and marketed, notably through online grocery and meal delivery services. It also explains how knowledge is shared across the value chain through digital platforms for farmers and blockchain-based traceability systems, among others.

**Figure 2.** Major digital and automation innovations available in agrifood chains



**EXTENDED VALUE CHAIN.** Blockchain for traceability systems, digital-based farming information and advisory services, marketplaces and fintech for farmers

**Source:** Adapted from Sodano, 2019.

Some applications of digital technologies seek to enhance the marketing of food products and services, while others target maximizing efficiency in production (e.g. use of water and energy throughout the value chain), enhancing traceability through the integration of technologies in systems (e.g. IoT, big data and AI are used in combination, as well as drones) or reducing risks. The latter category encompasses applications for reducing both the risks associated with emissions and climate change, and those in agricultural production, such as detecting crop pests and diseases early on in production through the use of drones.

Consequently, opportunities for digitalization exist at any link in the value chain, both on-farm and off-farm. In Asia, there is ample evidence **that all segments of the food value chain are undergoing some level of digital transformation.**

**Farming is becoming smarter** through the use of agricultural drones, precision agriculture – i.e. system for cultivating crops that uses data-based procedures where robots,<sup>21</sup> sensors, satellites and computers to increase yields, manage pests and diseases, and avoid over expenditure on inputs such as fertilizer, raw materials, and digital-enabled farming information services such as highly accurate weather forecasting (Chapter 2).

**Smart manufacturing** is on the rise across all industries, with the global smart factory market expected to reach \$214.7 billion in 2020.<sup>22</sup> The Fourth Industrial Revolution or Industry 4.0 is driving disruptive digital innovations all across the global and Asian economies, and the food and agriculture sectors are not exempt from this process, despite not being among the earlier adopters (Chapter 3) (FAO, 2019b).

**Food retailing and food services are also becoming more intelligent** as they experience a leapfrog growth of online grocery and ready-meal delivery services using platforms for e-business, facilitated by the development of online financial applications and last-mile delivery solutions, among other Retail 4.0 technologies. Asia is the global leader in these fields, hosting some of the most advanced online food commerce and delivery companies in the world (Chapter 4).

### 1.5.2. The importance of business model innovations

Companies and countries not only compete through new products, services or technologies, but also through innovative business models that adapt the organizational structures to the products and services offered, and emphasize the proposition of unique value (Sordi-Schiavi and Behr, 2018). There is a two-way interaction between technological and business model innovations. On one hand, new technologies can help transform the business model of a company because they allow the development of new ways of creating value for the market through an innovation process that expands the boundaries of the firm (Zott *et al.*, 2010). On the other hand, companies need to re-evaluate the adequacy of their existing business models in relation to the new technologies, which may introduce new opportunities and threats (Pacheco *et al.*, 2016), and react accordingly, by realigning their products or services, processes, skills and network relationships to deliver value to customers, old and new (Sainio, 2004; Teece, 2010). Gladwell (2011) adds that all innovations need to find an organizational fit, meaning a broader organizational system or business model where they could be made manifest. Business model innovations can take place at multiple and sometimes overlapping scales within food systems, such as farm, agribusiness, supply chain and region. They can offer solutions at various levels of the value chain. For example, at the primary production

<sup>21</sup> Robotic applications for precision agriculture includes weeding and spraying robots, harvesting robots, machine vision for diagnosing pests and soil defects, machine learning for diagnosing soil defects, drones and computer vision for crop analysis. For more information, please see <https://emerj.com/ai-sector-overviews/ai-agriculture-present-applications-impact/>

<sup>22</sup> For more information, please see <https://www.marketsandmarkets.com/Market-Reports/smart-manufacturing-market-105448439.html>

stage, specific solutions are being devised to produce food in cities, giving rise to new urban farming business models. According to Pölling *et al.*, (2017) urban agriculture requires unique business models whereby urban farmers utilize vicinity to final consumers to capture more value. The value proposition of such models can be based on cost strategies (relatively low transportation costs because of proximity to consumers); differentiation, often associated with quality attributes, such as freshness and organic, and niche production; and diversification, which is typically linked to a varied offering of food products, but can also be articulated to agritourism, and rural/ agritherapy and health-related products, among others (Pölling *et al.*, 2017; Nosratabadi *et al.*, 2020). An example of urban farming business models is offered in Chapter 2, concerning plant factories where crops are grown in a controlled environment in order to reduce pests or diseases, increase yields, save costs and improve sustainability.

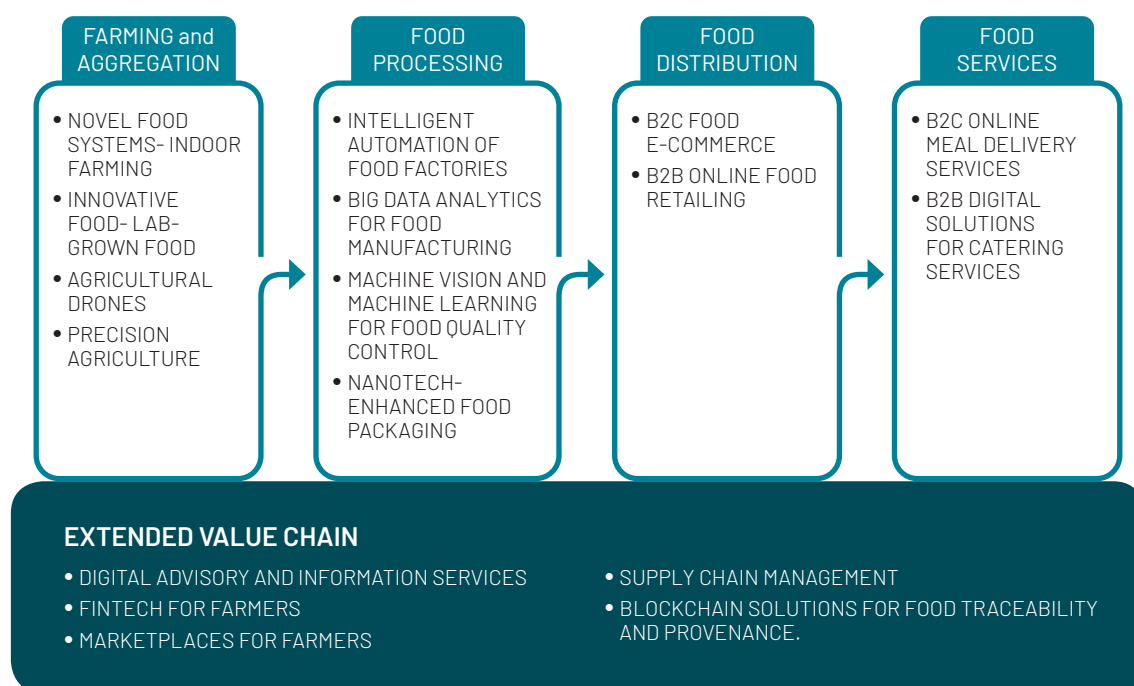
Business model innovations can also take place in food marketing and distribution

(Nosratabadi *et al.*, 2020). For instance, there is a transition to more direct business models that connect and shorten highly fragmented food supply chains in the region, mostly through digital marketplace platforms (Deloitte, 2015). The resulting food e-commerce business models can link different value chain players, leading to farm-to-consumer (F2C), farm-to-business (F2B) or business-to-business (B2B) modalities (Chapter 6).

### 1.5.3. Overview of innovations analysed along the food value chain

Innovation occurs at all stages of the value chain: from food production to manufacturing and retailing. Harnessing innovation within food systems entails understanding how each actor innovates and how the dense web of relationships and interactions that forms the value chain further contributes to generating and disseminating new products, processes and ideas (World Bank, 2012). Figure 3 places along the value chain the different technological and business model innovations studied in this publication.

**Figure 3.** Innovations analysed along the food value chain



**Source:** Own elaboration.



The figure underlines the massive technological shift that farming has experienced as of late. This shift involves the use of precision agriculture – which involves big data, drones, sensors, and farm management software – and new ways of financing and marketing. Innovative production methods that represent a significant departure from traditional agriculture are gaining ground, including plant factories and cellular agriculture (growing agricultural products from cell cultures in a laboratory setting). Not all farming innovations bring about disruptive change or are the result of corporate efforts. Smallholder farmers are also innovators, both by nature and necessity. Given that they produce over 80 percent of the world's food (FAO, 2014b), the implications for the entire value chain are far-reaching when they find new or better ways of growing, ensuring food safety, cutting food losses, financing their operations, and processing and marketing their products.

Similarly, food processors and retailers have consistently innovated over the past years. They have redefined their cost structure, rethinking their products, operating models and platforms through automation (changed machine functions) and digitalization (leveraging digital technologies and digitized data turned into intelligence and actionable knowledge) to meet current and evolving consumer needs. E-grocery businesses, in particular, have pushed the entire agricultural and food system into the digital age.

This study analyses 194 innovations in 21 countries in the region.<sup>23</sup> Of these innovations, 155 are technological and/or business model innovations, while the remaining innovations are institutional in nature (novel policies and PPPs). Of the technological and business model innovations documented, 47 percent occurred at the food distribution and food services stage, followed by 29 percent in the extended value chain (agribusiness services for farmers accounted for 23 percent and fintech for farmers was 6 percent), while 8 percent were on-farm and 3 percent were at the food processing stage. About 12 percent of the cases involved services for various stages of the value chain. These cases will be presented in the following chapters.

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<sup>23</sup> Bangladesh, Bhutan, Cambodia, China, Fiji, India, Indonesia, Hong Kong (China), Japan, Malaysia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, South Korea, Sri Lanka, Thailand and Viet Nam.



# PART II

## FOOD SYSTEMS 4.0

### TECHNOLOGIES AND BUSINESS MODEL INNOVATIONS

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Part II highlights critical areas where innovations are occurring in agricultural and food systems in the APAC region, drawing attention to those more relevant for smallholder farmers, small-scale firms, and less developed countries in the region.

Chapters 2 to 5 zero in on technological innovations mostly associated with the emergence of the “digital economy,” but not exclusively, at different stages of the value chain: farming, food manufacturing, food distribution and the extended value chain.

Chapter 6 describes in detail the new business models successfully implemented along value chains in the APAC region for digitalizing and shortening value chains. These include those taking place in primary production (e.g. farmer advisory, mechanization platforms), fintech for farmers, as well as online marketplaces, all the way to the advent of online meal delivery services.

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## 2. DIGITAL FARMING AND BEYOND

### 2.1.

#### A 21ST CENTURY FOOD AND FARMING REVOLUTION

There are two key innovations that are triggering a revolution in primary production in the APAC region: food grown in labs and plant factories, and smart farming. The first innovation involves producing food outside the farm, either in laboratories by cellular agriculture or in indoor facilities such as plant factories or vertical farms. These innovative landless food production methods are seen as a pragmatic solution for feeding growing cities in the region, while addressing soil degradation, overexploitation of fish stocks, and consumer demand for healthier foods and sustainable living.<sup>24</sup>

The second innovation is smart farming, which uses Agriculture 4.0 technologies to increase agricultural and livestock production both quantitatively and qualitatively, by optimizing the use of resources while minimizing

the environmental impact (FAO and ECLAC, 2020; Lytos *et al.*, 2020). A battery of online tools and services are available to smart farmers in APAC. These tools encompass the use of drones for farming and precision agriculture.

Smart farming enables producers to make evidence-based decisions and react faster to alerts about pests, diseases and weather-related hazards (FAO and ECLAC, 2020). Smart farming has engendered a farm-tech revolution with the potential to generate structural changes in unexplored ways, comparable to the Green Revolution of the 1960s. The Green Revolution was characterized by the adoption of practices that included mechanization, controlled water supply, improved seeds, chemical fertilizers and pesticides.<sup>25</sup> Its main goal was to increase farm productivity, which usually meant a more intensive exploitation of natural resources.

### BOX 5. ECONOMIC IMPORTANCE OF SMART FARMING

- **Global agricultural drone market:** \$1.2 billion in 2020 → \$5.7 billion by 2025 (35.9 percent CAGR). Asia-Pacific ranks third in the global market (after USA and EU), with China at the forefront (USD 2.9 billion by 2025). The rapidly increasing population, availability of arable farms, government support through subsidies, and the growing rate of adoption of smart agriculture techniques in China, India and countries in Southeast Asia, are the major factors driving the adoption of agriculture drones in APAC.
- **Global precision agriculture market:** \$7 billion in 2020 → \$12.8 billion by 2025.

**Sources:** Michalopoulos, 2015; [www.statista.com](http://www.statista.com); [www.asia.nikkei.com](http://www.asia.nikkei.com); [www.marketsandmarkets.com](http://www.marketsandmarkets.com) ; [www.datamintelligence.com](http://www.datamintelligence.com)

<sup>24</sup> For more information, please see <https://agrifoodinnovation.com/>

<sup>25</sup> For more information, please see <http://www.fao.org/3/i2230e/i2230e03.pdf>

Today's revolution revolves around digital technologies, which create unprecedented opportunities to move towards an agricultural sector that produces more with less water, less land, less energy, protects biodiversity and reduces carbon emissions (Rose and Chilvers, 2018). Nevertheless, agriculture is currently the slowest sector in terms of adopting digital technologies, according to the World Bank (2020).

The widespread use of smartphones in rural areas, and more recently of remote-sensing services and distributed computing, has opened up new opportunities to get information to or from smallholder farmers, and to carry out digitally enabled commercial transactions (USAID, 2018; FAO, 2019b).

## 2.2.

### LANDLESS FOOD PRODUCTION METHODS

Urban agriculture is becoming increasingly important to ensure a supply of locally produced, fresh food in Asia's cities (Graamans *et al.*, 2018). In recent years, new urban farming formats have emerged, from community gardens to rooftop farms<sup>26</sup> to indoor farms, which deploy a set of strategies adjusted to urban settings, such as high-value production, differentiation and direct marketing (Pölling, Sroka and Mergenthaler, 2017). In parallel, technologies that enable growing food in laboratories have also emerged and are being hailed for their potential to feed Asian cities.

#### 2.2.1. Indoor farms and other novel farming systems

Novel farming systems include indoor farms, such as vertical farms and plant factories, and novel aquaculture, insect and algae production

methods.<sup>27</sup> Indoor farms grow crops or plants entirely indoors, detached from sunlight hours and volatile weather conditions, by artificially controlling the cultivation environment (e.g. light, temperature, humidity, carbon dioxide concentration, and culture solution). Indoor farming is designed to maximize production density, productivity and resource use efficiency, bringing production closer to the urban consumer (Graamans *et al.*, 2018).

Indoor farming can take a wide variety of forms, from relatively lower-tech greenhouses to high-tech plant factories and vertical farms.<sup>28</sup> Plant factories are facilities that aid the steady production of crops all year round, often on a very large scale, using growing methods and tools that guarantee higher yields per square metre, such as hydroponics and artificial lighting systems.<sup>29</sup> Indoor farms can also be vertical farms.<sup>30</sup> As Platt (2007) puts it: "We live vertically, so why can't we farm vertically?"

These indoor, vertical farming systems can be of two types: centralized or distributed. Proponents of centralized facilities argue that large-scale production and financial viability depend on bigger farms. These centralized systems have dominated the vertical farming venture capital domain for several years. However, according to AgFunder's 2019 industry report, distributed and decentralized business models, such as deploying connected growing cabinets in supermarkets, are gaining pace.

The size of indoor and vertical farms is highly variable. For example, Spread, Japan's largest plant factory produces over a tonne of fresh vegetables a day.<sup>31</sup> Mirai Co. Ltd., another main proponent of the indoor farming model in Japan, can produce over 16 000 heads of lettuce each day across a number of plant factories.<sup>32</sup> Sustenir Agriculture grows produce in an over

<sup>26</sup> Rooftop farms are a popular type of urban farm in which growing facilities are located on the otherwise unused rooftops of city buildings, such as hotels, restaurants or residential buildings. Rooftop farms can involve a variety of growing facilities and systems, including greenhouses, open-air gardens, and vertical farms. For more information, please see <https://bit.ly/37Lw4Cn>

<sup>27</sup> For more information, please see <https://research.agfunder.com/2020/202-india-report.pdf>

<sup>28</sup> For more information, please see <https://www.asiafoodchallenge.com/>

<sup>29</sup> For more information, please see <https://bit.ly/37Lw4Cn>

<sup>30</sup> For more information, please see <https://bit.ly/37Lw4Cn>

<sup>31</sup> For more information, please see <https://spread.co.jp/en/>

<sup>32</sup> For more information, please see <https://miraigroup.jp/en/>

900 square metre facility for the Singaporean market and has recently entered into the Hong Kong market with a 2 300 square metre indoor plant dedicated to kale production. Singapore's Archisen operates a 650 square metre farm with a capacity of 100 tonnes per year.<sup>33</sup> At the other end of the spectrum, CityFarm Malaysia<sup>34</sup> has developed a vertical farm of 42 square metre with a capability of producing 2 000 heads of lettuce every month.

Singapore-based company Archisen states that its indoor farms consume 95 percent less water and 85 percent less fertilizers than traditional farms, thanks to its closed-loop auto-dosing system that recirculates any surplus and its proprietary smart operating system that uses sensors, IoT technology and data analytics to improve crop yields and efficiency. The company claims that by using its software and crop analytics models, its variable

**Table 1.** List of indoor farming startups mentioned

NAME OF STARTUP	COUNTRY
Mirai	Japan
Spread	Japan
CityFarm	Malaysia
Archisen	Singapore and Hong Kong
Singrow	Singapore
Sustenir Agriculture	Singapore

**Source:** Own elaboration.

Indoor farms can offer many advantages as compared with conventional farming. They can produce higher yields, up to a 400-fold increase over traditional methods, due to the use of highly sophisticated technologies and intense use of space. They reduce water use by 70 to 95 percent compared to outdoor farming. Indoor farms promote a more efficient use of land.<sup>35</sup> They produce food year-round, which is crucial for establishing solid market linkages. They reduce emissions and wastage, being a shorter intra-urban supply chain (Kozai, 2018; Skinner *et al.*, 2019).

costs have gone down by 30 percent, whereas its farm efficiency has increased by 50 percent. The company is deploying a robotics project that cuts labour costs in half, while increasing yields twofold.<sup>36</sup>

There are also disadvantages to indoor farming. It is highly capital-intensive, driven by the complexity of the technology involved and the high costs of energy and urban space. They payback period can be as long as 10 years, which may deter investors. Indoor farming also suffers from the lack of a mature supplier industry and costly requirements for custom technology (Kozai, 2018; Skinner *et al.*, 2019).

<sup>33</sup> For more information, please see <https://www.archisen.com>

<sup>34</sup> For more information, please see <https://cityfarm.my/>

<sup>35</sup> For import-dependent countries and territories with a lack of arable land, indoor farming can make an important contribution to food security.

<sup>36</sup> Information provided by Sven Yeo, Archisen's CEO, at the Asia-Pacific Agrifood Innovation Summit, on 20 November 2020.

The most successful indoor farms have proven profitable, while innovation in key areas (e.g. lighting technologies, the requirement for pollination in an insect-free environment, and cleaner and more affordable energy sources) can be expected to continue to drive down operating costs (Kozai, 2018). It is also possible to optimize seeds for indoor growing to a certain extent by applying modern biology tools. Genetics combined with lighting, environmental controls and other crop management tools, are vital to optimizing yields, production efficiencies and the consumer experience. Recent advances that can help significantly reduce costs include automating pollination and harvesting, as in the case of Singrow, an agritech company from Singapore that grows strawberries using an AI-enabled automated system that identifies both flowers and strawberries by deploying an optical scanner on a robotic arm. The system can recognize when the flowers are ready for pollination, in which case it activates the fan to blow faster for more effective pollination, or when strawberries are ripe to harvest with a suitable end-effector.<sup>37</sup>

Furthermore, to overcome the challenge associated with lack of specialized suppliers, some indoor farms have expanded their business to include the provision of inputs, training, marketing, design and building services to their peers. Examples of this are Mirai in Japan,<sup>38</sup> and CityFarm in Malaysia, whose website provides the option to buy the inputs and hydroponic farming system online both for small apartments and commercial farms.<sup>39</sup> In Singapore, Archisen not only operates its own farms, but also provides assistance to other indoor farmers, ranging from farm design, market analysis,

crop selection, sale of produce, the use of its proprietary AI-powered farm management software, financial modelling, and obtaining regulatory approvals.<sup>40</sup> In the same vein, Archisen launched in November 2020 “Just Harvest,” a deployable farming solution that provides hotels, restaurants and cafes (Horeca) with vegetables grown in mobile climate-controlled towers that can be harvested right before meal preparation to ensure utmost freshness and shelf-life. Once the tower is empty, the customers can contact Archisen to swap it for a new one with fresh produce ready for consumption.<sup>41</sup>

As of September of 2018, Kozai estimated the number of indoor farming companies at over 200 in Japan, about 100 in Taiwan, and over 500 in the world (Kozai, 2018). Kozai pointed out that plant factories in Japan and Taiwan have proliferated since 2010, linked to efforts to overcome food shortages in the wake of the 2011 tsunami that devastated Japan and caused Fukushima’s nuclear disaster. The number of companies using this business model has also increased remarkably in China, Europe, South Korea and the USA since the mid-2010s, following rapid advances in LED technology. In fact, the global horticulture lighting market (e.g. LED, fluorescent) for indoor and vertical farms and greenhouses is projected to grow from \$2.3 billion in 2020 to \$6 billion by 2025, a compounded annual growth rate-CAGR of 21.4 percent.<sup>42</sup>

This model has also gained traction in recent years in Singapore, Mongolia, Viet Nam, India and Malaysia, and more recently in Thailand and several other Southeast Asian countries (Kozai, 2018; Skinner *et al.*, 2019). Skinner *et al.*, (2019) predict that in the near future, indoor farms will spread to every major city in Asia,

<sup>37</sup> For more information, please see <https://www.singrow.sg/>

<sup>38</sup> For more information, please see <https://www.hortidaily.com/article/6031139/japan-s-oldest-plant-factory-company-charts-a-new-course/>

<sup>39</sup> For more information, please see <https://cityfarm.my/>

<sup>40</sup> For more information, please see <https://www.archisen.com>

<sup>41</sup> For more information, please see <https://www.justharvest.sg/>

<sup>42</sup> For more information, please see <https://www.marketsandmarkets.com/pdfdownloadNew.asp?id=13155972255>

and particularly the projected 27 megacities with over 10 million people that the region is expected to host by 2030. Anticipating this surge in demand, many high-profile investors are taking the view that indoor farming has an important contribution to play in overcoming Asia's food challenge. Indeed, indoor farms and other novel farming systems were among the fastest growing categories in funding received in 2019, only behind e-groceries and alternative proteins (AgFunder, 2020). It experienced a year-on-year 38 percent increase in terms of volume, but with 16 percent fewer deals, as the more mature startups raised later stage rounds. Even so, Asian indoor farming companies were absent from the top 20 novel farming systems deals reported by AgFunder (2020).

The promotion of food factories is becoming a key component of urban food strategies, as is the case of Singapore and its "30 by 30" strategy.<sup>43</sup> The city-state made plans in 2019 to ensure food security by increasing locally produced food from less than 10 percent of its nutritional needs today to 30 percent by 2030. Fostering the development of food farms and urban aquaculture systems are the core of the strategy. Two of the companies supported are Sustenir Agriculture, an urban indoor company that grows a variety of non-native plants indoors, from kale to strawberries using cutting-edge technology,<sup>44</sup> and Archisen, an agritech company that designs, builds, and operates high-yield farming solutions to grow ultra-fresh, ultra-local produce in cities.<sup>45</sup>

Nevertheless, vertical farming is not likely to solve food insecurity in APAC nor reduce rising food prices or the pressure on shrinking arable land. The economic limitations on electricity mean that only high value crops such as premium fruits and vegetables are worth producing. The financial model of vertical and indoor farms is not viable for producing staple

crops that currently take up the majority of arable land production, such as wheat, rice, soy, and root vegetables.<sup>46</sup>

Indoor farming may not be the magic bullet for Asia's urban food systems, but it will remain an exciting area of innovation and an important contributor to food quality and quantity for the cities over the coming decade (Skinner *et al.*, 2019). Moreover, the COVID-19 emergency has led to increasing awareness of the vital importance of urban agriculture in general, and indoor farming in particular, to ensure the availability of vegetables and other perishable crops for cities (Pulighe and Lupia, 2020). There are some actions that can be taken on the policy front to support this process: from outreach to capacity building activities and financial support. A good example is Singapore's support to urban farming through the launch of a national organic standard for vegetables grown in urban environments, in order to regulate the quality of the produce grown and increase its appeal to consumers.<sup>47</sup>

### 2.2.2. Cellular agriculture: producing alternative proteins through synthetic biology and industrial biotech

Consumers in the region are demanding more alternative proteins that can replace traditional meat as a good protein source, such as plant-based meat analogues and edible insects (Lee *et al.*, 2020). In 2018 the alternative meat market grew 11 times faster than the actual meat market,<sup>48</sup> particularly in Asia (Bagul *et al.*, 2020). More concretely, China's alternative protein market is expected to experience a 20 percent increase from 2018 to 2023, reaching nearly \$12 billion.<sup>49</sup> Part of the interest of

<sup>43</sup> For more information, please see <https://www.sfa.gov.sg/food-farming>

<sup>44</sup> For more information, please see <https://www.susteniragriculture.com/>

<sup>45</sup> For more information, please see <https://www.archisen.com/>

<sup>46</sup> For more information, please see [https://ssir.org/articles/entry/feeding\\_the\\_future\\_of\\_agriculture\\_with\\_vertical\\_farming](https://ssir.org/articles/entry/feeding_the_future_of_agriculture_with_vertical_farming)

<sup>47</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2018/04/12/Singapore-stakes-claim-on-first-organic-standard-for-produce-grown-by-urban-and-indoor-farming>

<sup>48</sup> For more information, please see <https://www.euromonitor.com>

<sup>49</sup> For more information, please see <https://www.euromonitor.com>



Chinese consumers in plant-based proteins is owing to the recent complications with local food contaminations, such as the DIV1 shrimp virus, African swine fever, and the public health risk of the meat-reliant system exposed by the COVID-19 outbreak.<sup>50</sup>

A 2019 IPSOS survey in 29 countries found that 73 percent of respondents in China and 63 percent in India said they would eat a plant-based substitute for meat, compared to an average of 42 percent for all countries surveyed. Forecasts are that this surge in demand will cause alternative meat revenues to account for 10 percent of total global meat revenues by 2025 (ABB, 2020). Skinner *et al.*, (2019) also agree that in the region, consumption of alternative proteins in both feed (insect-based) and food (plant- and cellular-based) will continue to develop at a faster pace than the overall protein market in coming years.

and sterile environment, using a nutrient-rich solution that helps cells proliferate, differentiate, and subsequently form muscle tissue resembling traditional meat. Lab-grown protein also encompasses dairy<sup>51</sup> and aquaculture products. For example, Singapore-based startup Shiok Meats is culturing prawn, lobster and crab meat from isolated stem cells,<sup>52</sup> and Hong Kong's Avant Meats is developing cultured fish products.<sup>53</sup>

In response to this surge in demand, an increasing number of startup companies in APAC are investing in manufacturing plant-based meat analogues and cultured meat, as alternative protein sources (UNCTAD, 2017). Likewise, the production of edible insects for the feed industry and for human consumption is also witnessing a surge across the region.

India and Singapore are aiming to become global hubs for cellular agriculture. The

**Table 2.** List of cellular agriculture startups mentioned

NAME OF STARTUP	COUNTRY	CORE ACTIVITY
Shiok Meats	Singapore	Cultured seafood
Avant Meats	Hong Kong	Cultured fish products
Future Fields	Canada and Singapore	Cultured meat

**Source:** Own elaboration

Omnivore, eco-conscious consumers would still prefer to eat meat as long as it is clean: produced using less energy and water, and with significantly less GHG emissions. Cultured meat, also called lab-grown, artificial or in vitro meat, represents a bioscience innovation that aims to satisfy the increasing demand for clean and sustainable animal protein (Chriki and Hocquette, 2020). Cultured meat is produced using animal cell culture technology. Meat is produced from animal cells in a controlled

Institute of Chemical Technology of Mumbai, in partnership with the Good Food Institute, hosts a dedicated research facility named the Centre of Excellence in Cellular Agriculture.<sup>54</sup> In 2020, Singapore granted the world's first regulatory approval for cultured meat as an ingredient in food, in line with its "30 by 30" strategy

<sup>50</sup> For more information, please see <https://www.smartcompany.com.au/industries/retail/plant-based-food-industry-covid-19/>

<sup>51</sup> For more information, please see <https://www.foodnavigator.com/Article/2020/10/14/Lab-grown-dairy-reaches-mass-scaleability-Tetra-Pak-exploresplausible-futures-of-dairy>

<sup>52</sup> For more information, please see <https://shiokmeats.com/>

<sup>53</sup> For more information, please see <https://www.avantmeats.com/>

<sup>54</sup> For more information, please see <https://www.indiatimes.com/news/india/mumbai-becomes-world-s-first-city-to-host-a-research-centre-dedicated-to-lab-grown-meat-362394.html>

towards food self-sufficiency.<sup>55</sup> The Singapore Food Agency (SFA) has put in place a regulatory framework for “novel food” to ensure that cultured meat and other alternative protein products meet safety standards before they are sold in Singapore.<sup>56</sup> China is also vying to get a foothold in the cultured meat market as its pork industry has been decimated by an outbreak of African swine fever in recent years. However, it lacks the regulatory framework to deal with this issue.<sup>57</sup> This did not prevent it from entering into a 2017 trade agreement with Israel worth \$300 million to import lab-grown meats.<sup>58</sup>

Besides regulatory uncertainties, cultured meat faces other serious challenges with cost reduction, scale-up and consumer concerns. First, it is much more expensive to produce lab-grown meat than plant-based products, up to ten times higher than the cost of conventional meat. The cost of producing the first-ever cultured meat burger was \$300 000 in 2013.<sup>59</sup> Since then, the price has plummeted, but it will still be as expensive as premium meat. This drop in production cost is largely driven by the decreasing costs of cell culture media, which according to Lejly Gafour, chief executive officer (CEO) and founder of Future Fields,<sup>60</sup> represent up to 95 percent of the cost of producing lab-grown meat. Second, cellular agriculture has yet to enter industrial production as most companies are still in the

research phase. However, if production reaches an industrial scale, it could potentially have vital implications for livestock agriculture in APAC countries. The third challenge is the reaction of consumers. Many consumers seem to dislike unnatural food and show scepticism regarding the application of bioscience within the food arena. On the other hand, eco-conscious consumers will be attracted to the claim that laboratory-grown meat uses less land and water, produces lower GHG emissions and can help prevent further disease outbreaks. Cellular agriculture companies believe that another vital aspect to improve market acceptance would be the ability to reproduce the diversity of meats derived from various species, breeds and cuts in tune with local preferences. Bryant *et al.*, (2019) cite higher levels of consumer acceptance in China and India than in other markets – almost two-thirds of Chinese consumers were very or extremely likely to purchase cultured meat.

### 2.3. USE OF AGRICULTURAL DRONES IN ASIA AND THE PACIFIC

Agricultural drones are a crucial technology for smart farming. The use of drones in agriculture was valued at \$1.2 billion in 2019, representing a fifth of the global market for commercial drones. It is a fast-rising segment projected to grow to \$ 5.7 million by 2025 (CAGR of 35.9 percent).<sup>61</sup> APAC ranks third in the global market after the USA and the EU.<sup>62</sup> However, the large presence of fragmented holdings in Asia, especially in parts of India, as a percentage of the total agricultural area drags the growth of the region’s agricultural drone market. In spite of this, APAC will be the fastest-growing region in terms of agricultural drone use over the next five years.<sup>63</sup>

<sup>55</sup> For more information, please see <https://www.aseanbriefing.com/news/singapore-approves-the-sale-of-lab-based-meat-market-potential/#:~:text=Expansion%20and%20Halal%20potential,up%20from%2010%20percent%20today>

<sup>56</sup> For more information, please see <https://www.straitstimes.com/singapore/environment/singapore-first-in-world-to-approve-lab-grown-meat-for-sale>

<sup>57</sup> For more information, please see <https://vegconomist.com/society/chinese-official-calls-for-national-strategy-to-allow-china-to-keep-up-with-other-countries-making-progress-in-cultured-meat/>

<sup>58</sup> For more information, please see <https://futurism.com/china-signed-a-300-million-lab-grown-meat-deal-with-israel>

<sup>59</sup> For more information, please see <https://agfundernews.com/mitsubishi-takes-mosa-meat-to-second-series-b-close-at-20m.html>; <https://medium.com/cellular-agriculture-canada/why-your-steak-costs-more-than-you-think-88057554f61b#:~:text=So%20what's%20the%20actual%20cost,USD%20per%20pound%20in%202018>

<sup>60</sup> For more information, please see [https://www.futurefields.io/Presentation at the Asia-Pacific Agrifood Innovation Summit, on 20 November 2020.](https://www.futurefields.io/Presentation%20at%20the%20Asia-Pacific%20Agrifood%20Innovation%20Summit,%20on%2020%20November%202020)

<sup>61</sup> For more information, please see <https://www.marketsandmarkets.com/Market-Reports/agriculture-drones-market-23709764.html>

<sup>62</sup> For more information, please see <https://www.datamintelligence.com/research-report/agricultural-drone-market>

<sup>63</sup> For more information, please see <https://www.grandviewresearch.com/industry-analysis/global-commercial-drones-market>

Some factors spurring this colossal growth in APAC are the surge in venture capital funding for the development of agricultural drones coupled with the population pressure on global food supply, and the improvement in cost-efficiency resulting from drone use especially in the wake of lower prices of agricultural commodities and rising labour costs, notably in China and Japan.

According to FAO and ITU (2018), drone technology is used in agriculture for a variety of things, ranging from precision agriculture, to surveying and mapping of agricultural land, crop dusting, crop insurance, and climate forecasting:

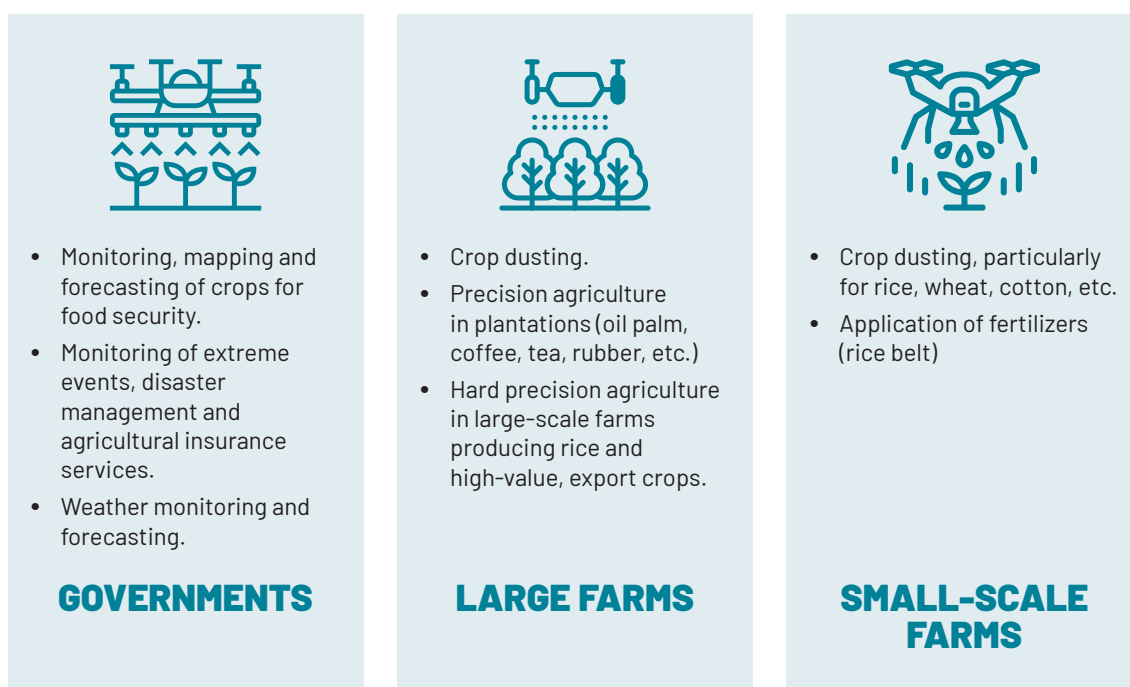
- **Precision agriculture** uses drones in an integrated manner with remote sensors, data analytics software, robotic equipment and autonomous vehicles to harvest, direct precise amounts of fertilizer to specific sites, and to irrigate crops, etc.
- **Drone-assisted field surveying and mapping** helps look at the condition of crops across different soil types and management zones to portray crop health and yield potential.

Aerial surveys of agricultural and forestry land using drones also provide a means to assess current environmental states, and monitor progress over time.

- **Drones are used for crop dusting**, the aerial application of pesticides for crop protection, fertilizers (also known as aerial topdressing) and of certain types of seed.
- **Drones are increasingly being used for crop and livestock insurance** as the images they capture (floods, drought, fires, pest damage or disease) are very useful for carrying out rapid and accurate assessments for insurance adjustment procedures and compensation.
- **Drones can help improve weather forecasting** for agriculture as they can gather critical information on how temperature, wind, and moisture evolve within the boundary layer under different weather conditions.

Across APAC, agricultural drones are mostly used by governments and large-scale farms, but for different purposes, and to a much lesser extent by some small farms (Figure 4).

**Figure 4.** Use of drones in the Asia Pacific region: most widespread applications by type of users



**Source:** Own elaboration.

**Governments in the region have adopted drone technology** for monitoring, mapping and forecasting crops that are strategic for food security, notably rice. The monitoring of rice fields using digital technologies helps governments and value chain actors make informed decisions in terms of domestic rice production, distribution, and import and export policies (FAO and ITU, 2018).

When it comes to field monitoring, it is possible to tap on satellite or drone technology, or a combination of both. However, many Asian governments opt for satellite-based remote sensing to monitor crops for food security purposes, as they need to cover vast areas of land (FAO and ADB, 2014).

Both satellite and drone sensing technologies have advantages and disadvantages, and often complement each other. Satellites have a vaster scope and capture complete and geo-referenced spatial images. Nonetheless, satellite based remote sensing suffers from various disadvantages such as prohibited use, less revisiting time, poor resolution due to great height and inability to operate in cloud cover situations (Bansod *et al.*, 2017). Drones, on the other hand, hover at a peak of 500 to 1 000 metres, offering various advantages in image acquisition such as high spatial and temporal resolution, full flexibility, and they are unaffected by cloudy weather although they are sensitive to wind. In addition, drone surveillance can prevent theft. Their use, however, has limitations: they have to be visible to the operator, cannot fly in the vicinity of controlled areas such as military objects or airports, and agreement from neighbouring farmers may be needed if drones fly over their fields. They have other shortcomings related to georeferencing, the mosaicking of images, and the analysis and extraction of information required for supplying a true end-product to farmers (Bansod *et al.*, 2017).

The issue of cost is not a straightforward one. Farming drones are expensive, either to purchase or to hire, and the vaster the area

covered the higher the expenses are. Drone imagery has to be processed with external software, which adds to costs, whereas satellite imagery can be interpreted in the cloud-based agricultural platforms that provide access to many tools. As a consequence, drones are recommended to survey small areas or when high precision is needed. Satellite observations satellites are simpler, more available and cost-effective than agricultural drones for larger areas and when there is flexibility in terms of image precision (Bansod *et al.*, 2017).

As an example, the Government of Bangladesh has developed a satellite-based decision support system to help monitor natural disasters and crops that are strategic for food security such as rice, cotton and sugarcane. However, the state agency in charge of this initiative, the Bangladesh Space Research and Remote Sensing Organization, noted that cloud cover significantly affected the accuracy of forecasts for short-duration crops such as rice due to data loss, whereas the impact on long-duration cash crops such as cotton and sugarcane was easily overcome (FAO and ADB, 2014). Similarly since 2007, the Government of Pakistan has also been using satellite-based systems for forecasting and estimating crops to improve food security. The satellite-gathered imagery is validated through the use of smart phones for ground data collection (FAO and ADB, 2014).

Some governments are also using drones for disaster management and agricultural insurance services, as drone imagery gives an accurate estimate of loss (FAO and ITU, 2018). For example, the Governments of the Indian States of Maharashtra, Gujarat, Rajasthan and Madhya Pradesh have partnered with Skymet, an Indian private provider of digital weather forecast solutions, and other companies to supply accurate and quasi real-time information captured by drones for the implementation of public crop insurance programmes (FAO and ADB, 2014).

The Government of the Philippines uses drones to identify land vulnerable to natural disasters and to assess food security through the analysis of drone-captured imagery of key crops. The information gathered by drones is combined with data from a microsatellite named Diwata-1, launched by the country's space satellite programme<sup>64</sup> to provide forecasts, weather monitoring and to survey farmland (FAO and ITU, 2018).

When it comes to the **private use of drones** for smart farming in the APAC region, large agribusiness companies dealing with rice, high-value crops and plantation crops are leading the way. In China, India and emerging Asia, drone technology for precision agriculture is mostly used for plantation management, and for industrial crops including cereal-based feeds. Agribusinesses in China and advanced Asia<sup>65</sup> are progressively adopting drones in combination with automation and big data analytics, to counter mounting labour costs. In China, sales of agricultural and forestry drones are forecast to reach \$2.9 billion by 2025, according to iiMedia Research.<sup>66</sup> The country uses drones mostly for crop protection, particularly in the rice and wheat belts of the northeast (Krishna, 2018). For example, in 2019, over 80 percent of rice grown in northeast China's Heilongjiang province was sprayed by drone.<sup>67</sup> The overall coverage is albeit limited, as drones are used for plant protection on only six percent of the country's farmland.<sup>68</sup> However, the market for this service is poised to grow to cover one-third of total farmland, as the price of the technology becomes more

affordable.<sup>69</sup> The business enjoys great vitality as exemplified by DJI, the Chinese company that controls two-thirds of the global commercial drone market, which has reportedly sold 20 000 spraying drones in China alone, conducted a large-scale cotton defoliation operation covering one million hectares, and provided crop protection services to 20 million hectares across the country in 2018.<sup>70</sup>

In Japan, the agricultural drone market was valued at approximately \$153 million in 2018 and was forecast to increase twofold by 2024.<sup>71</sup> Japanese farmers employ drones largely for crop protection, including spraying 42 percent of rice fields, with 1.05 million hectares sprayed per year (FAO and ITU, 2018). In fact, Japan was a pioneer in this field, with farmers in the country's rice belt using drones for crop protection as early as the 1990s (Krishna, 2018). Drones are also widely used in Japan and South Korea for pest control in vegetables, wheat, barley, and soybean production (FAO and ITU, 2018). In South Korea, fertilizer drones are also gaining ground as a viable option.<sup>72</sup>

The use of agricultural drones in India is still limited, although it is catching up with earlier adopters and gaining considerable momentum. As of March 2020, there were nearly 20 000 drones registered in the Digital Sky Platform, an online platform for the registration of drones and their operators launched by the central Government.<sup>73</sup> The Indian drone market is forecast to grow at an 18 percent annual rate

<sup>64</sup> For more information, please see <https://phl-microsat.upd.edu.ph/> last visited on 1 April, 2020.

<sup>65</sup> Japan, Singapore, South Korea, etc.

<sup>66</sup> For more information, please see <https://asia.nikkei.com/Business/China-tech/Chinese-drone-maker-targets-farms-in-Japan-South-Korea-and-Australia> last visited on 8 April 2020.

<sup>67</sup> For more information, please see <https://www.precisionag.com/market-intelligence/exclusive-precision-application-asia-executive-report/>

<sup>68</sup> For more information, please see <https://asia.nikkei.com/Business/China-tech/Chinese-drone-maker-targets-farms-in-Japan-South-Korea-and-Australia>, last visited on 8 April 2020.

<sup>69</sup> In 2019, the retail price for farming drones in China was roughly \$5 to 6 thousand and the service fee for drone-assisted plant protection was about \$21/ha. Source: <https://www.ft.com/content/afa5e042-4c50-11e9-bbc9-6917dce3dc62>, last visited on 8 April 2020.

<sup>70</sup> For more information, please see <https://www.ft.com/content/afa5e042-4c50-11e9-bbc9-6917dce3dc62>, last visited on 8 April 2020.

<sup>71</sup> For more information, please see <https://www.statista.com/statistics/1023650/japan-agricultural-drone-market-size/>, last visited on 14 April 2020.

<sup>72</sup> For more information, please see <http://www.investkorea.org/kotraexpress/2017/03/Industry.html>, last visited on 8 April 2020.

<sup>73</sup> For more information, please see <https://www.thehindubusinessline.com/news/19553-drones-register-on-dgcas-digital-sky-platform/article31057635.ece#>, last visited on 25 June 2020.

during 2017 to 2023 in terms of revenue, with applications in agriculture accounting for the largest share at about 32 percent of the total market.<sup>74</sup>

In emerging and frontier Asia,<sup>75</sup> the higher efficiency of drones compared to manual labour for certain agricultural tasks is expected to accelerate their adoption in the coming years, particularly for some agricultural applications such as crop protection. In particular, countries of the Association of Southeast Asian Nations (ASEAN)<sup>76</sup> represent a booming crop protection market, which in 2018 was valued in \$3 billion, with Viet Nam, Indonesia and Thailand at the forefront (German-Thai Chamber of Commerce, 2018). Drone usage is particularly growing for spraying pesticides and fertilizers in their rice belts. Thai rice farmers are gradually becoming familiar with this technology, although their access is still affected by the scarcity of service providers (Maikaesarn and Chantharat, 2020). Viet Nam piloted some initiatives in the Mekong Delta in 2019 and 2020.<sup>77</sup>

The majority of smallholder farmers in the region have not been able to afford the use of agricultural drones until recently. The above-mentioned market growth is an indication that rising numbers of smallholder farmers have started to use crop-spraying drones owing to the numerous startups and some major drone manufacturers working to raise the technological capabilities and reduce prices, which will hopefully incentivize more farmers to buy or hire drones to spray or monitor their fields.

## 2.4. PRECISION AGRICULTURE IN ASIA AND THE PACIFIC

Precision agriculture is a management strategy that depends on advances in collecting and using data, including real-time data (IAP, 2018). It involves analysing historical and current data series on crop production, yields, soil, hydration and climate. Drone and satellite imagery, combined with experience, inform farmers' decisions so that inputs and practices can be optimized.<sup>78</sup> It covers heterogeneous technologies that include the use of smart phones, satellite positioning and other sensor systems, autonomous machinery or robotics, AI including developments in image processing algorithms, and on-farm three-dimensional printing (IAP, 208; King, 2017).

<sup>74</sup> Data on wings – A close look at drones in India. PwC India. For more information, please see <https://pwc.to/31eJVhi>, last visited on 25 June 2020.

<sup>75</sup> Emerging Asia: Bhutan, Brunei, Cambodia, Indonesia, Laos, Malaysia, Mongolia, Myanmar, Nepal, Philippines, Thailand and Viet Nam. Frontier Asia: Afghanistan, Bangladesh, Fiji, Kazakhstan, Kyrgyzstan, Maldives, Pakistan, Sri Lanka, Tajikistan, Turkmenistan and Uzbekistan.

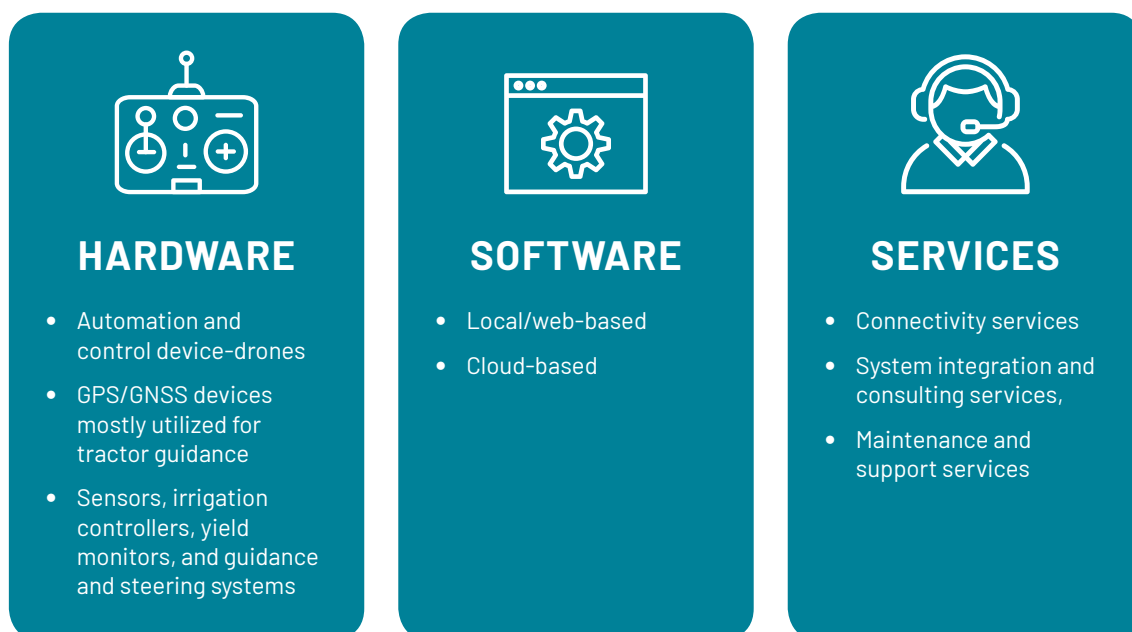
<sup>76</sup> Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam.

<sup>77</sup> For more information, please see <https://vietnamnews.vn/society/738430/central-province-to-use-drones-in-rice-farming.html>

<sup>78</sup> For more information, please see <https://www.ispag.org/>, last visited on 1 April, 2020.



Figure 6. Precision agriculture components



**Source:** Own elaboration based in Bhutani and Wadhvani, 2019.

units in 2013, or about 17 percent of the total installed base, to 2.3 million units by 2023.<sup>79</sup> In particular, China and India are promising markets for GNSS agricultural applications targeting their major crops, namely wheat, sugarcane and cotton.<sup>80</sup>

Precision farming is used for a variety of applications, from monitoring yields and the weather to field mapping, financial, waste and irrigation management (Bhutani and Wadhvani, 2019). The most common application is yield monitoring, with a market share of over 24 percent in 2018 (Bhutani and Wadhvani, 2019). Yield monitoring is made possible through the use of sensors (e.g. grain flow, moisture content, and cutting width sensor), and GPS antennas and receivers to gather data on crops or livestock. Weather monitoring and field mapping are second and third. The latter is projected to grow 16 percent annually until

2025 because of a greater reliance on GPS and Geographic Information Systems (GIS) (Bhutani and Wadhvani, 2019). GPS and GIS systems help gather and analyse real-time geospatial data to facilitate field mapping, soil sampling, and farm planning to enable farmers, for example, to identify the most effective soil and plant treatment strategies.

#### 2.4.2. Types of precision agriculture and their benefits

Precision agriculture can be classified as “soft” or “hard,” depending on the technological intensity of the operation.

**Hard precision agriculture** involves applying big data analysis skills and higher-cost, complex technologies, such as satellite-remote sensing, variable-rate application (VRA),<sup>81</sup> drones, combine, and tractor

<sup>79</sup> For more information, please see [https://www.gsa.europa.eu/sites/default/files/Agriculture\\_0.pdf](https://www.gsa.europa.eu/sites/default/files/Agriculture_0.pdf)

<sup>80</sup> For more information, please see [https://www.gsa.europa.eu/sites/default/files/Agriculture\\_0.pdf](https://www.gsa.europa.eu/sites/default/files/Agriculture_0.pdf)

<sup>81</sup> For VRA refers to a technology for guiding the automated application of materials (e.g. water, fertilizers, pesticides, etc.) based on data that are collected by sensors, maps and GPS, to a given landscape.



auto-guidance systems (Higgins *et al.*, 2017; EIU, 2018; HLPE, 2019). Similar management techniques and technologies could be used for precision livestock farming. The overall level of investment and skills required for using these technologies implies that larger farms are more likely to adopt them.

**Soft precision farming** is characterized by the visual observation of crops and soils, sometimes supported by some low-cost tools, such as chlorophyll meters, digital soil testing kits, smallholder algae production, solar-powered irrigation, and weather forecasting services. It is relatively more suitable for smallholder farmers (HLPE, 2019). Accordingly, precision agriculture can be adopted by small- and large-scale farmers in both higher-income and lower-income countries by focusing on tools suited for various needs and capabilities.

The **potential benefits** of precision agriculture depend on the degree of intensity of the operation. However, it is generally safe to say that it allows farmers to optimize yields and reduce costs by tailoring input applications to the real needs of specific locations at the right time (Kendall *et al.*, 2017). Precision farming can reduce environmental impacts by facilitating integrated pest and weed management, and soil amelioration. Farmers can improve water and yield productivity by adopting management practices that optimally match crop genotypes (HLPE, 2019). IAP (2018) underlines the increasing value of drip irrigation technology in precision agriculture systems for efficient water use. IAP adds that in Asia this innovation resulted from private investment in R&D, exemplifying the importance of public-private coordination and of incentives for the private sector to innovate sustainably. Moreover, these technologies can create incentives for sustainable production and new business models with relatively less administrative burdens (EIU, 2018).

### 2.4.3. Adoption rates of precision agriculture in the Asia-Pacific region

The global precision agriculture market is growing dramatically. It was estimated at \$7 billion in 2020, increasing from \$2.3 billion in 2014, and is poised to grow to \$12.8 billion by 2025 (Michalopoulos, 2015; Marketsandmarkets, 2020). Abdullayeva (2019) indicates that approximately 70 to 80 percent of all new equipment purchases in the field contain some sort of precision agriculture tools, giving an indication of the vast adoption rate of precision farming all over the world.

The actual usage of precision agriculture varies from region to region, depending on farm structure (e.g. farm size, tenure, farmer's age and education), infrastructure (e.g. connectivity, irrigation systems) and market factors, as well as regulatory and policy frameworks, including subsidies and support programmes (Antolini *et al.*, 2015; Ofori *et al.*, 2020). In Europe and the Americas, the uptake of these technologies has been outstanding. The adoption rate in the Netherlands was estimated at 65 percent of total arable farmland in 2015, compared with 15 percent in 2007 (Carolan, 2018). In the United States of America (USA), 72 percent of maize farms were cultivated using precision agriculture technologies in 2010, compared with only 17 percent in 1997 (USDA, 2016; HLPE, 2019).

The APAC region, however, is still in the early stage of adoption, except for China and Japan, which have already pursued precision agriculture on a grand scale. However, Kendall *et al.*, (2017) point out that awareness of the benefits and applications of precision agriculture is confined to larger nationally owned farms producing certain crops (maize, wheat, rice and cotton) in northeast China, which is the country's agricultural heartland. The uptake of precision agriculture is relatively low in other parts of the country and among smaller farms.

In emerging Asia, India and China, precision agriculture is commonly used for plantation management, such as in tea plantations in India and China, sugar cane in Thailand, and oil palm in Indonesia and Malaysia (EIU, 2018). Mitr Phol, Thailand's leading sugar cane production company, employs combine harvesters that use drones, satellite images and GPS tracking to increase its yields and reduce costs (German-Thai Chamber of Commerce, 2018).

In India, the Assam Tea Company uses drones for spraying fertilizers and for pest and disease monitoring in its 15 tea gardens. The firm expects an almost fivefold increase in productivity in the next few years due to the adoption of smart farming solutions.<sup>82</sup> Some tea plantations in Longjing, China, are using drones to transport freshly plucked tea leaves in areas with difficult terrain, thus, saving time and money.<sup>83</sup> Taking the harvested leaves down hills to a processing factory may take three minutes by drone versus 35 minutes for a worker.<sup>84</sup> Smart spraying and site-specific fertilization are also being applied to tea plantations. In addition to agricultural drones, Japan is gradually using robot crop pickers to farm tea because of high wages and scarce labour.<sup>85</sup> Drones have also proved their cost-effectiveness in reforesting tea plantations, as they can plant up to 40 000 seedlings a day, leading to cost reductions of as much as 85 percent.<sup>86</sup>

Coffee growers are also using drones to assess the health of their crops, monitor wildlife around plantations and perform other vital tasks to increase yields. Coffee plantations in Sri Lanka use drones equipped with near-infrared light sensors to monitor pests and diseases that may harm crops.<sup>87</sup> Krishna (2018) lauds the effectiveness of drones in spraying pesticides at variable rates and only in pest-affected spots in coffee plantations situated in hilly terrain, such as the hills of Southern India. He also says that drones can help monitor coffee blossoms and detect fruit maturity with great accuracy, as well as collect data through spectral imagery to prescribe customized fertilization plans across coffee plantations.

Oil palm plantations require regular scouting and monitoring of individual trees, a job perfectly suited for drones that can inspect thousands of hectares in a matter of few hours (Krishna, 2018). The 22.3 million hectares of oil palm plantations spread across Malaysia and Indonesia are fertile ground for the use of commercial drones and satellites, combined with field sensors for precision farming.<sup>88</sup> Drones collect data that is analysed to manage the plantation: for instance, to decide if the palms have enough water and nutrients, to map estates, count trees and their age determining if they need replacement, detect pests and diseases, understand the exact timing of pollination, and to spot fires or find leaks in irrigation systems. The use of robots for fertilization and for harvesting palm oil is also on the rise. The robots are equipped with cameras and sensors that use AI and machine learning to assess whether the palms are ready for harvest.

<sup>82</sup> For more information, please see <https://iot.electronicshobby.com/headlines/ai-enabled-drones-come-to-the-rescue-of-assam-tea-farmers/> and <https://www.indianweb2.com/2019/10/20/assam-company-india-use-ai-smart-drones-tea-farming/>, last visited on 8 April 2020.

<sup>83</sup> For more information, please see <https://www.telegraph.co.uk/news/2018/03/28/pictures-day-28-march-2018/drone-flies-mountains-transport-tea-leaves-tea-plantationin/>, last visited on 8 April 2020.

<sup>84</sup> For more information, please see <https://stir-tea-coffee.com/features/drones-become-aerial-workhorses-of-tea/>, last visited on 14 April 2020.

<sup>85</sup> For more information, please see <https://stir-tea-coffee.com/features/drones-become-aerial-workhorses-of-tea/>, last visited on 14 April 2020.

<sup>86</sup> For more information, please see <https://stir-tea-coffee.com/features/drones-become-aerial-workhorses-of-tea/>, last visited on 15 April 2020.

<sup>87</sup> For more information, please see <https://www.sustainability-times.com/sustainable-business/changes-in-how-coffee-is-grown-can-make-your-cuppas-truly-green/>

<sup>88</sup> For more information, please see <https://www.arpas.uk/drones-that-do-the-work-of-500-farmers-are-transforming-palm-oil/>, last visited on 2 April 2020.

Indonesia's IndoAgri, a subsidiary of the giant Indofood Corporation, has a total planted area of over 302 000 hectares of oil palm, rubber, sugar cane, cocoa and tea.<sup>89</sup> Considering the size and challenging location of its estates, IndoAgri decided to embrace precision agriculture by investing in AI and machine learning in the analysis of geospatial data for the early detection of pests, and for improving plantation management and supply chain efficiency. For example, the company uses drones for real-time monitoring of Ganoderma disease in oil palm plantations and to take precise remedial and preventive actions. Similarly, it uses drones in its sugar cane plantations to monitor cane growth and support the chemical ripening of sugarcane.<sup>90</sup>

The growth of precision agriculture for plantations has led to a proliferation of drone operators and providers of precision farming software and services targeting this market across the region. According to Krishna (2018), a number of agritech companies have emerged in Malaysia and Indonesia that offer drone-aided services and other related services to oil palm, rubber and other plantations. Among the services on offer are general evaluation of plantations using aerial imagery, mapping tree spread and plantation infrastructure, monitoring tree health using hyperspectral imagery that can reveal drought effects, diseases and pest attacks; surveying plantation boundaries and answering security concerns, predicting yields, using spectral images and appropriate software, and planning tree planting programmes. Malaysia's National

Applied R&D Centre, MIMOS Berhad,<sup>91</sup> has launched a web- and mobile-based solution to manage oil palm plantations. The system uses nano-temperature sensor technology to inform the timing of oil palm pollination. Garuda Robotics, a Singapore-based supplier of drones to Southeast Asian farmers, has developed a digital management solution for smart oil palm plantations including drone map hosting, plantation management and automated tree counting.<sup>92</sup> Indonesia's GeoPrecision Tech offers a menu of drone services for plantation and forest management.<sup>93</sup>

Although smart farming technologies allow oil palm estates to be monitored more frequently and to reduce the use of agrochemicals and water, the implications for AI-related loss of agricultural jobs are also undeniable. A single drone can capture images of about 2 500 hectares of oil palms a day, while a human can cover only 5 hectares.<sup>94</sup> This means that one drone can replace 500 workers. Similarly, the use of drones and robotic equipment on tea plantations will likely make many labourers redundant.<sup>95</sup> Smart spraying and fertilization on tea estates, in particular, generate labour savings by a factor of 10 versus tractor application of pesticides.<sup>96</sup> The impacts of these technologies on employment will be discussed in chapter 7.

<sup>89</sup> 250 thousand ha of oil palm, 17 thousand ha of rubber, 13.5 thousand ha of sugar cane and 20 thousand ha of other crops as of 31 December 2019. For more information, please see <http://indofoodagri.listedcompany.com/misc/ar2019.pdf>

<sup>90</sup> For more information, please see <http://indofoodagri.listedcompany.com/misc/ar2019.pdf>

<sup>91</sup> For more information, please see <http://www.mimos.my/>, last visited on 1 April, 2020.

<sup>92</sup> For more information, please see <https://garuda.io/>, last visited on 1 April, 2020.

<sup>93</sup> For more information, please see <https://www.mygeoprecision.com/company-profile.html>, last visited on 24 June, 2020.

<sup>94</sup> For more information, please see <https://www.mygeoprecision.com/company-profile.html>

<sup>95</sup> For more information, please see <https://www.telegraph.co.uk/news/2018/03/28/pictures-day-28-march-2018/drone-flies-mountains-transport-tea-leaves-tea-plantationin/>, last visited on 8 April 2020.

<sup>96</sup> For more information, please see <https://stir-tea-coffee.com/features/drones-become-aerial-workhorses-of-tea/>



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# 3. INNOVATIONS IN FOOD MANUFACTURING

## 3.1.

### THE FOOD PROCESSING LANDSCAPE IN ASIA AND THE PACIFIC

Food processing offers many opportunities to extend seasonal availability and shelf-life, develop healthy foods, fortify staple foods, widen food distribution, reduce food waste in the steps after production, and enable easier meal preparation to satisfy consumer demands (IAP, 2018). To capitalize on these opportunities, the sector needs to innovate.

Food processing, traditionally regarded as a low-intensity R&D sector, is now being pushed to reinvent itself through innovation (Bigliardi and Galati, 2013; Garzón Delvaux *et al.*, 2018).

A key factor that explains why it is comparatively more difficult to innovate in this sector is its heterogeneity. Food manufacturing is, in reality, a collection of multiple industries: from dairy to meat, from fresh produce to frozen food, edible oils and baked goods, and so forth. Each packaged food category encompasses many product lines to adapt to seasonal demand changes, personalized local demands of consumers and retailers, and regulatory requirements (Euromonitor, 2019). Today's food industry launches 30 times as many new food product lines each year as there were in the 1960s, in hundreds of

## BOX 6. APAC'S FOOD MANUFACTURING SECTOR

- APAC sales of packaged foods: \$692.2 billion, with CAGR 4 percent in the period 2018–2023.
- Ninety-eight percent of food processing enterprises in APAC countries are SMEs.
- Today's food industry launches 30 times as many new food product lines each year as it did in the 1960s.
- Asia's food processing industry needs a cumulative investment of \$456 billion above existing levels during 2020 to 2030 to meet the challenges ahead.
- The food industry has an estimated uptake of Industry 4.0 technologies of 20 to 40 percent. China and Japan are among the top three adopters of Industry 4.0 technologies globally, closely followed by South Korea and India. One-third of manufacturing leaders in China and Japan already had smart facilities in 2019, and an additional 40 to 45 percent were planning to become smart in the next five years.
- In Southeast Asia, 40 percent of manufacturing leaders report good progress in digitalizing their factories and processes.

**Sources:** Bagul *et al.*, 2020 ; CRI, 2019 ; FAO, 2018d ; MITI, 2018 ; Skinner *et al.*, 2019; [www.iaasiaonline.com](http://www.iaasiaonline.com); [www.marketsandmarkets.com](http://www.marketsandmarkets.com); <https://www.plm.automation.siemens.com>; [www.foodnavigator-asia.com](http://www.foodnavigator-asia.com); <https://asianroboticsreview.com>

different manufacturing environments around the globe.<sup>97</sup> In addition, the capacity of the industry to innovate is somewhat curtailed by the inherent intricacies of handling food, such as the perishability of raw materials and end products, the compulsory compliance with food safety and traceability standards, and the need to take into consideration the impacts of food production and consumption on food security and other social and environmental outcomes.

To take the innovation leap, the food-manufacturing sector needs to adopt digital or Industry 4.0 technologies such as automation, machine vision and data-driven approaches to ensuring food quality, and blockchain-enabled traceability. With an estimated uptake of Industry 4.0 technologies of about 20 to 40 percent, the food industry lags behind the automotive industry (45 to 60 percent uptake) and the oil and gas sector (over 80 percent uptake).<sup>98</sup>

But this is changing. The overall smart manufacturing market is estimated to grow from \$214.7 billion in 2020 to \$384.8 billion by 2025.<sup>99</sup> Although this increase will be more remarkable in the pharmaceuticals, aerospace and defence, energy and power industries, the tide will also rise for the food and beverages sector. The APAC market, which not coincidentally exhibits the fastest-growing demand for processed food and beverages, is the most dynamic for smart manufacturing technologies in the world (Bagul *et al.*, 2020). As a result, APAC's food manufacturers are switching en masse to Industry 4.0 technologies (MITI, 2018). Some of the chief innovations taking place encompass automation and digital technologies, including big data analytics,

machine vision and data-driven approaches to ensuring food quality, and using blockchain technologies for provenance and traceability. Two innovations in bioscience are also greatly impacting the region's food manufacturing: the use of nanotechnologies in food packaging, and the development of alternative proteins using biotechnology.

However, the sector still has a long way to go. An estimated cumulative investment of \$456 billion above existing levels is required for the food processing industry in Asia to meet the challenges of 2020 to 2030 (Skinner *et al.*, 2019). Over two-thirds of that required investment should add value to the food processed in response to the rising demand for better-quality food (e.g. safer food, healthier food and more sustainable food), with the remaining required for increased quantity (Skinner *et al.*, 2019). Leveraging digital solutions is a recommendable path to follow for making this value-add leap a reality.

### 3.2. KEY TECHNOLOGIES FOR BECOMING A SMART FACTORY: AN OVERVIEW

The coming challenges are coercing food manufacturers to leverage digitalization in order to secure reliable processing and increase manufacturing flexibility, meet price competition, launch innovative products and enter new markets, and improve quality and work to industry standards and Good Manufacturing Practices (IEC, 2015).

Smart manufacturing brings together the mechanical age of the industrial revolution, which focuses on automation, and the digital age, which depends on storing and retrieving in real time massive amounts of data in order to monitor and forecast manufacturing and enterprises functions (IEC, 2015). This is made possible by embracing Industry 4.0 technologies, which comprise the industrial IoT (IIoT), big data analytics, cloud computing, system integration, robotics and augmented reality, among others. All these technologies are interrelated.

<sup>97</sup> For more information, please see [https://www.plm.automation.siemens.com/media/global/en/DE4FB-Industry-Briefing-Digitalization-In-Food-And-Beverage-66023\\_tcm27-17780.pdf](https://www.plm.automation.siemens.com/media/global/en/DE4FB-Industry-Briefing-Digitalization-In-Food-And-Beverage-66023_tcm27-17780.pdf)

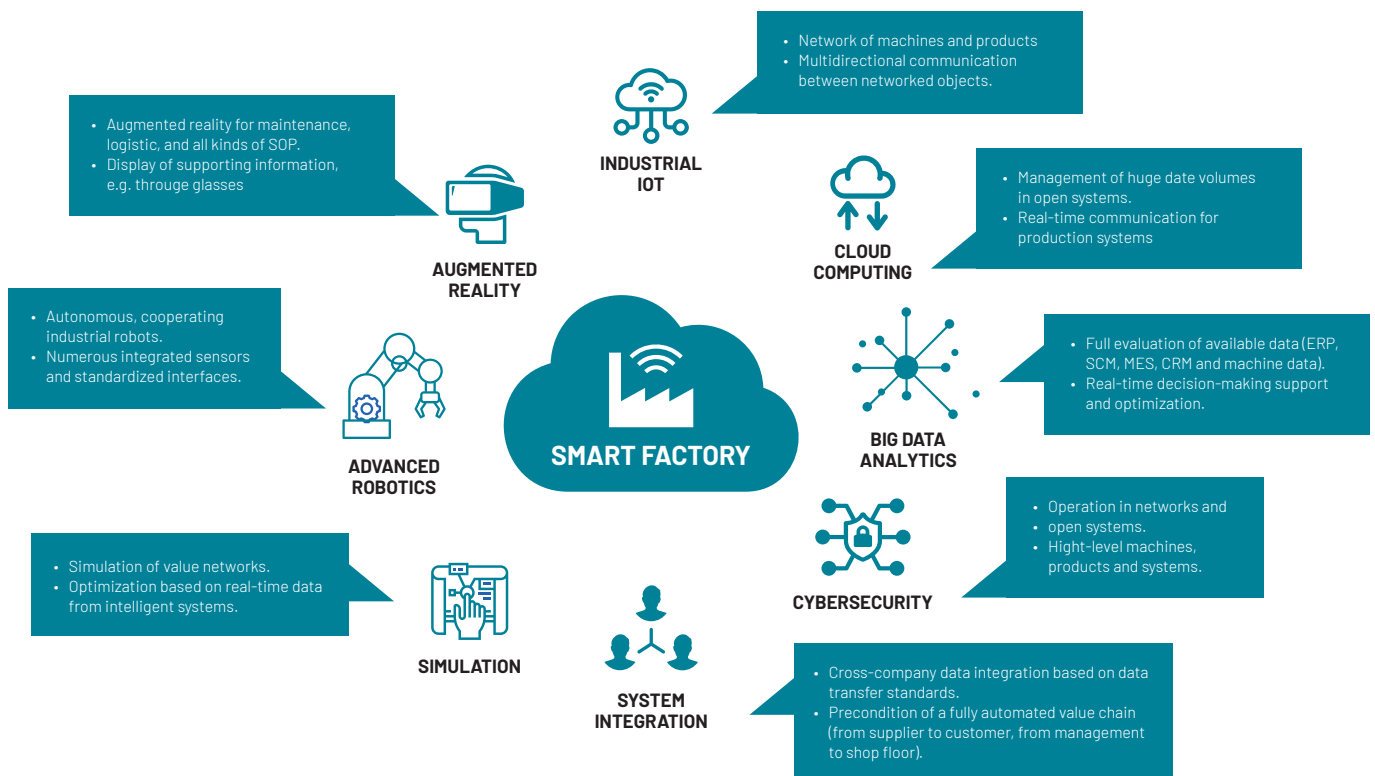
<sup>98</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2019/10/09/Flexibility-food-safety-and-productivity-Three-proven-benefits-of-Industry-4.0-for-the-food-and-beverage-industry-Tetra-Pak>

<sup>99</sup> For more information, please see <https://www.marketsandmarkets.com/Market-Reports/smart-manufacturing-market-105448439.html>

One way to bring food manufacturing into the future is by automating processes to reduce human intervention to a minimum to accommodate a wide range of raw materials, increase recipe agility,<sup>100</sup> eliminate repetitive loads and tasks, and reduce fixed costs (CRI, 2016). While manual production processes tend to generate very little data with significant

These pools of data need to be converted into a common format and imported into a common system, where they can be analysed and used to build models simulating possible scenarios. This common system integrates data from the floor plant with the value chain and enterprise data such as finances, employees, suppliers, customers, partners,

**Figure 7.** Technologies enabling Industry 4.0



**Source:** Own elaboration based on MITI (2018) and Rose *et al.*, (2016).

variance, automated processes generate large amounts of data that are stored throughout several computing systems using different formats. This requires investing in connectivity that leverages IIoT to collect data.

and other assets such as equipment, materials, parts, supplies and property. This is shown in Figure 7 as system integration technologies, which increasingly rely on AI to reconcile data from many data sources with different formats and semantics into meaningful records, and to enhance the usability of systems.

The data gathered can be stored on premises or in the cloud. Moving to the cloud allows food manufacturers to store large sets of data that can be accessed from anywhere in the company, and more importantly, shared within

<sup>100</sup> Recipe agility is the ability to flexibly manage product recipes and formulas, introduce variations to existing lines of food products and launch new ones. One way to achieve this is by digitalizing the recipe management processes.

the firm, thus ending information silos. It can also be shared with partners in the value chain. Cloud computing eliminates redundant or repetitive tasks such as data re-entry, saves costs and improves efficiency. Being data-driven, smart factories need to step up their cybersecurity programmes to ensure that their data is safe from loss, infringement and theft. The data are then analysed and transformed into knowledge to improve processes or solve problems. This task involves large data sets, or big data, with a sufficient number of cases to capture all the data variables impacting that case. Big data analytics are then used to examine large and varied data sets to uncover information such as hidden patterns. Machine learning models, a subset of AI, can be used to apply certain algorithms to recognize and learn from the different patterns that are gleaned from the available data. As the system collects more data for this model, the predictions get better and accuracy is improved. At this point, it is also possible to run simulations, for example by using digital twin applications

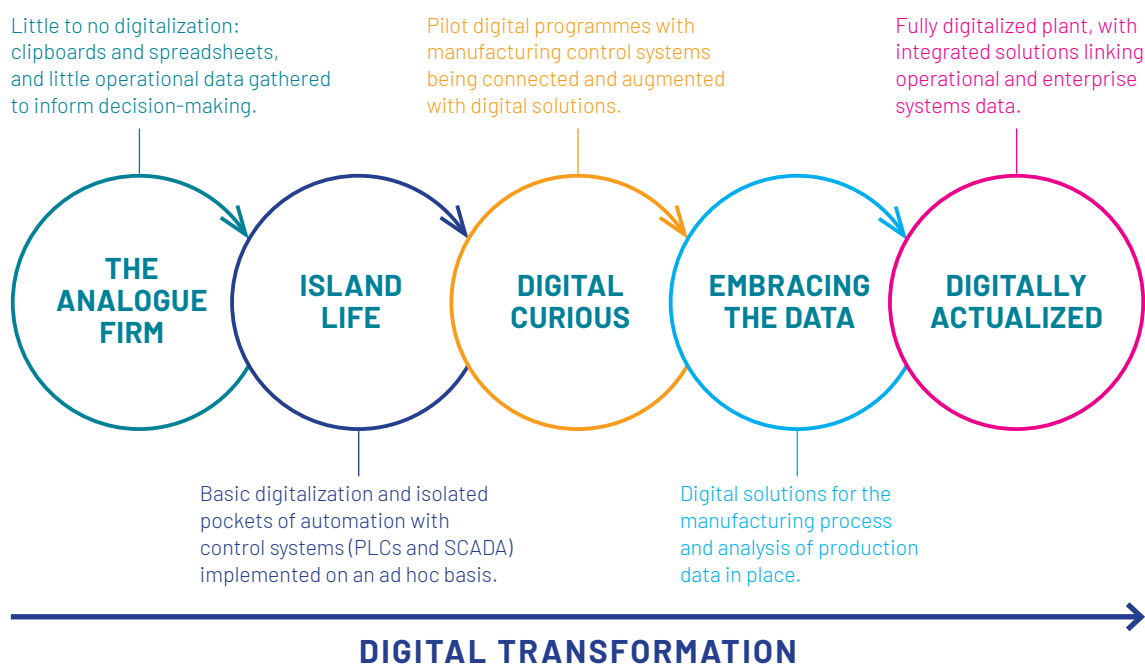
(i.e. a virtual representation of the company and the value chain), in order to provide accurate solutions for dealing with changing scenarios in real-time.

These technologies enable food processors to fully unleash the potential of real-time data from all manufacturing and enterprise processes for optimal decision-making and for initiating innovative added value processes.

### 3.3. A PHASED APPROACH TO BECOMING A SMART FACTORY

Becoming a smart factory requires costly investments that need to be gradually implemented and that build on existing assets and processes. All food manufacturers, regardless of their size and digital readiness, could benefit from a customized multiphase roadmap to help them determine which digital technologies and areas of the company they should prioritize first.

**Figure 8.** Phases of digitalization in food manufacturing



**Source:** Based on ABB, n.d.



**Analogue firms:** Although many food industry leaders are already investing significant sums in digitalizing their facilities and systems, the truth is that most food processing plants in the region are typically 30 to 50 years old and still rely on clipboards and spreadsheets for monitoring their production processes, with little to no automation (ABB, 2020). Those plant owners about to embark on the digital journey could start with something as simple as going paperless – transitioning from physical documents to electronic document management systems. A critical technology enabling the goal of going paperless in food factories is the use of industrial-grade mobile computing tablets, rather than clipboards, to input data and respond to ground-level situations.<sup>101</sup> This phased approach can buy them time to train their employees to be more digital-savvy and hire new staff to eventually fill the skills gap. It also provides time to build a digital culture in the company, with the buy-in of managers, supervisors and workers.<sup>102</sup>

The large majority of food companies are either in stage two or three, island life or digital curious, respectively (ABB, n.d.). Most food factories have in place some pockets, or **islands of automation**, such as automated weighing scales and packing equipment. It is common for food factories to target first either the raw materials and ingredients preparation areas or the secondary packaging area.<sup>103</sup> The areas where raw materials are handled and ingredients are processed are typically automated to gain additional capacity, for instance, by replacing batch production methods with a continuous-flow process.<sup>104</sup>

As these areas represent a high-risk environment for food safety, robots need to be made from stainless steel and food-grade oil must be used, among other precautions. The secondary packaging end is also commonly prioritized for automation. In this area the product is already packaged and can be handled much more easily and with low risk of contamination by using pick and place robots, and auto-palletizing robots. Automation often extends as well to warehousing facilities and dock loading.<sup>105</sup> Processing operations are also subject to automation with ample differences among subsectors. For example, meat, poultry, and seafood manufacturing companies use robots to perform functions such as defeathering, deboning, cutting, splitting, and packaging. Fruits and vegetables processors use robotics primarily for sorting, grading, cutting, peeling and cleaning.

However, automating a food factory is not free from challenges. First, automating the manufacturing of food products – whether carrots, pasta or sausages – entails coping with the high variability of the raw materials in size, shape, quality, weight and texture.<sup>106</sup> Second, food manufacturing typically involves multiple operations, thus intensifying the complexity of automated or semi-automated lines (Ghoshal, 2018). Third, the need to constantly adapt food products to satisfy ever-evolving consumer demands requires flexible automated processes. Last, high standards of machine sanitation are necessary to ensure food safety. This requires components manufactured from quality grade stainless steel and designed to avoid microbiological traps or water stagnation. Even advanced automated lines often fall short

<sup>101</sup> For more information, please see <https://www.foodqualityandsafety.com/article/internet-of-things-traceability/>

<sup>102</sup> For more information, please see <https://sie.ag/3dAy6Fd>

<sup>103</sup> For more information, please see <https://www.newfoodmagazine.com/article/5424/automation-in-the-food-industry/>

<sup>104</sup> For more information, please see <https://www.newfoodmagazine.com/article/5424/automation-in-the-food-industry/>

<sup>105</sup> For more information, please see <https://www.newfoodmagazine.com/article/5424/automation-in-the-food-industry/>

<sup>106</sup> For more information, please see <https://www.newfoodmagazine.com/article/5424/automation-in-the-food-industry/>

of meeting some of these requirements only to discover that there is a water trap or hygiene problem that must be rectified, demanding production be halted and some batches re-inspected or recalled.<sup>107</sup>

As factories become more automated they need to introduce control system solutions, such as programmable logic controllers (PLC) and supervisory control and data acquisition (SCADA) systems (Section 3.4.1.). In phase two, these systems are in place on an ad hoc basis, but there is no communication between the silos, making the manufacturing data incomplete. Managers do not have the full picture to make informed decisions. In this phase of digital maturity, the food manufacturer’s main goal is normally to increase productivity through a higher level of automation that reduces production time and enables better asset utilization and inventory management.

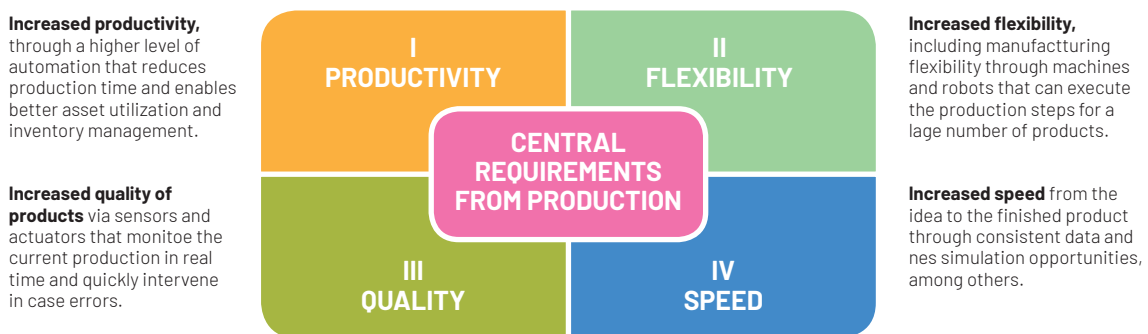
**Digital curious companies:** When food manufacturers become curious about digitalizing their companies (phase three), they start talking to suppliers of technology and know-how about making additional investments in plant-floor automation through

equipment upgrades (i.e. smarter products and full solutions built around them and automated processes) and connection to networks to attain increased efficiency, from energy savings to waste reduction.

The centrepiece of this phase is bringing all pockets of existing automation under an overall system of plant automation, from receiving raw materials to shipping finished food products. The PLC and SCADA systems are connected and augmented with IoT solutions, resulting in increased automation. Through industrial IoT, data from the plant floor can be effectively collected, analysed with the help of various algorithms and analytics, and shared throughout the enterprise.

In this phase, it is vital for food factories to rely on and partner with the suppliers of digital technology, manufacturers of food processing and handling equipment (FP&H) companies, and tech consulting companies. The FP&H sector comprises processing, packaging and commercial food service equipment, representing a market of nearly \$100 billion (McKinsey and Company, 2018). In Southeast Asia, the FP&H market is expected to reach \$1.152 billion by 2023.<sup>108</sup> This partnership

**Figure 9.** Stages of maturity of smart factories and associated benefits



**Source:** Rose *et al.*, 2019.

<sup>107</sup> For more information, please see <https://www.newfoodmagazine.com/article/5424/automation-in-the-food-industry/>

<sup>108</sup> For more information, please see <https://meticulousblog.org/tag/south-east-asia-food-processing-equipment-market/>

between food and FP&H manufacturers is conducive to designing equipment and components that are flexible and free from potential biological issues and water traps.<sup>109</sup> This flexibility refers both to the ability to spread investments across a wide customer base, and to be integrated into value chains in an adaptive and modular manner (Deloitte, 2019a).

A collaborative relationship with technology suppliers is also necessary for food manufacturers to benefit from customized, integral, cyber-physical solutions that are incorporated into production management systems and that leverage data to drive performance improvements (McKinsey and Company, 2018). This customization helps to prevent digital or e-waste such as discarded electrical or electronic devices (EEA, 2020). E-waste is a common problem when transitioning to Industry 4.0 without proper guidance, and unfit, redundant or soon-to-be-obsolete digital solutions are introduced.<sup>110</sup> Advanced tech guidance is also necessary to understand which digital solutions are worth the investment according to the Pareto Principle or 80/20 rule, which means that solving 20 percent of problems will produce financial gains of 80 percent. Therefore, completely changing how a facility operates may be counterproductive as it could take the focus off the important things and create bigger problems. Companies should focus instead on solving small issues that can yield the greatest benefits.

This phase is typically associated with a search for increased flexibility, and notably manufacturing flexibility through machines and robots that can execute production steps for a large number of products (Rose *et al.*, 2019). The progression is far from linear, so some

companies would already emphasize quality improvement, which corresponds to phase III in Figure 9.

**Companies that embrace the data:** In order to reach the last stage of digital transformation, food processors need to deploy a collaborative intelligent system where existing industry software capabilities are enhanced with industrial IoT and AI solutions, notably, machine learning (ABB, 2020). The emphasis in this phase is on implementing a single interface solution that gathers, connects and integrates data from every aspect of the production facility, back office functions and value chain network. The scope of data integration is not just the plant floor, it is the whole enterprise, and extends even to the value chain. This single platform should enable horizontal integration across the company's production network, breaking down the silos within and between partners to optimize supply chain and production processes across organizational boundaries. It should equally promote vertical integration between enterprise and operational systems, allowing for fast feedback and control loops from product design through production to sale (IEC, 2015).

At this point, food manufacturers can also think of moving the company data to the cloud and integrating third-party information such as weather data to complement their internal data (ABB, n.d.). Cloud-based manufacturing execution systems help integrate the operations taking place on the plant floor with the systems in top management for effective monitoring and decision-making. This holds true for a single production line or a large, multi-factory global operation. Cloud-based solutions enable data management and analytics, while lowering costs for IT and system maintenance. However, it does necessitate enhanced cyber security. Many food manufacturers are still unfamiliar with this solution and are sceptical about putting company data in the cloud because of cyber security and operational continuity concerns.

<sup>109</sup> For more information, please see <https://www.newfoodmagazine.com/article/5424/automation-in-the-food-industry/>

<sup>110</sup> For more information, please see <https://industrytoday.com/how-industry-4-0-will-effect-the-food-and-beverage-industry/>

This system weaves a digital thread, a seamless flow of data across the food product's lifecycle that can be captured, analysed, and acted on.<sup>111</sup> The digital thread can run from the identification of a consumer trend that inspires the development of a new product, through recipe formulation, supplier networking, batch and filling instructions, labelling and packaging, quality control, and even the marketing campaign and distribution plan to launch the product. If manufacturing and back office functions are not integrated, overproduction may occur. To prevent this, food and beverage manufacturers must apply IoT to gather data on market demand before changing production levels.

In this phase of digital maturity, food manufacturers are mostly guided by their desire to optimize the quality of their products through sensors and actuators that monitor production in real time and quickly intervene in case of errors.

**Digitally actualized food manufacturers:** These firms master big data analytics. They make sense of the large datasets captured from multiple sources, such as consumer buying patterns and smart-sensor readings along the processing line, and use them to create actionable insights. In particular, as automation increases, big data analytics becomes essential for food processors to decide which foods to manufacture and how to make them, because human workers are not involved in the process to raise concerns and pinpoint potential improvement opportunities that may arise. Thanks to their investments in AI and big data analytics, food manufacturers that are digitally actualized will be able to optimize the lifecycle through consistent data and new simulation opportunities, gaining in speed from ideation to launching the finished product.

The roadmap to digitalization implies going from **labour- to capital-intensive operations**, which also means a higher need for capital, more capital at risk, and asset specificity risks. Furthermore, **a change in mindset and workforce development** are required. The real changes taking place in innovation are in mindsets: managers need to understand the right type of digital technologies needed and the right pace to deploy them. More importantly, they need to shift to data-driven decision-making, towards partnering and weaving innovation ecosystems. A cross-functional team with personnel from various backgrounds and levels of the organization should be created to plan and execute the digital agenda. This mindset movement needs to go hand-in-hand with strategies to help the workforce adapt to and thrive in the new environment. Managers and workers alike need to hone their digital skills and master advanced technologies for increasing productivity, as well as achieving internal outcomes such as decision-making and learning (Deloitte, 2019a). Changes in workforce qualifications may be required to ensure competences in cyber-physical systems and analytical data processing (Rachinger *et al.*, 2019). If such skills are absent within the company, food manufacturers may need to develop a partner network to source them externally.

The digital transformation of a food processing facility is a multidisciplinary process that should involve personnel from engineering, information technology and business operations with complementary skills (IEC, 2015). Instead of solely relying on the IT team, a cross-functional team should be created to plan and execute the digital agenda. Such a team should include personnel from other backgrounds and levels of the organization to set the company culture, regulation compliance, investment priorities, commercializing data, new revenue streams creation, risk tolerance, and much more.

<sup>111</sup> For more information, please see <https://new.abb.com/cpm/industry-specific-solutions/food-and-beverage/fda-fsma-gmp-compliance-in-food-production-from-reactive-to-proactive>

### 3.4.

## KEY PHYSICAL AND DIGITAL TECHNOLOGIES FOR FOOD MANUFACTURING

The new generation of digital, automated technology shows promise for helping food manufacturers meet their key performance indicators (KPI) regarding efficiency and productivity, quality and nutrition, safety and transparency, and sustainability. Transparency, in particular, has become central to the food industry in recent years (Nielsen, 2017). Consumers are seeking transparency around food ingredients, process attributes (e.g. organic, provenance and genetic modification) and sustainability claims about fair trade, animal welfare and environmental concerns. Yet only 44 percent of consumers trust industrially prepared foods as a result of well-publicized food scandals, use of questionable additives and animal welfare concerns (Nielsen, 2017). Digital technologies such as big data, AI and blockchain have the potential to deliver assurances to both the general public and regulators, while increasing quality, efficiency, productivity and sustainability. Consequently, these technologies can play a key role in affording increased transparency and restoring trust in the food system.

Four innovative technologies are converging to enable food manufacturers to meet their KPIs and satisfy consumer demands: intelligent automation, big data analytics, machine vision and machine learning, and the use of nanotechnologies in food packaging.

Food manufacturers also apply blockchain technologies for food traceability and provenance. They are doing so as part of a wide-chain effort that affects retailers, farmers and other actors

### 3.4.1. Intelligent automation in food manufacturing

The automation of manufacturing processes involves an increased use of technology including robots and field devices in and outside of the food processing facility. This trend has been called “intelligent automation.” Intelligent automation and process control are on the rise among food manufacturers that seek to enhance their operational capabilities by speeding up processes, leveraging new possibilities and making their organizations more adaptable to future changes.

Consequently, the value of the global food automation industry is expected to rise to \$2.5 billion by 2022, growing at a 12 percent annual rate, according to a 2017 study.<sup>112</sup>

## BOX 7. THE ECONOMIC IMPORTANCE OF KEY INDUSTRY 4.0 TECHNOLOGIES

- **Global smart manufacturing market:** \$214.7 billion in 2020 increasing to \$384.8 billion by 2025.
- **Global food automation industry:** \$2.5 billion by 2022, 12 percent CAGR. Six out of the ten major global players in food robotics are Japanese and have strong distribution networks in APAC.
- **Global big data and business analytics market:** \$193 billion in 2019 growing to \$421 billion by 2027, CAGR of 10.9 percent from 2020 to 2027 globally vs. 15.8 percent in APAC.
- **Global machine vision market:** \$9.6 billion in 2020 growing to \$13 billion by 2025. The food industry is forecast to experience the fastest expansion during 2020 to 2025, particularly in APAC, with China, India, Japan and South Korea as main adopters.
- **Global market for food processing and handling equipment** is valued at nearly \$100 billion. In Southeast Asia it will be \$1.152 billion by 2023.

<sup>112</sup> For more information, please see <https://www.marketsandmarkets.com>; <https://www.globalmeatnews.com/Article/2017/04/28/Food-robotics-market-value-set-to-rise>

Intelligent automation tends to take place at certain points of the manufacturing process, such as during the raw materials and ingredients preparation, secondary packaging, warehousing and dock loading. In a smart factory, machines, smart sensors and robotic platforms generate data for monitoring, maintenance, and the basic management of the production line. What is vital to understand is that intelligent automation does not only include robotics, but also the computer systems that are required for their control, sensory feedback, and information processing.

There is a set of embedded software systems at various hierarchical production and manufacturing levels:

**The field level:** This level interfaces with the production process via sensors and actuators.

**The control level:** This level regulates both networked/connected machines and systems. Programmable logic controllers (PLC) sit on the control level and control manufacturing processes. In lay terms, PLCs are industrial digital computers adapted for the control of manufacturing processes, which are connected with field devices such as sensors, factory machines, and end devices.<sup>113</sup>

**The process line level:** This level needs to be monitored and controlled. Supervisory control and data acquisition (SCADA) systems enable various production process-level and supervisory tasks and is commonly used in industrial control systems. SCADA is an industrial control system architecture that connects PLCs and remote terminal

units to supervisory and coordinating computers in order to centralize data on the manufacturing process.<sup>114</sup> SCADA systems have a Human Machine Interface (HMI) unit to monitor and control anything that is connected to it.

**The operations level:** This level encompasses production planning and scheduling, quality management, workflow enforcement, and overall equipment efficiency. Manufacturing execution systems (MES) are typical solutions used at the management level and they encompass both manufacturing intelligence and operation intelligence.<sup>115</sup> MES traditionally links data flow control and monitoring on the plant floor, such as SCADA systems, with the next level of business systems, such as Enterprise Resource Planning (ERP). It can support multi-plant orchestration. It also constitutes a bridge for applications that link the real and virtual world of manufacturing, such as digital twins.

**The enterprise planning level:** This is the highest level and includes order management and processing, and the overall production planning and business process management. Intelligent ERP is used at the enterprise level to manage and monitor vital day-to-day processes such as inventory management, accounting, human resources and customer relationship management (CRM).<sup>116</sup>

<sup>113</sup> PLC is an industrial digital computer adapted for the control of manufacturing processes, such as assembly lines, or robotic devices, or any activity that requires high reliability, ease of programming and process fault diagnosis. For more information, please see [https://en.wikipedia.org/wiki/Programmable\\_logic\\_controller](https://en.wikipedia.org/wiki/Programmable_logic_controller)

<sup>114</sup> SCADA is an industrial control system that comprises software and hardware elements, and allows food manufacturers to: i) control the industrial process locally or at remote locations; ii) monitor, gather, and process real-time data; iii) directly interact with field devices; and iv) record events into a log file. For more information, please see <https://en.wikipedia.org/wiki/SCADA>

<sup>115</sup> For more information, please see <https://www.i-scoop.eu/industry-4-0/manufacturing-execution-systems-mes-evolutions-software-solutions/>

<sup>116</sup> For more information, please see <https://www.i-scoop.eu/industry-4-0/>

However, much of these data tend to remain in information silos within the factory. A higher integration of context data coming from these different IT systems can improve efficiency and speed up production processes. This is called vertical integration. The goal of vertical integration is to create a data ecosystem across various production and manufacturing levels, using data transfer standards and creating the basis for an automated supply chain.

These IT systems and IIoT technologies complement each other. For example, while SCADA focuses on monitoring and controlling, IIoT allows connecting SCADA systems with a wide network of intelligent devices in the manufacturing plant. These devices feed into the SCADA system, which in turn acts as a data source for big data solutions to analyse and scrutinize the data generated during production processes to improve productivity. By integrating all the manufacturing data, plant operations can be notified, for example, of defects in a batch of product. The operation can then be paused in order to analyse the data to identify the exact point in the manufacturing process where a problem has occurred, such as a malfunctioning canning machine. It can then be fixed to prevent further loss of product and reduce downtime.

Integrating data vertically across the various manufacturing and enterprise levels is not enough. Data have also to be integrated horizontally along the entire value chain, thus ensuring an end-to-end integration of IT systems and information flows with IoT and data analytics – from suppliers to production to end consumers and other stakeholders and partners. The benefits and drivers for this need for horizontally connected information systems in food manufacturing include improved speed and value creation, enhanced customer service and satisfaction, increased employee productivity and satisfaction, and improved collaboration with partners.<sup>117</sup>

<sup>117</sup> For more information, please see <https://www.i-scoop.eu/industry-4-0/>

**Large-scale Asian food manufacturers are eager adopters of industrial automation and process control** in an effort to reshape their business processes and increase profitability. They typically prioritize pick and place, packaging, repackaging,<sup>118</sup> and palletizing<sup>119</sup> operations<sup>120</sup> for automation using robotic technology. APAC is the fastest-growing region for food robotics, owing to the rapidly expanding processed food industry and the rising demand for packaged foods and particularly ready-to-eat food products.<sup>121</sup> This trend is further fuelled by the rising production of low-cost robots and their increasing functionality that allows them to easily perform repetitive and tedious tasks with accuracy and in compliance with safety standards, as well as lift large and heavy products easily. The key APAC markets for food robotics are Japan, China, South Korea, Indonesia and India.<sup>122</sup> For instance, six out of the ten major players in food robotics are Japanese and have strong distribution networks in Southeast Asia and other countries in the region.<sup>123</sup>

There are, however, two factors that hinder the adoption of automated processes by food manufacturing firms in the region. The first is the cost, not only of the individual robots but also of installing the robotic systems

<sup>118</sup> Repackaging refers to the secondary packaging of food products, which includes stretch wrapping, case packing, carton packing, and carton taping.

<sup>119</sup> Palletizing deals with the process of loading and unloading large and heavy boxes and parts to and from pallets in food manufacturing, distribution facilities and warehouses. Industrial robot palletizers perform this function automatically by carrying a large range of payloads and with extended reach in an efficient and consistent manner.

<sup>120</sup> For more information, please see <https://www.asiacoldchainshow.com/about-robotics-automation-4-food-and-pharma>

<sup>121</sup> For more information, please see <https://www.marketsandmarkets.com/Market-Reports/food-robotics-market-205881873.html>

<sup>122</sup> For more information, please see <https://www.marketsandmarkets.com/Market-Reports/food-robotics-market-205881873.html>

<sup>123</sup> Mitsubishi Electric Corporation, Kawasaki Heavy Industries, Fanuc Corporation, Seiko Epson Corporation, Yaskawa Electric Corporation and Mayekawa Mfg. For more information, please see <https://www.globalmeatnews.com/Article/2017/04/28/Food-robotics-market-value-set-to-rise>

that comprise peripheral equipment (e.g. safety barriers, sensors, PLC, HMI) and safety systems.<sup>124</sup> The second factor is the existing skills shortage in food robotics in most countries in the region, including China and India, where the food industry boasts strong growth prospects. This constraining factor will be difficult to overcome in the short run because of the limited branches of engineering that currently focus on robotics and the scarcity of qualified faculty to train students and practitioners in the multiple engineering disciplines required to become an expert in this field.<sup>125</sup>

**The uptake of automation and digital technologies is highly heterogeneous across subsectors.** Food manufacturing subsectors that are characterized by industry concentration, and large scale, standardized operations – such as dairy and sugar manufacturing – are among the first to deploy digital technologies and automation.

Bakery and dairy processing companies are early adopters of automation to minimize human contact in the production process. This is to comply with more stringent health standards.<sup>126</sup> The dairy industry in Asia has made substantial progress towards automation, in part because of health and safety regulations, in part because of the large economies of scale achieved through consolidation and the pressure to improve productivity and energy efficiency. For example, in China the three top dairy processing companies account for nearly 50 percent of market share, and the top two processors (Yili and Mengniu) purchase 45 percent of China's raw milk production.<sup>127</sup> They are pioneering

the digitalization of the industry and driving innovation throughout the entire value chain. Both Mengniu and Yili are building new smart factories or modernizing their existing plants by investing in automation, AI and big data analytics.<sup>128</sup> Yili's main factory in Huhhot has been completely automatized with no manual handling involved from production, to packing, to shipping.<sup>129</sup> The company's processing plant at Huanggang has also deployed an energy-management solution with a central control system and a full set of automation products. This has increased operational efficiency by 19 percent and reduced energy costs by 5 percent.<sup>130</sup> Plant managers and workers now have real-time information on the factory's energy-consumption KPI indicators, which are now measured in a single second.<sup>131</sup> Likewise, Mengniu has implemented in all of its factories an integrated software and hardware solutions that gathers data from the laboratory and the fully automated processing plant and warehouse.<sup>132</sup> The company's digitalization efforts have moved beyond the factory floor to the financial department, where finance processes have been automated and standardized to enhance efficiency and transparency.<sup>133</sup>

Similarly, in the early 2010s India-based Amul, the world's largest dairy cooperative, deployed an integrated automation and maintenance system that encompassed automation for milk reception, pasteurization,

<sup>124</sup> For more information, please see <https://www.marketsandmarkets.com/Market-Reports/food-robotics-market-205881873.html>

<sup>125</sup> For more information, please see <https://www.marketsandmarkets.com/Market-Reports/food-robotics-market-205881873.html>

<sup>126</sup> For more information, please see <https://www.marketsandmarkets.com/Market-Reports/food-robotics-market-205881873.html>

<sup>127</sup> For more information, please see <https://www.pwccn.com/en/food-supply/publications/modernization-of-china-dairy-industry.pdf>

<sup>128</sup> For more information, please see <https://assets.new.siemens.com/siemens/assets/api/uuid:fd7c80e0-9438-4c81-a8ab-9a513350f68a/version:1536658863/mengniuen0911.pdf>; <https://www.foodnavigator-asia.com/Article/2019/06/06/Hitting-the-100bn-mark-China-s-Yili-and-Mengniu-pour-in-investment-to-boost-milk-production>

<sup>129</sup> For more information, please see <https://www.daifuku.com/us/~Media/daifuku.com/solution/casestudy/pdf/Yili.pdf>

<sup>130</sup> For more information, please see <https://www.se.com/ww/en/work/campaign/life-is-on/case-study/yili-group.jsp>

<sup>131</sup> For more information, please see <https://www.se.com/ww/en/work/campaign/life-is-on/case-study/yili-group.jsp>

<sup>132</sup> For more information, please see <https://assets.new.siemens.com/siemens/assets/api/uuid:fd7c80e0-9438-4c81-a8ab-9a513350f68a/version:1536658863/mengniuen0911.pdf>

<sup>133</sup> For more information, please see <https://www.ibm.com/case-studies/mengniu-dairy-digital-transformation>



and monitoring and control while transferring milk, cream and butter milk from reception tanks to packaging machines, Amul also installed a customized cleaning-in-place solution to sanitize equipment such as silos, milk and cream pasteurizers, cream tanks, dispatch lines and butter-making machines.<sup>134</sup>

Sugar manufacturing is another industry with a noticeable uptake of automation. Most large-scale sugar mills in the region – notably in India, Indonesia, Pakistan and Thailand – have already automated their raw sugar production processes, but operators are still required to control the machines manually. In fact, according to Langhans (2019), 80 percent of all sugar factories in the world are far from having a centralized control system, although it is common to find some control areas where operators have a screen or a panel to monitor the plant operations.

The next step for sugar mills in APAC is to connect everything together and introduce a central operational management system that precisely controls, monitors and coordinates all the drives and electrical equipment. This system allows plant managers to eventually control and monitor all operations on a touch screen panel in the central control room or even by SCADA/HMI screens on tablets, computers and smartphones. For further optimization, a good idea is to add analysing software to enable predictive analytics, which allows forecasting the likelihood of a certain event by examining data from the past.

By introducing intelligent automation in their sugar mills, companies can save energy and reduce operating and maintenance costs. For instance, the Indian company Baramati Agro has deployed a digital control system in its sugar mills. The result is that it has increased its plant throughput by 25 percent and its plant

availability by 15 to 20 percent, while cutting manpower costs in half.<sup>135</sup> Through digital technologies, sugar plants can automate data collection on manufacturing processes and make key information available in real time for plant managers and maintenance engineers. This is particularly important when it comes to data about energy usage and carbon emission levels across the entire operations, which are typically quite energy-intensive, to identify areas to improve, further reduce emissions and increase energy savings.<sup>136</sup> It also helps to reduce downtime during the crushing season, which is extremely disruptive as sugar processing companies that can only operate for about 130 days a year. In addition, the digital thread generated facilitates compliance with increasingly stringent food safety standards that stress the need for better raw material traceability, laboratory sampling, and product control.

### 3.4.2. Big data analytics

Data has been called the new oil, new gold or new currency. Therefore, it should not come as a surprise that a key investment to become a smart food manufacturer is to deploy a **cyber-physical platform with open connectivity to gain capabilities and visibility into operational and enterprise performance data**. Such a platform is vital to integrate data that were previously trapped in silos and make them accessible throughout the entire company. As mentioned earlier, this integration has to be performed both horizontally – bringing together information from the different internal development, production and business processes and with all stakeholders along the value chain – and vertically by bridging information between the firm's plant floor systems and back office (IEC, 2015).

<sup>134</sup> For more information, please see <https://new.abb.com/control-systems/industry-specific-solutions/food-beverage/system-800xa-for-world-s-largest-milk-cooperative-amul-india>

<sup>135</sup> For more information, please see <https://new.abb.com/>

<sup>136</sup> For more information, please see <https://new.abb.com/cpm/industry-specific-solutions/food-and-beverage/taking-control-of-sugar-plant-emissions>

Once the data are gathered through the IT systems and integrated through a common platform, the time has come for bringing in **big data analytics and cloud-based solutions** for smart food manufacturing. These are valuable tools to expedite decision processes and result in improved efficiency, and cost and energy savings (CRI, 2016).

Cloud-scale data management and analytics solutions seek to enable a systems approach in which food manufacturers will have available all of the data necessary for their manufacturing and business requirements, allowing for better-informed decision-making (IEC, 2015). This system can be complemented by the creation of a **digital twin** of the processing line, the company or the value chain that enables the monitoring, management, and improvement of a food product throughout its life-cycle (Figure 10).

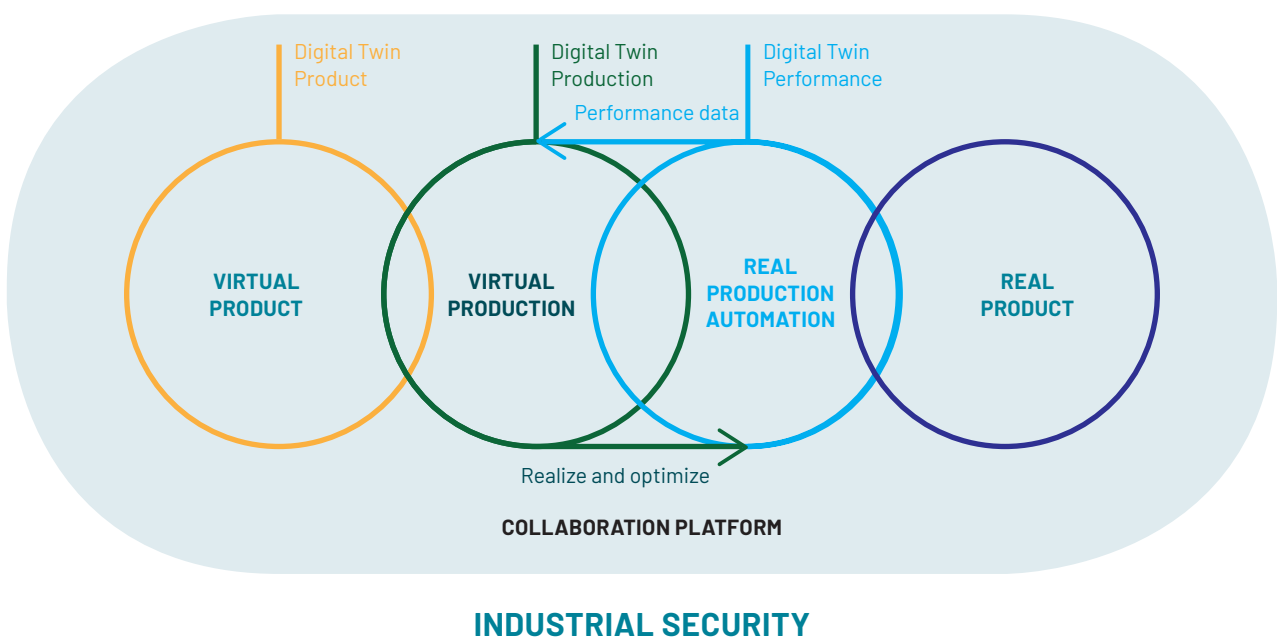
Digital twins go beyond automatically measuring and recording food-manufacturing data. They are designed to model complicated assets or processes that interact with their environments in many ways for which it is difficult to predict outcomes over an entire product life cycle. Food manufacturers can

build, through the digital twin, a complete digital profile of their products from design and development through consumption and feedback. These are linked to the physical world in a near-real-time manner (Deloitte, 2017b). Due to their complexity, the digital twins of the firm and the food supply chain can only be built accurately using machine learning algorithms. Once created, these facilitate more accurate diagnostic, predictive and optimization processes.

More and more food manufacturers are discovering the power of developing a digital model of the company’s products and processes to simulate all functions from product design to manufacturing and utilization. The digital twin aims at improving the performance of physical entities through leveraging computational techniques enabled through the virtual counterpart. In essence, this approach captures, stores and evaluates product information, and applies learning to the current product and future products throughout the manufacturing process and product life cycle (Jones *et al.*, 2020).

By leveraging this tool, a smart food factory could automatically transfer individual

**Figure 10.** Visual representation of the digital twin



**Source:** <https://new.siemens.com/global/en/markets/food-beverage/sugar.html>

product specifications to production plans, and distribute working instructions and machine configurations to the corresponding facilities through IT interfaces, planning tools and intelligent mapping mechanisms. These would extract respective manufacturing settings from digitalized product recipes and transfer them to executable production processes (IEC, 2015).

Within the food industry, **big data management is evolving from reaction to prediction**. This evolution is spawning four types of big data analytics with different requirements and uses. These are descriptive, diagnostic, predictive and prescriptive data analytics (FAO and ITU, 2019b).

Data analytics can be used to understand what is happening in real-time in the company – descriptive analytics – by mining the incoming data using a real-time dashboard or email reports.<sup>137</sup> It can also be used to look at past performance – diagnostic analytics – to gain insights into what happened and why, which are then customarily reported through analytic dashboards.<sup>138</sup> Or it can deliver a predictive forecast, based on the analysis of likely scenarios of what might happen – predictive analytics. Food processors can use predictive analytics techniques to anticipate trends and behaviour patterns by using AI to sort through the vast amounts of data and make sense of them in real-time (FAO and ITU, 2019b). Common examples include predicting future sales, the availability of raw materials, or when the components of the processing line will need maintenance or repairs, known as “predictive maintenance.”

Prescriptive analytics goes a step further. It focuses on gaining actionable insights that represent the best course of action in

a scenario given the available data (FAO and ITU, 2019b). This type of analysis reveals what actions should be taken and proposes recommendations for next steps. Prescriptive analytics applications offer food companies optimization modelling that includes multiple variables such as procurement of raw materials and packaging supplies, inbound logistics (costs, parameters, bills of material conversions), manufacturing (labour costs, resource calendar, product routing, production costs, fixed and variable costs), outbound logistics (transport networks and transport costs) and marketing (demand in volume and price, by customer, and by market).

Through big data analytics, food manufacturers can improve overall performance and reduce costs and time to market through virtualized product and process development to generate accountability, energy and cost savings, and transparency. Through prescriptive analytics, manufacturers can forecast supply and demand more accurately, adjusting operations accordingly and managing inventory more efficiently. They can, for instance, determine how a delay in the supply of raw materials may impact production and can quickly make changes to bring in materials from other suppliers or switch production to other products to ensure there is no downtime.

Furthermore, food manufacturers can gather and analyse data on food production processes to identify the “golden batch” (the best production run possible) utilizing time series and historical analysis tools. This can be used as a quality benchmark for subsequent production runs.<sup>139</sup> Following the thread allows food producers to consistently reproduce the “golden batch” by controlling in real time the execution of a recipe and the flow of product between equipment, managing in-process inventories, and monitoring the progress of a

<sup>137</sup> For more information, please see <https://imagine.next.ingrammicro.com/data-center/four-types-of-big-data-analytics-and-examples-of-their-use-1>

<sup>138</sup> For more information, please see <https://imagine.next.ingrammicro.com/data-center/four-types-of-big-data-analytics-and-examples-of-their-use-1>

<sup>139</sup> For more information, please see <https://emerj.com/ai-sector-overviews/artificial-intelligence-food-beverage/>

batch from the same supervisory and control environment. For example, predictive analytics can determine in real-time that the pH level is likely to start deviating towards a critical condition, by using a process model built on past scenarios and process knowledge. Operators can then correct the pH level and evaluate all affected food for safety.

Big data analytics can also guide food manufacturers to detect which markets and consumer segments to prioritize. This can help them to maximize the profitability of the product portfolio, and enhance customer experience by turning food products into services, and services into experiences. An example would be by providing information on provenance and ingredients, together with recipes by well-known chefs. Food manufacturers are also employing big data analytics to interpret customer sentiment and food preferences by assessing customer emotions that are expressed on social media networks.<sup>140</sup> Recipe flexibility is the ability to change the products' packaging, recipes, and time-to-market to better respond to consumers' demands. Recipe flexibility can also be improved thanks to digital recipe management tools that allow managing operations with several streams and products more efficiently. This enables mass customization, where tailored products are offered with the same economies formerly associated with mass production.

This technology can also be used to ensure consistent quality and improve traceability. Management and traceability software can prevent low-quality products from reaching consumers, and reduce food losses in perishable food chains by enhancing cold chains with smart sensors that control the temperature and humidity and report any deviations. Finally, it can increase manufacturing plant and equipment uptime

and reduce equipment breakage through remote monitoring and predictive maintenance. Thanks to smart sensors that are able to identify equipment anomalies at an early stage, companies are now able to extend the life cycle of some machines and avoid downtime.<sup>141</sup>

The global big data and business analytics market was valued at \$193 billion in 2019, and is projected to reach nearly \$421 billion by 2027, growing at a CAGR of 10.9 percent from 2020 to 2027. Asia-Pacific is expected to exhibit the highest CAGR of 15.8 percent during that period because of the massive volume of data generated by rapid digitalization and a rise in use of electronic devices and networks.<sup>142</sup> In food manufacturing, big data applications are expanding rapidly, with extensive scope for new innovations, and will grow even further pushed by the surge of big data analytics in the food retail sector, particularly e-commerce.

### 3.4.3. Machine vision and machine learning for ensuring food quality

Enhanced consumer confidence can arise from applying AI tools such as machine vision and machine learning in quality control to reduce human errors in food processing. Recognizing this, food manufacturers are increasingly using machine vision for sorting food and quality control. It is an AI technology that through a combination of hardware and software (such as mechanics, optical instrumentation, electromagnetic sensing, digital video and image processing technology) provides imaging-based automatic inspection and analysis for industry applications such as identification, inspection, guidance and more (Patel *et al.*, 2012). Machine learning models – another subset of AI – use algorithms in a big data environment to improve pattern recognition and more accurately identify what it captured by machine vision.

<sup>140</sup> For more information, please see <https://www.analyticssteps.com/blogs/role-big-data-food-industry>

<sup>141</sup> For more information, please see <https://bit.ly/2AakisZ>

<sup>142</sup> For more information, please see <https://www.alliedmarketresearch.com/big-data-and-business-analytics-market>

The global machine vision market was valued at \$9.6 billion in 2020, and is expected to rise to \$13 billion by 2025<sup>143</sup> driven by the increased importance of quality inspection and automation. The food industry is forecast to expand fastest during 2020 to 2025, particularly in the APAC market, with China, India, Japan and South Korea as main adopters.<sup>144</sup> The presence of large manufacturers of this technology in Japan is one of the key factors accelerating its usage among food processors in the region. Machine vision, powered by machine learning, can be applied to improve processing, packaging and distribution, and traceability.<sup>145</sup> Machine vision and machine learning contribute to building the digital thread across the product lifecycle, storing images of the ingredients, the processed product, the packaging, and so forth.

When it comes to production and processing, machine vision can be used to inspect food for product colour, ripeness, spoilage or damage, and proper cooking time (whether an item is undercooked or overcooked). For example, it can be used to automatically sort fruits or vegetables according to quality levels that depend on maturity, weight, size, density and skin defects. This is done by combining optical sorters with imaging algorithms, powered by deep learning, to interpret product attributes in order to ensure quality and grading of food products with high accuracy and consistency based on predetermined criteria. For instance, machine vision systems can examine blueberries on a vibrating conveyor belt and grade each one according to its hue, size, roundness, ripeness,

among other characteristics, reject those that do not meet the pre-established requirements, and identify ice chunks, twigs, insects and other foreign objects.

At the packaging and distribution stages, machine vision can ensure that a food product is adequately contained and labelled by inspecting container integrity, labelling and fill levels to ensure consistency. Machine vision can protect from loss caused by spillage and spoiling from improperly sealed containers, confirm that labels are correct and foil covers and anti-tamper seals are properly affixed.

Vision-based, track-and-trace systems can track ingredients and finished, packaged food products throughout the production process, and compile a tracking history of each product for future reference. They can also read test strips to weed out contaminated food and identify illegible, missing or mismatched product dates, lots, and barcodes to prevent food leaving the production line with missing or incorrect data. Moreover, machine vision systems can identify contaminants, foreign material that infiltrates food packages, and cross-contamination that could cause problems for consumers with food allergies.

The number of companies providing these services is growing in APAC. An example is AgNext, an Indian startup that uses tools such as computer vision, spectral analytics, IoT and AI to analyse produce quality in real-time. The company offers its services to agribusinesses involved in food processing, warehousing, and food collection centres in sectors such as tea, spices, grains, milk and animal feed. AgNext has partnered with the Tea Research Association of India to develop a tea leaf quality assessment system for several tea factories.<sup>146</sup>

<sup>143</sup> For more information, please see <https://www.marketsandmarkets.com>

<sup>144</sup> For more information, please see <https://www.marketsandmarkets.com>

<sup>145</sup> For more information, please see <https://www.integro-tech.com/5-ways-machine-vision-improves-food-industry-inspection/>; <https://www.visiononline.org/blog-article.cfm/Machine-Vision-Challenges-and-Applications-in-the-Food-and-Beverage-Industry/67>; <https://emerj.com/ai-sector-overviews/artificial-intelligence-food-beverage/>

<sup>146</sup> For more information, please see <https://www.financialexpress.com/industry/sme/the-rise-of-the-agripreneur-agritech-startups-trying-to-fix-some-major-issues-faced-by-agriculture-sector/2198583/>

### 3.4.4. The use of nanotechnologies in food packaging

Nanotechnology is conducted at the nanoscale, which is about 1 to 100 nanometres. It can be applied to many fields (Lindquist *et al.*, 2010), but in food value chains its main application to date is to enhance food-packaging materials, alongside nanoformulated agrochemicals and nano-antimicrobial cookware.

Food manufacturers are increasingly using nanotechnology to improve food packaging in order to extend the shelf life of processed foods, repair the tears in packaging, and minimize spoilage. Most importantly, nanotechnology-enhanced food packaging can ensure food safety by means of its antimicrobial properties, coupled with the use of nanosensors to detect any pathogen, toxin or pesticide, and to monitor food parameters, such as pH and fermentation (Hussain, 2018). Nanotechnology-enabled food packaging can be divided into three main categories:

- **Improved packaging** where the nanoparticles applied improve the elasticity and gas barrier characteristics of the food packaging, and the stability of parameters such as temperature and moisture.
- **Active packaging** where nanomaterials present in the package interact directly with the food and the environment to allow better protection and preservation of the product. A case in point is the use of silver nanoparticles as antibacterial agents in food packaging.

- **Intelligent or smart packaging** with embedded nanodevices that can sense biochemical or microbial changes in the food and the environment, as well as enhance traceability and protect against fraudulent imitation. Smart packaging can incorporate a tracking device for food safety and sensors to detect specific pathogens, such as *Escherichia coli* developing in the food, as well as toxins and pesticides. Nanosensors in plastic packaging can detect gases in food when it spoils and the packaging itself can change colour to alert the consumer. Furthermore, food packaging embedded with nanoparticles can release nano-antimicrobes to extend the food product's shelf life. Lastly, smart packaging can provide localization, sensing, reporting, and remote control of food items with improved efficiency and security (Grumezescu, 2017; Sharma *et al.*, 2017).

Industry experts expect nanotechnology will be used to manufacture about 25 percent of all food packaging in the near future (Kuswandi, 2016). However, the main challenge remains proving that nanoparticles used in food packaging do not migrate or leak into the food, and are therefore safe for consumers.



# 4. THE SOARING RISE OF ONLINE FOOD RETAIL AND MEAL DELIVERY SERVICES

## 4.1.

### THE DIGITALIZATION OF FOOD RETAILING AND DELIVERY SERVICES IN THE REGION

**E-grocery** depicts the business of the domestic grocery delivery arranged on digital platforms accessible by mobile and web-based apps, but excludes delivery services of ready-to-eat meals. It covers the online sale of fresh and packaged foods (excluding baby food), beverages and delicacies such as fruits, vegetables, pasta, snacks, sweets, refrigerated products, frozen food, soft drinks and alcoholic drinks.

The global e-commerce market reached \$9.09 trillion in 2019, with APAC holding the largest share with an estimated 55.3 percent. The momentum gained, in part due to the outbreak of COVID-19, will boost e-commerce sales to \$39.5 trillion worldwide by 2026. In 2019, e-commerce sales represented 14.1 percent of retail purchases worldwide.<sup>147</sup> Within this market, online sales of food and beverages, also known as e-grocery, represent less than 2 percent, but the segment is growing exponentially at 23.4 percent CAGR during the

period 2020 to 2030.<sup>148</sup> The global food and beverage e-commerce market was valued at \$14.9 billion in 2019 and is expected to grow to about \$22.4 billion in 2020, and to \$34.6 billion in 2023.

Consumers in the APAC region, already habituated to the online shopping experience through digital applications and e-commerce websites, are flocking online to buy groceries and ready meals. This trend is partly driven by the widespread use of smartphones, strong Internet connectivity<sup>149</sup> and the development of digital technologies that enable these operations. Technologies that support the trend include advanced digital payment solutions, digitally enabled logistics for last-mile delivery, and the use of AI in customer relationship management (CRM) that allows, for example, to send AI-enhanced personalized recommendations to consumers.<sup>150</sup>

Societal changes are also behind this shift towards the digital world, including the large and rising middle class, rapid urbanization and evolving consumer preferences. Asia is home to 40 percent of the global middle class and

<sup>147</sup> For more information, please see <https://www.thebusinessresearchcompany.com/report/food-and-beverage-e-commerce-global-market-report-2020-30-covid-19-implications-and-growth>

<sup>148</sup> For more information, please see <https://www.thebusinessresearchcompany.com/report/food-and-beverage-e-commerce-global-market-report-2020-30-covid-19-implications-and-growth>

<sup>149</sup> 53 percent of the world's population have Internet access (Angus and Westbrook, 2019).

<sup>150</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation>, last visited on 21 April, 2020.



## BOX 8. THE ECONOMIC IMPORTANCE OF FOOD E-COMMERCE AND ONLINE MEAL DELIVERY SERVICES

- **Global e-commerce market:** \$9.09 trillion in 2019, of which 55.3 percent is in APAC, increasing to \$39.5 trillion worldwide by 2026. E-commerce sales represented 14.1 percent of retail purchases worldwide in 2019.
- **Global food and beverage e-commerce market:**
  - \$14.9 billion in 2019 to \$22.4 billion in 2020 to \$34.6 billion by 2023 (23.4 percent CAGR during 2020 to 2030).
  - Four out of five of consumers who buy food and beverages online worldwide are in APAC (748.5 million users of 1 223.1 million globally).
  - In 2021, 61 percent (\$221 billion) of global revenue in the food and beverage e-commerce segment will be generated in APAC.
- **APAC market for online food delivery services:**
  - \$100 billion, led by China with a \$46 billion market.
  - Three out of five consumers who order food online worldwide are in APAC (818.8 million users of 1 335.1 million globally).
  - More than half (\$78.52 billion, 2021) of the global revenue from the online food delivery segment will originate in APAC.
- **In China** over 80 percent of food innovation startup investments today are downstream, including e-grocery and meal delivery services.

**Sources:** Skinner *et al.*, 2019; [www.foodnavigator.com](http://www.foodnavigator.com); [www.marketsandmarkets.com](http://www.marketsandmarkets.com); <https://www.statista.com>; <https://www.statista.com>

to over two billion urban dwellers for whom convenience is essential. Online food delivery services allow them to order ready-meals easily from a mobile application, and a small charge ensures delivery within half-an-hour. Ordering groceries online also offers an easy and convenient shopping experience. More than half of Chinese consumers and 60 percent of Indian adults are willing to spend money to save time when buying food (Mintel, 2019b).

This surge in demand has fuelled the rapid growth of digital grocery and food delivery companies in the region, making Asia the global leader in these two fields. Three of the top five global online grocery markets are in Asia. Another proof of the success of the e-grocery

model in Asia is the fact that nine out of the 20 top Agricultural marketplace deals of 2019 are Asian startups engaged in marketplace and e-commerce operations: six from China (Xinliangji, Qdama, Yimutian, Dafengshou, Just Free and Guoquan Shihui), two from India (Ninjacart and Agrostar) and one from Japan (Sorabito) (AgFunder, 2020).

China leads the pack in online sales of food and beverages, with e-commerce giants such as Alibaba – which owns TaoBao Marketplace, TMall, and Freshippo, among others – and JD.com, or most recently Pinduoduo (AgFunder, 2020). In 2018, e-grocery sales in China were valued at \$51 billion and are expected to grow fourfold in only five years (Table 3). Other

**Table 3.** Top online grocery markets in Asia 2021

	Revenue (USD billion)	Number of users (million)	Year-on-year growth
China	176.86	372.7	16%
Japan	21.69	46.1	12.9%
South Korea	8.75	22.4	13%
India	7.62	190.3	22.2%
Indonesia	2.47	43.6	24.3%
Thailand	1.92	10.4	32.1%
Viet Nam	0.37	11.6	14.6%

**Source:** <https://www.statista.com/>

**Note:** The information is proprietary and purchased

sources put the value of online groceries in China at \$180 billion in 2020 (FIA, 2020).<sup>151</sup> A large part of this growth is due to increased demand from new consumers, especially the younger generations, in third- and fourth-tier cities.

But China is not alone in this. Japan is also a significant market for online grocery shopping although it is growing at a significantly slower pace compared with China. South Korea is third in Asia in terms of e-grocery value and is expected to grow twofold by 2023. These segments are also showing impressive year-on-year growth in the rest of the region, notably in India, Indonesia and Thailand,<sup>152</sup> sustained by the surge of urban, middle class consumers. More concretely, India will be the fastest-growing online grocery market with an annual growth rate above 80 percent during 2018 to 2023, driven by demographic factors and major investments by e-commerce giants such as

Alibaba, Amazon and Walmart.<sup>153</sup> Indonesia reached \$9.37 billion e-grocery sales in 2020.<sup>154</sup> The whole region is rich in local e-commerce solutions, from Lazada, Shopee and 11Street in Southeast Asia, Flipkart in India, Rakuten in Japan, or Coupang in South Korea (MGI, 2019b).

Asian consumers are also increasingly ordering food online. The region has become a global leader in food delivery and convenience technology, with a food-delivery market of over \$100 billion (Skinner *et al.*, 2019). China leads the region with an online meal-delivery market estimated at \$46 billion in 2020, accounting for 75 percent of the country's total e-services. This is forecast to grow at a 7 percent annual rate during 2020 to 2024.<sup>155</sup> China (Alibaba and Tencent through Ele.me and Meituan, respectively), India (Swiggy) and Indonesia (Gojek) are driving growth, followed by other countries in the Asian region (Skinner *et al.*, 2019).

<sup>151</sup> For more information, please see <https://www.statista.com/outlook/253/117/food-beverages>

<sup>152</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation>

<sup>153</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation>

<sup>154</sup> For more information, please see <https://blog.euromonitor.com/indonesian-consumers-presented-with-growing-food-e-commerce-options/>

<sup>155</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation>, last visited on 21 April, 2020.

**Table 4.** Top online food delivery services markets in Asia 2021

	Revenue (USD billion)	Number of users (million)	Year-on-year growth
China	59.94	445.9	10.5%
Japan	3.40	22.5	9.3%
South Korea	2.89	16.5	12.5%
India	11.67	225.6	14.4%
Indonesia	2.28	42.3	16.9%
Thailand	0.33	11.6	20.0%
Viet Nam	0.37	11.3	24.8%

**Source:** <https://www.statista.com/>

**Note:** The information is proprietary and purchased

Some differences persist across countries in terms of the relative success of e-grocery commerce and e-food delivery. For example, in India perhaps because of the dabbawala<sup>156</sup> tradition, online delivery of prepared meals reached \$9 billion in 2020,<sup>157</sup> whereas e-grocery sales only amounted to \$742 million. Conversely, South Korea's \$2.3 billion market value of online ready-meal delivery pales in comparison with the \$10 billion spent on online grocery shopping.<sup>158</sup>

**Online grocery is not expected to overtake off-line market channels**, either formal or informal, in the foreseeable future anywhere in Asia. Despite its substantial growth rate, the food e-commerce phenomenon still represents a relatively small market share. Even in China, by far the world's largest e-commerce market, online groceries only account for 6.6 percent of the country's total grocery sales,<sup>159</sup> and 3.4 percent of total e-commerce.<sup>160</sup> By 2023, 10 percent of total market revenue in the

food and beverages segment in China will be generated through online sales.<sup>161</sup> Other sources cite higher estimates, such as van Ewijk *et al.*, (2020) who wrote that online grocery accounted for 32.5 percent of all grocery expenditures in China in 2018, up from 1.4 percent in 2010. India's food and grocery market is also dominated by traditional retailers (91.4 percent), followed by modern retailers (6.3 percent), with e-grocery representing only 2.3 percent of the total market.<sup>162</sup> Even in South Korea, which is the country where e-grocery will cut more into the sales of traditional channels, the online food commerce will only represent about 14 percent of the total market share by 2023.<sup>163</sup>

In fact, the large majority of APAC consumers are still purchasing their food from a broad range of off-line markets and outlets. These consist of traditional markets and street vendors and modern retail sources, such as supermarkets, convenience stores

<sup>156</sup> The Mumbai dabbawalas are food deliverymen that connect homes and workplaces, delivering thousands of meals cooked at home by mothers and wives for the city's workers.

<sup>157</sup> For more information, please see <https://www.statista.com>

<sup>158</sup> For more information, please see <https://www.statista.com>

<sup>159</sup> For more information, please see <https://www.igd.com/articles/article-viewer/t/igd-chinas-online-grocery-market-to-more-than-double-by-2020/i/16582> [last accessed on 13 February 2020].

<sup>160</sup> China is the world leader in e-commerce (45 percent of all global e-commerce) and e-services (29 percent of all global e-services), according to [www.statista.com](http://www.statista.com) [last accessed on 13 February 2020].

<sup>161</sup> For more information, please see <https://www.statista.com/outlook/253/117/food-beverages/china#market-onlineRevenueShare>

<sup>162</sup> Estimated value by 2024 according to 2020 RedSeer report available at: <https://redseer.com/reports/online-grocery-what-brands-need-to-know/>

<sup>163</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation>

and supermarkets (FAO, 2018d). Across Asia, formal food retailers enjoyed a 36 percent share of the market in 2015 (FAO, 2020b). In some countries in the region, traditional retail channels such as wet markets, small shops and street vendors clearly dominate the food retail market. In Indonesia and India they have over an 80 percent market share. In other countries, these markets are still holding ground, as in Malaysia where they have a greater than 50 percent share (FAO, 2018d). Nick Miles, head of Asia-Pacific IGD,<sup>164</sup> estimates that by 2023, about 84 percent of trade in the region will still be through physical stores, but he adds that these businesses will need to adapt to new technologies to stay relevant.<sup>165</sup>

This reflects the fact that grocery is relatively difficult to sell online, the main deterrent being that shoppers prefer to handpick items themselves. The supply side also faces challenges: produce is perishable, demanding hefty investments in cold chain and delivery capabilities to avoid wastage, while at the same time yielding low net margins compared with other categories of consumer goods sold online.

**Online food commerce and delivery services should not be disregarded as niche markets.** As the growth of e-grocery sales continues to outpace brick-and-mortar, it is undeniable that times are changing. These economic activities are deeply impacting food systems in the region along multiple pathways: from reshaping marketing channels to mainstreaming transformative technologies that are changing the way food is marketed, delivered, and paid for, or to the emergence of new actors and business models pushed forward by the opportunities available on the digital frontier.

## 4.2. THE RISE OF FOOD E-COMMERCE

As digitalization deepens, a **shift from offline to digital marketing models** is taking place. These include online only food retailing, but most commonly **omnichannel or online-to-offline (O2O) food retailing**, also known in China as “new retail,” which involves a combination of digital and physical channels (WEF, 2017; McKinsey & Company, 2017b). Consumers find online and off-line channels as different, but complementary ways to provide the attributes that they look for when shopping for food: value, convenience and choice.<sup>166</sup> Consequently, they tend to use a combination of digital and physical channels to buy their food, through which they are gaining an unprecedented visibility of price, quality and service, coupled with heightened transparency expectations.

There are different types of businesses selling food online: online-only grocers, online marketplaces selling food among many other products, and omnichannel or O2O food retailers (WEF, 2017; McKinsey and Company, 2017b). Digital transformation is rippling through the food retailing industry, changing market positions and structures.

**Omnichannel grocers.** Food retailers in the region have gradually taken their business online to pursue an omnichannel strategy that blurs the lines between physical and digital stores. Through this O2O model, food retailers entice customers within a digital environment to make purchases of goods or services from physical businesses and vice versa.

An example of O2O is Freshippo (known as Hema in Chinese), launched by Alibaba in 2015 as its omnichannel grocery chain.<sup>167</sup> Through

<sup>164</sup> IGD is a research and training non-profit dealing with the food and grocery industry. For more information, please see <https://www.igd.com>

<sup>165</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2020/02/06/Five-top-trends-set-to-shape-Asia-s-grocery-retail-sector-in-2020#>

<sup>166</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation>

<sup>167</sup> For more information, please see <https://insideretail.asia/2020/03/05/how-alibaba-has-refined-and-expanded-its-freshippo-new-retail-concept/>; <https://www.alibabagroup.com/en/news/press>

the Freshippo mobile app, shoppers can buy groceries online or have a digitally-enriched shopping experience in physical stores, such as paying through their linked Alipay account or learning about the freshness and provenance of food products just by scanning their smart labels with the app. Freshippo encompasses several formats catering to different Chinese consumer segments, including Freshippo Farmers, similar to a farmers market. Freshippo Farmers focuses on fresh produce sold in bulk and daily essentials that cater to more price-sensitive consumers, but where the experience is also upgraded with digitally enriched features and 30-minute delivery services. Another format is called Pick'n Go and allows customers to place their orders through the app for pick-up from a temperature-controlled locker that opens using a QR code generated by the app. The over 200 physical Freshippo physical stores also double as fulfilment centres for online purchases. Its direct competitor, 7FRESH or JD.com's grocery omnichannel chain, offers similar shopping experiences through its mobile app.<sup>168</sup>

**Online-only grocers.** The diversity of food e-commerce models in the region goes beyond traditional bricks-and-mortar retailers becoming omnichannel through the launch of a digital shopfront. An alternative model is the online-only grocer. These grocers do not need to invest in real estate apart from office space and front-end warehouses (FIA, 2020). However, online grocery is the most capital-intensive category within e-commerce, which puts commercial pressure on purely online players. Consequently, they tend to have limited product ranges that they compensate for with lower prices and/or more efficient delivery services. Being new in the business, they may not have, at least initially, strong existing relationships with suppliers nor an established reputation among customers.

<sup>168</sup> For more information, please see <https://jdcorporateblog.com/>

An example of the online-only grocer model is MissFresh that operates mainly in North China.<sup>169</sup> Founded as a startup in 2014, MissFresh acquired unicorn<sup>170</sup> status in 2017 and has become China's leading e-grocer, closely followed by O2O retailers backed up by giants Alibaba and JD.com. The company uses a combination of front-end warehouses – not physical grocery stores – with delivery-to-home service. It operates 1 500 front-end warehouses in over 20 Chinese cities and a logistics chain that enables order fulfilment in 30 minutes.<sup>171</sup> MissFresh recently launched its Warehouse 2.0 programme that calls for expanding the number of front-end warehouse to 10 000 and their size from 100 to 300 or 400 sqm.<sup>172</sup>

Another case in point is Singapore-based RedMart. Founded by entrepreneurs with a tech background, RedMart has built authority in certain categories to fulfil unique consumer needs, driving loyalty and helping avoid price competition with traditional retailers (FIA, 2020). By not carrying too many items, the company has managed to be faster at picking and delivering. RedMart has forged some deals with manufacturers that design exclusive products for them to help build category authority. For instance, APB's Archipelago Brewery supplies a craft beer exclusively to RedMart.

China dominated the e-grocery category in 2019, according to AgFunder, a specialist in agrifood tech venture investment. Its lineup of companies includes MissFresh, Yipin Fresh, Furon Xingsheng, Benlai Life, Beidian, Pupumall,

<sup>169</sup> For more information, please see <https://glg.it/articles/a-look-at-chinas-fresh-produce-retail-marketplace-amid-covid-19/>

<sup>170</sup> "Unicorns" are companies valued at a billion dollars or more that remain in private hands.

<sup>171</sup> For more information, please see <https://equalocean.com/analysis/201902221476>; <https://www.jumpstartmag.com/chinese-online-grocery-unicorn-missfresh-raises-us495m-series-f/#:~:text=Headquartered%20in%20Beijing%2C%20MissFresh%20was,round%2C%20along%20with%20other%20investors>

<sup>172</sup> For more information, please see <https://glg.it/articles/a-look-at-chinas-fresh-produce-retail-marketplace-amid-covid-19/>

Tongcheng Life, Dailuobo and Fresh Market (AgFunder, 2020). The popularity of this business model in China reflects the ability of these e-grocers to streamline the country's fragmented food value chains. This category is also expanding in India with Grofers and Alibaba-backed BigBasket racing to stake territory (AgFunder, 2020). Online marketplaces will also see increasing growth in Southeast Asia as the market matures, according to FIA (2020).

**Online marketplaces**, such as Alibaba's Tmall and JD.com in China or Lazada in Singapore, are more important in Asia than anywhere else in the world. Pacific countries are also seeing the emergence of local e-commerce platforms selling food among other products, such as Maua in Samoa and Vitikart in Fiji. This means both food manufacturers and retailers are keen to form partnerships with them. A good example of manufacturer-marketplace collaboration is the Strategic Regional Partnership for Southeast Asia between Danone and Lazada Group for Indonesia, Malaysia, Singapore and Thailand. The alliance intends to create a superior online shopping experience for key product categories, bringing convenience and content to consumers (FIA, 2020).

These marketplaces have become a must-have channel for selling online in Asia. This is true despite high fees for food companies to set up and operate stores on them because they attract a great deal of traffic, have large shopper bases, established payment and delivery systems and strong capability in analysing big data. Although grocery is a relatively small part of the overall business, the sheer size of e-commerce companies such as Alibaba's Tmall, JD.com, Lazada and Market Kurly means marketplaces lead online grocery. China, Japan and South Korea are home to the leading digital marketplaces, but these models will also see increasing growth in Southeast Asia as the market matures (FIA, 2020).

Furthermore, Asian consumers and particularly consumers in East Asia are increasingly turning to "super apps." These are multi-functional mobile apps that combine into a single platform all aspects of a consumer's life from mobile payment to food delivery and rideshare, messengers and games, among other services.<sup>173</sup> Super apps include China's WeChat, Indonesia's Gojek, South Korea's Line and Singapore's Grab. A large part of their growth is attributable to the rise of grocery and meal delivery services. In return, the rise of these super apps helps these companies to build up colossal user bases and expand their ecosystems, contributing to the increased commercialization and performance of new products and services (MGI, 2017a).

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<sup>173</sup> For more information, please see <https://apfoodonline.com/industry/preview-key-insights-and-cases-about-the-top-10-global-consumer-trends-in-asia-pacific/>

**Table 5.** List of digital food retailing cases

CASE	COUNTRY	BUSINESS ANALYSED
7FRESH/JD.com	China	O2O food retailing
Freshippo/Alibaba	China	O2O food retailing
Beidian	China	Online-only grocer
Benlai Life	China	Online-only grocer
Dailuobo	China	Online-only grocer
Fresh Market	China	Online-only grocer
Furon Xingsheng	China	Online-only grocer
MissFresh	China	Online-only grocer
Pupumall	China	Online-only grocer
Tongcheng Life	China	Online-only grocer
Yipin Fresh	China	Online-only grocer
RedMart	Singapore	Online-only grocer
BigBasket	India	Online-only grocer
Grofers	India	Online-only grocer
Alibaba's Tmall	China	Online marketplace
JD.com	China	Online marketplace
PinDuoDuo	China	Online marketplace
Lazada Group	Singapore	Online marketplace
Market Kurly	South Korea	Online marketplace
Maua	Samoa	Online marketplace
Vitikart	Fiji	Online marketplace
WeChat	China	Super app with food delivery function
Gojek	Indonesia	Super app with food delivery function
Grab	Singapore	Super app with food delivery function
Line	South Korea	Super app with food delivery function

**Source:** Own elaboration

### 4.3.

## ONLINE MEAL DELIVERY SERVICES

Online meal ordering and delivery services connect restaurants and caterers with consumers using digital applications. These services are on the rise in APAC. According to the 2019 AgFunder report (AgFunder, 2020), consumer food delivery apps have become an over-saturated marketplace where the more mature players have asserted dominance. There are three different types of providers of such services: aggregators, online restaurants, and subscription-based meal ordering and delivery businesses.

**Aggregators or restaurant marketplaces** are online tech platforms delivering food from a range of vendors (AgFunder, 2020). This model is exemplified by Ele.me and Meituan in China, Uber Eats, the Singapore's GrabFood, India's Swiggy and Zomato, South Korea's Line Man, Fiji Eats and the Samoan Seki Eats.<sup>174</sup> These companies have their own food ordering and delivery solutions in the digital space that to link restaurants and food outlets to consumers – most of them as part of a super app. In this model, consumers purchase meals from the partner restaurants through the aggregator, which creates its own brand and uses a variety of marketing strategies to attract customers' attention, ensures compliance with food quality and safety standards, and invests in logistics to optimize food delivery.<sup>175</sup> Most investment in this segment goes to finding subtle ways to diversify the offering to capture consumer loyalty, as in the case of Uber Eats' test run of airport gateside delivery (AgFunder, 2020).

**Online restaurants** are individual self-operation platforms, where the owner develops its own website, app or digital solution to sell meals online directly to consumers. This category is commonly known as “online restaurant” as restaurants are the most common adopters, but it can also be a catering firm or food outlet. This business requires intense investment and efforts on the part of the owner, not only in terms of the digital solution but also in terms of marketing and logistics. Online restaurants often find success catering to health-conscious consumers or consumers with dietary requirements and preferences. They tend to specialize in clean, plant-based, vegan, meals for weight loss, or keto or paleo meals such as PaleoRobbie.com or TheNutrichef.net in Thailand, or AMGD.sg and NutriflyMeals.com in Singapore.

The weekly or monthly meal subscription-based business pivots around a food ordering and delivery solution, with the necessary mobile apps and website, typically developed through software as a service (SaaS) company. First and foremost, a subscription means a lower price for the customers as they are buying in bulk, on top of added convenience as the food kits or meal orders (pre-made, frozen or fresh meals) are delivered to their doorstep. The ordering process is automated. The subscription business model amplifies the predictability of restaurants and food outlets, and allows them to improve their inventory management so they have neither food wastage nor shortage of ingredients. Examples include Nomnomby and MealPal in Singapore,<sup>176</sup> which work with about 100 and 250 restaurants, respectively. In 2020, MealPal Singapore also linked to food hawkers, following the UNESCO nomination of Singapore's hawker culture in 2019.<sup>177</sup>

<sup>174</sup> Although USA-based, APAC orders more Uber Eats than any other geography in the world, with 1.5 million unique cuisine choices available on the platform in the region. For more information, please see <https://yourstory.com/2019/07/uber-eats-food-delivery-drones-asia-pacific#:~:text=It%20also%20said%20Asia%2DPacific,since%20the%20start%20of%202019.>

<sup>175</sup> For more information, please see <https://www.deonde.co/blog/why-monthly-subscription-food-ordering-solution-in-demand/>

<sup>176</sup> For more information, please see <https://www.timeout.com/singapore/restaurants/the-best-meal-subscription-services-in-singapore>

<sup>177</sup> For more information, please see <https://www.msn.com/en-sg/money/companies/mealpal-expands-hawker-options-switches-to-classpass-like-credit-plan-from-dollar99-month/ar-BB104eC2>



**Table 6.** List of digital meal delivery cases

CASE	COUNTRY	BUSINESS ANALYSED
Ele.me (Alibaba)	China	Restaurant marketplace
Meituan (Tencent)	China	Restaurant marketplace
Uber Eats	Global/APAC use	Restaurant marketplace
Swiggy	India	Restaurant marketplace
Zomato	India	Restaurant marketplace
Fiji Eats	Fiji	Restaurant marketplace
Seki Eats	Samoa	Restaurant marketplace
Gojek	Indonesia	Restaurant marketplace
Grab Food	Singapore	Restaurant marketplace
Line Man	South Korea	Restaurant marketplace
AMGD	Singapore	Owner model
Nutrify Meals	Singapore	Owner model
Paleo Robbie	Thailand	Owner model
The Nutrichef	Thailand	Owner model
Meal Pal	Singapore	Meal subscription-based model
Nomnomby	Singapore	Meal subscription-based model

**Source:** Own elaboration

The aggregator category is by far the most common one as evidenced by the investment flows in the agrifood tech segment. In 2019, about 12 percent of global agrifood tech investment funded startups in the restaurant marketplaces category, whereas the two other models combined (online restaurants and meal kits) managed to attract only 4 percent of the total (AgFunder, 2020).

#### 4.4. THE ROLE OF DIGITAL TECHNOLOGIES IN RESHAPING FOOD MARKET CHANNELS

These changes in terms of digitalization and associated business models in APAC's food marketing system have been enabled by innovative technologies that offer more convenient services to capture and retain customers. Online grocery and food delivery

critically rely on an infrastructure that **bundles an ecosystem of digital technologies**.<sup>178</sup> The bundle is composed of digital payments such as mobile wallet apps, digital marketing and social media, and AI-enhanced solutions for logistics, particularly last-mile delivery, and supply management such as digital dashboards to improve inventory metrics or even personnel performance.

Wharton professor David Robertson dedicated his book "The Power of Little Ideas" to this bundling strategy (Robertson and Lineback, 2017). He considers it a third way to innovate that is neither sustaining nor disruptive. He expounds that this low-risk,

<sup>178</sup> Bundling is a marketing and distribution strategy that joins multiple products or services together to sell them as a single combined unit in order to deliver more value to consumers and/or more economic benefits to the business offering the products; here, it refers specifically to solutions that cover two or more digital technologies (CTA, 2019).

high-reward strategy creates a family of complementary innovations around a central product or service. The complementary innovations work together as a system to carry out a single strategy or purpose, all of which work together to make that product more appealing and competitive without changing it in any fundamental way.

#### 4.4.1. Digital payment solutions

Digital payment solutions, increasingly blockchain-based, are essential for online groceries and ready-meal delivery, but are also widely used in physical stores. The uptake of mobile-payment services in Asia is phenomenal, as they are currently used to handle more than half of all consumer purchases (McKinsey & Company, 2017b). Local mobile-pay service providers are prevalent across the region, with only two or three major providers per country, as in the case of China with the Alipay-WeChat Pay quasi-duopoly followed far behind by Union Pay and JD Pay; Kakao Pay, Samsung Pay, and Zero Pay in South Korea; or, Paytm, ItzCash, Hike, and MobiKwik in India (McKinsey & Company, 2017b). In Southeast Asia, GrabPay and Go-Pay are gaining popularity.<sup>179</sup> As this type of payment becomes mainstream, those food chain actors that do not offer it are bound to lose competitive edge.

#### 4.4.2. Digital marketing and social media

Asian grocery retailers are using digital marketing and social media to engage in two-way online communications with consumers for flash sales, new ideas, suggestions, feedback and customer service. McKinsey & Company (2017b) mentions the case of the Japanese Seiyu stores, which launched a Twitter campaign asking their customers to

vote for items they would like to find at lower prices. Seiyu ended up reducing prices for four weeks on 100 of the most voted items across stores nationwide. Another well-known case is the Alibaba 11.11 campaign, which has become the world's largest 24-hour shopping event. 11.11 is an important day also for farmers because they see their online sales grow significantly on that date. They prepare months in advance by adjusting their sowing and harvesting periods accordingly.<sup>180</sup>

Chinese grocery e-tailers have become world leaders in the use of “**live commerce**,” under the watchful eyes of food retailers worldwide. Live commerce combines live video streaming events, often featuring online celebrities, with the ability to buy immediately, for example through time-limited deals (often under two hours) and competitions or prize draws.<sup>181</sup> Live commerce achieves a much-higher sale conversion rate compared with traditional content-driven marketing by building a sense of urgency in shoppers that encourages quick buys. For example, AliExpress, an Alibaba subsidiary, launched a live commerce service called ‘AliExpress LIVE,’ which saw a conversion rate of 32 percent.<sup>182</sup>

As merchants in online commerce platforms (both individuals and SMEs) get more familiar with live-streaming services, many are shifting from more-basic streams to more advanced live-streaming events that include small farmers promoting their fruits and vegetables or chefs broadcasting cooking tutorials in restaurant kitchens. In 2019, Alibaba-owned Taobao Live hosted 1.6 million sessions featuring agricultural products.<sup>183</sup>

<sup>179</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation>

<sup>180</sup> For more information, please see <https://www.alizila.com/video/chinas-farmers-reap-the-rewards-of-11-11/>

<sup>181</sup> For more information, please see <https://www.channelnewsasia.com/news/commentary/coronavirus-covid-19-grocery-food-delivery-ecommerce-china-12606770>

<sup>182</sup> For more information, please see <https://www.channelnewsasia.com/news/commentary/coronavirus-covid-19-grocery-food-delivery-ecommerce-china-12606770>

<sup>183</sup> For more information, please see <https://www.alibabagroup.com/en/about/businesses>

In recognition of the importance of live commerce, the Thai Government has partnered with the Lazada Group – a subsidiary of China’s Alibaba and the e-commerce market leader in Thailand and Southeast Asia. They train SMEs on digital marketing and livestreaming in particular, including rural SMAEs involved in food processing and retailing.<sup>184</sup>

Another practice that is radically changing the landscape of online food shopping in China is “**social buying**.” Through social commerce, consumers can buy a product at a lower price by inviting their contacts through social networks to form a joint purchasing team. The larger the team, the more generous the discount. PinDuoDuo in particular relies heavily on this practice by piggybacking on Tencent’s messaging application WeChat, which has about one billion users.<sup>185</sup> This practice is extending to other Asian countries and elsewhere in the world.

Understanding consumer demand through big data analytics is particularly important for the food and beverage industry where the trend is towards customizing for local tastes. Accordingly, Asian food retailers are implementing more sophisticated **AI-facilitated CRM programmes** for tracking, analysing and monetizing consumer data. Blockchain technologies in particular stand out as a critical tool that enables food retailers to learn more about their consumers, to improve customer experience and monetize big data analytics through precision marketing. This entails using machine-learning-based forecasting to anticipate consumer demand and trends, customizing orders and promos accordingly, and providing apps for end-consumers (FAO and ICTSD, 2018).

E-grocers are now offering AI-facilitated tailored advice and pricing to food shoppers such as personalized content such as recipes based on the customer’s past shopping patterns and interests. They are offering digital couponing and other dynamic pricing strategies, such as mobile app offers, gamification and location-based services, among others (MGI, 2019b). This is forcing Asian food retailers to acquire new operational skills, such as mastering big data analytics very quickly. However, they benefit from more purchases, deeper customer loyalty and a positive loop in data capture that ultimately makes the system smarter through machine learning.<sup>186</sup> Customers, in turn, benefit from discounted prices on their favourite food products while also discovering new ones through personalized recommendations.

#### 4.4.3. Digital technologies for supply chain management

The e-grocery and e-food delivery phenomena are fostering new ways of moving goods and people through usage of smart devices, automated vehicles (drones and driverless vehicles) and integrating mobility and manufacturing solutions. These technologies have changed the “last mile” delivery capacity, increasing the quality while lowering the cost to serve consumers in the process. For example, companies in e-grocery and e-food delivery can use AI software to determine drivers’ itineraries for meal and grocery deliveries.

The change goes beyond the investment in digital supply chain management solutions, including AI-enhanced logistics management. Food retailers have been forced to rethink their operating model to make it more agile, likely shareable, and decentralized. The tendency in supply chain management is to evolve from

<sup>184</sup> For more information, please see <https://www.bangkokpost.com/tech/1216229/lazada-to-provide-online-training-to-local-smes>; <https://cep.cdd.go.th/wp-content/uploads/sites/108/2017/09/lazada.pdf>

<sup>185</sup> For more information, please see <https://www.channelnewsasia.com/news/commentary/coronavirus-covid-19-grocery-food-delivery-ecommerce-china-12606770>

<sup>186</sup> For more information, please see <https://digital.hbs.edu/platform-digit/submission/kroger-doubling-down-on-data-in-the-face-of-hungry-competition/>

a central distribution centre to decentralized stores that can purchase locally and manage inventories more nimbly, using AI to forecast inventories and manage stocks.<sup>187</sup> Blockchain technology is instrumental in helping grocery retailers to improve inventory performance, as it allows them to hold smaller and more manageable inventories, and to have real-time data on delivery details and sanitation measures (FAO and ICTSD, 2018). With the application of blockchain to inventory management it is possible to attain a remarkable reduction in food losses. According to WEF & McKinsey (2018), a reduction in food loss of 10 to 30 million tonnes could be achieved if blockchain was used to monitor the information in half of the world's food supply chains.

Some food retailers are also adopting machine vision and machine learning to reduce food losses.<sup>188</sup> They eliminate the need for manual inspections to assess the quality and freshness of produce and depend upon machine vision and a suite of applications that rely on machine learning algorithms. The algorithm typically factors in data from a sensor that monitors temperature and light conditions during transport and storage. Should the sensors indicate an issue in conditions while en-route, the shipment would be rerouted to the nearest distribution centre or store and prioritized to reach the shelf faster, if needed, with price markdowns.<sup>189</sup>

## 4.5 REGULATIONS AFFECTING CROSS-BORDER FOOD E-COMMERCE IN ASIA

As food e-commerce grows, so do cross-border e-grocery sales. As a result, some APAC countries have felt the need to introduce changes in their regulatory framework to address the additional challenges that this trade represents, particularly when it comes to food safety. These challenges include the need to comply with different regulatory requirements, in particular those regarding food safety and traceability. Another challenge is to offer food products in the language, currency and units of the importing country using secure payment methods known in the targeted market. Provide customer service, including a returns management system that works cross-border, is another hurdle. They need to offer transparency of shipping costs and additional fees at point of delivery in the form of duties and taxes. Lastly, they must adequately handle security issues related to personal data protection and electronic transactions (FIA, 2020).

Countries in the region have taken different approaches in regulating food products sold online. For example, recognizing the dramatic increase in online food sales and the legal loopholes that may compromise control of food safety and quality, in 2016, the China Food and Drug Administration (CFDA) issued regulatory Order 27<sup>190</sup> to improve the transparency and accountability of online food sales and advertising (FIA, 2020). Order 27 applies to all food producers and operators (including delivery service providers) engaged in online food trading and any third-party platforms that support online food trading. All these food business operators must register

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<sup>187</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation>

<sup>188</sup> For more information, please see <https://digital.hbs.edu/platform-digit/submission/walmart-using-machine-learning-to-reduce-food-waste/>

<sup>189</sup> For more information, please see <https://digital.hbs.edu/platform-digit/submission/walmart-using-machine-learning-to-reduce-food-waste/>

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<sup>190</sup> Order 27 of July 2016 on "Measures of the Investigation and Punishment of Illegal Conducts Concerning Online Food Safety", and enforced from October 2016 (FIA, 2020).

with the CFDA prior to trading food online. Food manufacturers must display their food production or operation license at a visible place on their trading pages or their home pages, if trading on third-party platforms or through their own websites, respectively. They must keep trading records for at least six months after the expiry date of the food item, or two years if no shelf life is specified. Where applicable, they must guarantee safe storage and transportation of food sold online which requires refrigeration, insulation or freezing. Lastly, they are not to publish any information about a food product online which differs from its label (FIA, 2020).

Order 27 also stipulates that third-party platforms are responsible for food products traded on their website. Consequently, they must establish a food safety management unit to monitor trading and ensure food products sold meet the relevant food safety requirements or may face penalties (e.g. fine or business license revocation) if they are in violation of these requirements. In addition, they are also responsible for any damage consumers may suffer as a result of consuming food purchased from the e-commerce platform (FIA, 2020). FIA (2020) notes that many food manufacturers and e-commerce platforms are still adjusting their framework to fit the bill. The enforcement process is also adapting and adjusting, as this Order requires tightening controls on the safety of food traded online. To start with, the mandatory registration with CFDA may cause a bottleneck in the process. More importantly, Chinese food safety officials are now expected to conduct on-site inspections when needed, sample food items, and review records to monitor activities regulated by Order 27. More human and financial resources will likely be needed to ensure adequate enforcement of this regulation. The importance of this legislation,

FIA adds, goes beyond China's domestic online grocery market, valued at \$180 billion in 2020. Chinese food e-commerce providers are now reaching many countries in the Asian region.

Similarly, India has issued guidelines for e-commerce food business operators, with a focus on food safety, which came into effect in February 2017 (FIA, 2020). The guidelines require sellers on the e-commerce platform to display their food business license and registration, and mandatory food information such as storage conditions, disclaimers, and warning statements. E-commerce platform providers must ensure there are no misleading information or false claims on their platforms pertaining to food products, the sellers, vendors, importers or manufacturers. Finally, any food product offered for sale by e-commerce is liable to sampling at any point of the supply chain (FIA, 2020).

In 2016, South Korea enacted the Special Act on Imported Food Safety Management, which mandated preregistration of all foreign food businesses wishing to sell food products in the country, including through e-commerce (FIA, 2020). In addition, the Ministry of Food and Drug Safety has discretion to conduct on-site audits of foreign food facilities, and may suspend imports from facilities or establishments that refuse on-site inspections (FIA, 2020).

All across the region, e-commerce food businesses need to comply with other relevant rules and regulations concerning food safety and standards, and e-commerce. For example, the Indian guidelines on food e-commerce build on the regulations in the Food Safety and Standards Act of 2006 and the Food Safety and Standards Regulation of 2011 (Licensing and Registration of Food Businesses). With regards to compliance with general e-commerce regulations, any online food business operator in Malaysia, for example, has to comply with the Electronic Commerce Act 2006, Digital Signature Act, Consumer Protection (Electronic Trade Transactions) Regulations, and Personal Data Protection Act. Likewise, any Singaporean online food businesses must follow with the requirements of the Electronic Transaction Act, Singapore Broadcasting Act, Personal Data Protection Act and the Internet Code of Practice (FIA, 2020).

Over the past decade, Asia has witnessed a **proliferation of efforts and tools to promote intraregional e-commerce of food products.** A relevant example is the progress made by ASEAN countries to develop harmonized standards for online food businesses to facilitate cross-border trade between member states. In 2001, ASEAN developed the e-ASEAN Reference Framework for Electronic Commerce Legal Infrastructure, which has as one key objective to allow the development of measures to facilitate e-commerce (FIA, 2020). This framework provides guidance for ASEAN member states with no e-commerce laws in place to accelerate the timeline to draft their own, and help those with existing e-commerce laws to facilitate cross-border e-commerce, in particular the cross-recognition of digital certificates (FIA, 2020). This harmonization effort has been complemented by the ASEAN Guidelines for the Design, Operation, Assessment and Accreditation of Food Import and Export Inspection and Certification Systems: 2014.<sup>191</sup>

On a related note, APAC countries can now use ePhyto, an electronic phytosanitary certificate platform developed by the International Plant Protection Convention (IPPC), to facilitate cross-border agricultural e-trading (FAO, 2020f). EPhyto can issue and exchange standardized phytosanitary certificates on a digital platform, bridging the certificates issued by exporting countries and required by importing countries. Housing phytosanitary certificates on an electronic platform reduces the time and costs associated

with sorting, distributing, retrieving and archiving these certificates. It lowers the risk of fraudulent certificates, improves communication, and reduces possibilities for misunderstandings and disputes. This trade innovation is particularly favourable for low-income APAC countries, as they can join the electronic system without having to bear the full costs of creating and maintaining the software (FAO, 2020f).

Lastly, the existing regulatory framework for food e-commerce has enabled the emergence of an innovative business model that facilitates regional and global online food trade, known as global-bonded warehouses. The main proponent of this trade innovation has been China. For example, Tmall Global, an extension of the Chinese online marketplace Tmall.com, allows overseas companies with no business licenses in mainland China to directly advertise and sell food to millions of Chinese using partner bonded warehouses in several of China's largest cities. Orders can be fulfilled and shipped from outside China, and customer payments are settled in the preferred native currency, as long as the overseas companies provide a China-based product return arrangement and Chinese language customer service support. By shipping food products in containers to these bonded warehouses first and then selling online, overseas merchants can reach Chinese consumers within just a few days with lower prices as consumers only incur personal postal articles taxes saving custom duties, value added and consumption taxes (FIA, 2020).

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<sup>191</sup> For more information, please see <https://atr.asean.org/index.php/standards/detail/297/asean-guidelines-for-the-design-operation-assessment-and-accreditation-of-food-import-and-export-inspection-and-certification-systems2014>



# 5. INNOVATIONS IN THE EXTENDED VALUE CHAIN

## 5.1.

### DIGITAL-BASED FARMING SERVICES

Digital-based farming services offer farmers access to tailored information and insights that allow them to optimize their production, such as real-time data on soil, climate, irrigation, pests and diseases. It gives them access to appropriate products and services, including inputs and financial services, and allows them to explore new linkages with markets.

These solutions can be divided into five categories according to the nature of the services provided: advisory and information services, market linkages, supply chain management, financial access, and macro agricultural intelligence (CTA, 2019).

Digital-based farming services can improve market efficiency by allowing different market agents to communicate more efficiently, particularly in rural areas where markets

are less integrated due to inadequate infrastructure. Farmers with access to mobile phones can better plan how much to plant in each season and what type of investments could be profitable based on supply and demand. These digital services can also reduce price variability. Improved information flow effectively limits the influence of local fluctuations and lets market prices reflect aggregate supply situations. In the short term, farmers can find markets offering higher prices or negotiate better with traders. Producers in areas with surplus harvests can sell their products in areas facing shortages, or can identify higher end markets for differentiated products. In the long term, farmers could change production patterns as they gain access to information about new agricultural techniques and more profitable crops and livestock.

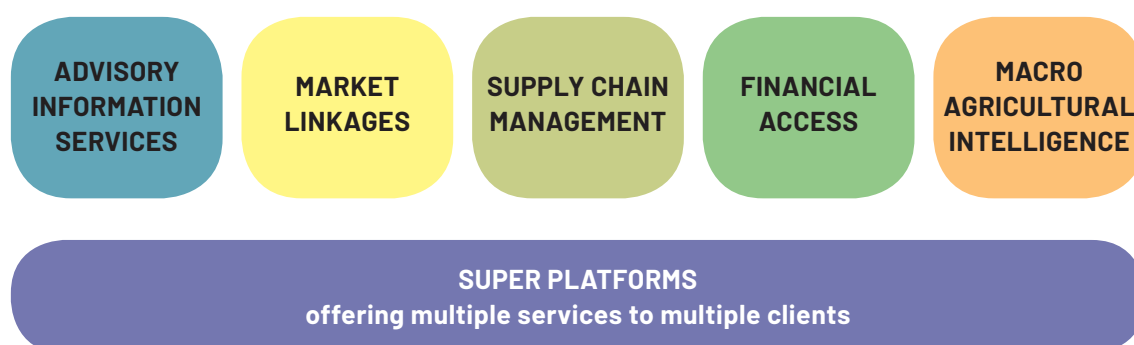
### BOX 9. THE ECONOMIC IMPORTANCE OF DIGITAL SERVICES IN THE EXTENDED FOOD VALUE CHAIN

- **Global market for digital-based farming services:** \$9.53 billion by 2023, with APAC being one of the fastest-growing regions.
- **Blockchain technologies will enable the food industry** to save \$31 billion by 2024 in food fraud globally and reduce compliance costs by 30 percent by immutably tracking food across the supply chain.

**Sources:** Michalopoulos, 2015; [www.statista.com](http://www.statista.com); [www.asia.nikkei.com](http://www.asia.nikkei.com)



**Figure 11.** Types of digital-based farming services



**Source:** Own elaboration based on CTA (2019).

The global market for digital-based farming services is expected to reach \$9.53 billion by 2023, with APAC being one of the fastest-growing regions.<sup>192</sup> The market is booming because of three reasons. First is the growth of food demand resulting from the combined effect of increasing population, continuing strong income growth and urbanization. Second are cost savings offered by these technologies and investment opportunities attracting established companies and startups. Lastly, are government and donor support to democratize these services.

## 5.2. DIGITAL FARMING ADVISORY AND INFORMATION SERVICES

Through digital farming advisory and information services, farmers can receive information through apps, text messaging and other digital platforms on a wide range of topics regarding their livelihoods. The availability of timely and better quality information regarding products and inputs, environmental conditions, and market conditions leads to higher crop

yields. These digital services also give farmers access to learning, which itself can enhance their technology adoption.

Digital farming advisory and information services can take the form of basic farmer information services or participatory and peer-to-peer platforms that deliver non-personalized agricultural information and early warnings about weather events or pest and disease outbreaks (CTA, 2019). They serve as unofficial providers of extension services in APAC countries. Education and building trust among the naturally risk-averse smallholder growing communities are essential for the success of such services (FAO, 2019b). In Asia, digital farming advisory and information applications tend to be locally driven to ensure the availability of content in local languages, local currency and local units of measurement. They also tend to include video and voice features for farmers who cannot read. For example, Myanmar-based Greenovator has launched its Green Way app with audio versions of popular content because literacy rates are still relatively low in rural areas, particularly among women.<sup>193</sup>

<sup>192</sup> According to a 2017 study by MarketsandMarkets. For more information, please see <https://www.marketsandmarkets.com>

<sup>193</sup> For more information, please see <https://www.adb.org/sites/default/files/linked-documents/48409-003-sd-06.pdf>

**Table 7.** List of digital farming advisory and information applications showcased

APPLICATION	DEVELOPER	COUNTRY	CORE SERVICE
AgriMap	Thai Ministry of Agriculture and Cooperatives and NECTEC	Thailand	Digital crop advisory and information
MimosaTEK	MimosaTEK	Viet Nam	Precision irrigation
Fasal	Fasal	India	Precision farming
Siri	Flybird Farm Innovations	India	Precision irrigation and fertigation
Aquaconnect	Aquaconnect	India	Precision aquaculture
Eruvaka	Eruvaka	India	Precision aquaculture
eFishery	eFishery	Indonesia	Precision aquaculture
Jala	Jala	Indonesia	Precision aquaculture (shrimps)

**Source:** Own elaboration.

These services are mostly provided by agritech startups and corporates. However, many companies offering these services, particularly startups, often struggle to profitably monetize their apps. This is why many agritech firms that initially provided digital information services exclusively have included over time new services such as online marketplaces and financial solutions that create revenue streams.

In some cases, these services are provided in the framework of government- or donor-supported initiatives. Many Asian governments are investing in digital farming advisory services via apps, websites and text messaging, which supply farmers with weather and climate information, and soil health management services. For example, Thailand's Ministry of Agriculture and Cooperatives in collaboration with the National Electronic and Computer Technology Centre (NECTEC) has developed a mobile application for farmers called AgriMap (Jones and Pimdee, 2017). The core idea of AgriMap is to downscale information to comprehensible, integrated and relevant reports that help Thai farmers in deciding

which plant they should grow in certain areas. This information is then disseminated by the AgriMap mobile application for farmers, often in partnership with the private sector and academia.<sup>194</sup> This effort is part of the Thailand 4.0 national strategy, a 20-year plan for advanced development. The Ministry of Agriculture and Cooperatives is supporting farmers to incorporate technology-led practices into their traditional farming systems through over 2 000 learning centres countrywide. The goal is to convert 20 000 households from traditional to smart farmers within five years.<sup>195</sup>

This category of digital farming advisory and information services includes precision agriculture advisory services and farm management software. These are designed enable farmers to more easily adopt precision

<sup>194</sup> For more information, please see [https://www.nationthailand.com/Startup\\_and\\_IT/30362978](https://www.nationthailand.com/Startup_and_IT/30362978)

<sup>195</sup> For more information, please see <https://thaiembdc.org/thailand-4-0-2/>, last visited on 1 April, 2020.

agriculture through more sophisticated and tailored agricultural advisory. The services tend to be provided by agritech startups or large-scale new entrants from the big-tech, big-agri or fintech sectors. A case in point is MimosasTEK, a cloud-based system for precision irrigation that allows local farmers in Viet Nam to control and manage their greenhouses or fields using sensors that measure variables such as soil moisture, precipitation, wind speed and air temperature. The collected information is processed, and a notification sent through an app to the user's mobile phone recommending an irrigation schedule, which can be executed remotely if so desired (Doan, 2020; EIU, 2018).

Another example is Fasal, an Indian precision-farming agritech startup that helps farmers predict ideal growth conditions and know when and how much to irrigate, fertilize or spray for pest and diseases.<sup>196</sup> Fasal monitors micro and macro climatic conditions including a farm-specific 14-day micro-climatic forecast, below the soil parameters, solar conditions, crop stage, and crop growth characteristics. The company informs farmers about water availability in the soil to optimize irrigation, alerts them to risk of disease and pests, and provides them with a farm management software to manage and monitor their finances. By acting on this information, subscribing farmers achieve on average 8 to 15 percent increase in yields, 18 to 25 percent reduction in pesticide use, and 20 to 30 percent decrease in water usage for irrigation.<sup>197</sup>

Another Indian startup, Flybird Farm Innovations, has developed Siri, a smart irrigation and fertigation applications controller that allows small farmers to control and automate water and fertilizer management through ground sensors that gather information on soil moisture, temperature, and humidity.

The company is supported by Villgro, India's social enterprise incubator.

A number of companies are offering these services for precision aquaculture:

- Eruvaka is an Indian startup that provides cloud-based aquaculture pond management solutions to help farmers reduce risk and increase productivity. Using their mobile application, growers can monitor the levels of dissolved oxygen and the pH of their ponds in real-time – vital factors in shrimp production – and get a voice alert if the water quality deteriorates, so they can react and avoid shrimp mortality. The system includes the option of installing intelligent control of aerators and feeders to reduce power costs and feed conversion ratios.<sup>198</sup> Aquaconnect is a Chennai-based startup founded in 2017 to pioneer precision aquaculture with the development of machine learning and satellite remote sensing technologies for improving farm productivity and market linkages for over 26 000 Indian shrimp and fish farmers.<sup>199</sup>
- The Indonesian startup Jala helps shrimp farmers improve their water quality through water monitoring and treatment systems.<sup>200</sup> Its IoT device collects data instantaneously, running it through algorithms that generate actionable conclusions. The data are even available offline, should there be no Internet connection.
- The Indonesian<sup>201</sup> startup eFishery has developed a smart feeder that uses motion sensors to detect a fish's appetite and automatically dispense food when the fish seem hungry or unsettled. Farmers can also check on their fish through the

<sup>196</sup> For more information, please see <https://fasal.co>

<sup>197</sup> Information provided by Aravind Kunapareddy, Marketing Manager of Fasal at the Asia-Pacific Agrifood Innovation Summit, on 20 November 2020.

<sup>198</sup> For more information, please see <https://blogs.worldbank.org/digital-development/agriculture-20-how-internet-things-can-revolutionize-farming-sector>

<sup>199</sup> For more information, please see <https://www.financialexpress.com/industry/sme/the-rise-of-the-agripreneur-agritech-startups-trying-to-fix-some-major-issues-faced-by-agriculture-sector/2198583/>

<sup>200</sup> For more information, please see <https://jala.tech/en/>

<sup>201</sup> For more information, please see <https://www.efishery.com/>

accompanying platform, and schedule feeding times or regulate the system in real-time if necessary. The overall effect of this digitally enabled strategy is an increase in production efficiency and better risk management.

### 5.3. DIGITAL MARKET LINKAGES SOLUTIONS OR AGRIBUSINESS MARKETPLACES

In Asia, and less so in the Pacific Islands, numerous technology-driven platforms are emerging as ‘marketplaces’ that connect participants along the food and agriculture supply chain, and facilitate the exchange of data and transactions between parties on an integrated digital platform. These digital solutions make use of the increasing penetration of mobile phones, digitalization, satellite maps, blockchain and other digital technologies to enable smallholder farmers to lower both their production and transaction costs, effectively reducing the size at which farms are viable and ensuring their integration in new markets (AgFunder, 2020; Skinner *et al.*, 2019).

Among such marketplaces are digital platforms that link farmers to providers of agricultural inputs, such as digitally enabled input distribution and online input marketplaces. A case in point is Agrostar, an Indian startup that helps farmers procure seeds, fertilizers, pesticides and agri-implements through its mobile-commerce platform.<sup>202</sup> It has over half a million farmers on its digital platform, mainly from western India, who can purchase inputs with a simple “missed call” or through the company’s app. Since its founding in 2013, Agrostar’s business model has expanded from providing agricultural inputs to include data analytics and agronomic advice.

Digital platforms for equipment leasing offer mechanization services for farmers, such as shared economy for mechanization or pay-as-you-go irrigation. For example, Trringo is an Uber-like mobile-based application that farmers can use to hire a tractor.<sup>203</sup> It has a website, and also a call centre where farmers that do not have access to the Internet can place their orders by telephone. The company has its own pool of tractors, complemented by

**Table 8.** List of digital agricultural marketplaces mentioned

CASE	COUNTRY	CORE ACTIVITY
Agrostar	India	Online agricultural input marketplace
Trringo (Mahindra)	India	Online agricultural equipment lease
FarmerFriend	India	Digital agricultural commodity trading platform
eNAM/Ministry of Agriculture	India	Digital agricultural commodity trading platform
BanQu	USA, China, India and Indonesia, etc.	Blockchain-based market linkages and supply chain platform

**Source:** Own elaboration.

<sup>202</sup> For more information, please see <https://corporate.agrostar.in/#home>

<sup>203</sup> For more information, please see <https://www.telegraph.co.uk/technology/2016/10/18/uber-for-farmers-trringo-tractor-hailing-app-launched-in-india/>, last visited on 1 April, 2020.

tractors from private owners who have signed up to provide the service. As of April 2020, Trringo was serving more than a thousand villages in five states in India.<sup>204</sup> In Myanmar, Tun Yat<sup>205</sup> has developed an on-demand platform that connects farmers and machine renters using high-quality European and Japanese tractors and harvesters and well-trained machine operators. Farmers can book the rental of a machine to till their land or harvest their rice paddy crop through the Tun Yat app and pay a market-rate per hectare using the app mobile wallet. The company has steadily built up a close-knit value chain to offer high-quality inputs, credit and crop marketing to farmers and send data points from farm plots to a platform for analysis. Hujjat Nadarajah, Tun Yat CEO, reported having served over 20 000 households, with 12 000 hectares of crops tilled and harvested and over 70 000 e-wallet transactions completed from October 2017 to October 2020.<sup>206</sup> Overall, Tun Yat's on-demand harvesting and tilling services save its farming customers an average of \$113 each season.<sup>207</sup>

Commodities trading platforms connect farmers to off-take markets such as wholesalers, retailers, or even to end-consumers. An example of this is Farmer Friend,<sup>208</sup> a digital platform currently operating in more than 20 cities across India that connects farmers directly to consumers and owners of restaurants and hotels.

The trend is towards developing platforms that follow an end-to-end integrated market linkage model, which seeks to facilitate digital

linkages to both inputs and markets, and agricultural buyer-seller digital marketplaces or exchanges. A case in point is India's National Agriculture Market, also known as eNAM. It is an online trading portal launched in 2016 by India's Ministry of Agriculture to enable trade in more than 100 commodities. The platform serves as an electronic trading facility that integrates a network of existing Agricultural Produce Market Committee (APMC) local markets. By using this platform, farmers gain from improved price discovery and transparency, as well as online clearance of payment (McKinsey & Company, 2019a).

Another example is BanQu,<sup>209</sup> a global digital platform working in roughly 40 countries, including China, India and Indonesia. It applies blockchain technology to value chain operations in order to unlock marketing opportunities. Participant buyers seek farmers on the platform, make the contractual arrangement and, when the transaction is completed, pay with virtual tokens that can be saved, redeemed for cash, used for paying bills or transferred as remittances (FAO, 2020f). The transaction history of participating farmers is available in the BanQu platform for the buyers to see. They can be shared with intermediary aggregators with the potential to unlock financing and marketing opportunities. By means of blockchain technology, the buyer, the farmer and BanQu acquire and maintain an identical record of each transaction. If a relationship with a buyer ends, farmers' records will still be accessible by the farmer (FAO, 2020f).

Digital marketplaces are mostly developed by the private sector, except for a few platforms driven by the public sector or established through PPPs. Skinner *et al.*, (2019) posit that these digital platforms are emerging in countries where farmers are least connected

<sup>204</sup> For more information, please see <https://www.mahindra.com/stories/trringo>, last visited on 1 April, 2020.

<sup>205</sup> For more information, please see <https://tunyat.com/>

<sup>206</sup> Presentation on 20 November 2020 at the Asia-Pacific Agrifood Innovation Summit.

<sup>207</sup> Presentation on 20 November 2020 at the Asia-Pacific Agrifood Innovation Summit.

<sup>208</sup> For more information, please see <https://www.farmerfriend.in>

<sup>209</sup> For more information, please see <https://banqu.co>

and engaged with the rest of the supply chain such as India, but also in China and Indonesia. The authors list a number of benefits associated with these platforms, such as reducing the need for intermediaries and allowing a better deal for farmers, processors and retailers.

However, digital marketplaces also face significant challenges. For example, GrowAsia *et al.*, (2020) have analysed several online marketing platforms in ASEAN countries and have found that a more enabling environment is needed for: i) developing mobile money services to facilitate cash flow and payments; ii) ensuring compliance with quality control mechanisms of the foods and agricultural inputs sold through these platforms; and iii) providing basic infrastructure, such as roads, Internet access and post-harvest facilities. Although these pieces of advice were meant for ASEAN policy-makers, they can be extended to the rest of the region.

#### 5.4. DIGITAL SUPPLY CHAIN MANAGEMENT SOLUTIONS

Digital supply chain management solutions are business-to-business (B2B) services that help agribusinesses, producer associations and cooperatives, nucleus farms, input agro-dealers and other intermediaries manage their relationships with smallholder farmers (CTA, 2019). They include digital quality assurance solutions for farm inputs and produce, enterprise resource planning (ERP) platforms for smallholder farmer cooperatives, nucleus farms, and outgrower schemes, and logistics management solutions for post-harvest cold chains, storage and transport (CTA, 2019).

These solutions seek to lower costs through greater efficiency, improve value chain quality through better traceability and accountability, and ultimately increase smallholder farmer yields and incomes by making it easier for commercial players to engage formally with large numbers of smallholder farmers.

For example, Credit AI, an agritech company based in Singapore and Bangalore (India), offers digital solutions to producer organizations to organize and digitize their day-to-day operations and business.<sup>210</sup> Sangram Nakaya, founder and CEO of Credit AI, reported having enrolled 72 producer organizations and cooperatives to help them manage their member base of over 30 000 farmers through its ERP Solution.<sup>211</sup> Credit AI's proprietary ERP platform enables these organizations to digitally aggregate the produce and the input demand of members, and create a predictive business scenario so that they can manage their business portfolio efficiently.

A prime example is SourceTrace, an ICT provider based in the USA that currently operates in 28 countries, including India, Bangladesh, Malaysia and the Philippines. SourceTrace has partnered with the Indian State of Haryana to empower nearly 100 000 horticultural farmers of the Small Farmers Agri-business Consortium Haryana (SFACH) with digital solutions in both the local language and Hindi that includes advisory services, market linkages, pest and disease management.<sup>212</sup> The app has a market linkage solution that enables registered buyers (e.g. middleperson, retailer, exporter or processor) to procure fresh produce directly from the producer organization. The app provides insights to all the parties involved. Buyers can look up the quantity of available produce displayed in real time using filters such as district, crop, variety and grade, directly get in touch with the seller and close the deal, all using the app.<sup>213</sup> SFACH farmers can, for example, access information on pests and diseases. The app shows pictures of major pests

<sup>210</sup> For more information, please see <http://creditai.co/>

<sup>211</sup> Presentation made at the Asia-Pacific Agrifood Innovation Summit, 20 November 2020.

<sup>212</sup> For more information, please see <https://www.sourcetrace.com>

<sup>213</sup> For more information, please see <https://www.sourcetrace.com/case-studies-detail/small-farmers-agri-business-consortium-haryana/>

and diseases along with the recommended treatment, in collaboration with the Indian Council of Agriculture Research. Alternatively, the farmer can upload a picture of the affected plant and he or she will receive an advisory delivered through SMS. The Department of Horticulture of Haryana obtains an overview of the supply base (horticultural growers, producer organizations and clusters) and real-time data on crop, production and input application. Through the app, the Department can also deliver information on schemes, benefits and advice to registered farmers.

Commonly, these services are provided in the framework of contract farming operations with multinational or domestic food companies (FAO and ITU, 2018). These enterprises can get a deeper understanding of their target segments, allowing them to better tailor their interventions to the needs of smallholder farmers. The required digital services can be provided directly by the buyer or through a third party. The latter is the case of the Thai firm AgriTech Global Services, which offers a digital crop monitoring and management solution that is currently being applied to 15 different crops including rice, corn, sugarcane, pineapple and oil palm.<sup>214</sup> AgriTech uses high-resolution satellite images, drones and on-the-ground sensors to gather crop data to offer advice to their subscribed farmers by smart phone or text message. These sensors are able to remotely detect the chlorophyll uptake in plants, the levels of nitrogen or potassium, and recommend soil enhancement or warn about overwatering in a given sector of the farm. AgriTech's subscribers are either small-scale producers engaging in contract farming or large farms. In the former scenario, both contracting parties share the subscription cost

of \$40 per hectare per year, which is only fair as the digital solution becomes a tool for the buyers to help them monitor the crops remotely.<sup>215</sup>

Another example comes from Viet Nam, where private and public Vietnamese and Dutch firms and organizations have formed a partnership called Sat4Rice for providing large-scale satellite-based information services to rice value chain actors in the Mekong Delta, the country's rice belt.<sup>216</sup> From the Vietnamese side, the lead partner is the Loc Troi Group (LTG), a rice processor with several mills in the Mekong Delta and the country's lead manufacturer and supplier of seeds, fertilizers and pesticides. LTG collaborates with the Ministry and Department of Agriculture, and Can Tho University.<sup>217</sup> The partners have developed a mobile application that uses a combination of satellite and field data<sup>218</sup> on rice growth, floods, pests and diseases. Contract farmers receive real-time information and advice for free, helping them to increase both the quantity and quality of their rice. The system supplies business intelligence to the buyer, LTG, to help it optimize core business processes such as logistics, extension services, and marketing in both fields and rice mills. Initially, the service reached over 50 000 smallholder farmers out of the 300 000 rice growers targeted by the Sat4Rice partnership. LTG is gradually using drones in rice farming, reporting that a drone could help spray fertilizer and pesticide on 25 hectares a day,

<sup>214</sup> For more information, please see <https://summit.techsauce.co/exhibitors/agri-tech-global-services>

<sup>215</sup> For more information, please see <https://www.bangkokpost.com/business/1816909/future-farming>, last visited on 1 April, 2020.

<sup>216</sup> The Sat4Rice partnership is supported by the Geodata for Agriculture and Water (G4AW) programme of the Netherland's Ministry of Foreign Affairs. For more information, please see <https://g4aw.spaceoffice.nl/en/g4aw-projects/g4aw-projects>

<sup>217</sup> For more information, please see <https://g4aw.spaceoffice.nl/en/g4aw-projects/g4aw-projects/22/sat4rice.html>

<sup>218</sup> Information on crop conditions is timely recorded and uploaded to the Sat4Rice mobile application by LTG's extension workers. The field data thus gathered are subsequently combined with satellite information and analysed to come up with actionable advice.

saving production costs in the range of \$8.7 to \$13 per hectare.<sup>219</sup>

Farmforce is another notable supply chain platform.<sup>220</sup> Using mobile technology, Farmforce digitalizes paper-based processes related to the management of smallholder farming schemes. By doing so, it enables the parties to share information and monitor contract farming operations in a transparent manner by accessing the digital platform. Equally important is that by digitalizing farm management and contractual operations, the platform provides traceability back to the farm, and facilitates e-extension and document compliance with voluntary standards such as GlobalGAP, organic and fair-trade. Farmforce is operating in over 25 countries, including China, India, Papua New Guinea, Sri Lanka, Thailand and Viet Nam. It covers over 30 value chains, mostly cocoa but also coffee, rice, maize, spices and pulses.<sup>221</sup>

Blocrice is a blockchain platform piloted by Oxfam in Cambodia in 2018 to manage contract farming arrangements between organic rice farmers and exporters, rice cracker makers and other buyers. The platform uses smart contracts that predefine the primary purchase price, trade volume, quality requirements, transportation method, organic certification and other conditions.<sup>222</sup>

The incorporation of blockchain technologies in farmer management platforms can ensure transparency, trust and integration among partners in contract farming transactions. However, it can also pose governance challenges related to the interaction design or operational challenges such as the scalability of backend data-management mechanisms.<sup>223</sup> Some of these digital farmer management platforms have emerged to better inform farmers of market prices. Buyers remain better positioned, nonetheless, with greater computational and analytical capital to forecast global production and demand, allowing them to set prices more in their interest (Ravis and Notkin, 2020). Perhaps their biggest downside lies in the relinquishing of data ownership and privacy on the part of the farmers, oftentimes without a proper understanding of this fact and its implications. In this regard, GrowAsia *et al.*, (2020) note that farmers and other users must be cognizant of the challenges associated with sharing data, such as privacy issues and errors in data, particularly self-reported data.

<sup>219</sup> For more information, please see <https://vietnamnews.vn/society/738430/central-province-to-use-drones-in-rice-farming.html>, last visited on 24 June, 2020.

<sup>220</sup> For more information, please see <https://farmforce.com/>

<sup>221</sup> For more information, please see <https://directory.growasia.org/farmforce/>

<sup>222</sup> For more information, please see <https://borgenproject.org/tag/smart-contracts-for-farming/>; <https://asia.nikkei.com/Business/Technology/Cambodian-rice-farmers-turn-to-blockchain-to-gain-pricing-power>

<sup>223</sup> For more information, please see <https://www.agrenta.com/smartcontractfarming>



**Table 9.** List of digital supply chain management solutions showcased

PROVIDER	COUNTRY	CORE ACTIVITY
Agritech Global Services	Thailand	Digital supply chain management platform for contract farming operations (15 crops)
Blockrice (Oxfam)	Cambodia	Digital supply chain management platform for rice contract farming
Credit AI	India	Digital supply chain management for cooperatives and contract farming operators
FarmForce	Norway-based startup operating in China, India, Papua New Guinea, Sri Lanka, Thailand, Viet Nam, etc.	Digital supply chain management platform for cocoa, coffee, rice, maize, spices, pulses and other crops.
Sat4Rice (LTG, Ministry of Agriculture, etc.)	Cambodia	Digital supply chain management platform for rice contract farming
Source Trace, State of Haryana and SFACH	India	Digital supply chain management platform

**Source:** Own elaboration.

## 5.5. DIGITAL FINANCIAL SERVICES

Digital financial services include online financial services that are relevant for smallholder farmers such as digital payments, savings, smallholder credit, and agricultural insurance. They also cover B2B digitalization and data analytics services for financial institutions that enable such institutions to serve smallholder farmers at substantially lower cost and risk (CTA, 2019).

At the core of digital financial services for farmers lies financial technology or fintech. Fintech refers to the integration of technology into offerings by financial services companies in order to improve their use and delivery to consumers, typically through their mobile devices (ADB and Oliver Wyman, 2017; FAO, 2017c). Fintech unbundles financial services into individual offerings and makes them more efficient, while reducing transaction costs. These services equip farmers to improve yields

and incomes and invest in the longer-term growth of their farms by using better inputs, mechanization and expanding to new crops.

These digital solutions adopt multiple forms, such as smallholder farmer payment solutions; digital agri-wallets and commitment savings systems; smallholder credit; smallholder insurance); and crowdsourcing services for farming ventures.

The most critical fintech tools for empowering farmers by democratizing their access to financial services are the following:

**Mobile money:** Also known as ‘mobile wallet’, mobile money is a specific form of fintech that allows people to receive, store and spend money using a mobile phone. Therefore, it enables unbanked farmers, and rural dwellers in general, to participate in the modern cashless economy (GrowAsia *et al.*, 2020). It the most used fintech solution, and also serves as the backbone for

a variety of other fintech solutions (McIntosh and Mansini, 2018). GrowAsia *et al.*, (2020) specify that mobile money is a prerequisite for access to digital marketplaces, and an enabler of a more efficient delivery of credit and insurance services to rural and farming communities. Mobile payments can put an end to paying smallholder farmers in cash, which can be an unsafe and inefficient practice that does not promote building up a credit rating.<sup>224</sup>

**Mobile lending for farmers:** Fintech can also make it easier for smallholder farmers to take out a digital loan using the ever-ubiquitous smartphone, by streamlining loan origination and processing. Fintech is being used both to enhance the ability of farmers to use collateral and to permit new forms of more flexible, uncollateralized credit. This is made possible, for example, by building a credit score progressively. Farmers can borrow only a small sum at first and after they pay back their loan, then they will be able to increase their limits. Different data sets can be used to determine creditworthiness, often using AI analytics.

**Digital solutions for agro-insurance:** Big data analytics improves the predictive ability of the models significantly. Blockchain technologies can help farmers processing their claims to the insurer by automating the process. It eliminates the need for on-site claim assessment by the surveyor, and facilitates instant payouts in case of adverse weather incidents (FAO and ITU, 2019a). Asian governments will have a key role to play in rolling out tech-enabled agro-insurance programmes that target smallholder growers, such as digitally-enabled index weather, precipitation, pest insurance.

**Crowdfunding platforms for smallholder farming and B2B fintech data analytics intermediaries:** Peer-to-peer (P2P) lending and crowdfunding startups have found ways to circumvent the lack of access to formal credit and loans that Asian farmers often face, owing to their inability to provide suitable collateral and the dearth of financial products for farming households (Deloitte, 2019b). These startups are made possible by the increase in mobile phone penetration, even among rural communities.

## 5.6. MACROAGRICULTURAL INTELLIGENCE

Macroagricultural intelligence refers to data analytics tools and digital decision-support solutions that integrate multiple data sources on farms, producers, households and markets and convert this information into insights at various levels of aggregation, from a value chain, to a given territory or the whole country. These tools guide policymakers, extension agencies, agribusinesses and investors to make informed decisions (CTA, 2019).

Common examples include government agriculture sector tracking dashboards, management tools for agriculture extension systems, agribusiness and agricultural investor national and regional intelligence systems, digital tools for setting the agricultural R&D agenda, and weather and climate observatories for agriculture.

## 5.7. AGRICULTURAL SUPER PLATFORMS

A sixth modality of digital solutions for food and agricultural supply chains is the so-called **super platforms**, which bundle together multiple services all in one platform. These services target farmers or other smallholder value chain intermediaries, and typically integrate digital advisory services, market

<sup>224</sup> For more information, please see <https://www.cgap.org/blog/making-digital-payments-work-low-income-farmers>

linkage services, and financial services, among others (CTA, 2019).

Examples of online super platform are PacFarmer from Fiji and Grape Mundo and e-Choupal from India. The Grape Mundo platform, supported by the central and state governments,<sup>225</sup> offers advice to producers in the Maharashtra grape cluster for optimizing the cultivation of high-quality grapes using minimum chemicals, as well as marketing services through an e-commerce platform called BestGrapes™. The platform uses plain, local language (Marathi) so that grape farmers can easily understand the advice provided to make informed decisions. E-Choupal<sup>226</sup> is an initiative by Indian conglomerate ITC Ltd that helps four million smallholder producers overcome multiple market failures (FAO, 2020f). It functions through a network of Internet kiosks in over 40 000 villages run by farmers who act as focal points.<sup>227</sup> This super platform offers information on farming practices, market prices, weather forecasts, and advice by agricultural experts. It provides financial services to farmers in partnership with banks, and input and output marketing through a network of warehouses and collection points. FAO (2020f) highlights the initiative's positive impacts on farming practices and farm incomes. For example, the introduction of e Choupal kiosks had a positive effect on soybean prices, which increased between 1 and 3 percent. This innovation also resulted in a 19-percent increase in soy production, leading to an overall 33 percent rise in farmers' net profits. A part of the increase in profits was due to a redistribution of surpluses from traders to farmers. There was also evidence that 1 to 5 percent of traders' profit margins were transferred to farmers.

Ricult is another super platform currently serving nearly 260 000 smallholder farmers in Pakistan and Thailand.<sup>228</sup> This startup provides farmers with a series of digital services through either an app or an interactive voice response system, including farm specific weather advice, advanced weather analytics, daily spot prices of various crops from mills, remote crop health monitoring through satellite imagery, bank loan applications, real time agronomy advice and a discussion forum. According to Deloitte (2019b), Ricult has reportedly helped to improve the productivity of subscribing farmers by about 50 percent, and their profitability by 30 to 40 percent on average.

In Myanmar, two such platforms can be highlighted: Impact Terra and Greenovator. The former is a startup founded by Erwin Sikma in 2016 to provide digital services to farmers through its Golden Paddy Platform that encompasses a mobile application, web application and a Facebook page.<sup>229</sup> Golden Paddy helps farmers improve crop productivity by sharing agricultural knowledge and specific, real-time recommendations and alerts. It facilitates access to market and financing opportunities. The platform offers crop-specific personalized advice to farmers to improve their productivity and become more resilient to extreme weather and pests. Buyers and service providers can also access the platform to collect insightful data, advertise their products and services, and support farmers.

Greenovator<sup>230</sup> is a social startup founded by Yin Yin Phyu and Thein Soe Mi, two graduates from Yezin Agricultural University. As of November 2019, the startup's free-for-use mobile application Green Way was providing information, services and data-driven solutions to more than 120 000

<sup>225</sup> For more information, please see <https://www.grapemundo.com>

<sup>226</sup> For more information, please see <https://www.echoupal.com>

<sup>227</sup> For more information, please see <https://blogs.worldbank.org/voices/planet-apps-making-small-farms-competitive>

<sup>228</sup> For more information, please see <https://www.web.ricult.com>

<sup>229</sup> For more information, please see <https://www.impactterra.com/>

<sup>230</sup> For more information, please see <https://www.mmgreenovator.com/>

registered farmers, 20 percent of whom were women.<sup>231</sup> Through the Burmese language app, farmers can access information about local weather, farm productivity, income and market prices for about 500 crops and livestock in several parts of the country. They can also ask questions (with photos) that are answered by verified agricultural experts through a moderated message board.<sup>232</sup> Greenovator has also developed the Zaytangi digital marketplace platform<sup>233</sup> that connects farmers with consumers, traders, other buyers, and input providers. The startup has entered into partnerships with the United Nations Educational, Scientific and Cultural Organization (UNESCO), WorldFish,<sup>234</sup> NZ Dairy<sup>235</sup> and the Myanmar Tea Cluster.<sup>236</sup>

These digital services are increasingly being provided through partnerships between private companies, the public sector or development organizations. An example is the Tonlesap App, developed by AMK, a microfinance institution from Cambodia, with support from the National Bank of Taiwan, the Feed the Future initiative of USAID<sup>237</sup> and the Innovations Against Poverty fund.<sup>238</sup> The Tonlesap App provides agriculture and marketing information to farmers and connects them with input suppliers, financial institutions and agriculture experts for solutions to their farm problems.<sup>239</sup>

The food and agribusiness company Olam International, headquartered in Singapore, is developing a super platform where farmers can avail a suite of services, including crop care service, farm input services, a market off-take platform and a credit platform (Olam, 2019). The super platform incorporates technologies such as proprietary IoT sensors, satellite imagery, crop image analytics, AI data, and voice-based engagement tools. The company launched the pilot Farmer Services Platform (FSP) in India in December 2018 through an app called AgriCentral. The app provides six free services (weather, market prices, crop plan, crop care, news and a community forum) in five local languages to farmers across several Indian states. The app was expected to be launched in Indonesia by the end of 2020 (Olam, 2019).

The financial services platforms are integrated into Olam's umbrella digital platform, which provides solutions for multiple stakeholders across the food and agricultural value chains. Besides the financial services platforms, Olam digital platform also incorporates AtSource (B2B sustainable sourcing and traceability platform), Olam Farmer Information System, Digital Supplier Engagement (for traceability and supplier engagement), Digital Warehouse (Vega, for improving efficiency of warehouse operations), Olam Direct (direct-from-farmer buying model) and Smart Trade (making trade transactions more efficient), among others (Olam, 2019). In particular, through AtSource the company can measure the supply chain footprint of nearly one thousand food and agricultural chains in several countries, including India, Indonesia and Viet Nam (Olam, 2019).

The data collected by these super platforms have a number of highly valuable uses. From the farmers' perspective, these platforms help them benchmark their crop performance with that of other farmers in their area and beyond, while being able to exchange expertise on inputs and farming methods. Furthermore, the data collected on farmers can potentially be used to

<sup>231</sup> For more information, please see <https://www.mmgreenovator.com/>

<sup>232</sup> For more information, please see <https://www.mmgreenovator.com/greenway-app/>; <https://directory.growasia.org/green-way-agri-livestock/>

<sup>233</sup> For more information, please see <https://zaytangi.com>

<sup>234</sup> For more information, please see <https://www.worldfishcenter.org/>

<sup>235</sup> For more information, please see <https://www.dairynz.co.nz/>

<sup>236</sup> For more information, please see <https://directory.growasia.org/green-way-agri-livestock/>

<sup>237</sup> For more information, please see <https://www.usaid.gov/what-we-do/agriculture-and-food-security/increasing-food-security-through-feed-future>

<sup>238</sup> Innovations Against Poverty (IAP) is a competitive fund established by the Swedish International Development Cooperation Agency (SIDA), and managed by SNV in partnership with BoP Innovation Center and Inclusive Business Sweden. It challenges the private sector to develop innovative products, services, and business models that contribute to sustainable economic development. For more information, please see <https://snv.org/project/innovations-against-poverty-iap>

<sup>239</sup> For more information, please see <https://agoramicrofinance.com/wp-content/uploads/2019/09/amk-mfi-ar-2018-eng-final-156136183897825-1.pdf>

**Table 10.** List of agricultural super platforms showcased

AGRO-BASED SUPER PLATFORM	COUNTRY
e-Choupal	India
Grape Mundo and associated Best Grapes e-commerce platform	India
PacFarmer	Fiji
Impact Terra’s Golden Paddy Platform	Myanmar
Greenovator’s Green Way app	Myanmar
Ricult	Pakistan and Thailand
Olam’s umbrella platform Agricentral (e.g. AtSource and others)	Singapore, India and Indonesia

**Source:** Own elaboration.

facilitate their access to finance at competitive loan rates or for input payments. Buyers, on the other hand, gain visibility of the supply base that is crucial for ensuring flexibility, implementing traceability schemes and identifying key issues and targeted solutions in areas such as food losses (Skinner *et al.*, 2019). However, the emergence of these super platforms raises the issue of data ownership. Wiseman *et al.*, (2019) highlight the lack of trust between the farmers as data contributors, and the third parties who collect, aggregate and share their data. Many farmers become users of these super platforms without fully understanding the implications of issues such as data ownership, portability, privacy, trust and liability. As they gain awareness of the value and commercial uses of their farm data, they often feel reluctant to engage in widespread sharing and may refrain from using these smart farming services.

## 5.8. BLOCKCHAIN TECHNOLOGIES FOR TRACEABILITY AND PROVENANCE

**Blockchain, AI and big data work together to provide trust** in data-based systems in the food industry (UNDP, 2020). Blockchain is a technology of trust that promises

transparency, since once data has been stored in a block across a vast digital network it becomes immutable and cannot be altered (FAO and ICTSD, 2018). This element of trust is further reinforced by the fact that blockchain provides open access to anyone with the right permissions, whether they are the farmer, the manufacturer, the retailer or the end consumer. Whereas blockchain enables secure storage and sharing of data pertaining to the food product lifecycle, AI can analyse the data to generate insights for decision-making and value-adding, including the ability to trace back the origin of food products.

Food value chain actors are currently using **blockchain for ensuring traceability**, as this technology records the journey of a food from farm to table, creating a digital ID, and makes it available for monitoring in real-time. This technology generates trust by decentralizing control of data and information in the food supply chain and allowing the tracking of the flow of information collected through all the stakeholders through a common platform (UNDP, 2020). This decentralization is a two-step process. First the information is digitized by creating a digital record of a product of the food chain. Then it is “tokenized:” a version of the digital record is shared with each participant of the value chain. The application

of blockchain for food traceability also reduces the cost of documenting records transactions such as certification of origin of the product, bill of lading, holding certification and permits such as phytosanitary certificates. Those become part of the digital ID of the traced food product. According to UNDP (2020), submitting and tracking these documents the traditional way is costly, up to 20 percent of transportation costs, and can take weeks resulting in delays and wastage, particularly for perishable food products.

Given these characteristics, blockchain technology enables food value chain manufacturers and distributors to monitor food at every stage of the production process, optimize tracing and eliminate tainted batches in order to ensure food safety for risk management and brand integrity. The digital thread is vital for preventing product recalls so revenue losses and reputational damage can be curtailed.<sup>240</sup> For example, when food contamination happens, manufacturers and distributors can root out the cause of the incident by following the digital thread to track and trace a food product all the way back through its production process and raw materials. The thread can also help food producers reduce downtime by pinpointing the source of contamination so they can address it quickly and resume production. Furthermore, through real-time predictive analytics, companies can get critical decision support to foresee food safety issues before an event occurs. They could even adopt “active avoidance” protocols by using advanced software with predictive analytics that leverage robust and reliable multivariate modelling to pre-empt food safety failure events based on historical models.<sup>241</sup>

In Fiji, the startup Traseable has launched a digital platform for product traceability and provenance in seafood and agriculture value chains.<sup>242</sup> Another example of the use of blockchain for food traceability is SourceTrace. The company started in 2007 as a financial service provider specializing in branchless banking and agent banking.<sup>243</sup> Five years later in 2012, the company decided to focus on agriculture instead of financial services<sup>244</sup> with the launch of a digital agritech platform the year after that. In an effort to make food systems traceable, the platform gathers farm-to-retail data on a dashboard through existing mobile and wireless data networks even in remote areas. The platform is designed for organizations working with farmers, producer groups and cooperatives rather than for direct use by the farmers themselves. The field staff of these organizations or lead farmers collect and disseminate data in the field, and conduct transactions using the mobile application. The data are aggregated in the server to assist decision-making, reporting and feed traceability solutions for specific value chains from the farms to the market.

Blockchain technologies are also being used for **ensuring the provenance** of a food item. This helps to get a premium price for quality linked to origin, such as in Geographical Indications, and combats food fraud. According to Juniper Research (2019), by 2024, blockchain technologies will enable the food industry to save \$31 billion in food fraud globally and reduce compliance costs by 30 percent by immutably tracking food across the supply chain.

Finally, blockchain is essential to guarantee **compliance with regulatory requirements and consumer demands through smart labels**. Food companies can rely on the digital thread, aided by barcodes, quick response (QR)

<sup>240</sup> For more information, please see <https://www.foodqualityandsafety.com/article/using-the-digital-thread-of-food-production-to-prevent-recall>

<sup>241</sup> For more information, please see <https://www.foodqualityandsafety.com/article/using-the-digital-thread-of-food-production-to-prevent-recall>

<sup>242</sup> For more information, please see <https://www.traseable.com/>

<sup>243</sup> For more information, please see <https://www.sourcetrace.com>

<sup>244</sup> For more information, please see <https://yourstory.com/2019/10/sourcetrace-agritech-agriculture-financial-services>

codes<sup>245</sup> or smart labels, to provide reliable data required by regulators and the general public in relation to the production of food and an understanding of the product being manufactured. For example, Singapore-based agritech firm DiMuto<sup>246</sup> stamps every piece of fruit with a QR tag that enables value chain partners to look up any item on its platform that ensures traceability of fruits through a blockchain and AI image analysis platform. The QR codes are applied to fruits and cartons by automated machines, and then are scanned by a digital asset creation device that also takes images of every fruit and carton to create a digital ID. The digital ID captures pictures of the fruits or cartons every step of the way, from the packhouse and logistics to distributors, retailers and consumers.<sup>247</sup> However, powerful data analytics and cloud capacity are needed to store and retrieve blockchain records of millions of pieces of fruit.

Smart labelling is an item identification slip that adds virtual functionalities such as memory, logic, sensors, and displays to the content of conventional labels. The first versions of smart labelling included QR codes that consumers could scan with their phone to learn about the product's health and nutritional information beyond that printed on the packaging.<sup>248</sup> QR codes are gradually being replaced by near-field communication technologies that allow consumers to tap the product with their smartphones to access digital content such as recipes, surveys, and coupons.<sup>249</sup>

Today's smart labels carry out any number of functions that provide consumers with information on the product, including requirements about salt, sugar and fat content (ABB, 2020). Equally important, they can help track products through the distribution chain, and even prevent theft and counterfeiting. Finally, they can contribute as well to the creation of a circular economy. For instance, smart labels can prevent food waste by providing real-time information on the condition of packaged produce collected by sophisticated sensors, so that retailers and consumers are able to identify which items need to be given priority so that food that is still edible is not discarded unnecessarily (ABB, 2020).

<sup>245</sup> QR code (abbreviated from Quick Response code) is a machine-readable optical label or barcode that contains information about the item to which it is attached.

<sup>246</sup> For more information, please see <https://dimuto.io/>

<sup>247</sup> Information provided by Gary Loh, Founder and CEO of DiMuto, at the Asia-Pacific Agrifood Innovation Summit, on 18 November 2020.

<sup>248</sup> For more information, please see <https://www.pkgbranding.com/blog/smart-labels-and-consumer-perception-what-food-brands-should-know>

<sup>249</sup> For more information, please see <https://www.pkgbranding.com/blog/smart-labels-and-consumer-perception-what-food-brands-should-know>





# 6. INNOVATIVE BUSINESS MODELS

## 6.1.

### INNOVATIVE BUSINESS MODELS: THE QUIET REVOLUTION

**Innovations in business models** across the food value chain entail consciously changing the existing business model or creating a new one to generate or capture more value within food systems. Business model innovations taking place in APAC food systems to enable digital transformation include farmer advisory and mechanization platforms, fintech for farmers, digital marketplaces and physical short-chain models.

**Business models in food systems are changing as a result of the digital transformation.** Rachinger *et al.*, (2019) emphasize that digitalization “developed from a form of technical evolution to a phenomenon that can impact any kind of organization” and therefore, its business model. They add that automation, big data, interconnections along the value chain empowered by blockchain technologies, and digital customer interfaces create the foundations for innovative business models. Digitalization presents an opportunity to progressively build new forms of cooperation between companies in the food sector, modify how they relate with customers and employees (Kiel *et al.*, 2016) or create radically new business models (Matzler *et al.*, 2016).

At the same time, digitalization also pressures agribusinesses into critically reflecting on their strategy and systematically identifying new business opportunities (Kiel *et al.*, 2016; Rachinger *et al.*, 2019). Those who do not adapt, ultimately perish. Pierre Nanterme, CEO of Accenture, said “Digital is the main reason just over half of the Fortune 500 companies have disappeared since the year

2000.”<sup>250</sup> Food and beverage companies are no exception.

Many agribusinesses in APAC have adapted some elements of their business models to Agriculture-Industry-Retail 4.0. They are using features such as automation, big data-enabled crop insurance, omnichannel food retailing, programmatic buying, personalized advertisements or integrating novel revenue models such as dynamic pricing, to name a few. Digitalization can impact the value proposition of companies within food systems. One example is Trringo, a smarter way to get tractor services. Through digitalization, companies can modify the way they create and capture value, for example by combining digital weather information services with agri-insurance services, shifting to super platforms, and introducing ads in for-free digital farming apps (Rachinger *et al.*, 2019). Many food-system actors in the region have shifted their go-to-market models from traditional long-chain interactions to digital (or O2O) shorter-chain ones.

The impact of these business models on the region’s food systems extends beyond the online realm. For instance, a new generation of startups and technology companies working within the new transport and coordination ecosystem serving the food system has brought delivery costs down, displacing traditional actors. By the same token, retailers and the Horeca sector have seen their businesses altered by startups providing cloud retail infrastructure, which includes the mounting number of technologies enabling businesses

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<sup>250</sup> For more information, please see <https://www.aoe.com/en/digitalization.html>

to provide customers with on-demand, at-home dining such as ghost kitchens and last mile delivery services including delivery robots (AgFunder, 2020).

**Business models are also changing to reflect the growing significance of shorter value chains and ESG criteria.** ESG is the environmental and societal impact of a company. As markets gradually take into consideration ESG matters in their purchase and investment decisions, agrifood companies are coming up with innovative business solutions that improve the inclusiveness, fairness, durability, transparency and financial sustainability of relationships with small-scale producers and other value chain partners. But they do this to different degrees. Young and Reeves (2020) claim that companies adapt their business models to meet ESG goals along a spectrum that extends from basic corporate social responsibility to sustainable business model innovation (Figure 12). Few companies in the food sector are engaged in sustainable business model innovation, but moving in that direction is a must for them to remain competitive in the current marketplace.

One category of innovative business models that has emerged within food systems to increase sustainability in all its dimensions is direct market access initiatives – dubbed ‘short value chains.’ All across the region, novel business models are emerging to shorten the food value chain by enabling disintermediation through physical or digital means, so that there are fewer layers of intermediaries between farmers and customers (GrowAsia *et al.*, 2020). Short food chains can be described as those that have as few links as possible between the food producer and the consumer (Galli and Brunori, 2013). However, the definition of a food supply chain as ‘short’ cannot possibly be reduced to the number of links in the chain, because different foods and different places require different numbers of intermediaries.<sup>251</sup> What eventually helps determine whether a food supply chain is short are the reasons for having reduced chain links, namely:

- Producers are able to reclaim value, addressing their need to sustain or expand their income.

**Figure 12.** Levels of ESG compliance of corporate business models



**Source:** Young and Reeves (2019).

<sup>251</sup> For more information, please see <https://partnershipbrokers.org/w/journal/brokering-shorter-food-supply-chains-2/>

- The food chain is transparent, addressing consumer demand for food that can be trusted.
- There is greater social and physical proximity between producers and consumers, so that societal demands for a more equitable, sustainable and trustworthy food system are met.<sup>252</sup>

Farmers' markets, CSA and food cooperatives, growing-your-own food programmes, farmgate, online farm-to-consumer sales and direct farm-to-buyer sales (including buyer-to-restaurateur sales), often by digital applications, are all variations of 'shortening food chains.' Galli and Brunori (2013) underscore the potential of these short-chain business models to act as drivers of change towards higher ESG standards. Short food chain models not only ensure fairness and trust through more direct consumer-producer relationships, they affirm but also tend to minimize the use of packaging and fossil fuels, and use more environment-friendly production methods.

These short chains offer an alternative to the increasingly industrialized food systems based on long and complex supply chains that involve multiple intermediaries. The removal of intermediaries between farmers and consumers in these short chains often results in fairer remunerations for farmers and increased value retention for SMAEs (Galli and Brunori, 2013; FAO and INRA, 2016). Short chain models show promise in terms of reducing environmental impacts and reconnecting food system actors in a more democratic and transparent way that guarantees local foods of known origin and higher quality.<sup>253</sup>

These two factors, digitalization and ESG targets, are closely interrelated. In the case of short food chain models, while their *raison d'être* has often been to materialize a greater alignment with ESG principles, digital technologies and e-commerce solutions in particular have become the means to attain it. Broadly speaking, ESG factors can be woven into the digital strategies of agribusinesses, while at the same time, digitalization can be used as a tool to improve existing programmes to track, mitigate and report on ESG risks and performance, and more broadly to help rethink operating and business models. On the other hand, agrifood companies face challenges in their journey to digitalization, including how to account for the ESG impacts of it. Among these are concerns regarding privacy, security, increased energy demand and e-waste.<sup>254</sup>

## 6.2. THE BUSINESS MODELS BEHIND DIGITAL FARMER ADVISORY, MECHANIZATION AND TRACEABILITY SOLUTIONS

The main idea behind these innovative business models is to offer solutions for technology-driven farming that allows for increasing farm productivity and better utilization of farm resources. Such solutions, enabled by the rapid development of modern technology, support farmers to improve all aspects of their business, from soil and crop performance to marketing, and financials.

The business models developed by agritech startups and established firms show some commonalities, but also clear differences in terms of their offerings, revenue models and growth strategies.

<sup>252</sup> For more information, please see <https://partnershipbrokers.org/w/journal/brokering-shorter-food-supply-chains-2/>

<sup>253</sup> For more information, please see <http://www.fao.org/family-farming/detail/en/c/885395/>

<sup>254</sup> For more information, please see <https://www.agcs.allianz.com/news-and-insights/expert-risk-articles/esg-risk-briefing-1-2020.html>

### 6.2.1. The business models of agritech startups

In 2019, agritech startups operating upstream managed to attract 9 percent of total global investments in the agrifood tech sector. Agribusiness marketplaces received 4 percent, farm management software sensing and IoT also drew 4 percent, and farm robotics, mechanization and equipment received 1 percent (AgFunder, 2020). The boundaries between these categories have become blurred, with several companies that initially only provided e-agricultural information services deciding to expand their business model to include marketplaces, evolving into super platforms.

With regard to **revenue models**, the viability of the business model is highly correlated with farmer income (Voutier, 2020), which means that digital technologies will gain more traction in value chains and countries where farmers are better off. In the region, some startups have developed free-for-use apps, whereas others impose transaction fees or subscription plans, but both groups have to have a clear monetization strategy to survive. In some cases, the subscription fees may be paid or subsidized by government or donor programmes, or by the buyer with whom the producer availing the service has entered into a contract farming arrangement. Other monetization models include income from advertising on the platform and selling data collected through the mobile app to interested parties. For example, Myanmar's Village Link<sup>255</sup> has monetized its farming advisory app, which is free for farmers, by introducing paid advertisements from agribusinesses and loyalty programmes.<sup>256</sup> Some revenue models are fairly inventive, such as the business model of Greenovator, a social enterprise based in Myanmar. Greenovator generates income from providing agricultural

services to domestic and international NGOs and enterprises,<sup>257</sup> coupled with grants received from international organizations, incubators and accelerators, such as UNESCO, Care International, and the GSMA Ecosystem Accelerator. Greenovator receives support from UKAid and Australian Aid, the development arms of the British and Australian Governments, respectively.<sup>258</sup>

Startups are also distinguished by their **growth strategies**. Many APAC agritech startups are facing slow customer acquisition. Gaining customers is done mostly through social media. For example, Village Link has acquired the majority of its customers through Facebook, which is popular among farmers in Myanmar to learn about agronomic practices. More recently, as customer acquisition through social media is becoming saturated, Village Link has begun working through NGOs and other organizations involved with farmers to improve customer acquisition.<sup>259</sup> Agritech startups in the APAC region can deploy various strategies to further expand their business:

**Growing the core:** This is achieved by acquiring new users, but market depth (paying customers) in most emerging economies tends to be shallow.

**Expanding geographical scope:** In most cases, this translates into expanding operations to new provinces or areas within the country of origin. A few startups expand to other countries, especially in the region, and eventually globally. For example, Myanmar-based Impact Terra is slowing expanding its reach to Viet Nam and Thailand.

<sup>255</sup> For more information, please see <http://www.villagelink.co/>

<sup>256</sup> Information provided by Adrian Soe Myint, CEO of Village Link at the Asia-Pacific Agrifood Innovation Summit, on 18 November 2020.

<sup>257</sup> For more information, please see [https://www.nationthailand.com/Corporate/30365537?fbclid=IwAR10ahvTNWrqP44h86-hkDFQjvRtpJJW0lUrZ0nfJ0db3\\_48Z6qW1OZ1uE](https://www.nationthailand.com/Corporate/30365537?fbclid=IwAR10ahvTNWrqP44h86-hkDFQjvRtpJJW0lUrZ0nfJ0db3_48Z6qW1OZ1uE)

<sup>258</sup> For more information, please see <https://newsviews.thuraswiss.com/greenovator-wins-six-digit-fund-gsma/>; <https://www.gsma.com/mobilefordevelopment/ecosystem-accelerator/>

<sup>259</sup> Information provided by Adrian Soe Myint, CEO of Village Link on 18 November 2020.

**Moving to new market segments:** This is particularly the case for digital marketplace startups, many of which have built on their F2C experience to penetrate the F2B or B2B spaces.

**Adding more and interrelated services:**

This is done by building on the technology and the intimacy that startups already have with their customer base to simplify the customer's decision process and reduce inertia in the purchase cycle. This strategy is giving way to the emergence of superapps: the trajectory of FarmerFriend conforms to this strategy. Another interesting case is India's Skymet,<sup>260</sup> which at first focused on offering digital-enabled weather and climate information. Today, Skymet<sup>261</sup> has grown to become India's largest company offering weather monitoring and agriculture risk solutions with a super platform specializing in climate, weather, and crop analytics.

**Venturing into adjacent sectors:** Skymet has expanded its coverage from measuring and predicting climate risk for small and marginal farmers, agriculture insurance companies, banks, and public sector institutions in India, to monitoring crop services from sowing till harvesting, and developing innovative insurance products.<sup>262</sup> Upon its creation in 2003, Skymet targeted mostly the media and the power sectors in India. However in 2008, it expanded its scope to provide agriculture-specific services, another climate-dependent sector.<sup>263</sup>

A combination of these strategies is also possible. For instance, India-based RML AgTech,<sup>264</sup> formerly known as Reuter Market Light, initially specialized in delivering farmers information on crops, weather and commodity prices by text messages for roughly \$1.50 a month. The information helped them decide when to plant, how to treat specific diseases, when to harvest and how much to sell for. Over the years, RML AgTech's app evolved from only offering agricultural information, to including a fintech product that connects farmers with banks and input retailers, and a marketplace for farmers to buy and sell products and inputs. The app now uses a subscription model.<sup>265</sup> In addition, RML has expanded its coverage to 550 crop varieties from 2,000 markets, serving 2.75 million farmers in 50,000 villages across 19 states in India. Indonesia's iGrow<sup>266</sup> has also used a combination of the above strategies. It first launched a B2C digital platform that linked farmers directly to consumers. But iGrow's founders soon realized that the B2B segment was more attractive and moved in that direction. By then, the company was ready to remove another roadblock that frustrated farmers – lack of access to finance. It adopted a peer-to-peer lending model that connected farmers with medium-class urban investors. The startup's business model continued to evolve from an initial profit-sharing to one where the company buys and sells the crops, obtaining a margin from the transactions. Another major refinement of the business model consisted of securing partnerships with crop buyers, input suppliers, skill-development organizations and the government in order to make the entire supply chain more efficient and ensuring better prices for farmers.<sup>267</sup>

<sup>260</sup> For more information, please see <https://www.skymetweather.com/>

<sup>261</sup> For more information, please see <https://www.skymetweather.com/>

<sup>262</sup> For more information, please see [http://www.fao.org/fileadmin/templates/rap/files/uploads/ESF\\_Presentations/Skymet\\_-\\_Nalin\\_Rawal\\_-\\_Innovative\\_solutions\\_for\\_Banking\\_Agri\\_Insurance.pdf](http://www.fao.org/fileadmin/templates/rap/files/uploads/ESF_Presentations/Skymet_-_Nalin_Rawal_-_Innovative_solutions_for_Banking_Agri_Insurance.pdf)

<sup>263</sup> For more information, please see <https://economictimes.indiatimes.com/small-biz/entrepreneurship/skymet-weather-services-jatin-singh-provides-services-to-climate-dependent-sectors-like-agriculture-energy/articleshow/12376298.cms?from=mdr>

<sup>264</sup> For more information, please see <https://rmlagtech.com/>

<sup>265</sup> For more information, please see <https://rmlagtech.com/>

<sup>266</sup> For more information, please see <https://igrow.asia>

<sup>267</sup> Information provided by Andreas Senjaya, CEO iGrow Resources, at the Asia-Pacific Agrifood Innovation Summit, on 18 November 2020.

**Table 11.** Agritech startups: cases examined

CASE	COUNTRY	BUSINESS ANALYSED
FarmerFriend	India	Digital agricultural commodity trading platform
RML AgTech	India	Agro-based super platform
Skymet	India	Agro-based super platform specialized in climate, weather, and crop analytics
iGrow	Indonesia	Agro-based super platform
Greenovator's Green Way app	Myanmar	Agro-based super platform
Impact Terra's Golden Paddy Platform	Myanmar	Agro-based super platform (rice value chain)
Village Link	Myanmar	Digital farming advisory services
Ricult	Pakistan and Thailand	Agro-based super platform

**Sources:** [www.farmerfriend.in](http://www.farmerfriend.in); [www.rmlagtech.com](http://www.rmlagtech.com); [www.skymetweather.com](http://www.skymetweather.com); [www.igrow.asia](http://www.igrow.asia); [www.mmgreenovator.com](http://www.mmgreenovator.com); [www.impactterra.com](http://www.impactterra.com); [www.villagelink.co](http://www.villagelink.co); [www.ricult.com](http://www.ricult.com)

Only a small percentage of startups survive the first five years of business, and even fewer of them are able to successfully implement viable business models (Voutier, 2020). The success of agritech startups is dependent on the founders' vision and perseverance. The history of agritech startups in the region is one of innovation, dogged persistence and persuasion. Their founders face many difficulties in using 'digital' to improve the livelihoods of smallholders. But the proliferation of Asian startups attempting to gain a foothold in this market is a testament to the countless opportunities that exist.

An analysis of the history of agritech startups in APAC reveals two types of founders. One type is a university graduate in IT, agricultural sciences or business and economics. Yin Yin Phyu and Thein Soe Mi, founders of Greenovator<sup>268</sup> met when studying at Yezin Agricultural University in Myanmar. Usman Javaid and Thai Aukrit Unahalekhaka of Pakistan, the Ricult founders,

met at an MIT entrepreneurship class.

Co-founders often have complementary skills and personality types.

The second type are mid-age professionals dissatisfied with jobs they find unfulfilling and so pursue a business idea they feel passionate about. Although they need to reinvent themselves and learn new skills, these founders have already accumulated knowledge and capital, and have built personal and professional networks they can tap into. Examples include Jatin Singh, founder of Skymet. He had been a journalist who saw first-hand how difficult it was in the 2000s to source reliable weather data in India and understood the market potential of data for climate-dependent sectors. Try Nguyen, co-founder of MimosasTEK in Viet Nam, decided to leave his job as CEO of Saigon CTT and CTO of DTS, and start a strawberry farm in his hometown of Dalat. The farm was not successful, but it taught Tri that farmers did not know enough about their crops. He thought the answer could lie in the digital world and started providing online services to farmers in his community, kicking off

<sup>268</sup> For more information, please see <https://www.mmgreenovator.com/>

the MimosaTEK journey.<sup>269</sup> The founders of Agrostar are two Indian brothers, Shardul and Sitanshu Sheth. After several years working in corporate America, Shardul went back to India and partnered with his younger brother Sitanshu, an MBA from the Mumbai-based SP Jain Institute of Management and Research, and Agrostar was born.<sup>270</sup>

Sometimes the business idea comes in the most serendipitous way. The story of Agung Bezharie, Harya Putra and Sofian Hadiwijaya, cofounders of the Indonesian retail startup Warung Pintar, provides an example.<sup>271</sup> Agung Bezharie was in the midst of setting up a co-working space in Jakarta for East Ventures, an early-stage venture capital firm, when a rather worried warung vendor approached him to ask if he would be chased out from his run-down roadside kiosk located on the pedestrian walkway. That fortuitous interaction sparked the idea of bringing these traditional kiosks to the digital world. The startup was launched in 2017 as a special project incubated inside East Ventures.<sup>272</sup> Some founders are serial entrepreneurs that bring up new business ideas leading to setting up new ventures. For example, Jatin Singh, founder of Skymet, also developed Gram Cover, a technology backed insurance distribution startup in rural India.<sup>273</sup>

## 6.2.2 The business models of corporations

As the digital farming market grows larger, more sophisticated and capital-intensive, it attracts both large-scale national and multinational corporations from the agrifood and other sectors. The initial entry points for most multinational firms in the region have been e-grocery and other digital marketplaces, plantations and large-scale farms dealing with industrial and high-value products. Today, these firms are venturing into new territories, including digitally enabled services for smallholder farmers (AgFunder, 2019a; 2020). In APAC, these large players have entered the digital farming market through new product development, exploratory acquisitions, and innovative partnerships with government and joint ventures with local firms.

**Agricultural multinational corporations** are turning to digital farming as a means to generate more revenue from traditional operations. This is the case for major agrochemical firms, farm equipment manufacturers and agrifood supply chain managers.

**Agrochemical corporations** have entered the digital farming service market, because adding digital farming services complements their seeds and crop protection operations, such as selling fungicides, herbicides, insecticides and biological crop protection. Adding digital services can lead to more sales. For instance, they can provide digital crop scouting services that enable growers to identify and map weed and disease threats using their smartphone, receiving instant advice on the specific crop protection products, doses and timing required. Other related services may include the visualization of field zones and automated operations, such as watering, fertilization and the application of crop protection products.

This strategy makes even more sense as farmers gradually become omnichannel, using a combination of channels when buying and using agricultural products and machinery

<sup>269</sup> For more information, please see <https://agfundernews.com/vietnamese-iot-agtech-startup-mimosatek-to-showcase-at-seedstars-world6019.html>

<sup>270</sup> For more information, please see [https://www.business-standard.com/article/companies/agrostar-agri-inputs-directly-to-farmers-115083100006\\_1.html#:~:text=After%20a%20not%2Dso%2Dsuccessful,directly%20to%20farmers%2C%20in%202013.&text=The%20two%2Dyear%20company%20recently,Ventures%20India%20and%20existing%20investors](https://www.business-standard.com/article/companies/agrostar-agri-inputs-directly-to-farmers-115083100006_1.html#:~:text=After%20a%20not%2Dso%2Dsuccessful,directly%20to%20farmers%2C%20in%202013.&text=The%20two%2Dyear%20company%20recently,Ventures%20India%20and%20existing%20investors)

<sup>271</sup> For more information, please see <https://www.forbes.com/profile/warung-pintar/#11054f4a2373>

<sup>272</sup> For more information, please see <https://www.compasslist.com/insights/warung-pintar-creating-a-little-place-of-happiness-with-smart-kiosks>

<sup>273</sup> For more information, please see <https://tieconkerala.org/speaker/jatin-singh/#:~:text=Jatin%20Singh%20is%20the%20Founder,in%20his%20present%20role%2C%20Mr>

such as retail stores, in-person representatives and online channels (McKinsey & Company, 2017a). While human interactions remain crucial, Asian farmers increasingly prefer digital channels for their initial research and repurchasing. It is easier to compare price and features online. Younger buyers favour digital purchases of agricultural products and services, notably using mobile devices, so this channel is expected to grow further in the coming years (McKinsey & Company, 2017a). For example, BASF is a multinational chemical company that offers smart farming services to Thai farmers by mobile applications so that they can optimize their yields and agrochemical use (German-Thai Chamber of Commerce, 2018). The company's Facebook page for crop protection provides information on commodity prices, crop stocks and weather forecast to more than 36 000 Thai farmers (German-Thai Chamber of Commerce, 2018).

**Farm equipment manufacturers** have also entered the digital farming service market, in an effort to guarantee a market for their products. For example, Mahindra & Mahindra, a farm equipment and car manufacturer that is part of the Indian conglomerate Mahindra Group, launched Trringo, an Uber-like application for tractors.<sup>274</sup> John Deere has also entered the big data space with their platform, MyJohnDeere, which connects their sensor-equipped agricultural machinery to input suppliers, local agronomies, agricultural retailers, and other value chain actors.<sup>275</sup> This way farmers can, not only get the spare parts they need, but also tailored information and advisory on soil and crop conditions, weather, fuel management and maintenance schedules.

**Agrifood supply chain managers**, such as Olam International, have also joined this game. In 2016, Olam launched an F2B digital platform "Olam Direct Origination," or Olam Direct, with a suite of solutions to digitalize the agrifood value chain. Using the Farmer App, smallholder farmers can bypass local agents and sell directly to exporters, receive payment, and connect on agronomy-related queries.<sup>276</sup> As of 2019, Olam Direct had registered 67 000 farmers across 14 countries, including thousands of cocoa growers in Indonesia and over 4 000 black pepper smallholders in Cambodia.<sup>277</sup> Through the Micro-collector app, which is part of the Olam Direct platform, the company employs rural entrepreneurs for first-mile logistics to collect produce from farmers, using digital technologies to assess product quality and ensure traceability.<sup>278</sup>

**Non-agrifood firms** tend to branch out into providing e-agriculture information services to generate new revenue streams. New non-agrifood entrants include agrochemical multinationals and farm equipment firms, financial institutions, and 'big tech' players that have found in e-agriculture a natural expansion of their core business. These large companies bring increased and substantial financial, human and technological resources to the sector, often accompanied by major investments in important underlying infrastructure.

In recent years, **big-tech and financial companies** have realized that blockchain technologies could also be applied to food supply chains to build trust and promote transparency by increasing the traceability

<sup>274</sup> For more information, please see <https://www.telegraph.co.uk/technology/2016/10/18/uber-for-farmers-tringo-tractor-hailing-app-launched-in-india/>, last visited on 1 April, 2020.

<sup>275</sup> For more information, please see <https://digital.hbs.edu/data-and-analysis/product-platform-john-deere-revolutionizes-farming/>

<sup>276</sup> For more information, please see <https://innovationaward.org/portfolio-item/olam-direct-2019/>; [https://www.olamgroup.com/content/dam/olamgroup/investor-relations/ir-library/olam-insights/olam-insights-pdfs/Olam\\_Insight2019\\_Issue1.pdf](https://www.olamgroup.com/content/dam/olamgroup/investor-relations/ir-library/olam-insights/olam-insights-pdfs/Olam_Insight2019_Issue1.pdf)

<sup>277</sup> For more information, please see [https://www.olamgroup.com/content/dam/olamgroup/investor-relations/ir-library/annual-reports/annual-reports-pdfs/olam-annual-report-fy19\\_strategy\\_report.pdf](https://www.olamgroup.com/content/dam/olamgroup/investor-relations/ir-library/annual-reports/annual-reports-pdfs/olam-annual-report-fy19_strategy_report.pdf)

<sup>278</sup> For more information, please see [https://www.olamgroup.com/content/dam/olamgroup/investor-relations/ir-library/olam-insights/olam-insights-pdfs/Olam\\_Insight2019\\_Issue1.pdf](https://www.olamgroup.com/content/dam/olamgroup/investor-relations/ir-library/olam-insights/olam-insights-pdfs/Olam_Insight2019_Issue1.pdf)



of food. This, in turn, can support the implementation of sustainability standards and labelling that provides information to consumers. One such case is the American-based multinational financial services corporation MasterCard, which started exploring practical applications of blockchain technologies in 2012.<sup>279</sup> Among the blockchain applications studied, some were conventional such as B2B payments and money transfer, and others were more out of the box, as in the case of MasterCard Provenance Solution,<sup>280</sup> which can be used for food tracking. This solution helps value chain actors provide visibility into product journeys and a clear record of traceability designed to contribute to consumer confidence and provide governance capabilities to complex supply chain networks. For example, using this technology, grocers will be able to stock shelves with confidence and to pinpoint issues in the food chain during any unfortunate events such as recalls. Pilot experiences involved seafood value chains that face a variety of food safety, and counterfeit mislabelling issues, which can be overcome by using seafood-tracking solutions.<sup>281</sup> This tracking solution also builds on the firm's reputation in highly regulated environments.

Even tech giant IBM has joined the race. In 2018, IBM launched a blockchain-based food supply chain solution called IBM Food Trust, designed for global use by major retailers and food suppliers, including Nestlé, Wal-Mart, Golden State Foods, McCormick and Tyson Foods.<sup>282</sup> The platform works to keep numerous food products safe and

traceable from farm to table, including olive oil, romaine lettuce and Norwegian salmon, among others.<sup>283</sup> In the same way, software giant SAP has also jumped on the food tracking bandwagon with the SAP Cloud Platform Blockchain.<sup>284</sup> This solution has already been applied to the yellowfin tuna value chain, allowing consumers and retailers to track the product from ocean to table. The majority of these food-tracking applications were launched in the past couple of years in developed countries, except for Alibaba's tracking solutions for ensuring food safety and fighting fraud.

The interest of big tech in digital farming goes beyond food tracking systems. For example, IBM has partnered with Yara to develop a digital farming platform with weather forecasts and crop yields as a service with personalized recommendations to minimize risks and losses. IBM's objective is to cover 7 percent of all arable land worldwide.<sup>285</sup> IBM has also partnered with the Indian State of Karnataka for tomato price forecasting using AI and machine learning technologies.<sup>286</sup>

<sup>279</sup> For more information, please see <https://builtin.com/blockchain/practical-applications-blockchain-technology>

<sup>280</sup> For more information, please see <https://www.mastercard.com/>

<sup>281</sup> For more information, please see <https://www.computerworld.com/article/3448399/mastercard-partners-to-launch-blockchain-based-food-supply-chain.html>

<sup>282</sup> For more information, please see <https://siliconangle.com/2018/10/08/ibm-food-trust-commercial-blockchain-launch-links-food-safety-farm-dinner-table/>; <https://www.computerworld.com/article/3448399/mastercard-partners-to-launch-blockchain-based-food-supply-chain.html>

<sup>283</sup> For more information, please see <https://siliconangle.com/2020/10/29/mastercard-joins-grainchain-provide-blockchain-visibility-grain-producers-buyers/>

<sup>284</sup> For more information, please see <https://news.sap.com/2019/03/bumble-bee-foods-sap-create-blockchain-track-fish/>

<sup>285</sup> For more information, please see <https://www.ibm.com/services/client-stories/yara>

<sup>286</sup> For more information, please see <https://nasscom.in/knowledge-center/publications/agritech-india-emerging-trends-2019>

**Table 12.** Corporates providing digital farming services to smallholder producers: cases examined

CASE	COUNTRY	BUSINESS ANALYSED
Alibaba	China	Food Trust Framework for food tracking
IBM	Global use	IBM Food Trust: digital platform for food tracking
IBM and Yara	Global use	IBM-Yara Digital farming platform
Olam	Global use	Olam Direct umbrella/super platform (e.g. food tracking, F2B marketplace, digital agricultural information and advisory services)
MasterCard	Global use	Provenance Solution: digital platform for food tracking
SAP	Global use	SAP Cloud Platform Blockchain service: digital platform for food tracking
Bayer	Global use	Climate FieldView digital platform
Bayer	India	FarmRise digital information and advisory services platform
Microsoft and ICRISAT	India	FarmBeats and AI Sowing App: digital information and advisory services platform
Trringo (Mahindra)	India	Online agricultural equipment lease
Olam Direct	Indonesia	Digital ag platform (cacao value chain)
BASF	Thailand	Digital smart farming platform
Olam Direct	Viet Nam	Digital ag platform (black pepper value chain)

**Source:** Own elaboration.

The main challenge this business opportunity presents, for multinationals and startups alike, is to adapt existing business models to serve poor farmers at scale. APAC, with more than 420 million smallholder farms,<sup>287</sup> is an attractive market, strong in numbers but low in payment capacity. Reaching those farmers at the bottom of the pyramid requires companies to adapt their digital tools and their business models for environments that are very different from their core markets. Bayer's digital farming portfolio exemplifies this adaptation process. With the launch of its digital farming platform Climate FieldView, dubbed the "Amazon of farmers," it targets mainly large farms in the United

States, Europe, Canada, Brazil and beyond.<sup>288</sup> Its FarmRise Mobile Farm Care system<sup>289</sup> aims at smallholder farmers in emerging economies. FarmRise was piloted in India where about 70 percent of smallholder farmers have access to smartphones.<sup>290</sup> The platform provides users with farming advice, updates on temperature, rainfall and humidity, and the latest crop prices for nearby markets. As of mid-2019, over 500 000 Indian farmers were using the FarmRise app to monitor their crops. The company's long-term goal is to reach 150 million growers in India.<sup>291</sup>

<sup>287</sup> Estimate based on FAO and UNDP (2016) and FAO's Family farming knowledge platform. For more information, please see <http://www.fao.org/family-farming/home/en/>

<sup>288</sup> For more information, please see <https://blogs.worldbank.org/digital-development/no-country-old-regulations-protecting-dynamic-competition-digital-agricultural>

<sup>289</sup> For more information, please see <https://climate.com/climate-farmrise>

<sup>290</sup> For more information, please see <https://www.ft.com/content/3eac4ec2-c569-11e7-b30e-a7c1c7c13aab>

<sup>291</sup> For more information, please see <https://journal.businesstoday.org/bt-online/2019/the-digitalization-of-farming-with-dr-mike-stern-of-the-climate-corporation>

FieldView provides farmers with free simple tools for timely decision-making, while premium features needed for hard precision agriculture require a paid subscription. The FarmRise app offers basic information at no cost for farmers. Expectations are that the pilot programme will become more sophisticated over time. For example, once the moisture level is known, the next step could be to offer advice on agricultural inputs or to spray the crops using drones.<sup>292</sup>

Another adaptive strategy that these companies use is to focus on devising partnerships for trialling and adapting their digital tools for use in other value chains and developing country contexts at a larger scale. For instance, Microsoft, in partnership with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), has run a digital programme in India called FarmBeats since 2015 (Vasisht *et al.*, 2017). FarmBeats is an IoT platform that connects 4 000 farmers in over 100 villages in Andhra Pradesh through a Sowing App and Advisory Dashboard. The AI Sowing App is a digital application that helps farmers determine the right time to sow crops, which in India, where drought and excess rainfall can be equally serious challenges, is a vital enabler. The app combines historical climate data with real-time weather information, and uses sophisticated forecasting models to determine the optimal time to plant, and other farming variables. The app then sends sowing advisories to participating farmers by SMS. No capital expenditures, such as installing sensors in their fields, are required.<sup>293</sup> In the pilot's first year, the AI Sowing App recommended 175 participating groundnut farmers to delay planting by three weeks from the customary date at the beginning of June. On average, they harvested 30 percent more per

hectare than their non-participating peers,<sup>294</sup> while reducing water intake by 35 percent (Vasisht *et al.*, 2017). FarmBeats' datasets could also be used to build more effective predictive models for non-participating farmers in the programme area.

### 6.3. FINTECH FOR FARMERS

Mobile payments have the potential to revolutionize the way that agricultural transactions take place in countries such as China, India, Indonesia, Viet Nam, and the Philippines. These countries have the world's largest concentrations of unbanked individuals, and receiving agricultural payments in cash is the norm (McIntosh and Mansini, 2018). Even for farmers in China, India or Thailand who have access to financial accounts, 80 percent still receive some of their agricultural payments in cash, and between 5 and 20 percent receive all of their payments in cash. Promoting the use of mobile payments in such contexts is critical to reduce dependency on cash transactions and physical agents.

To tap into this unmet demand, fintech ventures in the region are creating new business models to enable digital payments, target and collateralize agricultural loans, price and spread risk, and organize agricultural value chains (ADB and Oliver Wyman, 2017; McIntosh and Mansini, 2018).

The offering portfolio of fintech companies typically includes **mobile money and mobile lending services** that seek to bring the unbanked into the financial system. A case in point is Wave Money, a Myanmar-based fintech that is able to deliver savings, credit and payment services to previously unbanked farmers and other individuals through its mobile app WavePay.<sup>295</sup> In the wake of the

<sup>292</sup> For more information, please see [https://www.business-standard.com/article/companies/bayer-crop-science-brings-high-tech-digital-tools-to-india-s-farms-118091800863\\_1.html](https://www.business-standard.com/article/companies/bayer-crop-science-brings-high-tech-digital-tools-to-india-s-farms-118091800863_1.html)

<sup>293</sup> For more information, please see <http://www.fao.org/e-agriculture/news/harnessing-power-ai-transform-agriculture> last visited on 2 April, 2020.

<sup>294</sup> For more information, please see <http://www.fao.org/e-agriculture/news/harnessing-power-ai-transform-agriculture>

<sup>295</sup> For more information, please see <https://www.wavemoney.com.mm/about-us/our-company/>

COVID-19 pandemic, Wave Money entered into a partnership with the Myanmar Agricultural Development Bank in order to digitally-deliver cash aid to farmers through WavePay.<sup>309</sup>

The business model of fintech firms in the region typically involves generating digital profiles for farmers, in combination with cashless tools such as virtual credit cards and digital wallets, and AI-enabled credit scoring systems. On one hand, the digital profile, which will show over time the digital records of all cashless transactions, helps building a credit score from scratch so farmers can be rated as creditworthy borrowers. On the other hand, unlike traditional credit scoring methods focusing on the farmer's past financial performance, AI credit scoring is more sensitive to real-time indicators of the potential creditworthiness of farmers, such as data on basic demographics (e.g. marital status and household size and location), agronomic survey data and supply chain data, such as contract farming agreements). The digital profiles are augmented whenever possible by elements of credit history and transaction records (Grow Asia and SAFIRA, 2018). Basic demographic data is usually predictive of credit risk. For example, it is well-known that home owners are less risky than renters, women are less risky than men, and that risk decreases with age up to a point (Grow Asia and SAFIRA, 2018). Agronomic data provides an indication of the profitability of the farming business, while weather data can inform lenders about the risk of facing extreme weather events.

Monetization strategies may involve the direct provision of mobile lending services or matching the borrowers with other lenders, which will benefit from the digital credit scoring created by the fintech startup. There are many examples of these business models from India:

**FarMart**<sup>297</sup> is an agri-fintech startup based in Punjab that offers smallholder farmers low-cost digital credit by a virtual credit card through which they can purchase farm inputs. FarMart's proprietary credit underwriting model analyses over 50 data points that cover four categories: personal information, supplementary income of the family, agricultural profile, and household assets.

**Jai Kisan**<sup>298</sup> is a Mumbai startup with a similar business model. It provides low-cost and timely financing for agricultural assets such as agricultural and dairy equipment through a digital platform that relies on a credit score system. The system assesses multiple variables, from a farmer's financial, market, agronomic and environmental data to data related to psychometric, individual, and social factors, as well as satellite data.<sup>299</sup>

**Credit AI** uses AI and machine learning technology to generate dynamic credit scores of farmers, most of which are small and marginal landholders in India. This helps financial institutions, input suppliers, produce buyers, government and other stakeholders to identify and transact digitally with them.<sup>300</sup> The company does this by creating 'digital farmer profiles' that encompass information on the farmer, agronomic survey data, weather data and a package of practices for cultivation. Over the primary profile, Credit AI adds another layer of secondary information. This secondary information could include inputs purchase data from the input shops, income statements, loans and liabilities list, lifestyle-related demographics, and credit history from secondary sources. Using that

<sup>296</sup> For more information, please see <https://www.mmtimes.com/news/moving-money-masses.html>

<sup>297</sup> For more information, please see <http://www.farmart.co/>

<sup>298</sup> For more information, please see <https://jai-kisan.com/>

<sup>299</sup> For more information, please see <https://fintechnews.sg/36287/fintech/6-agri-fintech-startups-in-asia-to-follow-in-2020/>

<sup>300</sup> For more information, please see <http://creditai.co/>

information, it puts together the ‘Farmer Credit Score.’ According to the company’s CEO, Credit AI had digitized about 12 000 Indian farmers as of October 2020.<sup>301</sup> Using this scoring system, financial institutions can lend farmers ‘cashless’ through Credit AI’s digital wallet and can use the platform dashboards to monitor loan usage, transaction of farmers at the input shops, track the purchase of inputs, and repayment cycles. Participating farmers can check their loan eligibility, choose the lender, select the amount and repayment terms through the app. Credit AI has managed to monetize its farmer scoring system by charging smallholder farmers a small digitization fee, and lenders a lead generation fee, totalling \$20 per farmer per season, on average.<sup>302</sup>

A variation of this business model is exemplified by Cambodia’s Wing Limited Specialized Bank, which has developed an innovative loan collection feature in its mobile app that allows financial institutions to expand access to more customers, including farmers. It does this either by letting financial institutions use their own credit scoring and underwriting, or by using Wing’s data and algorithm to serve customers whose creditworthiness cannot be assessed otherwise for lack of acceptable data (GrowAsia *et al.*, 2020).

Digital solutions can also lead to new business models that offer **insurance services to poor farmers**. In India, the agritech startup GramCover has created a retail market for crop, livestock, personal and other insurance products in rural areas through their tech platform and point-of-sale partner network. Essentially, GramCover gets paid brokerage commissions by insurance companies. Since its inception in 2017, over 1.7 million Indian farmers

had purchased insurance through GramCover by February 2021.<sup>303</sup>

**Crowdsourcing for farming activities**, or ‘farmsourcing,’ is another agriculture-focused fintech solution. It uses a professional crowdsourcing strategy for funding farming activities (Minet *et al.*, 2017). The idea behind these platforms is to motivate consumers, investors and other actors to interact with the farmers by supporting, fundraising, lobbying and promoting knowledge exchange. Examples include Indonesia’s Crowde and iGrow Asia, or in the Philippines Cropital and FarmOn.ph that run platforms linking farmers with investors (Deloitte, 2019b). Another example is Indonesian startup HARA,<sup>304</sup> which connects rural smallholders with banks, insurance companies and input producers through the collection and sharing of hard-to-obtain data.

These crowdfunding platforms usually require only a small minimum sum for investors to get started. For instance, the Filipino startup Cropital allows individuals to invest between \$100 and \$500 in a farm, depending on the farm’s specific needs.<sup>305</sup>

Storytelling is at the heart of crowdsourcing campaigns so consumers and investors supporting the participating farmers know the farmers’ personal story and the impact their support is having on the farming families and their communities, in a way that they feel connected. Farmsourcing investors get the chance not only to share in the profits from the farming projects they support, but also to farm vicariously by monitoring the progress of the crops, from buying the seeds to selling the harvest. Examples of this are:

<sup>301</sup> Information provided at the Asia-Pacific Agrifood Innovation Summit, on 20 November 2020.

<sup>302</sup> Information provided by Sangram Nayaka, CEO of Credit AI, at the Asia-Pacific Agrifood Innovation Summit, on 20 November 2020.

<sup>303</sup> For more information, please see <https://www.financialexpress.com/industry/sme/the-rise-of-the-agripreneur-agritech-startups-trying-to-fix-some-major-issues-faced-by-agriculture-sector/2198583/>

<sup>304</sup> For more information, please see <https://haratoken.io/>

<sup>305</sup> For more information, please see <https://business.inquirer.net/282080/cropital-finds-fertile-ground-among-investors-with-a-heart>

**iGrow** (Indonesia), described as the “Farmville for real life,” offers the opportunity for anyone to partially “own” farms across the country by buying seeds to invest in a crop.<sup>306</sup> The local farmers take care of the agricultural operations, and both parties split the profits upon sale the harvest. As of November 2020, there were more than 10 000 farmers in over 100 projects participating. In about five and a half years, the startup has managed to channel \$15 million to farmers from middle-class Indonesian lenders who live in cities and want to invest their money in a venture that is both profitable and impactful.<sup>307</sup>

**TaniHub**<sup>308</sup> (Indonesia) runs a crowdsourcing platform called TaniFund that has been connecting farmers in need of loans with lenders since 2017. The fund also provides more clarity to both the borrower and lender on credit standing and terms,

and it is registered with the government-administered regulator, the Financial Services Authority.

**Crowde** (Philippines) is an agro-focused fintech startup that has linked 18 000 Filipino farmers with over 62 000 investors as of October 2020.<sup>309</sup>

**Cropital**<sup>310</sup> (Philippines) has reached 1 200 farmers in 10 provinces and has activated over 3 000 investor accounts.

Over time, these crowdsourcing startups may take up new functions. For instance, Cropital has broadened its services from providing loans and insurance solutions, to include farming advice and marketing linkages for its clients and their main crops, rice and corn.<sup>311</sup> The same way, iGrow Asia currently doubles as a marketplace and a crowdfunding platform linking farmers, landowners, investors, and crop buyers.<sup>312</sup>

**Table 13.** Fintech startups: cases examined

CASE	COUNTRY	BUSINESS ANALYSED
Wing Limited Specialized Bank	Cambodia	Digital platform for alternative credit scoring of farmers
Credit AI	India	Digital platform for alternative credit scoring of farmers
FarMart	India	Mobile banking for farmers
Jai Kisan	India	Mobile banking for farmers
GramCover	India	Insurance for farmers
Crowde	Indonesia	Crowdfunding for farmers
Hara	Indonesia	Crowdfunding for farmers
iGrow	Indonesia	Crowdfunding for farmers
Tanihub	Indonesia	Crowdfunding for farmers
Cropital	Philippines	Crowdfunding for farmers
FarmOn	Philippines	Crowdfunding for farmers

**Source:** Own elaboration.

<sup>306</sup> See for example the “How it works” explanation on <https://igrow.asia/>; <https://techcollectivesea.com/2020/03/23/discovering-agritech-startups-in-southeast-asia-indonesia/>

<sup>307</sup> Information provided by Andreas Senjaya, CEO iGrow Resources, at the Asia-Pacific Agrifood Innovation Summit, on 18 November 2020.

<sup>308</sup> For more information, please see <https://tanihub.com>

<sup>309</sup> For more information, please see <https://www.crowde.co>

<sup>310</sup> For more information, please see <https://www.cropital.com>

<sup>311</sup> For more information, please see <https://business.inquirer.net/282080/cropital-finds-fertile-ground-among-investors-with-a-heart>

<sup>312</sup> For more information, please see <https://igrow.asia/>

## 6.4.

### THE BUSINESS MODEL OF ONLINE MARKETPLACES

Of outstanding significance is the advent of digital marketplace platforms that connect and shorten highly fragmented food supply chains in the region to respond to key consumer and market trends. Farm produce e-commerce business models exhibit different modalities in terms of linkages: farm-to-consumer (F2C), farm-to-business (F2B) or business-to-business (B2B). These schemes differ according to the players linked: farmers to food processors, wholesalers, retailers, and/or restaurants and other actors in the catering industry (GrowAsia *et al.*, 2020). There are also some variations concerning who develops and manages the digital platform, from startups to regional or multinational e-commerce/e-service companies, and less frequently by 'software as a service' (SaaS) companies. These platforms can also operate exclusively online or combine online-offline (O2O) presence. Finally, another way to shorten food chains is to connect consumers with restaurant and caterers through online meal delivery platforms.

All of these new business models rely upon the existence of prerequisites such as adequate Internet connectivity, electronic payments and transport infrastructure such as feeder and trunk roads, cold-chain and postharvest storage facilities (FAO, 2017c; GrowAsia *et al.*, 2020).

#### 6.4.1. Farmer-to-consumer digital platforms

Farmer-to-consumer business models have good growth prospects because they are attuned to changing consumer preferences and habits (Bagul *et al.*, 2020). Consumers from the region are growing more interested in supporting farmers and products sourced close to home as a reaction to the prevailing global agro-industrial food system (FAO and INRA, 2016). They are also demanding more convenient food solutions, artisanal brands

and food experiences, resulting in the rise of the 'experience economy,' where consumers – especially cash-poor Millennials – actively choose to spend their money on doing something rather than physically owning something (ABB, 2020). Accordingly, there has been an explosion in the number of digital F2C marketplaces. Online farm-to-consumer sales include social e-commerce, online fresh food subscription models, F2C apps, F2C initiatives in the context of online e-commerce platforms, and F2C open-source and community-controlled software platforms.

**F2C social e-commerce** is where farmers use a social network as a marketing platform to connect with consumers. In Thailand and the Philippines, farmers are increasingly selling food products to consumers using social media to make up for the relatively low access of shoppers to digital payment solutions and credit cards.<sup>313</sup> Even in more challenging contexts, there is evidence that basic and low-cost digital marketing strategies can be fairly efficient for linking farmers to consumers. For example, in the Indian state of Bihar, women rearing goats are using their cell phones to upload photos of their goats on eBay-like sites to increase their potential market, where buyers can be up to 700 to 800 kilometres away. Thanks to this new practice, they are fetching anywhere from 20 to 47 percent more per head for their goats (McKinsey & Company, 2019a).

Online food subscription models offer fresh ingredients delivered from the farm-gate to the consumer's doorstep by websites and apps, making it easy to cook a healthy meal while addressing busy-lifestyles and needs (Bagul *et al.*, 2020). For the most part, these subscription services focus on organic or pesticide-free, seasonal products, and on providing options for special diet meals such

<sup>313</sup> For more information, please see <https://www.foodnavigator-asia.com/Article/2019/07/25/Food-and-beverage-e-commerce-The-future-for-retail-logistics-payment-and-personalisation>

as vegetarian, vegan, low calorie and low carbohydrate. In Thailand, several fresh food subscription services have cropped up in recent years, particularly during the pandemic and its staying-at-home periods in 2020. Some of these services are Orgbox, Veggie Favour, Bo.Lan and Vivin Maison,<sup>314</sup> among many others.

**F2C apps and platforms** are being embraced by many APAC farmers. These virtual marketplaces are specifically designed for them to sell produce directly to consumers. Helping farmers sell pesticide-free vegetables and fruits without the intervention of intermediaries, and thereby ensuring a reasonable price for their produce, was the reason that Pradeep PS founded Farmers Fresh Zone in Kochi.<sup>315</sup> As of 2019, the startup claimed to have a network of around 1 200 farmers and 15 000 registered users.<sup>316</sup> The company earns its revenue through the products sold on its platform by regular and subscription-based orders. The subscription model includes a customized package of organic products for a family delivered on a weekly basis. The startup has also developed tech-based algorithms for yield prediction and profit calculation, as well as for demand prediction to understand consumer demand patterns. Based on these, farmers can plan their crop cycles and manage their farms more efficiently.<sup>317</sup> Along the same line, the startup TaniHub has opened up opportunities for over 30 000 small-scale farmers across Indonesia to sell their agricultural produce to over 10,000 consumers through its app-based online marketplace specializing in trading agricultural commodities (Deloitte, 2019b). The startup is backed by \$10 million from firms

including Golden Gate Ventures, a Singapore-based venture capital firm investing across Southeast Asia.<sup>318</sup> Another marketplace startup trying to solve the issue of long, unfair supply chains is Indonesia's 8Villages<sup>319</sup> with an online trading platform for agricultural products directly linking farmers to consumers called RegoPantes, literally 'fair price' (Deloitte, 2019b). Another example is Urban Tiller Singapore,<sup>320</sup> a farm-to-home agritech company that grows, aggregates and distributes fresh vegetables sourced from a network of urban farms to consumers in Singapore. Through its digital platform, the company promises fresh produce grown locally and hydroponically, organically or in an environmentally sustainable way.<sup>321</sup>

**E-commerce** platforms have stepped in to bridge the gap by connecting farmers directly to consumers. By not relying on layers of brokers of market access, as happens in traditional food chains, subscribing producers can earn a better living. They are trained in e-commerce, finance, business operations and online marketing including livestreaming.

This business model has many variations. For example, while China's Taobao Live platform derives its income from advertising and it is free for farmers who pay no commission, revenue earned by China's Pinduoduo is largely made up of sales commissions and advertising (FAO, 2020f). Participating farmers can use Taobao's Foodie Livestream channel to connect with the platform's 41 million followers, mainly from first- and second-tier cities across China. Farmers are encouraged to improve their quality and overall performance by the platform's detailed online rating system, which promotes transparency and competition.<sup>322</sup> Pinduoduo boasts a much broader user base,

<sup>314</sup> For more information, please see <https://orgboxthailand.com/>; <http://veggiefavour.com/>; <https://www.linethaifoodandgrocery.com/>; <https://www.bolan.co.th/>; <https://vivinmaison.com/>; <https://www.bangkokpost.com/life/social-and-lifestyle/1897090/farm-to-table>

<sup>315</sup> For more information, please see <https://www.farmersfz.com/>

<sup>316</sup> For more information, please see <https://yourstory.com/2019/12/startup-bharat-farmersfz-agritech-organic-produce-ecommerce>

<sup>317</sup> For more information, please see <https://www.farmersfz.com/>; <https://yourstory.com/2019/12/startup-bharat-farmersfz-agritech-organic-produce-ecommerce>

<sup>318</sup> For more information, please see <https://techcollectivesea.com/2020/03/23/discovering-agritech-startups-in-southeast-asia-indonesia>

<sup>319</sup> For more information, please see <https://www.8villages.com>

<sup>320</sup> For more information, please see <https://urbantiller.sg/>

<sup>321</sup> Information provided by Jolene Lum, Urban Tiller Singapore, at the Asia-Pacific Agrifood Innovation Summit, on 18 November 2020.

<sup>322</sup> For more information, please see <https://www.alizila.com/taobao-live-keeps-china-produce-flowing-from-farm-to-table/>



with 300 million consumers that mostly belong to the more than 4 billion people who individually earn less than \$1 500 per year and live in third- and fourth-tier cities (Zhao *et al.*, 2019). The company combines continuous cost optimization with an aggressive pricing strategy. A large part of its appeal is the group buying function where the more people buying a product leads to a lower price. Pinduoduo offers very short-term discount coupons (typically two hours) and cash prizes to those who invite friends to sign up for the app.<sup>323</sup>

The number of variations is endless. For example, Zhang and Hinrichs, from the Asian Development Bank,<sup>324</sup> refer to an Indian online grocery platform that has adopted a community-selling model where it is asking apartment complexes to put orders together for their residents. This helps the company meet consumer demand despite having a smaller-than-usual workforce.

Another interesting business model that helps connect producers and consumers is **open source and community-controlled software platforms**. An example of this model has been developed by the not-for-profit global organization Open Food Network.<sup>325</sup> The business model of the Open Food Network has two innovative elements: the network itself and an open source digital B2C platform. The network members cooperate globally but organize locally through what they called ‘instances,’ which are local entities that cooperate to create more sustainable, horizontal and shorter local food systems. A local instance was launched in India in 2020<sup>326</sup> and another one is under way in Sri Lanka. The open source software platform allows farmers to sell produce online, either by selling through other shops on the platform or by creating

their own online shop, and collect payments.<sup>327</sup>

The platform model is flexible as it enables farmers to sell to consumers through multiple digital shopfronts, while at the same time allowing wholesalers to aggregate from multiple producers, manage buying groups, and supply produce through networks of food hubs and shops. The platform can host communities that bring together producers in an area to create a virtual farmers’ market. This type of platform offers an alternative to profit-driven corporate digital platforms such as Alibaba, Amazon and others selling food in the region.

#### 6.4.2. Farmer-to-buyer digital platforms

A number of digital F2B (farmer-to-buyer) platforms are emerging in APAC to enable more direct relationships between farmers and buyers. These include small retailers and Horeca businesses. The platforms bypass traditional intermediaries and shorten the value chain. The F2B segment has lower margins than F2C markets, but is operationally less intensive (NASSCOM, 2019). These marketing platforms generally use blockchain based solutions that help build trust and promote transparency.

A prime example of this business model is Meicai, a Chinese-based agritech digital platform launched in 2014 (Skinner *et al.*, 2019), and currently valued at \$7 billion.<sup>328</sup> Meicai – literally ‘beautiful food’ – helps farmers sell vegetables and spices to 10 million small- to medium-sized restaurants and produce shops in over a hundred first-tier cities in China.<sup>329</sup> Another player that warrants attention is Songxiaocai, another O2O system integrator that streamlines vegetable supply chains in China by linking food vendors with restaurants (Yao *et al.*, 2019). The most prominent difference between the business models of these two companies lies in their revenue

<sup>323</sup> For more information, please see <https://ecommercechinaagency.com/can-taobao-new-p2m-option-rivals-with-pinduoduo/>

<sup>324</sup> For more information, please see <https://blogs.adb.org/blog/how-covid-19-could-accelerate-digitization-food-supply-chain>

<sup>325</sup> For more information, please see <https://www.openfoodnetwork.org/a-new-way-of-working/>

<sup>326</sup> For more information, please see <https://www.openfoodindia.org/>

<sup>327</sup> For more information, please see <https://www.open/foodnetwork.org>

<sup>328</sup> For more information, please see <https://equalocean.com/retail/20190525-alibaba-and-meituan-competes-with-this-veggie-selling-startup-meicai>

<sup>329</sup> For more information, please see <https://radiichina.com/meicai-the-7-billion-usd-app-that-wants-to-change-how-china-eats/>

model: while Meicai buys bulk inventory itself, Songxiaocai focuses on information brokering services, passing the orders placed by small vendors and wholesalers on to producers.<sup>330</sup> Another striking difference is that Meicai relies on its own logistics, with a large fleet of refrigerated trucks, cold storage network and distribution centres.<sup>331</sup> Songxiaocai uses third-party logistics services, which are centrally managed through the company's mobile application (Yao *et al.*, 2019). As a result, Meicai is theoretically more exposed to volatility in food cost and the vagaries of fuel costs, but has more control over its integrated supply chain.

According to Yao *et al.*, (2019), the business models of these two digital platform-based supply chain integrators share several traits. They improve the quality and standardization of the food products sold. They integrate common digital payment systems into their platforms, such as Alipay, WeChatPay and UnionPay. And they reduce transaction costs,

which encompass transportation costs, and information search and monitoring costs. Both companies are able to reduce transportation costs along the supply chain. Meicai, through its proprietary AI-powered transportation management system, can determine each car's optimized load weight and plan the delivery route.<sup>332</sup> Songxiaocai has also cut transportation costs by means of centrally managing third-party logistics services to achieve economies of scale, and by pooling orders from producers or buyers in the same area. Both companies have managed to cut transport time with direct delivery from producers to wholesalers or vendors, so only 12 to 18 hours lapse from field to fork.<sup>333</sup> Similarly, with the information about products, prices and real-time trading orders collected through the digital platforms, the costs in the search for market information and the costs in monitoring the quality of product have been remarkably reduced.

**Table 14.** List of F2B digital platforms studied

CASE	COUNTRY	BUSINESS ANALYSED
Meicai	China	F2B digital platform (restaurants and produce shops)
Songxiaocai	China	F2B digital platform (restaurants and produce shops)
Crofarm	India	F2B digital platform (retailers and Horeca)
FarmerFriend	India	F2B digital platform
Kisan Network	India	F2B digital platform (retailers and bulk buyers)
KrishiHub	India	F2B digital platform (retailers and Horeca)
Ninjacart	India	F2B digital platform (retailers and Horeca)
WayCool	India	F2B digital platform
Kedai Sayur	Indonesia	F2B digital platform (vegetable hawkers)
TaniHub	Indonesia	F2B digital platform (wholesalers and retailers)
Warung Pintar	Indonesia	F2B digital platform (traditional mom-and-pop retail stores)

**Source:** Own elaboration.

<sup>330</sup> For more information, please see <https://equalocean.com/retail/20190525-alibaba-and-meituan-competes-with-this-veggie-selling-startup-meicai>; <https://www.unicornanalytics.net/post/meicai-the-intermediary-between-farmers-and-consumers>

<sup>331</sup> For more information, please see <https://equalocean.com/analysis/2019052511115>

<sup>332</sup> For more information, please see <https://equalocean.com/analysis/2019052511115>

<sup>333</sup> For more information, please see <https://equalocean.com/analysis/2019052511115>; Yao *et al.*, (2019)

In India, F2B has emerged as a key revenue-generating segment for agritech startups due to long-term business sustainability, with market linkages and supply-chain efficiency as key focus areas, particularly when it comes to selling farm produce (NASSCOM, 2019). In fact, over half of all agritech funding goes to supply-chain startups such as Ninjacart, Crofarm and Farmer Friend<sup>334</sup> that link farmers to retailers and Horeca businesses. Ninjacart<sup>335</sup> is an Indian agritech startup that connects 4 500 fruit and vegetable farmers to about 9 500 retailers and restaurants. By shortening the supply chain this way, producers that subscribe to Ninjacart's digital platform get 20 percent more revenue on average, while buyers guarantee the sourcing of traceable-to-farm high-quality graded produce in less than 12 hours. At the time this study was written, the startup was operating in seven Indian cities and moving 1 400 tonnes of perishables from farms to businesses every day.<sup>336</sup>

Crofarm has a similar business model linking horticultural farmers to over 300-plus retailers and businesses through its digital platform.<sup>337</sup> The company operates in the Delhi National Capital Region of India and has procurement engagements with farmers across the states of Uttar Pradesh, Haryana and Delhi. Crofarm claims that produce wastage in its supply chain has been cut to 5 percent, compared to 50 percent on average in conventional, longer food chains.<sup>338</sup> Delhi-based Kisan Network is another online F2B marketplace for farmers to connect directly to retailers and bulk buyers, instead of selling their produce in 'mandis,' or local markets. Kisan Network also provides farmers with grading, sorting, packaging and

transportation services if needed.<sup>339</sup> More startups are cropping up in other Indian cities, such as WayCool in Chennai<sup>340</sup> and KrishiHub<sup>341</sup> in Bangalore. KrishHub's online platform links over 200 vegetable farmers directly to retail stores and Horeca.

Startups in this field are emerging in other countries in the region, with novel business models that reflect the local context and specificities. For example, in Indonesia, the TaniHub app also allows producers to sell agricultural products to wholesalers and retailers, including 400 SMEs.<sup>342</sup> The startup Kedai Sayur connects vegetable hawkers directly to farmers.<sup>343</sup> It cuts out intermediary costs and allows hawkers to potentially receive comparatively fresher vegetables instead of the leftovers at the end of the distribution chain. Also in Indonesia, the startup Warung Pintar<sup>344</sup> has positioned itself as a mom-and-pop retail digitalization enabler. The company allows thousands of traditional small stalls known as 'warung' to sell staple food items at their digitally enhanced kiosks. 'Pintar' means smart. At the core of the company's business model is the recognition of the important role that the warung plays in Indonesia's food system and social life, coupled with the firm belief that is possible to take these stalls to the next level by digitalizing their operations. By linking farmers with warung owners, Warung Pintar enables farmers to find a market for their products and get a better selling price. Subscribing warung owners can access a more diverse range of high-quality staple foods directly from producers. Warung Pintar combines an online market place with physical points of sale

<sup>334</sup> For more information, please see <https://www.farmerfriend.in>

<sup>335</sup> For more information, please see <https://ninjacart.in/>, last accessed on 29 September 2020.

<sup>336</sup> For more information, please see <https://ninjacart.in/>, last accessed on 29 September 2020.

<sup>337</sup> For more information, please see <https://crofarm.com>

<sup>338</sup> For more information, please see <https://tracxn.com/d/trending-themes/Startups-in-B2B-Farm-Produced-E-Commerce>

<sup>339</sup> For more information, please see <https://tracxn.com/d/trending-themes/Startups-in-B2B-Farm-Produced-E-Commerce>

<sup>340</sup> For more information, please see <https://tracxn.com/d/trending-themes/Startups-in-B2B-Farm-Produced-E-Commerce>

<sup>341</sup> For more information, please see <https://tracxn.com/d/trending-themes/Startups-in-B2B-Farm-Produced-E-Commerce>

<sup>342</sup> For more information, please see <https://tanihub.com>

<sup>343</sup> For more information, please see <https://techcollectivesea.com/2020/03/23/discovering-agritech-startups-in-southeast-asia-indonesia/>

<sup>344</sup> For more information, please see <https://warungpintar.co.id/>

after its 2019 acquisition of Limakilo, another Indonesian startup that managed a network of over a thousand physical kiosks.<sup>345</sup>

#### 6.4.3. B2B platforms in food retail and catering

The strong dynamism experienced by Asian B2B e-commerce is reaching the food market and leading to the development of specialized B2B platforms serving food retailers, restaurateurs and caterers. This is a reflection of broader global and regional trends, such as the growing importance of online marketplaces<sup>346</sup> and B2B channels,<sup>347</sup> particularly in Asia's booming mobile commerce landscape. B2B marketplaces are becoming increasingly specialized.<sup>348</sup> As a matter of fact, the first generation of B2B marketplaces in the APAC region, characterized by a multisectoral format that resembled a business directory or an Alibaba-style large online bazaar, is giving way to a new generation of B2B marketplaces with a more targeted sectoral and geographical scope.<sup>349</sup>

The growth of the B2B channel within the food sector is attracting companies with an

Internet background and experience in B2C food delivery services. This is notably the case in China, where the country's two biggest food delivery platforms, Meituan and Alibaba's Ele.me, are now investing in the B2B sphere. Other countries in the region are following suit. For example, in Thailand, Central Food Retail launched Chef Yim in late 2020.<sup>350</sup> Chef Yim is a B2B e-commerce platform for restaurants, cafes, hotels, caterers and other food retailers to buy raw ingredients from a network of over 1 000 Thai and international suppliers. The interest of Central Food Retail in this segment reflects the convergence of several factors. The Thai B2B food channel, valued at nearly \$29 million,<sup>351</sup> is attractive, especially with the rise of online commerce (including B2B) in the wake of the Covid-19 pandemic. Central Food Retail's parent company Central Group has an e-commerce technology arm Central Tech that had previously developed an omnichannel e-commerce platform, and Central JD Money, a fintech subsidiary, had already introduced the Dolfín e-wallet.

**Table 15.** List of B2B food digital platforms studied

CASE	COUNTRY	BUSINESS ANALYSED
Ele.me (Alibaba)	China	B2B and B2C digital platform
Meituan	China	B2B and B2C digital platform
Chef Yim	Thailand	B2B digital platform
SupplyBunny	Malaysia	B2B digital platform
Meatbox	South Korea	B2B digital platform
CaterSpot	Hong Kong and Singapore	B2B digital platform

**Source:** Own elaboration.

<sup>345</sup> For more information, please see <https://kr-asia.com/from-farm-to-kiosk-indonesian-micro-retail-startup-warung-pintar-acquires-limakilo>

<sup>346</sup> Online marketplaces are expected to account for 40 percent of the global online retail market (Ecommerce Foundation and Nyenrode Business University, 2019).

<sup>347</sup> About 75 percent of B2B procurement spending will be done online, according to a 2018 report by Gartner Research available at: <https://www.gartner.com/en/documents/3882875>

<sup>348</sup> For more information, please see <https://medium.com/@Arcadier/have-b2b-marketplaces-taken-off-in-asia-991ae4270d00>

<sup>349</sup> For more information, please see <https://medium.com/@Arcadier/have-b2b-marketplaces-taken-off-in-asia-991ae4270d00>

<sup>350</sup> For more information, please see <https://www.bangkokpost.com/business/1991967/central-food-retail-to-launch-b2b-platform>

<sup>351</sup> For more information, please see <https://www.euromonitor.com>; <https://www.bangkokpost.com/business/1991967/central-food-retail-to-launch-b2b-platform>

Other examples include Malaysia-based SupplyBunny, South Korea's Meatbox and CaterSpot in Hong Kong and Singapore.<sup>352</sup> SupplyBunny is an online B2B marketplace that enables restaurant and cafe owners to source grocery and supplies from verified wholesale food and beverage suppliers. Subscribed suppliers sell at wholesale prices and impose a minimum order quantity. Paying homage to the popular Korean barbecue, the startup Meatbox has developed an online B2B marketplace that connects meat suppliers with wholesalers and retailers. The company provides information on real-time market prices of various meat products and delivers orders through partnered third-party logistic service providers.<sup>353</sup> CaterSpot is a digital B2B platform that simplifies corporate catering and party-food delivery for businesses in Hong Kong and Singapore. The platform connects food caterers and restaurants with officer managers wishing to order tailored meals for their employees, meetings or events.<sup>354</sup>

The COVID-19 pandemic has forced B2B players from all sectors, including food and beverage, to shift their go-to-market model from traditional to digital. A report by McKinsey & Company (2020e) notes that the large majority of B2B sales leaders now believe that their new digital sales models are more efficient at reaching and serving customers: about 81 percent of Chinese B2B leaders, 78 percent in South Korea, 74 percent in India and 70 percent in Japan. They are also willing to invest substantial amounts in making new or improving their existing digital channels, using e-commerce solutions, video-conferencing and online chat as the key tools for customer-sales representative interactions. What started out as a crisis response has now become the next normal, fostering a change in the mindset

of the B2B leaders, who have witnessed how these non-traditional, digital channels are now driving the lion's share of their revenue. For these reasons, B2B leaders perceive that these new digital or O2O business models will stay a fixture throughout 2021 and beyond (McKinsey & Company (2020e).

## 6.5. PHYSICAL AND MIXED SHORT-CHAIN BUSINESS MODELS

A number of physical, direct farm-to-consumer initiatives have been put forward in recent years, such as farmers' markets and community-supported agriculture (CSA) initiatives.

### 6.5.1. Farmers' markets

Farmers' markets represent public or private initiatives, as long as they aim to facilitate personal connections and bonds of mutual benefits between farmers, shoppers, and communities.<sup>355</sup> Such benefits include improving the access of farmers to markets, and providing fresh, local and sometimes organic produce to consumers in the cities. There are tens of thousands, possibly more, farmer's markets in the world and their number expands year by year.<sup>356</sup>

In APAC, a large number of wet markets fall in the category of farmers' markets. Wet markets are fairly common in China, Southeast Asia and South Asia. IPC-IG (2016) mentions the existence of about 300 farmers' markets in over 30 provinces and municipalities in China. In the last decade, a new generation of farmers' markets has been emerging with an emphasis on organic or agro-ecological food products, according to FAO and INRA (2016). Some of them are even going digital, as in the case of Bangkok Farmers' Market.<sup>357</sup> Founded in 2013,

<sup>352</sup> For more information, please see <https://www.supplybunny.com>; <https://www.meatbox.co.kr/>; <https://www.caterspot.hk/>; <https://www.caterspot.sg/>

<sup>353</sup> For more information, please see <https://tracxn.com/d/trending-themes/Startups-in-B2B-Farm-Produce-E-Commerce>

<sup>354</sup> For more information, please see <https://www.caterspot.hk/>; <https://www.caterspot.sg/>

<sup>355</sup> For more information, please see <http://www.fao.org/cfs/home/blog/blog-articles/article/en/c/1044767/>

<sup>356</sup> For more information, please see <http://www.fao.org/cfs/home/blog/blog-articles/article/en/c/1044767/>

<sup>357</sup> For more information, please see <https://bkkfm.org/>

**Table 16.** List of F2C schemes studied

CASE	COUNTRY	BUSINESS ANALYSED
Bangkok Farmers' Market	Thailand	Online and physical farmers' market
Little Donkey	China	CSA scheme
Shared Harvest Farm	China	CSA scheme
Mae Tha	Thailand	CSA scheme
OrgBox	Thailand	Online food subscription model
Veggie Favour	Thailand	Online food subscription model
Bo.lan	Thailand	Online food subscription model
Vivin Maison	Thailand	Online food subscription model
Farmers Fresh Zone	India	F2C app
TaniHub	Indonesia	F2C app
RegoPantes app by 8 Villages	India	F2C app
Urban Tiller	Singapore	F2C app
Taobao (Alibaba)	China	E-commerce platform's F2C initiative
PinDuoDuo	China	E-commerce platform's F2C initiative

**Source:** Own elaboration.

it launched an online version in June 2020 to cope with the restrictions of movement of people and food products imposed by the government because of the Covid-19 outbreak.

Traditionally, farmers' markets have been developed to promote a more direct connection between urban consumers and rural or peri-urban producers (IPC-IG, 2016). By helping bypass the dual squeeze experienced by both growers and consumers, these markets can build more harmonious relations between rural and urban areas, agriculture and industry, producers and consumers (IPC-IG, 2016). However, some countries in the region have now started to look at these markets as alternative outlets for a new generation of innovative and resource-efficient urban farmers.<sup>358</sup> Singapore, for example, is

promoting farmers' markets to support urban farmers, and by so doing diversifies food sources and optimizes local production in order to rely less on imports, which exceed 90 percent of the food consumed, mainly vegetables. In parallel, the Singaporean government is helping these urban farmers to invest in technology and adopt efficient farming methods so they can grow more with less land such as vertical farms and rooftop farms.

### 6.5.2. Community-supported agriculture

Community-supported agriculture, or CSA, is a partnership whereby consumers pledge to support one or more local farms, and share the risks and benefits of food production (CSA4EUrope, 2015). FAO and INRA (2016; 2018) add that CSA mechanisms are embedded within local sociocultural contexts and represent initiatives where community members invest in both production and consumption processes,

<sup>358</sup> For more information, please see <http://www.fao.org/cfs/home/blog/blog-articles/article/en/c/1044767/>

building on grassroots entrepreneurship and setting in motion an innovative process that triggers knowledge creation, knowledge sharing and resources mobilization. The 2019 IPES-FOOD report notes that CSA schemes entail a commitment to diversified, seasonal, and usually organic production overseen by the participating consumers.

The CSA phenomenon is particularly important in Japan, where the concept developed in the late 1960s and early 1970s. It drew inspiration from the so-called Teikei movement, in which consumers purchase food directly from small-scale, local, organic farmers.<sup>359</sup> Some of these communities assume the form of food cooperatives, which are consumer cooperatives where members decide on the production and distribution of the food.

In recent years, China has seen a surge of CSA partnerships, with approximately 1 000 CSA initiatives with over 100,000 consumers in more than a dozen cities.<sup>360</sup> One of the first Chinese CSA initiatives called Little Donkey<sup>361</sup> now has 700 members, most of them residents of Beijing. Members can have a regular membership and receive a weekly supply of seasonal, pesticide-free produce delivered or picked up from the farm, shops and restaurants in the city. Or they can hold a working share, where they rent about 30 sqm and are provided with seeds, organic fertilizers and other inputs and tools as required, with technical assistance to grow their own vegetables. The Little Donkey farm is also used as a hub for community activities, training and research, with the possibility to organize visits and ecological farming demonstrations.<sup>362</sup> FAO and IFOAM (2019) document the case of another Chinese CSA called Shared Harvest Farm that cultivates an area of 5 hectares in Beijing. Shared Harvest

Farm's members include small and local farmers, families and disadvantaged groups such as people from ethnic groups and women with young babies.

The CSA movement is also growing in India and Thailand, among other countries in Asia. Osswald (2013) mentions several CSA initiatives in metropolitan areas of India, such as Mumbai, Pune and Hyderabad. These CSA schemes connect active, educated middle- or upper-class urban consumers with peri-urban farmers who typically have landholdings of less than two hectares, grow organically but do not necessarily aim for third-party organic certification (Osswald, 2013).

In Thailand too, CSA is mostly an urban phenomenon. For example, Mae Tha is a CSA launched in 2010 in the city of Chiang Mai, which now connects five farming families with 30 consumers. The farmers do weekly home deliveries and distribute from a local school to sell boxes of organically grown produce.<sup>363</sup> In the capital city, Nakorn Limpacuptathavon, a young leader of Bangkok's urban gardening movement, has organized a 650-square-meter urban farm as a CSA initiative that produces organic food for five families and doubles as an urban farming learning centre.<sup>364</sup> In a time of rapid urbanization, CSA provides Thais with the opportunity to grow their own food in urban gardens and farms, or even to return to the farmland of their ancestors and make a good living.

The CSA movement is becoming more organized in several parts of the region. CSAs in China, India, Japan and Thailand are building their local networks as chapters of the International Network for Community Supported Agriculture (URGENCI), which is supporting its members to move towards the creation of a regional Asian CSA network.<sup>365</sup>

<sup>359</sup> For more information, please see <https://urgenci.net/japan-cradle-of-csa/>

<sup>360</sup> For more information, please see <https://urgenci.net/10th-china-community-supported-agriculture-conference/>; <http://www.fao.org/family-farming/detail/es/c/325680/>

<sup>361</sup> Little Donkey Farm was launched in 2008. For more information, please see <http://www.littledonkeyfarm.com/>

<sup>362</sup> For more information, please see <http://www.littledonkeyfarm.com/>

<sup>363</sup> For more information, please see <https://www.pyxeraglobal.org/organic-farming-johndeere-thailand/>

<sup>364</sup> For more information, please see <http://www.mekongcommons.org/urban-farming-bangkok/>

<sup>365</sup> For more information, please see <https://urgenci.net/10th-china-community-supported-agriculture-conference/>





# PART III

## FINDINGS AND CONCLUSIONS

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**Part III outlines the opportunities and challenges posed by food system innovations, policy solutions and lessons learned.**

Chapter 7 zeroes in on the opportunities provided by food system innovations, as well as challenges related to the environment, governance (e.g. exclusion of vulnerable actors and data governance) and society at large (employment). It highlights the fact that innovation comes at a cost, which small-scale actors in agrifood chains, all too frequently, cannot afford.

Chapter 8 documents innovative policy solutions to solve both traditional and emerging issues affecting food systems in the region, including offsetting the concerns described in the previous chapter. It discusses policy solutions to improve societal outcomes, restore agro-ecosystems, promote low-waste and low-plastic food chains, and to make food value chains shorter and fairer.

The final chapter summarizes the key findings and offers a final reflection on how innovations are changing APAC food systems, and on the implications for policymakers wishing to accelerate sustainable innovations for more sustainable food production and consumption, while closing the innovation and digital gaps created. It also discusses the possible way forward, emphasizing the need to rethink food systems in the region in the wake of the COVID-19 outbreak.

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# 7. OPPORTUNITIES, CHALLENGES AND RISKS OF INNOVATIONS ALONG THE VALUE CHAIN

## 7.1.

### **FOOD SYSTEM INNOVATIONS: OPPORTUNITIES, CHALLENGES AND TRADE-OFFS**

The innovations showcased in this publication can have both positive and negative impacts on the environment, society or the governance of food systems and value chains. High-tech farming can help us rethink food production so that it becomes more efficient, sustainable and resilient to climate change. Food factories and vertical farming could be the future of agriculture, especially in urban areas where most of the global population will reside. Meat, milk and seafood produced by cellular agriculture could represent an alternative to meet the demands of eco-conscious consumers for alternative proteins that do not damage the environment. Furthermore, automation, big data and machine learning can take food processing to unprecedented levels of efficiency with greater ability to predict end demand, reduce cost, manage inventory, and decrease waste and carbon emissions. In the same vein, blockchain technology could be mainstreamed into food chains to revolutionize their transparency and address consumer concerns over food safety and the origin of the food they purchase. Expanding and ever more efficient digital marketplaces can solve the issue of highly fragmented, unfair and wasteful food supply chains.

However, a less rosy picture is also just as plausible. Digital technologies can pose several risks to food systems in the region, including an overconcentration of market power of service providers, exclusion and potential job losses for some activities, and concerns about food safety, nutrition and health. The digitalization of food systems also entails, all too frequently, risks for the environment and governance, such as the lack of data ownership and privacy, and cybersecurity breaches (World Bank, 2020).

Different forms of innovation – be they digital technologies, local product marketing systems or bio-farming – are bound to have multiple, varying impacts on food system governance, the environment and society. For example, the aim of many business model innovations in the APAC region is to change the structure or the power relations that determine how financial, material and human resources are distributed within food systems and value chains (Gatzweiler and von Braun, 2016). These innovations show promise in terms of reclaiming value for vulnerable actors and reducing environmental impacts, while also helping to reconnect food system actors in a way that restores fairness, accountability, and trust in food systems.

However, there are trade-offs between the impacts of any given innovation on food systems. Some innovations may only benefit stockholders, but are detrimental to consumers, farmers and broader segments of society.

Others may generate positive social outcomes, such as increased food security, while damaging the environment. On the other hand, some social and environmental challenges are mutually interdependent,<sup>366</sup> so their impacts will likely be multiplied and exert even more pressure to innovate along the entire food system.

Whitfield *et al.*, (2018) caution about the techno-centric narratives associated with smart farming, which can be extrapolated to smart food manufacturing and retailing. Technology is a double-edged sword that has the potential to both benefit and harm. The digital revolution can deepen the growing digital divide experienced by smallholders and SMAEs in the APAC region (FAO, 2019b), but it can also enable the appearance of bottom-of-the-pyramid business models that provide those small farmers with access to markets, services and information. Addressing these risks calls for public policies to develop basic infrastructure, support skills development and foster inclusion through targeted support to smallholder farmers, youth, women, vulnerable groups, and SMAEs at all stages of the food value chain. Digital technologies and other innovations examined in this study have impacts on small-scale producers and SMAEs, the environment, employment, and data governance issues, which can undermine the economic interests of vulnerable value chain players (Jouanjean *et al.*, 2020).

## 7.2. OPPORTUNITIES PROVIDED BY DIGITALIZATION TO VALUE CHAIN ACTORS

Digital technologies enable the development of applications that hold promise for players throughout the food value chain (WEF and McKinsey, 2018).

**Digital agriculture provides many opportunities to smallholder farmers, food processors and distributors in the region.** They have better access to digital technologies thanks to improvements in connectivity, significant drops in the price of digital devices and scalable business models:

**Improved connectivity:** In the past two decades, the number of mobile telephone subscriptions per 100 people has expanded substantially in the region, and has reached more than 100 in Southeast Asia and the high-income APAC countries (FAO, 2018d). The combination of mobile phones and Internet greatly facilitates access to new information in a manner that was previously unthinkable. Today, farmers can use their smartphones to get customized weather advisories or information on local prices, and use their phone camera to identify a pest or disease.<sup>367</sup> Food manufacturers and retailers can get to know more accurately and in almost real time what consumers want and need, and maximize their performance through analysis of gathered data. The percentage of the population using the Internet has increased markedly since the turn of the century, even though more than half the populations in South Asia, Southeast Asia, and the Pacific are still not using it (FAO, 2018d). India, for instance, has seen a deepening in digital penetration among farmers, with 200 million plus active users, as reported by NASSCOM (2019). According to the same source, Indian farmers have experienced a 1.7-fold increase in average income in the last decade, enabling them to try new tech solutions.

<sup>366</sup> For example, climate change is a major “hunger-risk multiplier”: by 2050, climate change may put at risk of undernourishment an additional 120 million people.

<sup>367</sup> For more information, please see [https://yourstory.com/2020/05/digital-technology-revolutionised-agricultural-sector-globally?utm\\_pageloadtype=scroll](https://yourstory.com/2020/05/digital-technology-revolutionised-agricultural-sector-globally?utm_pageloadtype=scroll)

### **The price of smart farming technologies keeps decreasing:**

The price of drones has plummeted. Furthermore, the quality of satellite information and satellite images has improved significantly, resulting in better and more updated climate forecasts. The same trend is taking place in food manufacturing technology. The adoption of these technologies depends not only on the price, but also on the labour-market dynamics including labour supply quantity, quality, and associated wages as in the cases of raising labour costs in Japan and China. Social acceptance and benefits beyond labour substitution are also factors.

**Scalable digital business models:** A new generation of business models is emerging in the region for delivering digital tools that show great potential to empower smallholder farmers to become more efficient and profitable.

#### **7.2.1. Opportunities for farmers**

##### **The adoption of digital technologies holds great promise for smallholder producers.**

The use of precision agriculture and drones offers farmers major cost savings, enhanced efficiency, and more profitability. Agricultural drones can report on crop health, improve spraying accuracy, and monitor livestock and irrigation systems in a fast and cost-efficient manner. Precision farming allows growers to optimize yields and reduce their costs by tailoring input applications to the real needs of specific locations, at the right time (Kendall *et al.*, 2017). It can also reduce environmental impacts by facilitating integrated pest and weed management, and soil amelioration, while improving water and yield productivity by adopting management practices that optimally match crop genotypes (HLPE, 2019). In addition, it can create incentives for sustainable production and new business models with relatively less administrative burdens (EIU, 2018).

### **Bottom-of-the-pyramid business models**

have sprung up in the region to make data-driven farming a possibility for small-scale farmers. Smallholder growers in APAC account for 74 percent of the world's family farmers and provide up to 80 percent of the food supply in Asia (FAO and UNDP, 2016). The advent of business models that serve producers at the bottom of the pyramid avails them of a wide range of digital-based farming services, and marketing and fintech solutions, among others.

These models use cutting-edge digital technologies to make smart farming affordable for smallholders by reducing transaction and discovery costs. In APAC, numerous startups and large businesses now capitalize on the information revolution, encouraging farmers to improve their economic model, their yield and/or their environmental and social footprint. For instance, the World Bank (2020) reports that the rise in e-commerce in China has opened market opportunities for farmers who operated 9.85 million online shops as of 2017, employing over 280 million people.

Just as with entrepreneurs, farmers now have access to a suite of solutions through apps and e-platforms that tell them what crop will fetch them better returns, the best time to sow, when to water, where to sell and at what price, and much more. In addition, widespread availability of information through apps and digital platforms also allows small-scale farmers to better understand consumer preferences and develop niche products and services, such as organic foodstuffs and farm-to-table services.

Most of these solutions are being offered at no cost for farmers or have a price point that even a small farmer can afford.<sup>368</sup> For instance, instead of purchasing a drone with infrared sensors to detect signs of plant stress, small-scale growers can just hire the service of drone-performed infrared crop mapping for as

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<sup>368</sup> For more information, please see <https://blogs.worldbank.org/voices/planet-apps-making-small-farms-competitive>

little as \$12 per hectare, and achieve an increase of crop yields of up to 20 percent.<sup>369</sup> Other business solutions need groups of farmers to come together. In other cases, the small fee charged for these services is fully or partially subsidized by a third party, be it the buyer or a government or donor initiative.

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 for smallholders. Digital fintech ventures can have a substantial positive impact on farmers' livelihoods and rural development, especially in developing and emerging APAC where the financial digitalization process is still at an early stage and financial inclusion needs to improve (McIntosh and Mansini, 2018). Digital technologies can prove crucial for granting previously unbanked farmers' access to finance. Mobile money and other fintech services are useful vehicles to deliver reliable, affordable and trustworthy financial services for growers and other individuals particularly in rural areas in ASEAN (GrowAsia *et al.*, 2020) – and other APAC countries.

**Digitalization has increased public support and support from supply-chain partners directed to smallholder farmers:**

**Digitally enabled public extension services:**

APAC governments and development partners have acknowledged that digital technologies are the future of extension services and market information systems, and are also entering the digital agriculture space. These technologies can reduce the cost of extension visits and help overcome the problem of poor infrastructure making it easier and less costly for public extension agents to visit remote areas. Consequently, digital technologies enable more frequent two-way communication between farmers

and extension agents to continuously update farmers with the latest developments and follow-up information, while also improving the accountability of extension agents.

**Support from supply chain partners:** The digital journey on which food manufacturers have embarked is also changing their relationship with farmers. Asian food processors are now building closer relationships with their supply base, which implies helping the smallholder farmers supplying them to upgrade and add digital capabilities (MGI, 2019a). This is often the case in the dairy industry. The same applies to short-chain models whereby retailers purchase directly from farmers through digital platforms, and train them on several aspects, including the use of digital marketing and mobile banking. Without this support, small farmers would struggle to comply with demands by these supply-chain partners, including the use of blockchain for traceability and provenance.

**There is greater public-private collaboration to upscale digital initiatives reaching out to smallholder farmers.** In many instances, governments in the region join forces with private companies through PPPs, both startups and multinational firms, in order to reach the large masses of small-scale farmers (FAO, 2016a). Through these PPPs, the public sector seeks to ensure the provision of digital services to farmers and avoid their exclusion from food value chains. The private sector aims to build or expand business segments and the customer base of medium- and small-scale farmers, tap into local resources, and get a better understanding of how to adapt existing digital tools to the specific country or region.

For Myanmar-based startup Greenovator, a meaningful milestone was the signing of an agreement in 2017 with the Department of Agriculture to use the Green Way app as one of the Department's agricultural tools. The

<sup>369</sup> For more information, please see <https://theaseanpost.com/article/drones-reviving-agro-industry>

agreement ensured real-time government announcements and collaboration with the firm's team for visits to farmers. The firm partnered with the Agriculture and Market Information Agency to provide real-time market prices of more than 400 agricultural commodities at 22 wholesale markets across Myanmar.<sup>370</sup>

A quick analysis of the Table 17 shows that private partners range from local startups, such as Skymet or Greenovator, to large-scale domestic corporations such as Alibaba or the Loc Troi Group, and multinational companies such as IBM and Microsoft. It also reveals the heterogeneity of public partners, which span ministries to state governments in countries

**Table 17.** PPPs for providing digital-based farming services in Asia

Country	Private partners	Public partners	Other partners	PPP object
China	Alibaba and local managers of the digital service centres	Local governments		Establishment of Taobao digital villages that offer purchasing and delivering services that enable farmers to sell their products directly to urban consumers through the Taobao e-commerce platform, buy high quality agricultural materials such as greenhouses and machinery or access financial services (mobile payments, loans and insurance).
India	Skymet (Indian startup specialized in providing digital weather forecast solutions)	State Governments of Maharashtra, Gujarat, Rajasthan and Madhya Pradesh		Provision of accurate and quasi real-time drone imagery for the implementation of public crop insurance programmes targeting smallholder farmers
India	SourceTrade	Government of the State of Haryana)	Small Farmers Agri-business Consortium Haryana (SFACH)	Provision of digital solutions to 100 000 horticultural farmers, such as advisory services, market linkages, pest and disease management.
India	IBM	Government of the State of Karnataka and the Karnataka Agricultural Prices Commission (a decentralized agency of the Government of India, attached to the Ministry of Agriculture and Farmers Welfare).		Advanced forecasting using AI and machine learning technologies for Karnataka tomato and maize growers.

<sup>370</sup> For more information, please see [https://www.nationthailand.com/Corporate/30365537?fbclid=IwAR10ahvTNWrqP44h86-hkDF0jvRtpJJW0IUrZ00nfJ0db3\\_48Z6qW10Z1uE](https://www.nationthailand.com/Corporate/30365537?fbclid=IwAR10ahvTNWrqP44h86-hkDF0jvRtpJJW0IUrZ00nfJ0db3_48Z6qW10Z1uE)

Country	Private partners	Public partners	Other partners	PPP object
India	Microsoft	Government of the State of Karnataka	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Provision of digital farming services to smallholder farmers via Farmbeats, a Sowing App that provides farmers customized advisory services on optimal sowing timings, land preparation, seed treatment, application of nutrients, pest and disease management, water management and harvesting.
Myanmar	Greenovator	Department of Agriculture of Myanmar		DA's extension agents use Greenovator's Green Way App to provide information and advice to farmers
Myanmar	Wave Money	Myanmar Agricultural Development Bank		Digital delivery of cash aid to farmers affected by the COVID-19 pandemic
Viet Nam	Loc Troi Group (LTG), Vinated and Dutch firms (Nelen and Schuurmans, SAR Vision)	Ministry and Department of Agriculture	Can Tho University, Ministry of Foreign Affairs of the Netherlands, Netherlands Space Office and Geodata for Agriculture and Water	Provision of digital information and advisory services to rice growers engaged in contract farming with LTG, such as rice growth, pests and diseases management, weather, etc.

**Source:** Author's compilation based on cases illustrated in previous chapters.<sup>371</sup>

with a federal structure such as India, and local governments. Universities and development partners are often present in these business arrangements.

### 7.2.2. Benefits for agro-industries

Approximately 100 000 formal enterprises operate within the global food system, supplying agricultural inputs, animal health services, and finance, crop and livestock insurance to 570 million farms around the world (World Bank, 2020). Likewise, millions of formal and informal enterprises process, transport and sell food and agricultural outputs to 7.5 billion consumers, of whom nearly 4.7 billion live in the APAC region (World Bank, 2020).

The large majority of these firms are SMEs. For example, the vast bulk of food manufacturing firms in the APAC region are micro or small enterprises employing fewer than ten people (FAO, 2018d). Despite their

<sup>371</sup> Jones and Pimdee (2017); FAO and ADB (2014); Vasisht *et al.*, (2017). For more information, please see <https://g4aw.spaceoffice.nl/en/g4aw-projects/g4aw-projects/22/sat4rice.html>; [www.sourcetrace.com](http://www.sourcetrace.com); <https://nasscom.in/knowledge-center/publications/agritech-india-emerging-trends-2019>; <https://cep.cdd.go.th/wp-content/uploads/sites/108/2017/09/lazada.pdf>; <http://www.fao.org/support-to-investment/news/detail/es/c/1069630/>; <https://www.mmtimes.com/news/moving-money-masses.html>; [https://www.nationthailand.com/Corporate/30365537?fbclid=IwAR10ahvTNWrqP44h86-hkDF0jvRtpJJW0IUrZ00nfJ0db3\\_48Z6qW10Z1uE](https://www.nationthailand.com/Corporate/30365537?fbclid=IwAR10ahvTNWrqP44h86-hkDF0jvRtpJJW0IUrZ00nfJ0db3_48Z6qW10Z1uE)

numbers and innovative potential, their share of total sales is minimal (1 percent in India and Indonesia, and 2 to 3 percent in China), while firms with more than 50 employees have 60 to 80 percent of total sales in these countries.<sup>372</sup> Globally, only ten companies control almost every large food and beverage brand (Oxfam, 2016).

Digital technologies could potentially benefit small and medium food manufacturers through several pathways. By going digital, agro-industries can improve quality, safety control and maintenance. They can meet price competition and reduce fixed costs, while increasing recipe agility and manufacturing flexibility so that they can quickly react to customer needs and access markets. They can also reduce food losses, and save energy and water (IEC, 2015; World Bank, 2020). They can also access more affordable, efficient and secure payment and credit solutions enabled by digital technologies.

### 7.2.3. Benefits for retailers

E-grocers and food-delivery businesses use data to better know their customer preferences so they can deliver tailored food products and experiences, and optimize supply management and last-mile delivery. The innovations analysed can help food retailers and wholesalers reach high levels of food safety, improve traceability, cut down waste, reduce costs and risks, save energy consumption, improve smooth operation and supply chain management, and lead to efficient logistics (FAO, 2021).

Although these innovations entail substantial investments and the acquisition of new operational skills, adopters can benefit from more purchases, deeper customer loyalty and a positive loop in data capture that ultimately makes their systems smarter and more attuned to consumer needs.<sup>373</sup>

Digitalization can also potentially reduce the costs of linking small-scale food retailers with suppliers and consumers by decreasing transaction costs and matching buyers and sellers more efficiently (World Bank, 2020).

### 7.2.4. Benefits for consumers

Digital technologies, automation and associated business models in food value chains are already leading to better informed and engaged consumers who are able to connect more directly with producers. These innovations improve the ability of retailers and agro-industries to meet consumer needs and preferences through enhanced ability to comply with requirements pertaining to food quality, safety, traceability, convenience, and better understanding consumer preferences through big data with less time needed for developing new products from design to launch.

Urban consumers, in particular, can enjoy fresher, more nutritious and convenient foods thanks to indoor farming and improvements in last-mile infrastructure.

### 7.2.5. 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.

Food system innovation has come largely from agritech startups in recent years.<sup>374</sup> In APAC, a new generation of startup entrepreneurs is seeing farming through fresh eyes and developing new business models to optimize modes of cultivation and better serve consumers. Some startups based in Asia's large cities have adjusted to food system and demographic trends by stepping into novel

<sup>372</sup> Euromonitor International. 2017. Passport global market information database [online]. For more information, please see <http://www.portal.euromonitor.com>

<sup>373</sup> For more information, please see <https://digital.hbs.edu/platform-digit/submission/kroger-doubling-down-on-data-in-the-face-of-hungry-competition/>

<sup>374</sup> For more information, please see <https://www.eu-startups.com/2020/10/the-future-of-agtech-wearables-for-cows-vertical-farming-ai/>



farming systems that allow them to produce more sustainably in urban environments, such as indoor farming facilities and rooftop farms. Other startups have availed smallholder farmers of a wide range of digital-based agricultural services.

Many of the early entrants in the smart farming field have been local agritech startups that acquired the technology and skills needed, such as a small pool of drones and certified drone operators, and started serving neighbouring farmers for a fee. Afterwards, they gradually increased their outreach to other communities, provinces and countries in APAC. A case illustrating this was Mimosatek, a Vietnamese startup founded by Tri Nguyen, an IT professional turned farmer who started providing precision agriculture services to fellow farmers in his community. He helped them improve their irrigation and farming practice and is now serving nearly a thousand farmers (Doan, 2020).

Many governments and the development community are increasingly backing these startups through a series of programmes and policies that integrate their country's digital agenda for the agricultural and food sector, and initiatives specifically supporting SMEs. Well-designed policies, strategies and schemes to sustainably promote agritech entrepreneurship at the local, country and regional levels rely on a good understanding of who these entrepreneurs are and what drives them to thrive and serve their local communities.

Financial backing from investors in general, and venture capital firms in particular, is truly vital for local and regional agritech startups. Global investment into the more than 10 000 agritech startups has grown by 250 percent over the past five years to reach \$19.8 billion in 2019 (AgFunder, 2020; OLAM, 2019). Although the USA still dominates the sector, China and India contributed some of the largest deals in recent years. For instance, California-based venture capital firm Omnivore has backed

Indian startup Eruvaka.<sup>375</sup> Chinese, Indian, Indonesian, Singaporean and Thai venture capital firms in particular are investing in this type of local and regional startup (AgFunder, 2019a; 2020). For example, Kedai Sayur has managed to raise \$5.3 million so far from organizations such as Jakarta-based East Ventures.<sup>376</sup>

Investor backing is crucial for startups to scale up their businesses and remain competitive. Evidence of this is Skymet, which only after receiving an undisclosed amount from Omnivore Capital – a venture capital company backed by the Indian conglomerate Godrej – in 2011, could hire more people, invest in R&D and buy and install weather sensors in different parts of India to get more accurate data, which were critical factors for Skymet's success.<sup>377</sup>

A group of investors making a real difference in APAC agritech startups are impact investors. They make private capital investments that generate social or environmental benefits while also turning a profit.<sup>378</sup> Impact investors are supporting and mentoring agrifood technology companies in Asia, but not so much in the Pacific, as a means to rapidly transform the food and agriculture system using the ESG lens. A case in point is AgFunder, which launched an impact fund in mid-2020<sup>379</sup> to support startups that are developing technologies and utilizing innovative business models to deliver impact across the food system. However, recent assessments of 'responsible investments' in the region and elsewhere concluded that they still lack real impact on achieving ESG targets.<sup>380</sup>

<sup>375</sup> For more information, please see <https://www.crunchbase.com/organization/eruvaka-technologies>

<sup>376</sup> For more information, please see <https://techcollectivesea.com/2020/03/23/discovering-agritech-startups-in-southeast-asia-indonesia/>

<sup>377</sup> For more information, please see <https://www.firstpost.com/business/meet-jatin-singh-the-weather-man-behind-skymet-919243.html>

<sup>378</sup> For more information, please see <http://www.fao.org/support-to-investment/news/detail/es/c/1061863/>

<sup>379</sup> For more information, please see <https://agfundernews.com/agfunder-is-launching-an-impact-fund-heres-why.html>

<sup>380</sup> For more information, please see <https://www.growasia.org/single-post/2020/02/24/Investing-in-Innovation-Food-Agriculture-and-Forestry-in-Southeast-Asia>

Agritech startups are also funded by incubators, accelerators, government funds and donor programmes. For example, Mimosatek has received funding from Malaysia-based Corporate Venture firm Captii Ventures, but also from Singapore-based accelerator CLAS-Expara Viet Nam, and a grant in 2017 by the Mekong Business Initiative, a development partnership between the ADB and the Government of Australia.<sup>381</sup> Mimosatek was also the winner of Seedstars World<sup>382</sup> Vietnam 2016 (\$1 million as seed funding) and Venture Cup Vietnam 2015 (\$15 000 prize money).<sup>383</sup> Impact Terra has received a \$3 million grant from Geodata for Agriculture and Water, a programme by the Netherland's Ministry of Foreign Affairs.<sup>384</sup> Similarly, Ricult has received funding from MIT delta v, MIT's premier venture accelerator, seed funding from the Bill and Melinda Gates Foundation, Thailand's Bualuang Ventures, and Wavemaker Partners, a Singapore-based cross-border early stage venture capital firm.<sup>385</sup> Finally, Indonesia's Jala Tech has received funding from 500 Startups, EU-funded aquaculture accelerator Hatch Blue,<sup>386</sup> and Conservation International Ventures, a USA-based venture capital firm.

### 7.3. OVERALL BENEFITS FOR THE REGION'S FOOD SYSTEM

Unlocking the potential of these innovations can help drive socio-economic growth, ensure food and nutrition security, alleviate poverty

and improve resilience to climate change in the region. Digital transformation can make value chains more efficient thanks to accurate and real-time data analysis to support decision-making, intelligent automation and improved public services. It can also lead to shorter and more transparent value chains through enhanced access to finance and strong value chain linkages such as e-commerce, blockchain-enabled traceability and mobile service delivery. Furthermore, it can guide demand towards more nutritious and environment-friendly foods (WEF and McKinsey, 2018). In addition, there are some opportunities for more localized production and shorter supply chains through indoor agriculture, urban aquaculture systems and cellular agriculture, which can make APAC's cities more food-secure.

Digital technologies can have a positive environmental impact on the value chain through yield optimization, reduced use of inputs, water, plastics and electricity along the supply chain, reduced food losses and waste, and increased resilience. In particular, digital technologies can contribute to significantly reducing the environmental footprint of agro-industries. Smart agro-industries often retrofit existing facilities with digital technologies that are conducive to greening the manufacturing process in several ways. These include reducing waste, water, energy utilization and carbon emissions in food manufacturing, trimming the environmental impact of transport operations, and using green packaging. Food factories can achieve energy savings by implementing simple actions such as switching to LED lighting, setting the temperature to 25 degrees Celsius, or through large-scale projects such as adopting renewables or deploying power factor correction devices.<sup>387</sup>

By using digital solutions and creating digitized and interconnected industrial

<sup>381</sup> For more information, please see <http://www.expara.com/cas-expara-vietnam-accelerator-ceva-batch-1-graduates>

<sup>382</sup> Seedstars World is a worldwide competition to discover the best startups in emerging markets, available at: <https://www.seedstarsworld.com/about-us/>

<sup>383</sup> For more information, please see <https://tracxn.com/d/companies/mimosatek.com>; [https://www.crunchbase.com/organization/mimosatek-2/company\\_financials](https://www.crunchbase.com/organization/mimosatek-2/company_financials)

<sup>384</sup> For more information, please see <https://g4aw.spaceoffice.nl/en/about-us/>; [https://www.crunchbase.com/organization/impact-terra/company\\_financials](https://www.crunchbase.com/organization/impact-terra/company_financials)

<sup>385</sup> For more information, please see [https://www.crunchbase.com/organization/ricult/company\\_financials](https://www.crunchbase.com/organization/ricult/company_financials)

<sup>386</sup> For more information, please see [https://www.crunchbase.com/organization/jala/company\\_financials](https://www.crunchbase.com/organization/jala/company_financials)

<sup>387</sup> Power Factor Correction industrial equipment is a technology which when installed allows factories to optimize the use of energy by maintaining the level of reactive power consumption.

production, agro-industries can monitor their energy consumption and ensure the systematic management of myriads of small, inexpensive adjustments that contribute to continuously lightening the energy footprint.<sup>388</sup> To this end, big data techniques are instrumental because of their ability to produce relevant statistics that enable better-informed decision-making on environmental issues. For example, cloud-based energy monitoring software can generate a 3 to 7 percent annual efficiency gain within the factory gates.<sup>389</sup> Likewise, fitting motors with variable speed drives controlled by a digital central control system can help optimize energy efficiency in food manufacturing processes.<sup>390</sup> In addition, such systems can control the performance of a large number of interconnected robots using an algorithm that reduces their energy consumption up to 30 percent, according to UNIDO (2017a). Another energy saving potential associated with digital and interconnected manufacturing is the ability to cost-effectively produce customized food products due to the higher degree of flexibility. Producing customized products does not need to be significantly costlier than mass-produced foods (UNIDO, 2017a).

Similarly, agro-industries use substantial volumes of non-product water for cleaning (either cleaning in place<sup>391</sup> or manual cleaning) and for heat exchangers, such as cooling towers (Schug, 2016). Digital technologies can help them achieve **water savings and zero water discharge solutions**<sup>392</sup> across

manufacturing processes and promote the reduction of water consumption along the whole supply chain from farm to fork, given that on average 25 000 litres of water are needed to produce a day's supply of food for a family of four.<sup>393</sup> For example, monitoring water usage and water treatment processes such as pH, and temperature through the creation of a digital twin of the factory, combined with machine learning and sensor data, can support predictive analytics to identify and implement water saving measures and enable real-time or pre-emptive maintenance. This would not only save water but also enable better quality and safety standards (UNIDO, 2017a).

Agro-industries, wholesalers and retailers could also improve the environmental footprint of their **transport operations**, whether from their own fleet operations or third-party haulers. Digitalization can offer solutions to adopt a 'fewer and friendlier food miles' food-transport policy. One example would be by using blockchain technologies to optimize transport routes. Reducing this environmental footprint is one of the key reasons behind the development of short chains characterized by physical proximity, alongside organizational and social proximity (Rawlikowska *et al.*, 2019). They could also integrate renewable energy sources such as wind and solar into their electrical power systems by using smart grid technologies. Such grids draw on digital solutions to monitor and efficiently manage the generation and consumption of electricity from different sources to meet the customized demands of their facilities (UNIDO, 2017a).

Digital technologies can also help agro-industries and food distributors to strive for zero waste within manufacturing and distribution processes, and take action to ensure sustainable waste management and stewardship across the whole supply chain.

<sup>388</sup> For more information, please see <https://www.iaasiaonline.com/tetra-pak-and-abb-pioneer-digital-energy-assessment-programme-to-help-food-producers-reduce-environmental-impact/>

<sup>389</sup> For more information, please see <https://www.foodmanufacture.co.uk/Article/2019/08/16/A-lighter-footprint-going-green-in-manufacturing>

<sup>390</sup> For more information, please see <https://www.foodmanufacture.co.uk/Article/2019/08/16/A-lighter-footprint-going-green-in-manufacturing>

<sup>391</sup> CIP is a method of cleaning the interior surfaces of pipes, vessels, process equipment, filters and associated fittings, without disassembly. For more information, please see <http://www.fao.org/support-to-investment/news/detail/es/c/1061863/>

<sup>392</sup> For more information, please see <https://www.socotec.co.uk/news/blog/archive/water-usage-in-the-food-and-beverage-industry/>

<sup>393</sup> For more information, please see <http://savethewater.org/education-resources/water-facts/>

IoT-powered interconnected and interrelated systems and processes allow these actors access to data on the manufacturing and distribution processes to help them reduce waste. For example, agro-industries can calculate through digital control enterprise systems an estimated level of waste, track the actual waste and compare the two to improve efficiency in manufacturing operations. These systems can also help them manage multiple product versions, minimizing errors in recipes or formulas, further contributing to trimming waste. They can also anticipate product or equipment failure, contributing to prevent further waste of raw materials (MITI, 2019). The use of these technologies can have a great impact on the environment.

## 7.4. CHALLENGES AND RISKS FACING VALUE CHAIN ACTORS

The innovations studied along food value chains in the region also pose the following challenges and risks to different segments of the supply chain and to the entire food system.

There is a need to scale up these innovations and reach a larger number of beneficiaries in a sustainable and inclusive way, taking into account the trade-offs between the benefits and risks of any given innovation on food systems.

### 7.4.1. Challenges and risks for farmers

While some smallholder farmers in APAC are benefitting from the digital revolution, others are being sidelined (FAO, 2019b). They are not shielded from the fast systemic changes taking place in APAC's food supply chains, including digitalization. The challenges and opportunities smallholder farmers face are partly shaped by the disrupting effect of new technologies and business models, coupled with shifts in power relationships within the supply chain. Digital technologies foster horizontal integration in the food chain, which tends to favour large food suppliers, potentially endangering the

livelihoods of farmers as a result. Similarly, as corporate food suppliers invest in smart farming they tend to vertically integrate their operations to gain efficiency (Pesce *et al.*, 2019).

A major **digital divide exists between large and small farmers in the region**. Currently, the adoption of digital technologies among small producers in APAC is low, lagging significantly behind the adoption rate by commercial farms. Yet,<sup>394</sup> this divide does not manifest itself only in terms of adoption rates, but also in terms of the sophistication of the digital technologies used, and corresponding effects on productivity, efficiency, environmental and resource savings achieved. For example, the benefits of precision agriculture depend on the degree of intensity of the operation. Therefore, large-scale farmers who can afford hard precision agriculture operations will reap relatively more gains than small-scale farmers who have to make do with soft precision agriculture, in the best-case scenario. Regardless, soft precision agriculture can help small-scale farmers optimize yields and reduce costs even if to a lesser extent, by tailoring input applications to the real needs of specific locations, at the right time (Kendall *et al.*, 2017). Broadly speaking, while an average farmer in developed economies and large agribusinesses in Asia can afford drones to spray pesticides or have IoT-enabled irrigation systems, this is not the case among the overwhelming majority of farmers in the region, although some bottom-of-the-pyramid business models have emerged to deliver this kind of service to smallholders. For APAC small farmers, digital innovation does not necessarily refer to drones, artificial intelligence, big data or precision agriculture. For them more often than not, digital technologies help them get the basics right, such as access to markets, finance, advisory services and information through digital

<sup>394</sup> For more information, please see <https://ccafs.cgiar.org/blog/what%E2%80%99s-store-asian-smallholder-farmers-big-data-hype> last visited on 9 April 2020.

platforms, apps and social media (Đurić, 2020; World Bank, 2020).

Among the issues limiting the digitalization of smallholder farming are some structural problems, affordability issues, skills gaps and regulatory bottlenecks.

**Structural concerns regarding land tenure issues and connectivity in rural areas.** No farmer will invest in digital technologies if they do not own their land or have secure tenure. Farmers also need good connectivity. Generally, APAC producers have good access to smartphones and data services, and are also for the most part familiar with social media (FAO, 2018d). There are still some problems, though, regarding connectivity in farming areas in terms of both affordability and infrastructure, especially in the less-developed countries and locations. In Papua New Guinea, fixed and mobile Internet subscriptions only cover 11 percent of the population. Remote rural areas suffer disproportionately from poor connectivity.<sup>395</sup> Within countries, substantial differences in connectivity persist in remote areas and between genders. According to India's fifth National Family Health Survey released in December 2020, there is a growing digital divide among rural women: only 34 percent of Indian women in rural areas have ever used the internet, compared with 55 percent of men.<sup>396</sup> The existing socio-economic gender gap will keep widening with digital illiteracy, if corrective measures are not taken.

Addressing supply-side factors, such as expanding Internet coverage in rural areas and increasing the availability of digital applications in the region, could further facilitate the adoption of digital technologies by smallholder farmers, helping them to access farming knowledge and to connect with buyers and end

consumers directly (FAO, 2018d; FAO, 2019b; World Bank, 2020). In parallel, promoting the digitalization of smallholder farming requires also addressing demand-side factors, including affordability, complementary investments, trust, skills and knowledge (World Bank, 2020).

The region has an **affordability problem** when it comes to the adoption of digital technologies. Such barriers include expense and financial factors. The cost of digital technologies is a major factor limiting their adoption among APAC small-scale producers. For example, drones from a mainstream maker that meet the basic needs of small farmers start at around \$1,500.<sup>397</sup> A complete basic system for a small farm may cost \$5,000,<sup>398</sup> whereas a multi-device system with extra payload capabilities is in the \$15 000 to \$25,000 range.<sup>399</sup> The price increases steeply with technological complexity, as in the case of drones equipped with Laser Imaging Detection and Ranging (LIDAR) sensors that may cost between 60,000 to \$150,000, which means that only large farmers can afford them.<sup>400</sup> Additionally, for the more complex systems, operating costs can be as high as 25 percent of the capital costs per year.<sup>401</sup> The cost of GNSS-based auto-guidance in agriculture is also unaffordable for most small growers in APAC. Farmers can purchase either factory-installed or after-market GNSS equipment packages with costs ranging between \$5 000 and \$35 000, depending on the accuracy of the positioning sensors, the inclusion or not of a base station,

<sup>395</sup> For more information, please see <https://etradeforall.org/es/wef-this-pacific-island-is-working-towards-a-digital-revolution/>

<sup>396</sup> For more information, please see <https://www.dw.com/en/indias-digital-divide-grows-among-rural-women/a-55949074>

<sup>397</sup> For more information, please see <https://stir-tea-coffee.com/tea-report/longjing-drone-air-taxi/>

<sup>398</sup> For more information, please see <https://theaseanpost.com/article/drones-reviving-agro-industry>

<sup>399</sup> For more information, please see <https://stir-tea-coffee.com/tea-report/longjing-drone-air-taxi/>; <https://stir-tea-coffee.com/equipment-news/tea-drone-technology/>

<sup>400</sup> The LIDAR technology creates three-dimensional images of the fields and can alert users to drainage and soil erosion, pest and disease spreading, and can define land masses and elevation changes, as well as measure the height of plants in real-time. For more information, please see <https://stir-tea-coffee.com/tea-report/longjing-drone-air-taxi/>; <https://stir-tea-coffee.com/equipment-news/tea-drone-technology/>

<sup>401</sup> For more information, please see <https://stir-tea-coffee.com/tea-report/longjing-drone-air-taxi/>

and the level of compensation for unusual vehicle attitude caused by rolling terrain, among other factors.<sup>402</sup>

Another question is the opportunity cost of digital investments versus other investment options, such as irrigation, improved storage or cold chain infrastructure. Investing in cold-chain technologies has been shown to be a cost-effective way to connect farmers with higher value markets and reduce post-harvest losses, particularly in Asia where lower cold-chain capacity is a constant across many food chains (Skinner *et al.*, 2019). For example, whereas mature economies have post-harvest losses for fruits and vegetables of 5 to 10 percent, China's losses are estimated to be around 30 to 50 percent and India's is 30 to 40 percent (Skinner *et al.*, 2019). The cold-chain logistics market is poised to grow in ASEAN at a compounded annual rate of 13 percent between 2019 and 2024,<sup>403</sup> but will this buoyancy reach smallholder farmers and small traders or will it further deepen the existing divide? More improved storage, processing and cold-chain solutions are needed upstream and for farmers of all sizes to ensure a safe and reliable supply from farm to fork. These investments are also necessary to participate in e-commerce. But in order for these solutions to work they would need to be deployed at an affordable cost.

**Capacity building and regulatory issues** also hinder the dissemination of smart farming among smallholders. The human factor, including digital illiteracy alongside aspects related to risk aversion and a farmer's age, will crucially influence the adoption of digital technologies. At least in the early stages of implementation, farmers tend to distrust digital technologies (FAO and ECLAC, 2020). There is also a lack of awareness and knowledge about e-agriculture options among small farmers,

as well as social differentiation in access and illiteracy in understanding and using these technologies. The use of digital technologies often requires more specific skills, and smallholder farmers are poorly positioned to acquire them compared to large-scale farmers (World Bank, 2020). Support to small-scale farmers, particularly women and youth, through skills development and entry cost can help lessen inequality risks.

As for APAC's regulatory landscape concerning smart farming and agritech in general, it is still in an early stage of development compared with other regions. The cost of regulatory compliance can be prohibitive and uncertainty makes farmers unwilling to innovate. A good example is that drone users need a pilot training/certification or license to operate them, on top of insurance and registration. Add to that the fact that analysing images generated by drones involves specific skills (FAO and ITU, 2018).

**After weighing the factors playing against or supporting the digitalization of smallholder farming, the conclusion is threefold:**

- i) Small farmers now have better access to digital technologies, but still not at scale.
- ii) The adoption rate of digital technologies by smallholder farmers will likely continue to lag behind that of large-scale farmers.
- iii) Unless properly supported, small farmers in the region will struggle to comply with the requirements that processors and retailers demand as part of supply-chain wide digitalization, such as using blockchain for traceability and provenance.

All of the above raises concerns over the risks of smart farming, together with smart food manufacturing and retailing, widening the economic and digital divide in the agrifood space. To close this digital divide, APAC governments need to step up their efforts to address both supply- and demand-side factors through a range of public policy actions (World Bank, 2020).

<sup>402</sup> For more information, please see [http://www.ipni.net/publication/ssmg.nsf/0/D73AB7FFCF893991852579E500780A1B/\\$FILE/SSMG-46.pdf](http://www.ipni.net/publication/ssmg.nsf/0/D73AB7FFCF893991852579E500780A1B/$FILE/SSMG-46.pdf)

<sup>403</sup> For more information, please see <https://www.mordorintelligence.com/industry-reports/asean-cold-chain-logistics-market>

#### 7.4.2. Challenges and risks for small-scale industries

A 2019 study by Capgemini Research Institute that analysed the adoption rate among industry leaders of Industry 4.0 technologies revealed that China and Japan were among the top three adopters, closely followed by South Korea and India. At the time, about one-third of the factories surveyed had already been transformed into smart facilities, and an additional 40 to 45 percent were planning to become smart in the next five years. Southeast Asia followed behind, with 40 percent of manufacturing leaders reporting good progress in terms of adopting digital technologies in their factories and processes.<sup>404</sup> For example, 30 percent of manufacturers in Thailand are already using robots.<sup>405</sup>

Despite effective adoption by large food manufacturers, many SMEs, which make up 98 percent of enterprises in most APAC countries, are underinvesting in engineering innovation and the adoption of technology (FAO, 2018d). For example, in Malaysia the digital adoption rate among manufacturing SMEs is approximately 20 percent, but it is considered to be much lower among those in the food industry (MITI, 2018). In fact, these technological innovations in food manufacturing in APAC could lead to a “winner takes all” outcome that will deepen the existing economic gap between large-scale food manufacturing firms and SMEs.

This is becoming more of a challenge in the current scenario where the evolving supply-chain dynamics demand the adoption of Industry 4.0 technologies. APAC food processors now contend with logistic and marketing constraints derived from the pervasive presence of e-commerce and the rise of omnichannel retailing (McKinsey and Company, 2017b). The resulting new food retail

model relies on advanced big data analytics that enable sharing real-time market intelligence with food manufacturers regarding product demand, trends and category gaps. But, being more reactive to retail changes calls for agile food manufacturing, which implies improving production and logistics processes to cope with shorter time-to-market requirements, increasingly complex inventory management needing alternative fulfilment methods, and advanced technologies to optimize the shelf-time of food products, all of which become easier with digital technologies. These developments are adding more pressure to small food manufacturers, and may potentially result in furthering the digital and economic divide.

The magnitude of the digital divide separating small and large food manufacturers will depend on the complex interplay of several factors.

**Awareness raising among SMEs** to help them realize that while Industry 4.0 technologies can cost more upfront, the benefits in the long run will exceed that investment. The relatively low adoption rate of Industry 4.0 technologies is due to some extent to the uncertainties on the part of the SME owners. They have insufficient knowledge about the technical background, business models and benefits involved, so that they remain restricted to well-known traditional concepts and solutions (IEC, 2015).

**The cost of digital innovations.** As digital innovations for food manufacturing are further developed on a larger scale and with affordable distribution, the upfront investment needed will be less of a barrier for SMEs.<sup>406</sup> Despite this trend, adopting Industry 4.0 technologies is still a costly

<sup>404</sup> For more information, please see <https://www.iaasiaonline.com/digital-disruption-for-smarter-food-manufacturing-in-asia/>

<sup>405</sup> For more information, please see <https://asianroboticsreview.com/home92.html>

<sup>406</sup> For more information, please see <https://apfoodonline.com/industry/digital-disruption-smarter-food-manufacturing-asia/>

affair for food manufacturing SMEs. It is not only a question of the initial investment, smart manufacturing comes with hidden costs such as constant maintenance and higher-paid employees. Small food manufacturers would require adequate incentives and funding options by both government agencies and private entities to afford the substantial investment required to develop and deploy advanced intelligent technologies and processes.

**Collaborative efforts between service providers of smart factory technologies and solutions and SMEs** that are the users and adopters will need to emerge. This can also contribute to reducing entry barriers for these firms (IEC, 2015).

**Public support** is needed to promote digitalization and overall competitiveness, and to address market failures and information asymmetries through business development services and financial support.

#### 7.4.3. Challenges and risks for small-scale food retailers

The food retail revolution and its underlying dynamics may signify that small-scale food retailers and traditional marketing agents that operate mostly offline are at risk of exclusion. The large food e-tailers have heavily invested in establishing e-grocery business models that are asset-heavy, including digital platforms, warehouse systems, and delivery fleets. E-grocery operations are intensive in terms of labour and marketing spending as steep competition erodes market share and customers can choose among many similar offerings. Omnichannel marketing is increasing competition among food retailers even further, favouring organized, formal food retailers that deploy O2O strategies, to the detriment of traditional stores and supermarket chains that have not jumped on the digital bandwagon. The latter not only miss the chance of capturing

more consumers online, but also incur more real estate, utility and personnel costs than their online competitors. In the APAC region, food e-tailers are visibly eating into the sales of retailers with only a physical presence. They are also precipitating the end of some modern retail formats such as hypermarkets, which enjoyed great success in China and other parts of Asia during the 1990s and 2000s. Consumers now favour high-end, physically close or online stores (McKinsey and Company, 2017b).

Traditional small-scale retailers and startups are finding it difficult to carve out a space that can be sustained over time.<sup>407</sup> This is particularly true in Asia, where the fierce competition among food retail giants is creating a highly concentrated e-grocery market where a few players hold substantial market power. On the other hand, e-commerce platforms can unlock the potential of SMAEs (World Bank, 2020). The power of e-platforms lies in, among other things, the vastly reduced search cost of matching SMAEs with consumers and other businesses. This process has the potential to sharply reduce past market failures and shorten value chains.

PPPs are also being established to provide digital support to SMEs involved in food retailing in the region.

<sup>407</sup> For more information, please see <https://digital.hbs.edu/platform-digit/submission/would-you-rather-lead-a-light-or-a-heavy-company/>



## BOX 10. E-COMMERCE IN CHINA AND MARKET POWER: A DELICATE BALANCING ACT

There is a great concentration of market power by just a few players in e-commerce in China. The three leading online retailers – Alibaba, JD.com and PinDuoDuo – accounted for nearly 80 percent of the total online retail sales in 2019.<sup>408</sup> In the fresh-food e-commerce market, the top five companies had a combined market share of 63.1 percent.<sup>409</sup>

Both Alibaba and Tencent (the main shareholder of both JD.com and PinDuoDuo) are integrated groups that mix retail, content, platforms, gaming, communications, messaging and social media not only in China, but all over Asia.<sup>410</sup> These companies have the resources to drive competitors out of the market through pricing strategies and privileged access to mobile pay solutions and social media platforms, if not through the sheer scale and efficiency of their AI-supported logistical networks. For example, foreign-invested supermarket chains have been driven out of the Chinese market because of their inability to compete with these firms that have fully integrated digital ecosystems that include self-owned mobilepay and social media applications. The extreme competition in the e-grocery segment has also resulted in the failure of at least 150 online grocery delivery startups in China alone in recent years.<sup>411</sup>

All of the above means that the big firm can dictate almost unilaterally the terms of engagement with other supply chain actors, including SMAEs. The effects of this concentrated market power are also felt in the rest of the region, as these companies are also funding dozens of new unicorns in this segment across APAC.

On the other hand, these e-commerce companies have opened up opportunities for SMAEs. For instance, the World Bank (2020) mentions that Alibaba has launched several initiatives in China “to become a one-stop shop for SMEs conducting business online, including online marketplaces, backend e-commerce merchant services, and a cloud-computing e-commerce platform.” Alibaba’s Taobao Marketplace launched the Rural Support Programme in 2014 in collaboration with the government to bring e-commerce to over 30 000 villages in China, opening up business opportunities for SMEs.<sup>412</sup> At Taobao’s core are service centres run by locally hired SMEs in rural communities, in collaboration with local governments.<sup>413</sup> These SMEs act as viable last-mile agents who offer agricultural, marketing and financial services that are more accessible for low-income rural customers, notably farmers (FAO, 2017c). These SMEs earn revenue from various purchase transactions of dozens of goods and services, including digital financial services, making their business sustainable.

Other digital companies in Asia, such as StoreKing and Paytm Mall in India, and Gojek and Grab in Indonesia, are implementing similar approaches to expand their rural coverage by recruiting diverse agents, including mom-and-pop stores and other SMEs.<sup>414</sup>

<sup>408</sup> For more information, please see <https://www.statista.com/statistics/880212/sales-share-of-the-leading-e-commerce-retailers-in-china/>

<sup>409</sup> For more information, please see [http://www.iresearchchina.com/content/details7\\_56071.html](http://www.iresearchchina.com/content/details7_56071.html)

<sup>410</sup> For more information, please see <https://ecommercechinaagency.com/the-new-retail-era-in-china/>

<sup>411</sup> For more information, please see <https://www.jumpstartmag.com/chinese-online-grocery-unicorn-missfresh-raises-us495m-series-f/>

<sup>412</sup> For more information, please see <http://www.fao.org/support-to-investment/news/detail/es/c/1069630/>

<sup>413</sup> For more information, please see <https://blogs.worldbank.org/eastasiapacific/e-commerce-poverty-alleviation-rural-china-grassroots-development-public-private-partnerships>

<sup>414</sup> For more information, please see <https://www.cgap.org/blog/how-e-commerce-transforming-idea-rural-agent>

**Table 18.** PPPs for providing digital support to SMAEs in Asia

Country	Private partners	Public partners	Other partners	PPP object
China	Alibaba and local SMEs that manage the Taobao digital service centres	Local governments		Establishment of SME-run Taobao digital centres that offer purchasing and delivering services (crops, agricultural inputs and machinery) and financial services (mobile payments, loans and insurance) through the Taobao digital platform.
Thailand	Lazada Group and Alibaba	Thailand's Office of SME Promotion, Ministry of Digital Economy and Society, Department of International Trade Promotion	Thammasat University and the University of the Thai Chamber of Commerce (UTCC), Thai Post	Provision of training to SMEs (including firms in food processing and retailing) on e-commerce and e-finance, and development of digital platform for SME, as part of Thailand SME 4.0 initiative.

**Source:** Own elaboration.

There are, however, a few startups that enable the digitalisation of mom-and-pop shops, such as Warung Pintar,<sup>415</sup> which allows thousands of traditional small stalls known as 'warung' in Indonesia to sell staple food items at their digitally-enhanced kiosks. 'Pintar' means smart.

#### 7.4.4. Challenges and risks for SMEs in the extended value chain

Despite the talent and motivation of their founders, many startups will inevitably fall by the wayside particularly during the first years of life (Voutier, 2020). The competition is getting tougher because of new entrants, large players in particular, in the already crowded digital farming space. Today, the APAC region is one of the world's most dynamic markets when it comes to digital farming and online food commerce. This booming market is attracting numerous multinational players to invest in smart farming in the region, raising concerns

over risks of local and regional agritech startups being crowded out. APAC agritech startups have to compete with later-stage enterprises entering the market with far greater financial muscle, R&D budgets, networks and technical expertise. These entrants are not only based in the USA and Europe, but are also large-scale Asian tech companies, notably from Japan and China, which are expanding their operations in other countries of the region.

However, local startups have a better understanding of what smallholders really want and need from these digital tools. They know the local language, the traditions, the regulatory and policy framework, and the idiosyncrasies of farmers and other value-chain actors. They are also aware of the role that the younger generation can play in pushing the digital agenda. Accordingly, most of them have based their outreach strategy around giving valuable incentives to youths to facilitate marketing, particularly through social media.

Nonetheless, agritech startups providing digital services to farmers in the region commonly face problems regarding

<sup>415</sup> For more information, please see <https://warungpintar.co.id/>

monetization, customer acquisition and scaling up. Their strategies to overcome these issues typically include shifting to a digital marketplace model, whereby the provision of a [free] information and advisory system is bundled with the sale of products through their online platform, generating revenue. Another strategy is securing and scaling up partnerships with government institutions and development programmes. The problem with these strategies is that later-stage companies are doing exactly the same things, but with more resources, greater economies of scale and more visibility that may tip the scales in their favour when it comes to entering into partnerships with the public sector.

Against this backdrop, public support for these startups is of paramount importance to level the playing field. Equally significant is for APAC governments to be diligent in their selection of private partners for the delivery of digital (or O2O) services to smallholder producers. Should they choose to collaborate with large multinational companies entering the APAC digital farming market, they need to ensure that their partnerships do not result in local firms and entrepreneurial talent being crowded out. A good practice seems to be to pair the capabilities of big tech, big agro or big financial companies with the localized knowledge of startups and other organizations on the ground that are well positioned to design products that serve the needs of farmers in their region and business models that will work given local conditions.

#### **7.4.5. Challenges and risks facing consumers**

Consumers are affected by the increased concentration of market power in the hands of a few digital marketplaces and service providers, and by the uncertain long-term impacts on their health of new technologies such as cellular agriculture. They are also increasingly struggling to control the personal data they share with organizations and how

organizations use that data. The digitalization of production and marketing processes within food value chains increasingly depends on monopolistic or oligopolistic markets for big-data platforms.

## **7.5. CHALLENGES AND RISKS FACING THE REGION'S FOOD SYSTEM**

Changes and risks in the region's food systems are manifold. Among them are exclusion, an over-concentration of service providers and potential over-concentration of market power. Other negative impacts deal with potential job losses for some activities, data governance concerns such as lack of data privacy and cyber security breaches, and a negative environmental footprint.

### **7.5.1. Unintended consequences for the environment**

Food and agricultural systems use several technologies that degrade natural resources. They rely on intensive production systems that focus exclusively on productivity while ignoring environmental aspects. For instance, the surge of food e-commerce is also associated with increased carbon emissions, waste and intense use of resources.

Technological innovations are central to supply chain resilience but inertia and old mindsets often prevent their adoption. Agribusinesses and technology providers can work in partnership with farmers to support the adoption of more sustainable, environment-friendly practices. For example, food waste is estimated at nearly 80 kg of food per person each year in developed Asia and 11 kg in developing Asia (FAO, 2019c). This suggests that the amount of food and packaging waste depends on the level of economic development. Waste is linked to consumer lifestyles, and the prevailing long supply chains and mass retail model.

Food waste severely affects the environment in many ways. The per capita food wastage footprint is an average of 810 kg of CO<sub>2</sub> in industrialized Asia, and 350 kg of CO<sub>2</sub> in Western Asia and Central Asia, South and Southeast Asia (FAO, 2019c). Food losses and waste also have implications in terms of water footprint, especially taking into account that 85 percent of humanity's water footprint is related to the consumption of agricultural products, and notably those of animal origin.<sup>416</sup> With such high rates of food waste contributing to food insecurity, hunger and GHG emissions, companies of all sizes are tackling food waste throughout the supply chain across the APAC region by introducing innovations to minimize waste and upcycle sidestreams into valuable products. Opportunities exist for industry to collaborate to tackle food waste and turn it into something of value.

Further developing bio-technologies and systemic technologies such as precision agriculture and agro-ecology can reduce the impacts of food and agricultural systems on the environment. Research on their development, limits and potential drawbacks is ongoing. It is important to ensure that safety and other aspects are properly addressed early on. It is essential to bring developing countries and small-scale value chain players along to avoid a technological divide whereby only rich nations, large farmers and firms can take advantage of new solutions. This could further exacerbate disparities in productivity and markets access.

Governments and corporates should also consider that **digital technologies have their own carbon footprint**. The share of digital technologies in global carbon emissions increased from 2.5 to 3.7 percent between 2013 and 2018.<sup>417</sup> Every digital device potentially contributes to digital pollution and the demand for increasingly scarce raw production

materials, such as lithium and heavy rare earths (UNIDO, 2017a). Farmers, food processors and retailers need to examine the environmental trade-offs of their digital solutions.

One area where it is **critical to reduce energy utilization and carbon emissions in food-manufacturing operations**. Global food processing and distribution activities consume roughly the same amount of energy as the entire United States consumes in a year, according to Ladha-Sabur *et al.*, (2019). The food industry is indeed energy-intensive. Many factories have high process-related thermal requirements independent from daily and seasonal weather-related fluctuations (Sipilä, 2016).

**Packaging** also contributes to the unsustainable use of natural resources and environmental waste. In 2016, the global food and beverage industry used a staggering 3.13 trillion units of retail packaging, or 92 percent of all retail packaging volume. Most of this was not recycled.<sup>418</sup> With increased online ordered home deliveries because of the COVID-19 pandemic, it is reasonable to assume this number has soared. Discarded plastic food packaging is particularly damaging if not disposed of responsibly and kept in the circular economy. It is critical to minimize the impact of food-product packaging, in addition to encouraging innovation in packaging technology and design for environmental sustainability.

Digitalization may be an ally of sustainable packaging. For example, e-commerce reduces the need for inventory stocking and paper-based advertising. Smart or digital printing has less environmental impact than traditional printing. It saves time and materials at set up, allows for cost-efficient short runs, and offers a streamlined process for ordering and customizing food packaging. Furthermore,

<sup>416</sup> For more information, please see <https://www.waterfootprint.org/en/>

<sup>417</sup> For more information, please see <https://en.reset.org/knowledge/our-digital-carbon-footprint-whats-the-environmental-impact-online-world-12302019>

<sup>418</sup> For more information, please see <https://www.digitalistmag.com/improving-lives/2019/07/24/power-of-sustainable-packaging-06199820>

food processors can now access real-time environmental data on conditions experienced by food packaging solutions during the journey from the plant to the store. Using that data, they can collaborate with the packaging industry to develop more efficient and greener packaging specifications with improved mechanical and barrier properties. In addition, they could create a digital twin of the value chain to track the packaging performance, recycling and reutilization. However, e-commerce logistics generate larger volumes of packaging waste than conventional commerce, along with carbon emissions through freight transport for rapid deliveries and returns (Bjerkan, Bjørgen and Hjelkrem, 2020).

Although the above measures are mostly private sector driven, APAC governments can help maximize the environmental potential of Industry 4.0 by responsible policy design, partnerships, supporting standardization, and providing incentives for food manufacturers. In particular, they should provide financial and technical support for SMEs to adopt green manufacturing initiatives (UNIDO, 2017a).

### 7.5.2. Unintended consequences for employment along the value chain

Agriculture employs more people than any other sector in many countries in the region, accounting for an estimated 41 percent of total employment in South Asia, 38 percent in Pacific island small states and 27 percent in East Asia excluding high-income countries.<sup>419</sup> The food system also accounts for a large share of manufacturing and services jobs (World Bank, 2020). The capacity of the food system to generate employment is affected by the ongoing digital transformation.

Efficiency increases generated by digital technologies can result in potential job losses in the food sector (UNIDO, 2017a). This risk cuts across all segments of the economy, including the food system. The use of robotics or (semi-) autonomous machines will enable farmers to save labour costs (Prause *et al.*, 2020). The World Bank concludes that digital agriculture's impact on employment is: it depends.<sup>420</sup> In the majority of APAC countries labour is cheap and capital relatively expensive, although this is changing. The agricultural sector is dominated by smallholder farmers who tend to their plots themselves or with support from family members. In that context, it is unclear whether these small-scale farmers will find it cost-effective to adopt Agriculture 4.0 technologies in the short term, particularly those that replace their own labour or the casual workers they seasonally employ. Over time, though, they can gradually adopt cheaper and appropriate technologies that could contribute to a shift in employment out of the sector.

Conversely, in countries where capital is relatively cheaper and labour costs are increasing, such as China and Japan, the adoption of these technologies is more appealing for farmers and firms. In this case, Agriculture 4.0 might lead to job losses in the agricultural sector (Carolan, 2019) and increased migration from rural communities to urban centres (Rotz *et al.*, 2019). For example, farms between 100 and 400 hectares, which are common in APAC, hold the largest market share of precision planting and seeding equipment, which is growing at over 5 percent annually.<sup>421</sup> Although this technology allows farmers to improve their production levels and to achieve substantial cost savings, it also has implications for on-farm employment.

<sup>419</sup> For more information, please see [https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?name\\_desc=false](https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?name_desc=false)

<sup>420</sup> For more information, please see <https://blogs.worldbank.org/jobs/farmer-ex-machina-digital-agriculture-beginning-end-agricultural-employment>

<sup>421</sup> For more information, please see <https://www.marketsandmarkets.com/pdfdownloadNew.asp?id=96394217>

The adoption of automation, IT systems and other Industry 4.0 tools in Asia's food industry will likely have a negative net impact on employment (Cézanne *et al.*, 2020). Redundant workers could in theory be absorbed by other industries, but these automation and digitalization processes are happening across the board in all industries. The challenge remains to get labour productivity and salaries/wages to poverty alleviating levels. Conversely, this deep transformation of the industry and the workforce could also lead to new employment opportunities, but many current jobs may be displaced or necessitate new skills to adapt to automation and AI (World Bank Group and DRC, 2019). This possibility highlights the need to retrain staff to adapt to the digital environment. The number of jobs might not be reduced, but instead their content and style might change towards more flexible and innovative working modes. While medium-skill routine jobs may disappear, jobs related to robot or PLC programming and other engineering tasks may be in high demand. The solution to building the skills of the food-manufacturing workforce may come from the digital technologies themselves. For instance, intelligent assistance systems could be implemented to facilitate the transfer of knowledge among workers and enable them to focus on creative, value-adding and knowledge-intensive activities and limit routine and stress-intensive tasks (IEC, 2015). Digital technologies are also making inroads into tasks and jobs that were considered non-automatable in food factories only a few years ago.

The current wave of Retail 4.0 technologies has begun to create jobs within and beyond the food retail sector. For example, food e-commerce has given rise to growth in related areas such as package delivery and other logistics activities (MGI, 2016). However, many authors have raised hard questions about the quality of these jobs in the so-called gig economy, which can leave workers open to exploitation and low wages (Hill, 2015; Sundararajan, 2016; Kalleberg and Dunn, 2017).

A related factor is the need to strike a balance between food-system wages and capital gains. Remunerative employment opportunities all across the food system have to be ensured, while equitable profit sharing is required for capital owners. This issue is gaining relevance in light of the ongoing capital intensification of many production processes within and outside agriculture, increasingly relying on automation, big data, e-commerce and innovations implying intellectual property rights.

In conclusion, the adoption of these 4.0 technologies in food and agricultural systems raises challenges for governments, companies, and individual workers to harness their power and at the same time prepare for the substantial transformation of work that they imply, including job destruction and shifts in the nature of work, skills, occupations, and wages (MGI, 2017b). Additional concerns stem from the fact that labour costs reduce as food manufacturers adopt automation and advanced robotics. Their proximity to consumer markets, access to resources, workforce skills, and infrastructure quality assume more importance, which might lead to a decision to relocate (MGI, 2019a).

Efforts are ongoing to promoting better employment opportunities by providing training in digital technologies, and addressing key challenges related to jobs in the gig-economy. These include providing benefits, income-security measures, and training and credentials. Another solution would be to eradicate unfair practices in hiring workers in agricultural and food value chains through smart employment contracts. Smart contracts are both immutable and public because they rely on blockchain technology. They could help improve the conditions of agricultural and food workers across the region (FAO, 2020f). This innovation could be particularly impactful to improve the fairness of seasonal labour markets, which are common in the region's agricultural sector and often known for their unfair hiring practices.

Smart employment contracts could reduce costs and increase transparency. FAO (2020f) postulates that through these blockchain applications, smart contract information could be made available to the employer, employee and legal authorities, such as welfare and social insurance programmes, and immigration departments. This information could also be critical for companies looking to ensure that their value chain partners treat their workforce in a fair and ethical manner (FAO, 2020f).

### 7.5.3. Data governance issues

Utilizing big data enables food system actors to make real-time innovative decisions. At the same time, there are also concerns surrounding data governance, namely who controls and owns food system data, and how can data acquired by digital technologies be stored, accessed and used safely. For example, private companies can gather extraordinary amounts of data on farming practices through remote sensing by satellite and drone imagery and through their digital applications and data storage platforms for farmers. These enterprises could potentially misuse the data in many ways, including making the data available to third parties (World Bank, 2020).

Along the same lines, with the rise of e-commerce, consumers are also increasingly concerned about their online privacy, including the collection of their biometric data and other personally identifiable information by food processors and retailers (World Bank, 2020). Farmers, SMAEs and consumers are often reluctant to share their data because they feel it might be unsafe due to privacy and security issues. A key challenge for policy makers lies in finding a balance between protecting the privacy and confidentiality of food system 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 the sector (Jouanjean *et al.*, 2020).

One of the core principles of data governance is that farmers, consumers and other vulnerable food system stakeholders should be able to control both the personal data they share with organizations and how organizations use that data. However, the digitalization of production and marketing processes within food systems increasingly depends on monopolistic or oligopolistic markets for big-data platforms. The e-platform business model is capable of extracting and controlling immense amounts of data on production and consumption processes along the food value chain, provided through the use of mobile phones, geo-localization, social media, credit cards and all other sorts of digitalized transactions (Nosthoff and Maschewski, 2020). With this shift, APAC food systems have seen the rise of large transnational corporations that manage such data, potentially leading to an overconcentration of market power (World Bank, 2020; Nosthoff and Maschewski, 2020). Rules governing data ownership and use within food systems in the region rarely take into account the implications of these technological dynamics and concentration, and as result are often inadequate and incomplete (World Bank, 2020).

Jouanjean *et al.*, (2020) warns policymakers that unclear and unequal data governance arrangements may leave smallholder farmers feeling disempowered, hence weakening their willingness to adopt digital solutions. They add that, in turn, this may limit the availability and accessibility of food system data for policymaking and developing services for farmers. Likewise, poor data governance mechanisms can also erode the confidence of consumers in digital innovations and agribusinesses. Policymakers need to make sure that governance mechanisms and business models still allow small actors, including farmers, to own their own data.

Furthermore, coming to terms with the dramatic shift in data-driven agriculture involves understanding the inherent limitations of big data. This includes the lack of standardization in the digital solutions in relation to data, which generate problems with data use because of the disparate formats, and the risk of data inaccuracy and biases. While data can be used to tell remarkably deep stories with complex visualizations, their apparent sophistication and precision can effectively disguise a great deal of inaccuracy (Nijhuis, 2017). Data-based claims can be fallible, particularly if the algorithms they are based upon are hoodwinked by meaningless correlations or reflect the cultural biases of their programmers.

There is a dearth of legislation covering the collection, sharing and use of data in agriculture, both globally and in the APAC region. This leaves farmers and other vulnerable actors unprotected in the face of challenges such as data ownership, data rights, data privacy, data security and definitional issues such as whether all or some farm data should be considered personal. Strengthening regulations for the independent generation, storage, use, dissemination, property rights and confidentiality of big data in the region's food systems are required. APAC governments should devote more efforts to develop workable arrangements that give farmers sufficient confidence about data privacy and which are not overly restrictive for service providers (World Bank, 2020). Open data approaches can also be used to allow any actor in the food value chain to have access to relevant data under equal and non-discriminatory terms (Jouanjean *et al.*, 2020). Furthermore, public sector capacities need to be built on data harvesting, storage, management and control to ensure independent, transparent and accountable data generation, validation and utilization processes within food and agriculture systems, and their conversion into statistics. These measures should be accompanied by public campaigns to raise

awareness on the topic among farmers, SMAEs, consumers and civil society (World Bank, 2020).

These data governance issues are not unique to agriculture and food systems. Addressing them requires improving data practices, strengthening policies, and fostering coherent implementation and enforcement across sectors and countries in the region, and globally. Concurrently, APAC governments need to assess how existing regulatory arrangements affect food systems and ensure that broader data policies are applied in a more tailored way to meet the specific needs of food systems. Governments should determine whether there are persistent gaps in existing data governance arrangements for agriculture and food systems and improve communication around policy and regulatory frameworks for data governance to build confidence in the use of digital solutions, especially among farmers and consumers (Jouanjean *et al.*, 2020).





# 8. INNOVATIVE POLICY SOLUTIONS FOR INCLUSIVE AND SUSTAINABLE VALUE CHAINS

## 8.1.

### **INNOVATIVE POLICY CHOICES FOR INCLUSIVE AND SUSTAINABLE FOOD VALUE CHAINS**

In APAC, smallholders cultivate approximately 90 percent of all farms (Teng *et al.*, 2015; IAP, 2018), and average farm size keeps declining over time (FAO, 2018d). They provide up to 80 percent of the food supply in Asia (FAO and UNDP, 2016). Smallholders face coordination and aggregation problems, high transaction costs and struggle to meet downstream consumer requirements, especially those regarding food quality and safety.

This situation calls for comprehensive pro-smallholder farmer policies in the region. Such support has traditionally taken the form of policies, strategies and programmes to support collective action through cooperatives and producer groups, in recognition of the benefits of aggregation they deliver. The main goal of such support was to increase the bargaining power and capacity to innovate of agricultural cooperatives and producer associations, which help them to negotiate fairer terms and stay competitive.

Policy support to producer organizations requires multifaceted and coordinated actions by the government, the private sector and civil society (FAO, 2020f). The effects of these initiatives have been quite remarkable in some instances. In India, for example, the number of

producer organizations has been growing by nearly 18 percent per year, in part because of the improved intra-organizational transparency derived from government-led electronic trading platforms, which are now used by about 30 percent of these organizations (McKinsey and Company 2019a).

In recent years, governments across APAC have complemented this traditional support to smallholder farmers with a series of innovative measures that aim to strike a fairer balance in food chains. The way that food system and value chain policies are made and priorities are set needs to change. Without change, much-needed technological innovations will not reach their full potential. It is necessary to scale up ongoing efforts to reach more value chain actors. Furthermore, not all issues can be addressed through viable business models. Policies and regulations are vital to help shape markets for development so that incentive systems, trading schemes, and other initiatives that influence markets strengthen the capacity of entrepreneurs and communities to innovate (SFI, 2019). Consequently, APAC countries are putting in place policy and regulatory solutions that aim to upscale innovations in agricultural value chains, while promoting inclusion. These policy solutions will also be essential for offsetting the negative impacts of innovations on the sustainability of food systems.

First of all, it is of paramount importance to **scale up innovations in food and agricultural value chains**. This will require addressing supply-side factors, such as low rural network coverage and availability of digital applications, and demand-side factors, including the need for better skills and knowledge, trust, affordability, and the absence of complementary investments. APAC Governments need to invest in critical infrastructure, such as Internet and transport connectivity, value chain storage and cold facilities, collection centres and laboratories.

The intricacy of the issue calls for a **food policy framework** that underscores the different strands of policies and the complex interactions between them. Taking inspiration from the integrated policy framework proposed by IPES-FOOD in 2019, a policy framework has been built around three main objectives: 1) building shorter food value chains, 2) building fairer food value chains, and 3) rebuilding greener food value chains.

Attending to this framework, policymakers can find vital **insights on how to make food value chains and food systems more sustainable**. In this respect, the key underlying principle that engendered these innovative policies is to promote the internalization of the hidden costs of current food production systems, and notably of social, environmental, nutrition and health externalities. For example, imposing a sugar tax – an innovative nutrition-sensitive legislation to reduce the consumption of sugar – is a means to foster the transition away from conventional low-cost food value chains that emphasize the delivery of cheap calories through mass production and trade. These need to be replaced by a true-cost food system that focuses on reducing health externalities and on providing incentives to value chain actors to produce and consume sustainable, healthy food (IPES-FOOD, 2019). Yet, this true-cost system may be unaffordable for the poor.

A critical pro-environment innovation in food policy is the adoption of smart agricultural subsidies that aim to reduce GHG emissions,

and land and water degradation. By doing so, governments step towards correcting the economic distortions that were artificially making conventional farming more viable than agro-ecological farming. Sometimes, a single policy can address both health and environmental hidden costs. For instance, levying taxes on emissions-intensive foods, notably red meat, could avoid numerous deaths, while at the same time decrease GHG emissions and the use of natural resources (Springmann *et al.*, 2017).

The rapid and profound processes of globalization, consolidation and specialization have altered the interactions and power balance among the different nodes of modern food value chains (FAO, 2017d; FAO, 2018d). Consolidation in food and agricultural input and output markets has led to the concentration of market power in increasingly fewer companies. This holds true for various domains: from crop seeds and agricultural chemicals, to veterinary pharmaceuticals, agricultural machinery, fertilizers, livestock genetics, food processing and commodity trading. For example, approximately 80 percent of food sold by supermarkets is processed and made by a decreasing number of manufacturing firms (OECD, 2014).

The ensuing pressure has been transferred disproportionately to farmers, agricultural and food workers, and consumers (FAO, 2018d; IPES-FOOD, 2019). Food-system wages have been lagging behind that of other sectors (IPES-FOOD, 2019). Consumers have also been adversely impacted by the persistent power imbalances and lack of transparency in food value chains, notably in relation to price volatility and value distribution (IPES-FOOD, 2019). More significantly, consumers now pay around 30 percent more for their food than in the 1990s.<sup>422</sup> Yet, these increases in food prices have not benefitted farmers (FAO, 2018d;

<sup>422</sup> For FAO, 2020. FAO food price index in nominal and real terms. FAO web site, visited on 3 September 2020.

IPES-FOOD, 2019). To the contrary, their revenues have decreased as the price of agricultural commodities have become progressively decoupled from consumer prices (Giovannucci *et al.*, 2012).

For all these reasons, food value chains have become less and less fair. At the core of this is the fact that just a handful of midstream and downstream companies capture the lion's share of the value created. The fewer but larger retailers and manufacturers that have emerged from the consolidation and concentration of the food sector now wield unprecedented market power over producers. They can negotiate lower prices for agricultural commodities, and decide with whom to work – mostly large-scale preferred suppliers, to the detriment of smallholder producers (Giovannucci *et al.*, 2012). According to FAO (2013), this trend is exemplified by the surge in recent years in contract farming as the preferred model of agribusiness firms – at least in modern market channels – in a number of value chains that are especially suitable for large-scale operators, such as livestock and high-value horticultural products. In FAO (2013), Da Silva and Rankin provide evidence of the preference for procurement from larger and wealthier farmers, with a limited number of companies engaging in large-scale contracting of smallholder farmers for many commodities in the region. This hinders the ability of small farmers not only to get paid for the full value of their produce, but also to access higher-paying markets (OECD, 2014).

By the same token, SMAEs are more prone to face unfair trading practices in business-to-business relationships with large operators in the chain because of their relatively weaker bargaining power and limited alternatives for getting their products to consumers (IPES-FOOD, 2019). Whereas some countries and regions – notably, the European Union – have issued some regulations in recent years to prevent these practices throughout the food

supply chain,<sup>423</sup> APAC has not done much in this respect so far.

The digitalization process sweeping across Asian food chains is amplifying existing challenges. As a result, large-scale digitalized companies are changing the face of food production, processing, retail and delivery. While leading to remarkable gains in efficiency, these changes have been achieved in some cases at the expense of inclusiveness and equitability, as exemplified by zero-hour contracts and unfair wages (IPES-FOOD, 2019). Likewise, the increased investments in mechanization and digitalization of primary production have commonly led to lower participation of farmers in the net gains of production and to growing concerns about job quality and job destruction in rural areas (IPES-FOOD, 2019).

In light of the rising inequity of food systems, APAC countries are devising innovative policies and programmes to move towards more balanced relations among food value chain actors and a fairer distribution of added value. The rationale behind these measures is mainly to level the playing field through the provision of support to organized smallholder farmers and SMAEs. Such support can include initiatives to support small-scale farmers to aggregate supply, add value to their production, help them comply with food safety and hygiene measures, and access public procurement contracts. APAC countries should adopt institutional procurement programmes that source from small-scale producers, and digitalization programmes targeting these actors (IPES-FOOD, 2019).

But two words of caution are needed. First, the policies that affect APAC food value chains and food systems are many and have been developed in an ad hoc, non-integrated manner over decades, both at national and regional levels. As a result, there are numerous gaps,

<sup>423</sup> For more information, please see <http://www.fao.org/family-farming/detail/en/c/1116478/>

inconsistencies, and contradictions between them. For example, recently adopted anti-obesity strategies coexist with non-smart agricultural subsidies and agritrade policies that make unhealthy food inexpensive and convenient.

Second, the economic, social and environmental trade-offs between the impacts of these policies on the different nodes of the food chains – farmers, processors, retailers and consumers – are not always understood. Digital innovation and the other innovations won't automatically deliver win-win-win strategies. Further research is needed to clarify the implications of innovations for dietary shifts, and the potential trade-offs regarding climate change mitigation and use of natural resources, and water in particular (Muller and Schafer, 2017; IAP, 2018). Chances are that policies designed to protect vulnerable stakeholders will actually deprive them of power even further if value chain dynamics have not been adequately factored in. As a consequence, vital food system priorities may fall through the cracks, and spiralling socio-economic and environmental costs may fail to translate into effective policy responses.

## 8.2.

### POLICIES TO FOSTER PRO-INCLUSIVE INNOVATION

**Making innovation in agricultural chains more inclusive** will necessitate addressing existing market failures (i.e. exclusion, job losses, data concerns and negative environmental impact) by implementing incentive systems, trading schemes, and other measures that strengthen the capacity of farmers, entrepreneurs and communities to innovate. What is needed is a combination of traditional support to smallholder farmers and agro-based SMEs. This includes support to aggregate supply, add value, ensure compliance with food safety and hygiene measures, subsidies, better access to appropriate financial products and access to public procurement contracts. Innovative measures that aim to strike a fairer balance in food chains are also necessary.

#### 8.2.1. Expand Internet connectivity and build digital capabilities

APAC governments need to improve Internet connectivity in rural areas. They need to build digital capability and broader skills development through support to smallholder farmers, small entrepreneurs, youth, women, and other vulnerable groups. The first step involves expanding and strengthening digital infrastructure, often in partnership with the private sector, as highlighted in national e-agriculture strategies, such as in Bhutan and Sri Lanka (FAO, 2019). One innovative measure is the establishment of 'digital village' programmes. These create Internet-connected villages where residents can receive various e-services from government or private players. The importance of this topic is acknowledged in FAO's 1 000 Digital Villages Initiative.<sup>424</sup>

<sup>424</sup> For more information, please see <http://www.fao.org/director-general/news/news-article/en/c/1320506/>

## BOX 11. DIGITAL VILLAGES IN ASIA AND THE PACIFIC

A digital or smart village is an Internet-connected village where residents can receive various e-services from government or private players. This concept is a gateway to rural development that seeks to improve people's lives through the use of ICT solutions and applications agriculture and commerce, but also mobility, health, tourism and education, among others. It can also help address the connectivity gap between the urban and rural segments of the food value chain, thus enabling disintermediation (EC, 2019; ENRD, 2019). Although the main focus of smart villages is on digitalizing rural areas, e-platforms and the data economy can also stimulate the use and roll-out of precision farming and other digital technologies by small- and medium-sized farmers, and can help them connect more directly to markets, getting a better price for their products (EU, 2018).

Digital village interventions can have different components, including the following:

- Ensuring access to fast Internet, including fibre-optic broadband and high-speed Internet access reaching the local areas
- Providing a range of services that can span from Internet connectivity to digital marketplaces and communication, e-banking and mobile payments, e-government services, among others
- Providing training and on-job skills for entrepreneurs and service users, such as farmers and household members
- Mechanisms need to be in place for involving local stakeholders in the identification of digital needs and in the co creation of digital solutions.
- Promoting cooperation with other digital players in wider regional and national food systems, and digital/innovation ecosystems. For instance, e-commerce companies can help local farmers and villagers to market local products and enable farmers to use the new media platforms to share and exchange data and information with buyers, customers, suppliers, and government agents.
- Engaging intermediaries, brokers and 'spaces' to support a digital transition, such as digital hubs, fab-labs, co-working spaces, living labs and other intermediate bodies can help to develop local capacity to innovate (ENRD, 2019; ADB and IFPRI, 2019).

Asia has taken an enhanced interest in the digital village concept in recent years. China, India,<sup>425</sup> Japan, Malaysia, South Korea, and Thailand have piloted different variations of this model. China is one of the leading promoters of digital villages focused on expanding e-commerce and farmers' connectivity to markets and urban consumers (ADB and IFPRI, 2019). Some examples worth-highlighting are:

<sup>425</sup> For more information, please see <https://www.digital-village.in/>

In rural **China**, the number of Taobao digital villages that engage in e-commerce with at least 100 active online shops has increased from 20 in 2013 to 4 310 in 25 provinces as of August 2019.<sup>426</sup> These digital villages offer purchasing and delivering services, through the Taobao e-commerce platform, that enable farmers to sell their products directly to urban consumers and to buy high quality agricultural materials such as greenhouses and machinery. They have access to financial services offered by Ant Financial, Alibaba's financial spin-off, which operates digital payment services and provides agricultural loans and insurance services (FAO, 2017c). Through Alibaba's big data, farmers can analyse consumer preferences to optimize their product mix and their production calendar. They also receive training to become live-streamers to better market their products, and expand and upgrade their businesses.

**Malaysia** is pursuing a smart village initiative as part of the Ministry of Rural Development Policy 2030. Through a private-public partnership with the telecom company ONE TM, it will install high-speed Internet infrastructure and digital technologies centres in up to 15 000 villages.<sup>427</sup> This will help villagers to access digital marketplaces to sell their products.

**Thailand**, through its Net Pracharat programme,<sup>428</sup> is investing in broadband network and digital community centres in villages nationwide to facilitate access to online marketing and banking to rural dwellers across the country.

In **Indonesia**, the digital village project in Indramayu Regency (West Java) aims to digitize over 5 000 villages equipped with wireless networks, social media accounts, and e-commerce systems for agriculture- and fisheries-related activities such as catfish production.<sup>429</sup>

**Bangladesh** is also moving steadily to install digital centres in villages as part of its rural digitization drive. One example is the Pajuliya E-Village near Dhaka, established in 2017 as a partnership<sup>430</sup> between the public Bangabandhu Sheikh Mujibur Rahman Agricultural University, a Bangladeshi not-for-profit policy R&D institute the Centre for Research and Information, and a Chinese IT firm named Isoftstone. The partnership aims to develop a digital information and advisory platform with field sensors and a smartphone app to give Pajuliya farmers timely information about soil, environment and crop health, and tailored advice on the use of pesticides, fertilizers and irrigation. Following the successful rollout of the app, the e-village project is set to be replicated in other districts, and to also cover fisheries and livestock value chains.

<sup>426</sup> For more information, please see <https://www.alizila.com/taobao-villages-driving-inclusive-growth-rural-china/#:~:text=After%2010%20years%2C%20the%20Taobao,according%20to%20data%20from%20AliResearch>

<sup>427</sup> For more information, please see <https://govinsider.asia/digital-economy/tm-one-inside-malysias-smart-village-project/>

<sup>428</sup> For more information, please see [https://netpracharat.com/Netpracharat\\_EN/one-page/](https://netpracharat.com/Netpracharat_EN/one-page/)

<sup>429</sup> For more information, please see [https://www.jabarprov.go.id/En/index.php/news/6923/Digital\\_Village\\_How\\_West\\_Java\\_Provincial\\_Government\\_Faces\\_Industrial\\_Revolution\\_4\\_0](https://www.jabarprov.go.id/En/index.php/news/6923/Digital_Village_How_West_Java_Provincial_Government_Faces_Industrial_Revolution_4_0)

<sup>430</sup> For more information, please see <https://cri.org.bd/2017/04/04/e-village-digitally-empowering-villages/>

should also include training in agricultural techniques, marketing, finance managerial skills, and the diffusion of information such as meteorological and market data. An often-successful practical measure is to increase farmers' and SME's exposure to innovative technologies and business models through exchange visits, digital exchanges and learning platforms.

In addition, it is essential to launch programmes aimed at supporting and leading research in agricultural technologies to help reduce barriers to widespread technology adoption on-farm. These should include enhancing the provision of e-agriculture services and developing mobile apps, social media and network solutions targeting farmers (FAO, 2019). For example, in South Korea, agribusinesses can obtain phytosanitary certificates generated, issued and sent in electronic form. Bangladesh, India, the Philippines and Viet Nam have online access to catalogues that inform farmers and retailers on the list of available and registered fertilizers, making it easier for extension agents to advise farmers (FAO, 2019b).

### **8.2.2. Increase the space for private sector activity**

Acknowledging the importance of the private sector and using public investments to help crowd-in private sector investment are key measures for improving digital services, infrastructure and skills in rural areas (FAO, 2020a; World Bank, 2020). Increased private-public collaboration can help infuse excellence and innovative attitudes along the food value chain, and unlock value for the grassroots level in areas such as mobile payments and credit, and e-commerce. This approach includes fostering public-private and corporate-startup collaboration to overcome the existing challenges to technology adoption at scale by smallholders. This includes mainstreaming the delivery of tailored digital advisory, e-commerce and fintech services at scale, and

transferring innovation and technologies to smallholder farmers (Rankin *et al.*, 2018; World Bank, 2020).

Increasing the space for private sector activity and using public investments to help crowd-in private sector investment are key measures for improving digital infrastructure and skills in rural areas, especially in the agricultural and food markets of developing countries (FAO, 2020f; World Bank, 2020).

To close the digital divide in smart farming in APAC, the public and private sector should collaborate to first identify which smart farm and off-farm technologies are more appropriate for small-scale farmers. For example, a low-cost farming drone with limited carrying capacity, and no cameras or communications equipment may be all a small farmer needs to carry out aerial surveys, light spraying, crop monitoring, tracking of water levels and weed growth. For small growers with less than 20 hectares, aerial imaging from drones could be a more cost-effective solution than satellite imaging. Drone-captured imaging is comparatively less expensive, but also presents added benefits such as higher image resolution, increased frequency, remaining functional despite cloud cover.<sup>431</sup> Substantial deployment among APAC small growers may require the downscaling of new technologies, whereby more applications need to be developed in local languages and tailored to fit small farms.

Another step would be to promote business models and initiatives that enhance the access of small-scale farmers to finance, knowledge and skills to understand and uptake these technologies. As mentioned earlier, the agriculture and food industry, both startups and large companies, is making headway towards finding profitable smallholder agritech business models. The priority would be then

<sup>431</sup> For more information, please see <https://stir-tea-coffee.com/features/drones-become-aerial-workhorses-of-tea/> and <https://stir-tea-coffee.com/equipment-news/tea-drone-technology/> last visited on 14 April 2020.



to pool resources through PPPs for innovation and technology transfer (IIT) that facilitate more efficient transfer of technology, as well as PPPs for the delivery of tailored digital farming services at scale to smallholder producers (Rankin *et al.*, 2018). In both types of PPPs, the benefits could be outweighed by potential risks pertaining to abuse of market power and consumer protection (CGAP, 2019). As the companies involved in these partnerships amass significant market power, they may be tempted to crowd out competitors offering superior products and services. They could also be tempted to lock farmers into services that are not in their best interest, but are profitable for the provider (CGAP, 2019). These issues have to be considered and safeguards introduced when designing PPP schemes.

The most common type of ITT partnerships is the development and commercialization of agricultural inputs, such as new seed and plant varieties with specific genetic traits such as pest and disease resistance, and climate adaptation. Another common type is partnerships designed to demonstrate and stimulate demand for new technologies, such as agricultural machinery, and adoption of advanced integrated farming practices including sustainable farming systems. Rankin *et al.*, (2018) documented several cases of IIT partnerships in the region including experiences from Indonesia, Pakistan and Thailand, where farmers play a key role. In some cases they are contract outgrowers for new seed varieties produced under buy-back agreements, in others they are participants in field trials of new varieties and prototypes, or they are adopters of new technologies. Under these ITT partnerships, the public partner gets access to cutting-edge technology, research methods and management skills required to move from research to commercial applications. Private partners, in turn, benefit from sharing investment costs, while tapping into extensive public extension services and other local technical skills, as well as transport and storage infrastructure (FAO, 2016a).

Such partnerships provide a framework for coordinating the partners' financial, R&D and governance activities of innovation systems into networks that enhance the demand-driven nature of research solutions and facilitate more efficient transfer of innovative technologies to farmers.

### **8.2.3. Facilitate the access of farmers and agro-based SMEs to e-commerce solutions**

This can be done by means of:

#### **Building the skills of farmers and SMEs to operate and manage e-commerce businesses.**

Digitally connected farmers, agricultural cooperatives, and sorting, packaging and processing enterprises can connect directly to consumers through online platforms, shared sale points, and smart logistics (FAO, 2020a). The first step in this direction is to develop strategies and programmes for ensuring Internet connectivity in rural areas and for building farmers' digital capability.

#### **Developing public e-commerce platforms for connecting farmers to markets.** An example is the Indian marketplace eNAM.

**Providing financial and credit support to smallholder farmers to help them cope with e-commerce requirements.** This support should not just be working capital but also needed investments in storage and transportation of agriculture products (ADB and IFPRI, 2019).

**Investing in storage and transportation for the development of e-commerce in agriculture.** For example, in China over two thirds of the farmers surveyed by ADB and IFPRI (2019) said the biggest barriers preventing them from engaging in e-commerce were the lack of storage and preservation facilities (particularly for fresh agricultural products) and logistics constraints, alongside the lack of necessary skills.

**Improving market regulations.** This should be to generate an environment conducive to the development of agricultural e-commerce, including efforts to tighten regulations on food safety, transparency and the safety of transactions, and develop dispute settlement mechanisms to build the trust of consumers in purchasing agrifood products online (ADB and IFPRI, 2019).

**Engaging in public-private-producer partnerships to move direct e-commerce initiatives forward.**

Farmers with online marketing skills and simple food products that do not need complex processing, packaging or cold chain could in principle sell their products directly to consumers with relative ease. However, not all smallholder farmers can be expected to attend to production issues and at the same time become experts in marketing their food products online. Indeed, Zhang and Hinrichs<sup>432</sup> note that a recent ADB study among farmers in Southeast Asia and East Asia found that only a small fraction of farmers with smartphones are using dedicated e-commerce applications. This obstacle can be overcome by getting the private sector involved. The private sector has a comparative advantage in expanding and adapting e-commerce and other platforms into food supply chains. This is why many governments in the region are offering incentives to, or partnering with, companies that source directly from local smallholder farmers through e-commerce platforms. Through such partnerships, governments can help promote shorter business models that provide a unique opportunity to reach farmers directly, bypassing the middlemen. Increasingly, thanks to digital platforms, they can help them scale up and become more sustainable and equitable.

**8.2.4. Encourage the shift to digital fintech solutions to revitalize rural areas**

This requires providing financial inclusion, insurance and jobs. Because of digital technologies, financial institutions can enter rural markets without establishing a costly physical presence, bringing financial inclusion to rural populations. ADB and Oliver Wyman (2017) posit that mobile money could close 40 percent of the unmet need for payment services and 20 percent of the need for credit. The same authors found that widespread implementation of digital financial services could increase GDP growth in Indonesia and the Philippines by 2 to 3 percent per year, and in Cambodia by as much as 6 percent.

Financial institutions can also use digital technologies such as blockchain, Earth observation, satellite rainfall estimates and remote sensing, combined with data to support index-based insurance programmes at lower costs. Therefore, they could reach millions of smallholder farmers, many of who were previously considered uninsurable. By 2030, big data-enabled insurance solutions could provide crop insurance to an additional 200 to 300 million farmers worldwide, generating 40 to 150 million tonnes of additional food valued at \$15 billion to \$70 billion (FAO, 2020b; WEF and McKinsey, 2018).

Digital technologies also allow for better access to appropriate financial products for SMEs in agricultural and food value chains, including but not limited to angel investors, venture capital, debt, equity, quasi-equity and crowdfunding (FAO and ECLAC, 2020; SFI, 2019).

Key actions identified on the policy front include: i) incentivizing the expansion of digital payments infrastructure and agent banking models; ii) advocating for digital and financial literacy programmes; iii) reducing the associated transaction fees; iv) passing regulations to foster the use of mobile technology for financial services, and to protect consumers, clarifying what constitutes “reasonable” interest rates and

<sup>432</sup> For more information, please see <https://blogs.adb.org/blog/how-covid-19-could-accelerate-digitization-food-supply-chain>

removing predatory and hidden fees; and v) addressing the different standards and licensing requirements by each country (ADB and Oliver Wyman, 2017; GrowAsia *et al.*, 2020).

Governments and development partners in the APAC region are setting the pace and providing much of the funding needed to enhance farmers' access to digital agriculture. Such efforts include measures for ensuring Internet connectivity in rural areas and developing mobile apps, social media and networks targeting farmers.

Some relevant examples of the latter were the Thai Government's application AgriMap or the Sat4Rice partnership supported by the Ministry of Agriculture of Viet Nam. Governments may use a combination of solutions that range from WhatsApp groups to online agroportals and other digital tools. By way of illustration, in India, mKisan is a popular government portal that offers a variety of mobile apps for agriculture, horticulture, animal husbandry and related fields.<sup>433</sup> Moreover, public extension agents often use videos produced by Digital Green,<sup>434</sup> a global NGO that harnesses technology and grassroots-level partnerships to empower smallholder farmers, to reach farmers in thousands of villages across the country. Also in India, the Department of Agriculture of Karnataka requests its agricultural development officials to use a WhatsApp group call "Baliraja" for regularly sharing information, messages and circulars with chain stakeholders. Through this group, farmers from different villages can seek and share agricultural advice, connect with experts in various fields and learn new practices (FAO, 2019b).

APAC governments are launching programmes to support and lead research in agriculture technologies, and are helping to reduce barriers to widespread technology adoption on-farm. They are also enhancing their understanding of farmer segments through digital intelligence to improve macro-decision policy-making and the design and implementation of their programmes and projects (chapter 5). Last but not least, they are recognizing the role that private investments can have in mainstreaming such services in the region. Consequently, they are facilitating the emergence of startups and other operators specialized in e-agriculture that provide good value, affordable smart farming services. In parallel, they are entering into partnerships with large firms in their efforts to offer digital farming services to a large number of smallholder farmers.

#### 8.2.5. Promote entrepreneurship programmes

Government support is needed to help farmers and startups become competitive with large-scale players, while at the same time fostering collaboration and partnership-based models to accelerate innovation. Several APAC governments are launching programmes to in various industries, including food and beverages:

- In 2019, Malaysia supported SMEs in the adoption of Industry 4.0 technologies by releasing its National Policy on Industry 4.0 (Industry4WRD). It allocated a budget of over \$1.2 billion to help businesses adopt Industry 4.0, of which \$480 million was allocated under the Business Loan Guarantee Scheme to incentivize SMEs to invest in these technologies (MITI, 2018).

<sup>426</sup> For more information, please see <https://mkisan.gov.in/>

<sup>427</sup> For more information, please see <https://www.digitalgreen.org>

## BOX 12. DEFINITION OF KEY AGROTERRITORIAL TOOLS

- **Business incubators** are enterprise development hubs that provide a common physical and/or virtual environment to nascent companies or startups, where they have access to shared infrastructure, business and financial services, networking, mentoring and coaching (FAO, 2017a).
- **Business accelerators** are for scale-ups or growth-stage enterprises (companies growing at 20 percent over the past three years), while business incubators specifically nurture startups (OECD and EC, 2007). Accelerators speed up the pace and intensity of the entrepreneurial support provided to these scale-up companies for a limited period of time (FAO, 2017a). They usually take an ownership stake in the company supported, often in the form of an angel investment, rather than collecting fees on the services or space provided (OECD and EU, 2019).
- **Agro-industrial parks** are centrally managed, physical platforms that offer infrastructure, logistics and specialized facilities and services to a community of tenants, formed by agribusinesses, service providers and research and knowledge institutions (FAO, 2017a).

- Thailand has slated over \$6 billion for robotics and logistics upgrades in ten targeted industries, including food manufacturing.<sup>435</sup> The Thailand 4.0 national strategy encourages Thai food companies to adopt robotics technologies into their manufacturing processes.
- Singapore launched the “SMEs Go Digital” programme in 2017, which subsidizes up to 70 percent of the cost of pre-approved digital solutions, such as robotics and IoT, and provides basic digital advice for SMEs.<sup>436</sup>
- China’s industrial strategy “Made in China 2025” (MIC25) supports ten core industries including food manufacturing to become digital leaders in the world by 2025 (Zenglein and Holzmann, 2019). By fostering the adoption of Industry 4.0 technologies such as robotics, power equipment and next-generation IT, MIC25 seeks to significantly increase the level of digitalization of these industries by 2020, and expects them to become fully digitalized by 2025 (State Council, 2015). MIC25 envisages financial tools to support the adoption of digital

technologies by food manufacturing SMEs, and direct funding for pilot projects (Zenglein and Holzmann, 2019).

Another measure involves the development of business incubators and accelerators to support agro- and food-based firms. Agro-industrial parks, and business incubators and accelerators are commonly used policy tools to support SMAEs (or a mix of SMAEs and large-scale firms) by providing them with access to R&D, advisory and mentoring support, and quality infrastructure, facilities and ancillary services (FAO, 2017a). By so doing, they generate positive externalities for the concerned SMAEs, creating a fertile ground for innovation and enhanced productivity (FAO, 2017a). While agro-parks emphasize the provision of agro-industrial, ancillary, knowledge-based facilities and services at a specific location, the incubator and accelerator model focuses on the “celebration factor” that encourages associated SMAEs to come up with creative solutions and take calculated risks (FAO, 2017a; UNIDO, 2019). These initiatives contribute to strengthening the entrepreneurial and innovation ecosystems that nurture agricultural and food system innovation and technology development and transfer (FAO, 2017a). They cannot, however, make up for a regulatory environment that is not conducive to the starting and operation of a firm, for example, an economy with a low

<sup>435</sup> Next-gen automotive, intelligent electronics, tourism for high-income tourists and medical tourism, agriculture and biotechnology, food processing, robotics, logistics, and aviation, including biofuels and biochemical. For more information, please see <https://asianroboticsreview.com/home92.html>

<sup>436</sup> For more information, please see <https://www.imda.gov.sg/programme-listing/smes-go-digital>

ease-of-doing-business score, or for the absence of early-stage investment (SFI, 2019).

These programmes can be sector-agnostic or sector-specific, such as specialized in providing support to agro-based companies (FAO, 2017a; OECD and EU, 2019). Industrial parks are often industry-agnostic, although in recent years there has been a shift towards food parks in the region. They can be not-for-profit, for-profit or hybrids. As business incubators and accelerators rarely achieve financial sustainability through revenue generated by service consulting or programme participation fees, government-affiliated entities working on these areas are more common in the region than for-profit entities (SFI, 2019). Even in developed economies, such as Japan or South Korea, they are largely dependent on government funding, sponsorship, or philanthropy (SFI, 2019). Some incubators, known as ‘academic,’ are based in universities and research centres and provide support to students or academic personnel to materialize their business ideas, often in collaboration with private sector firms (OECD and EU, 2019).

Agro-parks are widely popular in Asia, but not so much in the Pacific (FAO, 2017a). Under this generic term, there is a broad range of concepts that reflect the differences in the objectives, functions or forms of these parks. There are high-tech zones, such as the Gangwon Technopark in South Korea, which includes some food-tech companies. Some are industrial zones, for example Indian agro-industrial parks designed to attract and promote industries in downstream agricultural processing. Others are export processing zones, such as Bangladesh’s export processing zones, some of which include agribusiness. There are also special economic zones, free-trade zones, and so forth (FAO, 2017a; UNIDO, 2019).

In China, public support for e-commerce most often takes the form of sector-agnostic e-commerce parks where local and regional governments also offer rent and utility subsidies to firms operating there, besides the investments in industrial and ICT infrastructure (ADB and IFPRI, 2019). Sector-specific food park

initiatives in the region include the Mega food park programme<sup>437</sup> in India, promoted by the Ministry of Food Processing Industries (FAO, 2017a); the announced establishment of an agrifood innovation park in Singapore expected to be ready by mid-2021;<sup>438</sup> Thailand’s Food Innopolis<sup>439</sup> launched in 2016 (BOI, 2017); or the ongoing development of the Taizhou Sino Dutch Precision Agricultural Economic Park Project in China.<sup>440</sup>

Both incubators and accelerators are fairly common in India and China, and increasingly in Southeast Asia (FAO, 2017a). China has become the country with the most business incubators in the world, nearly 12 000 as of mid-2019, according to the Chinese Ministry of Science and Technology.<sup>441</sup> Several of these host agritech or food-related companies, such as the HAX incubator and accelerator platform based in Shenzhen (McCuaig-Johnson and Zhang, 2015), or Brinc,<sup>442</sup> a food tech-focused accelerator based in Hong Kong.<sup>443</sup> In India, more than 600 incubators have registered with the government portal Startup India,<sup>444</sup> of which about a third support companies in the agricultural and food sectors. The 2019 SFI report identified nearly 300 incubator and accelerator programmes across emerging and frontier APAC countries. A handful of them are specialized in supporting entrepreneurs in the agrifood sector.

<sup>437</sup> For more information, please see <https://mofpi.nic.in/Schemes/mega-food-parks>

<sup>438</sup> Alvin Tan, Minister of Trade and Industry of Singapore during the Asia-Pacific Agrifood Innovation Summit, 18 November 2020. For more information, please see <http://www.boop.it/singapores-1st-agrifood-innovation-park-time-to-start/>; <https://www.mti.gov.sg/Newsroom/Speeches/2019/11/Speech-by-SMS-Koh-Poh-Koon-at-the-Opening-of-AsiaPacific-Agrifood-Innovation-Week>

<sup>439</sup> For more information, please see <http://foodinnopolis.or.th/en/home/>

<sup>440</sup> For more information, please see [https://www.hortibiz.com/news/?tx\\_news\\_pi1%5Bnews%5D=27910&cHash=a971510453262e9bd7af87164d3ea6e9](https://www.hortibiz.com/news/?tx_news_pi1%5Bnews%5D=27910&cHash=a971510453262e9bd7af87164d3ea6e9)

<sup>441</sup> For more information, please see <https://www.chinabankingnews.com/2019/06/14/china-host-to-11808-business-incubators-nationwide-ministry-of-science-and-technology/>

<sup>442</sup> For more information, please see <https://www.brinc.io/>

<sup>443</sup> For more information, please see <https://tracxn.com/d/investor-lists/Accelerators-&Incubators-in-China>

<sup>444</sup> For more information, please see <https://www.startupindia.gov.in/>

APAC policymakers need to understand the current dynamics of these agro-territorial tools in order to create an enabling environment that is conducive to their success. Incubators and accelerators for agro- and food-based firms in the region are increasingly virtual and private driven.

Virtual incubators and accelerators focus solely on providing services such as mentoring and access to investors without offering a physical space or infrastructure. This allows them to operate in various locations, such as the London-based Startupbootcamp<sup>445</sup> with a presence in Chengdu, Singapore and Mumbai, among other places. The ability of these incubation and acceleration programmes to go global is partly related to their increased focus on digital technologies for different industries, including foodtech and fintech. Examples are ImpacTech<sup>446</sup> in Singapore, Thailand and Japan, or Zeroth's accelerator programme<sup>447</sup> that backs founders working on AI, blockchain and robotics in Bengaluru, Hong Kong and Tokyo. Their worldwide reach is also based partly on the globalization of capital markets in general, and venture capital in particular.<sup>448</sup>

Many are also private-driven. The private sector, and multinational companies in particular, has become the main engine of a new generation of business incubation and acceleration ventures. Therefore, newer incubator and accelerator programmes in the region are nearly twice as likely to be established as for-profit companies (SFI, 2019). Examples include the Indian business incubator Venture Catalysts,<sup>449</sup> the Shanghai-based Chinaccelerator,<sup>450</sup> the InnoHub accelerator programme in Thailand set up by Bangkok

Bank,<sup>451</sup> or BCG Digital Ventures,<sup>452</sup> the innovation, incubation and investment arm of The Boston Consulting Group, located in Shanghai, Singapore and Tokyo, among other cities.

These programmes recognize that agritech startups are creating the future of the agriculture and food sector, and supporting them is a way to close the digital divide, empower rural communities and smallholder farmers, and to create job opportunities for rural areas. One case in point is the Startup India hub,<sup>453</sup> launched by the Government of India in 2016 (NASSCOM, 2018). Startup India offers services to startups, incubators, corporates and accelerators, in collaboration with investors and government agencies. Over 99 000 startups, of which almost 10 percent are related to the agricultural, food and beverage and grocery retail sectors, have already registered in this online portal to get access to free tools and resources and to participate in programmes and challenges.<sup>454</sup> Another case is SPACE-F, a Bangkok-based food tech incubator and accelerator programme that supports startups developing sustainable and tech-forward food solutions in Thailand and Southeast Asia.<sup>455</sup> Another food incubator is Innovate 360 recently established in Singapore by Cheng Yew Heng, a sugar processing company, to guide and support promising entrepreneurs and startups in the food space.<sup>456</sup> Also based in Singapore, are GROW, an agrifood tech accelerator operating in Southeast Asia<sup>457</sup> with support from key industry partners, and backed by AgFunder,

<sup>445</sup> For more information, please see <https://www.startupbootcamp.org>

<sup>446</sup> For more information, please see <https://www.impactech.com/>

<sup>447</sup> For more information, please see <https://www.zeroth.ai>

<sup>448</sup> For more information, please see <https://pitchbook.com/news/articles/vcs-decade-in-data-how-the-2010s-reshaped-a-market>

<sup>449</sup> For more information, please see <https://venturecatalysts.in/>

<sup>450</sup> For more information, please see <https://chinaccelerator.com/>

<sup>451</sup> For more information, please see <https://www.bangkokbankinnohub.com/>

<sup>452</sup> For more information, please see <https://www.bcgdv.com/>

<sup>453</sup> For more information, please see <https://www.startupindia.gov.in/>

<sup>454</sup> For more information, please see <https://www.startupindia.gov.in/>

<sup>455</sup> For more information, please see <https://www.greenqueen.com.hk/thai-food-tech-incubator-accelerator-space-f-calling-for-southeast-asian-startups/>

<sup>456</sup> For more information, please see <https://innovate360.sg/incubator/>

<sup>457</sup> For more information, please see <https://www.gogrow.co/>

and the Yield Lab Asia Pacific<sup>458</sup> launched in 2019 as both a fund and accelerator aiming to support agritech innovation from precision agriculture to food ingredients and supply chain and logistics, across the entire region. Other recently launched acceleration and venture capital programmes with a focus on agriculture and food are China' Bits x Bites,<sup>459</sup> founded in 2016 to support food tech companies, and India's Gastrotope established in 2017 as a catalyst and farm-to-fork accelerator.<sup>460</sup>

Another incubator serving SMAEs is the Nepal Agribusiness Innovation Centre, supported by InfoDev, a World Bank Group multi-donor programme that supports entrepreneurs in developing economies.<sup>461</sup>

Supporting vulnerable entrepreneurs, particularly women and the youth (OECD and EU, 2019) is another role for these programmes. For example, yGap,<sup>462</sup> a non-profit that runs accelerator programmes across Africa and APAC, has launched yHer in six Pacific Island countries and in Bangladesh (open to all South Asia) to support women-led impact ventures.

### Improve value chain governance

This can be achieved in many ways. First is by keeping service provider entry barriers low, and providing good data governance, as unclear and unequal data governance arrangements may weaken the willingness of smallholder farmers and of consumers to adopt digital solutions (Jouanjean *et al.*, 2020). Also, promote the digitalisation of inclusive contract farming schemes to reduce transaction costs related to searching partners, bargaining and monitoring contracts and enjoy better governance and transparency powered by blockchain

(FAO, 2020a). Lastly, enhance the public sector's understanding of farmer segments through digital intelligence to improve macro-decision policy-making, and the design and implementation of programmes and projects.

## 8.3.

### INNOVATIVE POLICIES FOR BUILDING SHORTER VALUE CHAINS

Building shorter value chains can be achieved by supporting social innovation, while at the same time improving access to the internet, digital technologies in general, and e-commerce in specific for all value chain actors. APAC policy-makers are increasingly supporting local experimentation and promoting social innovation to build shorter food supply chains. They realize their potential to address current food system failures and generate synergies across multiple sectors, from rural development to energy, infrastructure, waste, and employment.

Policies that support short value chains include the promotion of **local food initiatives such as farmers' markets, CSA and food cooperatives**. By adopting these initiatives policy-makers seek to circumvent conventional markets and food supply chains in order to move towards a future food landscape that enhances rural-to-urban food linkages and that blends together business and community to empower small farmers, SMAEs and consumers.

Nonetheless, national policies are still ill-equipped to encourage this type of experimentation in many APAC countries. More favourable policy and regulatory environments for local farmers and short food chains are needed, especially with respect to food safety, tax regulations and regulations to enable the development of more inclusive agricultural e-commerce. Even when supportive policy frameworks do exist, the opportunities are often under-communicated, ineffectively implemented or subordinated to competing priorities, such as boosting competitiveness

<sup>458</sup> For more information, please see <https://www.theyieldlab.com/asia-pacific>

<sup>459</sup> For more information, please see <http://www.bitsxbites.com/>

<sup>460</sup> For more information, please see <https://gastrotope.com/>; <https://www.foodnavigator-asia.com/Article/2017/09/19/India-gets-agri-business-and-food-tech-startup-accelerator#>

<sup>461</sup> For more information, please see <http://nabic.com.np/>; <https://www.infodev.org/>

<sup>462</sup> For more information, please see <https://ygap.org/yherpacificislands/>

in conventional markets or subsidizing food system intermediaries. Encouraging short-chain initiatives requires **addressing the existing gaps in policy and regulatory frameworks** through complementary actions at regional, national, and local levels. This needs to become a priority, particularly in urban Asia.

**Public support is needed to promote e-commerce among farmers and SMEs.** Digitally connected farms, agricultural cooperatives, and sorting, packaging and processing enterprises can connect directly to consumers through online platforms, shared sale points, and smart logistics (FAO, 2020f). Notwithstanding the increased connectivity in rural areas, only a fraction of smallholder farmers sell their products online. A survey by ADB and IFPRI (2019) on e-commerce in China found that only 2 percent of the farmers interviewed sold agricultural products, mainly fruits and vegetables, on the Internet in 2016, and just 1 percent of farmers purchased agricultural inputs online. However, 27 percent of the farmers surveyed expressed their willingness to sell their agricultural products online because they believed that selling online could get them higher prices and give them access to a larger group of potential buyers.

Digitalization has widened several existing gaps. The space has grown between large- and small-scale agricultural producers and enterprises, and between different economies and sectors. Gaps are now larger between early adopters and reluctant parties, between genders and the degree of urbanization (FAO, 2019b). To close these gaps, policy-makers need to further improve support structures that enable smallholder farmers and SMEs to adopt the new technologies. Such support structures include tax and regulatory policies, investments in basic agricultural and technology infrastructure, along with last-mile infrastructure and fostering collective action. Producer organizations, cooperatives and value chain associations can help their members to develop, adapt and access innovative solutions (EIU, 2018).

## 8.4. SOLUTIONS FOR REBUILDING GREENER FOOD VALUE CHAINS

- Globally, food and beverage packaging account for 14 percent of total plastic waste. More than half of global plastic waste occurs in APAC.
- Plastic litter costs APAC fishing, tourism and shipping industries \$1.3 billion per year. Over 60 percent of interventions to reduce plastic waste are implemented by micro or small-scale companies, and not by large agrifood companies.

Sources: Geyer *et al.*, 2017; FIA, 2018; UNEP, 2018; UNEP and FIA, 2020.

The health and resilience of food and agricultural systems in APAC are being impaired by the degradation of natural resources, and the increased frequency and intensity of extreme weather events that disrupt supply chains and cause destabilizing damages. According to the IPBES Report on Land Degradation (2018), the paradox is that, at the same time, unsustainable food production systems are among the main culprits of degraded soil and water quality and biodiversity loss in the APAC region.

Governments in the region are progressively implementing policies to tackle these issues in order to green food value chains, making them healthier, cleaner and more resilient to climate change. The key underlying principle behind these innovative policies is internalizing the hidden costs of environmental externalities.

Key measures in this sense include the promotion of digital technologies that track food loss and waste all throughout the value chain, allowing for devising specific reduction measures. Also included are digitally enabled innovations to restore agro-ecosystems by



reducing land and water degradation, and GHG emissions. Lastly, are cellular agriculture and other innovations that increase the supply of cleaner, improved traditional and alternative proteins (FIA, 2018; UNEP and FIA, 2020).

A shift towards **agro-ecology** that integrates smart subsidies, research and extension, and innovation policies, is needed to ensure sustainable food and agriculture production throughout the value chains (IPES-FOOD, 2019). The adoption of agro-ecology as the central paradigm for government policies and programmes also implies prioritizing public support to farmer-led, action-research on agro-ecology, and mainstreaming digital innovations into agro-ecological systems based on open source and horizontal exchange.

The agro-ecology approach may be accompanied by a number of measures to reduce land and water degradation, and GHG emissions. These include replacing traditional subsidies with smart agricultural subsidies; and introducing eco-friendly behavioural taxes, such as taxes on emission-intensive foods and on foods that contribute to water pollution. Other measures are incentivizing the consumption of improved traditional and alternative proteins, and rethinking trade policies to mitigate the negative impacts of greater trade on the environment.

For example, the Chinese Ministry of Environmental Protection, acknowledging that livestock farms are largely responsible for water pollution, introduced an environmental tax on large farms effective from January 2018 to restore damaged waterways (FAIRR, 2017). The tax brought in a new charge of \$0.20 per animal for larger farms, defined as farms with more than 50 cows, 500 pigs or 5 000 or more birds.<sup>463</sup> The tax is levied according to the amount of effluent produced, and farmers

can be exempted if they install wastewater treatment plants.<sup>464</sup> It primarily aims to reduce wastewater emissions and generates revenue estimated at \$7.14 billion per year that is used to clean up polluted waterways (FAIRR, 2017).

China has also started implementing policy and legal measures to decrease meat production and consumption for environmental and health reasons. The country accounts for more than 26 percent of the global requirement for protein (Skinner *et al.*, 2019) and is the world's largest consumer of meat, with a retail value of \$170 billion<sup>465</sup> and a 3 percent growth rate annually.<sup>466</sup> The predicted rise in China's meat consumption is expected to add roughly 233 million additional tonnes of GHG to the atmosphere each year, according to WildAid (2016), as well as a steep increase in water footprint (FoodPrint, 2018). One key measure was the Ministry of Health's 2016 release of revised dietary guidelines promoting reduced meat consumption. The new guidelines recommend a maximum annual per capita meat consumption of 27 kg, about half of the 2013 consumption figure of 49.7 kg (FAIRR, 2017). Lowering meat consumption could help to reduce China's GHG emissions by one billion tonnes, besides improving public health.<sup>467</sup> Another measure is a shift from farmed meat to cultured meat, as exemplified by the already mentioned trade deal to import lab-grown meat from Israel, one of the world's pioneers in this field.<sup>468</sup>

<sup>463</sup> For more information, please see <https://bit.ly/3h8HKRT>

<sup>464</sup> For more information, please see <https://bit.ly/3h8HKRT>

<sup>465</sup> For more information, please see <https://www.euromonitor.com>

<sup>466</sup> For more information, please see <https://www.statista.com/statistics/691439/china-meat-consumption/>

<sup>467</sup> For more information, please see <https://www.theguardian.com/world/2016/jun/20/chinas-meat-consumption-climate-change>

<sup>468</sup> For more information, please see <https://www.onegreenplanet.org/news/china-to-import-israels-lab-grown-meat-technology/>

China is also considering a ‘sustainability’ tax on meat (FAIRR, 2017; Springmann *et al.*, 2017). According to Springmann *et al.*, (2017) taxing GHG intensive foods such as red meat is a way of incorporating environmental externalities (i.e. the price of the associated damages on climate and land and water pollution) into the price of the food. Such taxes could reduce global GHG emissions by about one billion tonnes. The study found that beef prices, for instance, would have to increase by 40 percent on average in order to reduce global beef consumption by 13 percent. It also concluded that this tax scheme could avoid half a million diet-related deaths if smartly designed.

Policies for designing low-waste food value chains are also becoming of critical importance in the APAC region. The harmful impacts of food systems on the environment are exacerbated by the fact that around 15 to 20 percent of the food produced in APAC is lost or wasted (FAO, 2019c). In particular, the region is a hotspot for losses in the fruit and vegetable value chains (50 percent), rice (up to 37 percent) and meat and dairy products (20 percent) to spoilage, damage and other causes (FAO, 2019c). A case in point is the “Clean Your Plate” campaign successfully launched, with the support of China’s Government, to encourage consumers to end food waste (FAO, 2019c). Many restaurants and catering operators have joined the campaign, as have food delivery platforms, catering associations in more than 18 provinces, the China General Chamber of Commerce and the China Cuisine Association.<sup>469</sup>

Finally, many governments in the region are actively tackling plastic waste in food systems through policies and regulations (UNEP and FIA, 2020). Such measures pivot around reducing inputs into the food system, enhancing collection rates for after-use plastics, plugging leakage in post collection and creating value for waste reuse (FIA, 2018).

## 8.5. SOLUTIONS FOR TACKLING SOCIO-ECONOMIC CHALLENGES POSED BY INNOVATION

### 8.5.1. Solutions for coping with employment issues in agricultural value chains

Efforts are ongoing in the region to promote better employment opportunities by providing training in digital technologies, and addressing challenges related to jobs in the gig-economy, such as benefits, income-security measures, and training and credentials to make these jobs acceptable.

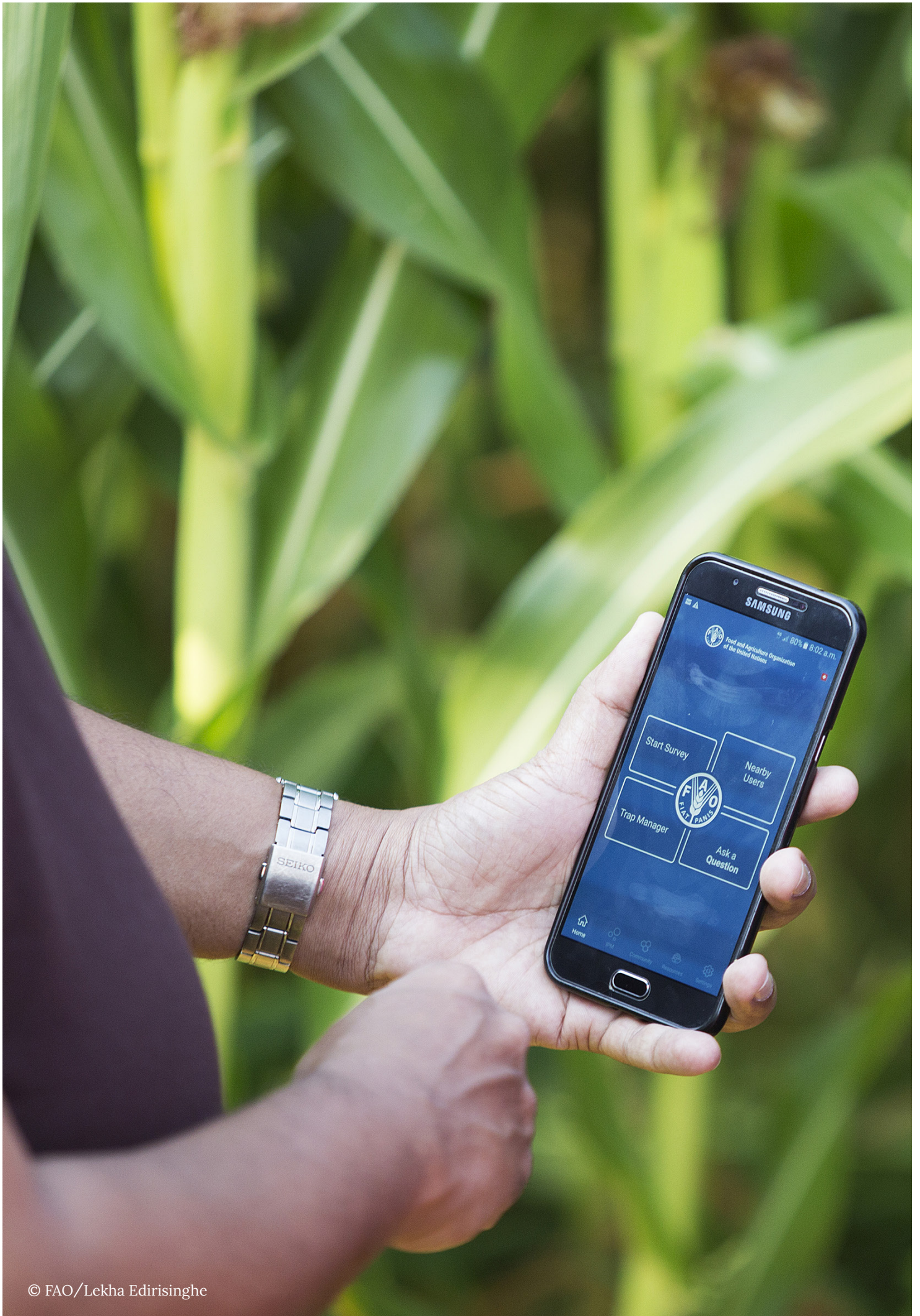
Another solution is eradicating unfair practices in hiring workers in agricultural and food value chains by using smart employment contracts. Smart contracts are both immutable and public because they use blockchain technology. This can help improve the conditions of agricultural and food workers across the region (FAO, 2020a). This innovation could be particularly impactful to improve the fairness of seasonal labour markets, which are common in the region’s agricultural sector and often known for their unfair hiring practices. Smart employment contracts could reduce costs and increase transparency, especially when seasonal workers are concerned. FAO (2020a) postulates that through these blockchain applications, smart contract information could be made available to the employer, employee and authorities such immigration, welfare and social insurance agencies. This information could also be critical for companies to ensure that their value chain partners treat their workforce in a fair and ethical manner.

<sup>469</sup> For more information, please see <https://www.scmp.com/tech/apps-social/article/3097628/chinas-biggest-food-delivery-platforms-act-after-state-backed>

### **8.5.2. Solutions for the betterment of data governance**

APAC governments need to improve regulations governing big data in general and in food systems. These regulations should cover data generation, storage, use, dissemination, property rights and confidentiality. To improve regulations APAC Governments need to assess how existing regulatory arrangements affect food systems, and ensure that broader data

policies are applied in a more tailored way to meet the specific needs of food systems. They should determine whether there are persistent gaps in existing data governance arrangements for agriculture and food systems, and improve communications around policy and regulatory frameworks for data governance. This would help to build confidence in the use of digital solutions, especially among farmers and consumers (Jouanjean *et al.*, 2020).



# 9. KEY FINDINGS

## 9.1.

### LESSONS LEARNED ABOUT INNOVATIONS IN APAC FOOD VALUE CHAINS

Based on the ideas discussed in this paper, we offer five lessons for APAC policymakers to make sense of innovations in food systems, and further accelerate them in a manner that is sustainable for the economy, the environment and society.

**Lesson 1.** APAC policymakers need to comprehend the **nature of innovations along food value chains, articulate them and reflect them in their policies.** In this regard, countries need to consider both technological and organizational innovations in their policy agenda. Sustained growth in yields and productivity at every stage of the food supply chain requires technological, organizational and institutional innovations, so that food production, handling and processing remain sustainable and profitable at a lower per-unit cost for consumers (FAO *et al.*, 2020). Technological innovations (chapters 2 to 5) will also inform and be informed by innovations in business model innovations, which essentially change the set of decisions that determine how a business earns its revenue, incurs its costs, and manages its risks. Ensuring coherence between policy, technology and institutional innovation responses is another critical factor for creating successful agrifood innovation ecosystems.

But policymakers should also take into consideration that innovations at different stages of the food value chain dovetail into, and interact with each other. Using the value chain approach for designing and implementing pro-innovation policies aimed at raising productivity and sustainability in food systems, allows policymakers to navigate the complexity

of food systems and identify opportunities for enhanced innovation at different stages. All actions along the food value chain ultimately affect what happens in all other stages of the chain. An innovation introduced by a value chain stakeholder will affect all the others, even more so as food systems grow increasingly complex and intertwined, especially in rapidly growing metropolitan areas.

**Lesson 2. Innovations in agricultural value chains are driven by changes in demand, in technological factors and in the enabling environment.** Drivers of change include supply side factors mainly related to falling data costs, increased connectivity and technological breakthroughs such as artificial intelligence, big data, the Internet of Things and blockchain.

Changes in demographics, consumer behaviour and preferences are key factors driving innovation. Re-envisioning agrifood systems for the next decade calls for APAC policymakers to understand what consumers want. They need to comprehend their complex and changing relationship with food, in terms of healthy diets, packaging, food safety, supply chain traceability, convenience and increased reliance on online marketing channels.

Online grocery shopping and delivery services have expanded in recent years, and even more so during the pandemic. They impact what consumers buy, as well as how they buy. A balance is needed between demand for fresh, healthy, whole foods versus shelf-stable products and convenience foods. With consumers seeking out both healthier, immunity-boosting foods, and indulgent, mood-boosting treats, food brands are responding by developing fortified and functional foods, for example to target stress and anxiety.

As more and more APAC governments target obesity and diabetes through sugar reduction, several food brands are reformulating their products and using ingredient innovation to offer healthy indulgence. A shift is taking place towards plant-based diets, opening new opportunities for some food supply chains in Asia. These include pulses, fruits and vegetables, and meat analogues and cellular agriculture. These trends and challenges have to be factored into policies dealing with food, agriculture, innovation and digital transformation.

Other key drivers of innovation along the value chain concern the enabling environment, such as climate change, increased pressure on the environment and the COVID-19 pandemic. The latter factor, in particular, has dramatically changed the innovation dynamics within APAC food systems. On one hand, innovation finance has sharply declined in the current crisis both in APAC and globally (Cornell University, INSEAD and WIPO, 2020). On the other hand, the pandemic has quickened the pace of innovations. It could prove to be a decisive turning point for contact-free economy in general and e-commerce in particular, notably for the food and beverages sector. Companies, governments and markets are pivoting to a new normal after the COVID-19 crisis provoked unprecedented shutdowns of economies (FAO, 2020h). The pandemic has accelerated the digitalization processes, with e-commerce being the most visible. As a result, many aspects of food retailing have deeply changed, including how companies source their products and market them (FAO, 2020h; McKinsey & Company, 2020a; 2020e).

To start with, the pandemic has given a strong momentum to food e-commerce because of health restrictions that made it impossible or undesirable for consumers to make food purchases in their usual supply centres (FAO, 2020h). In the earlier months of the COVID-19 outbreak, food retailers faced as much as a sevenfold spike in demand in

their e-commerce sites (McKinsey & Company, 2020b). Initially, this surge in demand created bottlenecks in last-mile delivery, struggles to overcome disruptions in supply chains, and challenges to maintain the smooth running of their IT systems.

The pandemic has also accelerated a change in shopping habits that were already well established in Asia. It has attracted new customers and markets to the online food businesses, for example, Chinese citizens aged 36 and over, and residents of third-tier cities (McKinsey & Company, 2020c). The effects of the crisis on consumer purchase and transaction behaviour in favour of e-grocery shopping will be long-lasting (FAO, 2020h; McKinsey & Company 2020b). The resulting situation has given a major push to food retailers to become more tech-heavy and lean towards e-commerce and AI-supported supply chain management. The growth in online food retailing has been accompanied by changes in formats and digital solutions across the O2O spectrum, including the surge in click-and-collect formats and the trend of food stores to become cashless or virtually cashless (McKinsey and Company, 2020b). Since the pandemic hit, food distributors that traditionally supplied restaurants have seen their core sales decimated. To survive, they have set up digital direct-to-consumer channels, creating a new influx of competitors and bringing new ideas into the market (McKinsey & Company, 2020d). This change in the go-to-market model of Asian food retailers is likely to last beyond the crisis, with a continuous unfolding of multiple forms of digital engagement with customers (McKinsey & Company, 2020b).

While the pandemic has created new business opportunities for food retailers in their value chains and ecosystems, for e-commerce companies the surge of online food sales is unlikely to translate into significant growth of gross merchandise value, as these are low-cost items. During the crisis many e-commerce players in China and elsewhere waived

commission rates and subsidized deliveries to keep their suppliers afloat. However, that had a negative impact on revenue streams. The crisis also negatively affected e-commerce platforms that rely on advertising revenue instead of transaction fees, such as Alibaba's Taobao Marketplace.<sup>470</sup>

In this scenario, there is growing pressure for food retailers to increase profits by becoming more efficient through cost reductions, technological innovations, and even by branching out into related businesses such as food services. Food retailers have taken a strategic step towards this goal by diversifying their sourcing bases, with a primarily local supplier mix. They have also improved supply chain management by investing in warehousing and transportation technologies that reduce labour costs and increase efficiency (McKinsey & Company, 2020a). For example, they have embraced machine learning in their forecasting to spot abnormalities and adjust immediately to smooth out unexpected peaks in the supply chain (McKinsey & Company, 2020a). Similarly, they are switching their operational procedures and warehouse management systems to an e-commerce-type process. For instance, to manage fulfilment, both in physical stores and e-commerce, many food retailers are now using "dark stores," or centralized distribution centres that are not open to the public. These dark centres are flexible enough to handle the logistics of shipping both large quantities required by physical store fulfilments, but also smaller quantities required by direct online customers. In response to the pandemic, APAC food retailers have also reinforced their digital marketing strategies, employing livestreaming in particular. These practices that appeared during the pandemic will most likely become standard procedures going forward to lessen the risks posed by future shocks (McKinsey & Company, 2020a; 2020b).

<sup>470</sup> For more information, please see <https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/e-commerce-drives-china-s-stay-at-home-economy-in-coronavirus-aftermath-57642723>

As for farmers, the initial restrictions on movement resulted in food losses because they curbed their access to finance and to markets to buy inputs and sell products and accumulated unsold crops (FAO, 2020i; 2020l). Once the initial shock abated, farmers starting making greater use of social commerce, mobile e-commerce (FAO, 2020g) and mobile banking, as physically visiting a bank was impossible because of restrictions on movement or undesirable because of the risk of infection.<sup>471</sup>

In some cases, the shift towards e-commerce was facilitated by retailers. For instance, in February 2020 Taobao's "Rural Support Programme" connected farmers across China through the Taobao's Foodie Livestream channel at no cost to them. They sold about 15 000 tonnes of products during the first three days of livestreaming. The programme also involved working closely with county-level governments to identify selling points and increase the visibility and recognition of local farmers participating in the livestreaming.<sup>472</sup> FAO (2020h) advised that it would be necessary to monitor whether or not small farmers continue to make greater use of digital sales and if they are able to cope with sustained demand.

There has also been a shift to digital extension and advisory services for smallholder farmers (FAO, 2020j). In Bangladesh, a pilot initiative implemented by FAO is using virtual call centres that provide advisory services to farmers and help them use e-commerce and cashless payment solutions.<sup>473</sup> The 57 virtual centres set up have embraced available technologies such as mobile phones, web-based messaging service, social media, digital money like bKash, Rocket and Nagad, and online meeting platforms. They have established

<sup>471</sup> For more information, please see <https://www.wbcsd.org/Overview/Panorama/Articles/Investment-in-agriculture-and-farmer-innovation-are-key-to-post-COVID-food-security>

<sup>472</sup> For more information, please see <https://www.alibabagroup.com/en/news/press>

<sup>473</sup> Author's personal experience with FAO project GCP/BGD/064/GAF. For more information, please see <https://extranet.fao.org/fpmis/index.jsp>

an O2O ecosystem linking 10 000 farmers, of whom 46 percent are women, with input suppliers and off takers, while complying with physical distancing. Through the virtual call centres, participating farmers have sold products worth nearly \$500 000 to buyers, including private companies, and purchased essential agriculture inputs worth over \$70 000 from suppliers in the first months of the pandemic. The virtual call centres sprouted on the fertile soil of the farmer organization's network, strong membership base and trust, all of which facilitated the uptake of the digital technologies.

Furthermore, the COVID-19 pandemic is expected to boost automation further in the food processing industry to allay concerns about food safety and remove human contact from the system where possible.<sup>474</sup>

**Lesson 3.** Innovation is key to enable APAC countries to future-proof their food systems and value chains. The world's population is projected to grow from over 7 billion today to 9.7 billion by the year 2050.<sup>475</sup> As population increases, so do nutritional needs. To feed humankind in 2050, 45 percent more food supplies would be required – over 100 percent in South Asia – along with 50 percent more energy and 40 percent more water (FAO, 2017e; World Bank, 2016c). Current yield levels and production methods not only will fall short, but also make the environmental footprint of food grow even larger. That is no small danger, given that the food system currently accounts for 21 to 37 percent of total GHG emissions (FAO *et al.*, 2020).

The question of food security in the region will become more pressing each year. By 2030, half of the world population will reside in the region. Despite being a global food centre,

APAC will be unable to produce enough to feed itself. It will have to rely extensively on food imports. This is one of the main reasons behind the rise of Chinese agricultural investments in Africa (Lu, 2015). In the wake of the COVID-19 crisis, ensuring food security in the region has become an even more critical issue. Some parts of the region may endure a sharp rise in hunger because of inequalities and the economic calamity brought about by the pandemic (FAO *et al.*, 2020).

Governments, corporations and civil society are faced with the dilemma of how to reinvent food systems to produce more with less, avoid biodiversity loss and generate a smaller carbon and water footprint. The challenge is how to produce better, safer, more nutritious and affordable food in a sustainable and equitable manner? How can food systems ensure food security while also cutting down on food waste, reduce the risk of future pandemics, and ensure long-term sustainable development (FAO, 2017e)?

Any meaningful solution will only come from accelerating innovation across value chains and food systems. A myriad of innovations are already taking place at each and all of the stages of the food supply chain. Innovations could be steered to where they would have the most impact on food security, health and sustainability. Building a new and improved food system is a shared responsibility that requires collective action from the public sector, producers, investors, supply chain participants and consumers. The COVID-19 outbreak has turned the spotlight on the vulnerabilities of the current food system. However, it has also shown that in times of crisis, collaboration among countries, between the private and the public sectors, between corporations and startups, and among all value chain players is the only sensible response. The pandemic has also highlighted the importance of using technology to accelerate positive change across food value chains.

<sup>474</sup> For more information, please see <https://blogs.worldbank.org/jobs/farmer-ex-machina-digital-agriculture-beginning-end-agricultural-employment>

<sup>475</sup> For more information, please see <https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html>



One crucial element in this future-proofing exercise is that cities will have to be at the forefront of the food innovation agenda. By 2030, more than 2.8 billion people across Asia will be living in cities. Feeding urban dwellers sustainably with nutritious and safe food will require a transformation of the current supply chain. Disruptions and food security risks from COVID-19 and trade tensions have also added to the urgency and complexities in addressing this challenge.

To make Asia's cities more food-secure opportunities exist for more localized production, or shorter supply chains, such as scaling up controlled environment agriculture and urban aquaculture systems, or promoting cellular agriculture. The COVID-19 crisis has increased consumer demand for local, safe food sources. Some urban growers are capitalizing on this opportunity by investing in plant factories and adapting their business models around the new dynamics of the food service and food retail sectors. More government and financial support is needed, however, to scale

up the controlled environment agriculture industry. In addition, government must combine that with regulatory improvements and sound urban planning. The example of Singapore's "30 by 30" strategy to ensure food security for the city-state comes to mind. FAO is developing a tool for rapid appraisal of food systems for cities (Rapid Urban Food System Appraisal Tool – RUF SAT). The tool aims to identify hotspots that compromise or constrain the performance of urban food systems, and offer evidence-based priority interventions to address the challenges. The RUF SAT tool is being tested in Dhaka, Bangladesh.<sup>476</sup>

**Lesson 4. The region has a dual innovation ecosystem.** The new industrial and digital revolution has particularly affected agrifood systems in Asia and the Pacific. This revolution is bringing about innovations characterized by universal connectivity, digital disruption, automation and big data. Such changes are sparking a deep transformation in the region's food systems enabled by technologies and ideally sustained through capacity building.

**Table 19.** Best-ranked APAC economies in the Global Innovation Index 2020

COUNTRY	Position in global ranking
Singapore	8
South Korea	10
China	14
Malaysia	33
Viet Nam	42
Thailand	44
India	45
Mongolia	58
Indonesia	85

**Source:** Cornell University, INSEAD and WIPO, 2020.

<sup>476</sup> For more information, please see <http://www.fao.org/in-action/nadhali/en/>

**Table 20.** Innovation cases by country

COUNTRY	BUSINESS AND TECH INNOVATIONS	POLICY INNOVATIONS
China	23%	8%
India	25%	26%
Indonesia	9%	3%
Singapore	11%	8%
Thailand	9%	16%
Other countries	23%	39%
TOTAL	100%	100%

**Source:** Own elaboration.

**Table 21.** Venture capital investments into agricultural and food startups 2019

COUNTRY	BUSINESS AND TECH INNOVATIONS	POLICY INNOVATIONS
Global	19.8	100%
China	3.6	18%
India	2.4	12%

**Source:** AgFunder, 2019b; AgFunder, 2020; <https://research.agfunder.com/2020/202-india-report.pdf>

Today, Singapore, South Korea and China are leading the world in innovation, including food innovation. Their advances have been notable in matters related to online food marketplaces, meal delivery services, and digital platforms for smallholder farmers. To a lesser extent Malaysia, Viet Nam, Thailand and India are among the region's top performers in innovation. In fact, Cornell University, INSEAD and WIPO (2020) claim that, China, Viet Nam, India, and the Philippines are the economies with the most significant progress in overall innovation in recent years. Other APAC countries are lagging.

The different pace of innovation is reflected in the cases examined in this publication. Of the 155 business and technological innovations studied, nearly 80 percent took place in only five countries: India, China, Singapore, Thailand and Indonesia. Similarly, 58 percent of the policy innovations analysed originated in only four countries: India, China, Thailand and Singapore.

Chinese food and agriculture startups raised \$3.6 billion in 2019, down 38 percent from \$5.8 billion in 2018 (AgFunder, 2019b). Despite this, the sector remains dynamic, with 80 percent of food innovation startup investments occurring in e-grocery, meal delivery services and other downstream activities (AgFunder, 2019a). In India, total investments in agrifood startups for 2020 stood at \$1.1 billion, down from \$2.4 billion in 2019. Downstream investments accounted for 70 percent (\$741 billion) of total investments in 2019, while the remaining

30 percent (\$312 billion) went to upstream agrifood startups. Downstream investments were highly concentrated, the two top players in each of the e-grocery and restaurant marketplaces categories (Swiggy and Zomato) gobbled up over 75 percent of all agrifood startup funding in 2019.<sup>477</sup>

## 9.2.

### HOW TO ACCELERATE INCLUSIVE AND SUSTAINABLE INNOVATION IN FOOD VALUE CHAINS

Enhanced efficiencies from innovations along the food supply chain accompanied by concrete policy and regulatory measures can help mitigate the challenges associated with innovations and create a virtuous circle. The region is well positioned to boost sustainable growth through technological leapfrogging. Today, Asia is home to more than one-third of the world's unicorns (MGI, 2020). Over the past decade, the region accounted for 52 percent of growth in tech company revenues, 43 percent of the growth of global investment in startups, and 51 percent of the growth in global R&D spending. Moreover, Asia is home to more than half of the world's Internet users (MGI, 2020).

By building on those assets, APAC governments could play a pivotal role in accelerating innovations in the sector. Unlocking the potential of innovation can help APAC governments drive socio-economic growth, ensure food and nutrition security, alleviate poverty and improve resilience to climate change. All of that would help to achieve the SDGs. Because innovation is a complex process in which governments and other key stakeholders play different roles, a system-wide approach should be adopted.

APAC governments should focus on the following themes:

**1. Creating a strong agrifood innovation ecosystem** that infuses innovation, investment and entrepreneurship into food value chains. Enhancing the innovation potential of APAC agrifood chains, will make them more capable of adapting to change and increase their competitiveness, sustainability and resilience in regional and international markets. As APAC enters an unpredictable period for the global economy, ensuring that the region's agrifood innovation ecosystem has the support and funding it needs to bring new solutions to scale is of paramount importance. To overcome market failures, policymakers have a responsibility to boost entrepreneurship, and provide critical infrastructure and funding.

First, APAC governments need to invest in critical infrastructure, such as Internet and transport connectivity, value chain storage and cold facilities, collection centres and laboratories. Second, entrepreneurship programmes are also needed to boost agripreneurship to a much more significant extent. Government support is needed to help farmers and startups become competitive with large-scale players. At the same time, it needs to foster collaboration and partnership-based models to accelerate innovation. Increased private-public collaboration can help instil excellence and innovative attitudes along the food value chain, and unlock value for the grassroots level in areas such as mobile payments and credit, and e-commerce.

Governments need to learn from their past mistakes in incentive schemes for entrepreneurs that, although well-intentioned, have not performed as well as desired. The first step for designing successful entrepreneurship initiatives is understanding and internalizing the nature of entrepreneurial ventures. These ventures are highly concentrated, and therefore of venture capital in innovation hotspots such as Hong Kong, Bangalore and Singapore, which means that entrepreneurship programmes only perform well in selected locations. They are also cyclical, with boom and bust cycles. Lastly,

<sup>477</sup> For more information, please see <https://research.agfunder.com/2020/202-india-report.pdf>

they rely on human factors, such as motivation, instinct and skills, which are critical for success (Cornell University, INSEAD and WIPO, 2020).

Against this backdrop, governments need to insulate entrepreneurial policymaking from day-to-day political pressures, which could steer towards investing in locations without enough potential or benefit some firms over others. They should opt for matching funds as a means to overcome distortions in fund allocation due to political, rather than economic, considerations or a lack of understanding of how markets work (Cornell University, INSEAD and WIPO, 2020).

APAC governments need to provide funding mechanisms, following the above-mentioned principles, in order to stimulate innovation along food value chains. They can use a range of instruments from agricultural funds, focused research institutes, business incubators and accelerators, and venture capital approaches. In India, for example, venture capital has started flowing to agricultural and food system projects through programmes such as Startup India. While some APAC governments such as China, India, Singapore and Thailand are investing in incubators and accelerators to support home-grown agrifood startups, there are still critical gaps across countries.

Finally, APAC governments should make their policy environment more transparent, predictable, and enforceable to attract more foreign and domestic capital for innovation in food systems. They also need to integrate key lessons learned into their policy and innovation agenda, such as prioritizing innovative solutions for urban food challenges, understanding the new Asian consumer, and the conditions for successful innovation towards sustainability.

**2. Fostering greater collaboration between corporations, investors, accelerators, universities, and startups** is essential to building a more robust environment for agrifood technology innovation and commercialization. Transformative, systems-level partnerships involving players

across the value chain can contribute to building a sustainable, resilient food system that is also cost effective. Therefore, APAC governments need to systematically foster dialogue and joint knowledge on innovation by bringing together all the stakeholders in the food system. But building innovative communities for food systems and agriculture requires improved governance through new social pacts based on collaboration and competition in equal parts. In this regard, governments in the region should engage more actively in PPPs to leverage public-sector investment, enhance private sector involvement in food system infrastructure, R&D and smallholder-oriented business models, and fill gaps in the delivery and adoption of innovation.

This engagement should happen both at national and local (sub-national) levels, fostering robust links between public research institutions, firms, and the grassroots. Engaging universities and their students in these partnerships is critical to tap into hidden innovation and intellectual property. Regional and global cooperation in technology transfer and openness to trade in technology should also be encouraged, leading to more innovation convergence regionally and globally.

**3. Harnessing the power of digital technologies** to pilot, accelerate and scale innovative ideas with high potential for impact in food and agriculture, transforming digital solutions and services into global public goods. APAC policy-makers need to explore the responsible application and adoption of digital technologies, design and scale new services, tools and approaches to empower farmers and inspire youth entrepreneurship in food and agriculture. In particular, they should further invest in connectivity and public e-services, which are particularly underdeveloped in the agricultural and rural sector, with few countries providing e-farming services. They should use digital solutions for e-learning processes and agricultural extension services (FAO, 2020m).

Public policies aimed at improving access to digital agricultural technologies could be used to better connect producers and consumers, and facilitate citizen science.

**4. Putting farmers and SMAEs first** to increase their uptake of new technologies, including digital solutions. APAC governments need to strengthen the position of farmers and SMAEs in value chains through innovative approaches that enhance transparency, information flow and management capacity. This involves empowering them by providing access to digital technologies and the new service platforms. Digitalization has become a driver of food system transformation, unlocking new opportunities for smallholder farmers and SMAEs. Yet, at the same time, digital disruption comes with a heightened potential for exclusion of the most vulnerable actors. The outcome will depend, to a large extent, on how value chain actors take advantage of the digital transformation to ensure inclusiveness, efficiency and environmental impacts.

Some of the factors hindering the transition are the lack of specific public policies, low e-literacy, poor connectivity, lack of advice or actionable services, and low capacity. The digital transformation of the agrifood sector should take an inclusive, efficient and sustainable approach. This approach requires significant action by governments to establish enabling policy frameworks and incentives. Governments' efforts to achieve the digitalization of the agrifood sector should focus on infrastructure and connectivity, accessibility, the level of education and institutional support, and designing services for the unconnected.

At the same time, technological innovations and new business models can make agricultural and food systems more fair. Providing preferential access to land and tax relief to enhance farmers' incomes, and offering market support for promising technologies are also enabling policy measures.

**5. 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 startups working in this field. This premise is based on the understanding that new technologies only reach farmers and other value chain actors at scale when they are delivered within a functioning business model. Precisely, this new generation of business models uses digital technologies to generate value by operating at scale, while delivering far lower transaction costs (GrowAsia, 2020).

**6. Building capacities along food systems.** APAC policy-makers should enhance the capacity of actors within agrifood chains to design new processes leading to new business models and more efficient, equitable, sustainable and better-performing food value chains. Governments need to create further opportunities for training and education not only for the development of new technologies, but also for enabling the current workforce along the food value chain to use digital tools.<sup>478</sup>

Agricultural extension efforts to disseminate knowledge about new technologies and to demonstrate their business case are of immense importance, whether they use physical or digital modalities. These services should also include training in agricultural techniques, marketing, finance managerial skills, and information such as meteorological and market data. A practical measure that is usually successful is to increase exposure of SMAEs and agricultural cooperatives to innovative technologies and business models through exchange visits, digital exchange and learning platforms.

<sup>478</sup> For more information, please see <https://www.newfoodmagazine.com/news/98666/report-identifies-next-steps-for-food-manufacturing-digital-technologies/>

### 7. Overcoming regulatory challenges.

Regulatory costs have increased and much pressure has been put on regulators, who are struggling to keep up with the pace and scope of changes in food systems. These changes range from worker rights (food distribution) to food safety, alternative financial channels and systems, and data governance. APAC regulators are struggling to cope with the pace and breadth of innovations in food value chains. An area where this is particularly so is the use of drones in agriculture, and the regulatory landscape concerning smart farming and agritech in general. There is ample room for creating improved food safety, quality and traceability standards based on the capabilities of new digital technologies. Similarly, some APAC countries need firmer regulations on functional foods, the promotion of baby food<sup>479</sup> and the full implementation of the World Health Organization recommendations on marketing of non-alcoholic beverages, confectionery and other foods with unhealthy product compositions to children (Giner and Brooks, 2019). Governance and regulations for new technologies, such as genome editing and nanoparticles, are also required to prevent undesired side effects of research and development in this field and to govern issues regarding ownership and societal benefits sharing. Effective guidelines and policies are required for the safer utilization of nanoparticles in food in Asia, and particularly in China and Japan, which lack proper nanotechnology-specific regulations despite being major nanomaterial producing countries (Nile *et al.*, 2020).

Regulatory measures are also needed to address the challenges surrounding the excessive concentration of market power, data governance and the development of fintech solutions, among other topics. This may mean revising competition and consumer protection

laws related to mobile and online payments, online credit and e-commerce business models to oversee and prevent unfair trade practices, misleading advertisements, information disclosures, payment protections, unsafe food products and dispute-resolution and consumer-redressal mechanisms.

Finally, streamlining regulations and reducing bureaucracy around farmers is also a good way forward, particularly when striking a balance between traditional and advanced farming technologies. The same applies to SMEs in food value chains (Cornell University, INSEAD, and WIPO, 2017).

**8. Analysing and managing the impacts of digitalization and other new technologies** on agriculture, employment generation and destruction, nutrition, and the environment. Agriculture and food systems today are radically different compared to a couple of decades ago: they are more digital, smarter, and more integrated.

A concerted effort towards more granular and food system-specific data collection on innovations, if possible, even at the level of the value chain, is needed to understand what works and what does not, and the impacts on the economy, society, and the environment. Governments need to be aware of the potential of these new technologies to limit the negative impacts of agrifood chains, and find ways to harness such potential.

**9. Rethinking food value chains in Asia and the Pacific after COVID-19.** COVID-19 has changed the public policy agenda, laying bare weaknesses in food supply chains (FAO, 2020). The exposed vulnerabilities are manifold. Chief among them are climate change and the unpreparedness of value chain actors and governments to cope with sudden crises such as COVID – which may have originated from within the food system. Other vulnerabilities include the risk of letting the politics of food overtake the economics of food, the underinvestment in food production in the region, and the lack of economies of scale in

<sup>479</sup> For more information, please see <http://archive.ipu.org/splz-e/vientiane14/parl-role.pdf>

smallholder agriculture, which is still the norm in APAC. Most crucially, the pandemic has put a spotlight on all the inequalities in the region's food supply chains.

Whereas the crisis has given affluent APAC consumers more reasons to buy healthier, nutritious foods, poor consumers might go hungry following COVID-19's exacerbation of pre-existing disparities. While large food retailers in the region were quite advanced in their digitalization processes and ready to profit from the increase in online sales, small and medium-sized food retailers are facing significant bottlenecks associated with O2O migration: lack of investment in logistics, low human resource qualifications, in addition to deficits in their processes and organizational structure (FAO, 2020h). The COVID-19 pandemic has disproportionately affected smallholder producers, particularly those producing perishable and high-value commodities, hindering their access to markets, finance and support services (FAO, 2020k).

The pandemic has placed increased emphasis on the urgency of facilitating the sustainable transformation of food systems (FAO, 2020l). This is particularly so when it comes to investing in rural development linked with inequality and tied to the digitalization transformation, diversification and resilience of food systems. The pandemic has raised the stakes for greater investments in rural development programmes and more upstream investments, as opposed to more downstream investments in the pre-COVID days, to increase primary production, generate employment and absorb the excess labour from the tourism, food-services, and other heavily hit sectors. APAC governments will also seek to generate an environment conducive to the development of food e-commerce with growth potential, including setting up O2O conversion programmes for SMAEs and agricultural cooperatives, and encouraging large retail companies to integrate small producers and SMAEs into their list of suppliers (FAO, 2020h).

The issue of disaster preparedness and emergency responses has climbed higher on the APAC agenda. This issue is linked to public programmes for safeguarding livelihoods and expanding social protection and safety net systems, which are essential during COVID-19 and in its aftermath. Strengthening the capacities of community and local institutions for multiple risk management is also essential. With regard to disaster preparedness, APAC countries are now painfully aware of the likelihood of similar pandemics in the future, informing their handling of transboundary diseases with added concerns for zoonotic and other potential pandemic-generating crises.<sup>480</sup> Detecting outbreaks early, and intervening rapidly to limit their spread and impact beyond the initial outbreak, requires adopting emergency preparedness procedures and contingency plans, improving current surveillance and laboratory systems and ensuring the availability of emergency funds.<sup>481</sup>

These priority topics will not go away immediately after the pandemic is over, but will likely remain at the top of the agenda over the next decade.

<sup>480</sup> For more information, please see <http://www.fao.org/asiapacific/resources/2019-ncov-asiapacific/en/>

<sup>481</sup> For more information, please see <http://www.fao.org/3/cb1513en/cb1513en.pdf>

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# Scaling up inclusive innovation in agrifood chains in Asia and the Pacific

Scaling up inclusive innovation in agrifood chains in Asia and the Pacific examines the many innovations taking place at all stages of the food value chain in Asia Pacific: from production to manufacturing and retailing as well as the extended value chain, including input supply, financial services and agribusiness support services.

Thanks to digital technologies such as precision agriculture, agricultural drones, digital farming services and marketplaces, as well as other innovations, yields are improving and primary production is becoming more resilient.

By examining these emerging trends and providing concrete examples, Scaling up inclusive innovation in agrifood chains in Asia and the Pacific aims to show how these innovations are affecting food systems and value chains, positively or negatively, and how food producers and farmers can deal with trade-offs.

The report can be a vital resource in future-proofing the region's food systems by showing the impacts of recent innovations, policy solutions identified and lessons learned, particularly in the wake of the COVID-19 pandemic.

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