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DIGITAL TECHNOLOGY UTILIZATION IN THE AGRICULTURE SECTOR FOR ENHANCING FOOD SUPPLY CHAIN RESILIENCE IN ASEAN: CURRENT STATUS AND POTENTIAL SOLUTIONS

Project Report



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CONDUCTED BY CENTRE FOR NON-TRADITIONAL SECURITY STUDIES (NTS Centre)

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OVERVIEW AND STRUCTURE OF REPORT

This project report provides the findings from the assessment of utilization of digital technologies in agriculture to achieve food supply chain resilience and food security in Southeast Asia, conducted in 2020-2021, and commissioned to the Centre for Non-Traditional Security Studies (NTS Centre), S. Rajaratnam School of International Studies (RSIS), Nanyang Technological University, Singapore (NTU). This project was supported by the Association of Southeast Asian Nations (ASEAN) Secretariat as well as the Economic Research Institute for ASEAN and East Asia (ERIA). It is the second component of the larger project, "Enhancing Food Supply Chain Resilience and Food Security in ASEAN."

The report categorises digital technologies in agriculture --digitalisation in production (agtech), supply chains (blockchain)¹ and finance (fintech) -- and finds that there is still a nascent adoption of these technologies in ASEAN. Findings were drawn from desk reviews and analysis of existing databases; virtual workshops and surveys with relevant ASEAN Sectoral Working Groups and Technical Working Groups in agriculture; and surveys and interviews of private sector experts. Based on these, the report identifies key barriers to upscaling the adoption of digital technologies in ASEAN food supply chains, including smallholder financing capitalisation and attitudes; trade and e-commerce practices; inter-operability across digital applications; and enabling infrastructure for digitalisation. It concludes with policy recommendations for addressing each of these barriers, including developing an ASEAN Platform for Cross-Boundary E-Commerce in Agriculture (APCEA), a Harmonised Standard for Data Applications in Agriculture (HSDAA) and an ASEAN Platform for Data Applications in Agriculture (APDAA), among others.

• Chapter 2 presents the key challenges in ASEAN food supply chains and food security, which the succeeding chapters on digitalisation will address. ASEAN food security has suffered from waning gains in agricultural productivity that were achieved through the First Green Revolution (1960s-1990s). These result from

¹ While the term "blockchain" is only one among the digital applications within agricultural supply chains, we use this term here as a shortform for "digitalisation in supply chains" for ease of recall.

the impacts of climate change on agricultural production, among others, which have led to rising food prices and undernourishment levels, both serving as a clear sign for the need for a "Second Green Revolution" in ASEAN agriculture. The COVID-19 pandemic has only worked to reinforce this need, and to expand the prospects for agricultural transformation beyond the production level, and moving it towards developing resilience in regional food supply chains as well. This requires significant financing support to farmers, who are simultaneously food producers, as well as potential users of novel technologies for boosting productivity and supply chain resilience.

- Chapter 3 identifies the key entry points for digitalisation in boosting supply chain resilience towards food security. Amidst ASEAN's push for raising the levels of digitalisation integration across the region, as highlighted by the ASEAN Leaders' Statement on Advancing Digital Transformation in ASEAN, and the ASEAN Agreement on Electronic Commerce or AAEC (signed in Hanoi, Vietnam in January 2019), insufficient focus has been given at the regional institutional level to the application of digital technologies to agriculture. In fact, at the 43rd Meeting of ASEAN Ministers on Agriculture and Forestry (AMAF), the "ASEAN Guidelines on Promoting the Utilization of Digital Technologies in the Food and Agriculture Sector" was officially endorsed. This chapter seeks to contribute concrete policy recommendations to support their implementation, towards the utilization of digital technologies in agriculture for achieving food supply chain resilience and food security in ASEAN. In this regard, it categorises three key entry points for digitalisation in agriculture, namely, digital technologies in agricultural production ("Agtech"), in agricultural supply chains ("Blockchain"), and in digital financial access ("Fintech"), and provides a potential trajectory or evolution of digital agriculture in ASEAN, across the three facets.
- Chapter 4 provides an assessment of the state of digitalisation in ASEAN agriculture, and how far ASEAN is from the envisioned futures for digital agriculture highlighted in Chapter 3. It also provides a landmark consolidation of key existing databases on the adoption of digital technologies in the region, integrated with focus group discussions with members of the ASEAN Sectoral Working Groups (ASWGs) in agriculture. These include insights from our review of existing literature and databases on the top technologies practiced, and the key gaps as well in the region; government perspectives from the focus group discussions (FGDs) hosted by ERIA; and from our online survey. The reader is

directed to **Table 4.1** which summarizes the findings from our database assessment, and **Table 4.2** which summarizes the findings from the FGDs and online surveys.

- Chapter 5 reflects in-depth analysis that dissected the key issues surrounding the task of enhancing food supply chain resilience and food security with the utilization of digital technologies. These are drawn from the interviews with experts in the field of digitalisation in agriculture, with the objective of identifying potential root causes of the challenges to scaling up ASEAN digitalisation in agriculture, and of identifying policy directions to address them moving forward. The interviewees comprised individuals from the digital financing sector, multinational sector, innovation agencies/catalysts, "offtakers" or aggregators, multinational, the non-profit/international sector, and an individual who has had broad experience in strategic marketing and commercialisation, with a lengthy career in both the private and public sector. The names of the individuals have been anonymised except for cases when the individuals were willing to share their identities.
- Chapter 6 provides policy recommendations for addressing these issues. These are drawn from the interviews which the authors conducted, integrated with the findings in this chapter. The recommendations include: 1) Conduct Crop-Market-Area Value-Chain Assessments and Private-Sector Consultations; 2) Develop a Consortium of Private and International Financing Providers for Supporting Digital Transformation; 3) Encourage ASEAN Member States to Explore Combined "Online-Offline" Modes of Delivering Agricultural Extension Services; 4) Develop an ASEAN Platform for Cross-Boundary E-Commerce in Agriculture (APCEA); 5) Integrate Digital Traceability Requirements into ASEAN Food Safety Regulatory Framework (AFSRF); 6) Develop Targeted Information Campaigns on the Importance of e-Commerce Services in the Agricultural Sector to Target Consumers and Farmers; 7) Develop A Harmonised Standard for Data Applications in Agriculture (HSDAA) and an ASEAN Platform for Data Applications in Agriculture (APDAA); 8) Integrate Data and Intellectual Property Protection and Security in Agriculture within ASEAN Framework Agreement on Intellectual Property Cooperation; and 9) Encourage Country-Level Plans in Mapping Out "First-to-Last" Mile Travel Routes and Digital Connectivity, to Enable E-Commerce. Appendix 4 likewise provides a potential strategy map for ASEAN in food supply chain resilience and food security with the utilization of digital

technologies, while further details on interview findings are included in **Appendix 5**.

• Chapter 7 provides a summary of the findings on the state of digital utilisation in agriculture in ASEAN, drawn from interactions by the study team with the ASEAN Sectoral Working Group on Crops (ASWGC), ASEAN Sectoral Working Group on Fisheries (ASWGF), ASEAN Sectoral Working Group on Livestock (ASWGF), and the ASEAN Technical Working Group on. Agricultural Research and Development (AWTG-ARD), an important challenge observed was that the attention given to digital agriculture is still nascent. This is understandable since digital agriculture emerged only in the 21st century alongside the Fourth Industrial Revolution. As such, the application of digitalisation to the food and agricultural sector remains to be esoteric to some of the participants, requiring further elucidation.

KEY CHALLENGES IN ASEAN FOOD SUPPLY CHAIN RESILIENCE AND FOOD SECURITY

Undernourishment in Southeast Asia reached an important turning point in 2014, when the number of undernourished increased from 60 million people in 2014 to 63 million people in 2016, according to the UN FAO's 2018 State of Food Insecurity in the World Report (UN FAO, 2018a; Montesclaros, 2021) (**Figure 2.1**). A key driving factor behind these trends is the slowing productivity growth in cereal crops, especially in ASEAN countries with large populations. Across Southeast Asia, rice makes up 80.7% of the total cereal production with over 189 thousand tonnes of production in 2020, followed by maize (18.9%, with 44 thousand tonnes); together, these compose 99.6% of total cereal production in tonnage, in **Figure 2.2** (UN FAO, 2021). Given that rice makes up majority of the diet in the region, and that land size is relatively fixed, it is important for productivity to grow at pace with demand growth to prevent future food scarcity.



Figure 2.1: Undernourishment in ASEAN (millions)

Source: Adapted from UN FAO (2018a), The state of food security and nutrition in the world 2018: building climate resilience for food security and nutrition, Rome: UN FAO and UN FAO (2019), 'Suite of Food Security Indicators', UN FAOStat database, https://www.fao.org/faostat/en/#data/FS, accessed 30 May 2019.





Source: Adapted from UN FAO (2021), 'Crops and livestock products', UN FAOstat Database, UN FAO. http://www.fao.org/faostat/en/#data/QCL, accessed 17 September 2021.

Yet, whereas the average cereal productivity levels (yields) grew at 2.12% growth per annum in the earlier three-decades of 1961-1990 amid the First Green Revolution, it fell to 1.48% per annum in the latter three decades in 1990-2020 (UN FAO, 2021) (**Figure 2.3**). Climate impacts can be observed from the increasingly unstable growing environments (droughts/floods/pests) based on data from the ASEAN Food Security Information System (AFSIS); in fact, over 1.4 million hectares of rice cropped areas were damaged by environmental factors in 2020, of which more than 82% (1.2 million hectares) was due to droughts and 7% (111 thousand hectares) was due to floods in 2020 alone (AFSIS, 2020).

Floods were more prominent in 2021, damaging 580 thousand hectares of rice cropped area, representing 84% of total crop damage that year, followed by droughts (98 thousand hectares, representing 14% of cropped area damaged) (AFSIS, 2021). The region is also suffering from declining fish stocks caused by over-fishing generally, and from illegal, undocumented and unregulated (IUU) fishing activity, given difficulty in policing; these amount to 11-26 million tons of fish per year, with a potential value of ten to 22 billion US dollars per year (The ASEAN Post Team, 2020).

Figure 2.3: Annual Growth in Cereal Yields in ASEAN in Previous Decade (1961-1990) and in the Recent Decade (1990-2019)



Source: Adapted from UN FAO (2021), 'Crops and livestock products', UN FAOstat Database, UN FAO. http://www.fao.org/faostat/en/#data/QCL, accessed 17 September 2021. Note: As rice makes up 80.7% of total ASEAN production, these trends are mostly reflective of rice, with the remainder representing maize which represents 18.9% of total production.



Figure 2.4: Timeline of COVID-19-induced Movement Controls in ASEAN

Source: Adapted from Hale et al., Blavatnik School of Government, Oxford University (2021), Oxford COVID-19 Government Response Tracker).

Note: For each date (horizontal axis), the vertical axis indicates the total scores on stringency of movement controls applied across ASEAN countries.

Moreover, while there is growing importance of halal and safe food, and traceability, a further problem is in supply chains, is that COVID-19 movement controls disrupted food distribution/purchases (Blavatnik School of Government, 2021) (**Figure 2.4**). Prior to the pandemic, food prices had risen by 20 to 25 percent because of challenges in logistics and transportation, as well as disruptions to post-production processing, storage, distribution and marketing (Teng and Lassa, 2016). In the first year of the COVID-19 pandemic, food prices rose by 25% from March 2020 to March 2021, based on the UN FAO's Food Price Index (**Figure 2.5**), largely driven by vegetable oil price inflation (86%), cereal price inflation (26%) and sugar price inflation (30%). In the second year of the pandemic, from March 2021 to December 2021, food price inflation further accelerated to 47% based on the Food Price Index which covers all food products; these were also driven by increases in vegetable prices (130%), cereal prices (43%) and sugar prices (72%). Moreover, meat and dairy prices grew faster in the second year of COVID-19, with meat prices growing by 17% and dairy prices growing by 36%.



Figure 2.5: Percentage (%) Changes in Global Food Prices amid COVID-19 Pandemic

Source: UN FAO (2022). "World Food Situation- Food Price Index." UN FAO Website. Accessed 19 January 2022.

Even if increases in the price of food ideally benefit farmers, the problem is that farmers may not receive a fair share of the profits from the sale of their products. This is given that middlemen can hold significant bargaining power, as evidenced by the small share of total market margins received by farmers.² A study by Dawe et al. (2008) showed that in the Philippines, farmers receive only 62% of the revenues for every kilogram of rice produced, since the remaining 37% goes to millers (12%) and distributors (25%), while in Thailand, farmers receive a larger share of 86% of the revenues per kilogram of rice produced, while millers and distributors receive only 14%. They concluded that wholesale traders in the Philippines were receiving "excess profits" from rice trade, and identified collusion among traders as one explanation for this. Yet these problems are not unique to the Philippines. In Indonesia, for instance, a study of a village in its Bone Regency shows farmgate prices are only 60% of the prices when they reach consumers (Saadah et al, 2021), meaning that millers and wholesalers together are able to markup rice prices by as much as 40%.

A further challenge is access to finance, which smallholder farmers need in order to acquire the needed technologies for boosting productivity levels. A cursory analysis by Dahlberg Advisors (2012: 15) estimated the financing needs for smallholder farmers globally to improve their productivity and sustainability amounted to USD 450 billion, while the total disbursements from local lenders was only USD 22 billion, and much a smaller amount of USD 350 million was available from social lenders. A later report by the ISF Advisors (2019: 10) reflected that within South and Southeast Asia, the short-term total financing needs for smallholders amounts to USD 68 billion, but the current funding available was only USD 22 billion, leaving a 68% funding gap. A much larger gap was reflected in the long-term financing needs of USD 60 billion, of which only USD 1 billion was available, reflecting a 98% funding gap. Further analysis by the World Wide Fund for Nature (WWF), the Mastercard Foundation Rural (MFR) and Agricultural Finance Learning Lab (AFLL) reflected that, with an estimated 100 million smallholder farmers in Southeast Asia, an additional USD 100 billion annually is needed, but funding supplies are scarce relative to demand (Mikolajczyk et al., 2021: 12). Such challenges are likely to be felt in lower-income ASEAN Member States (AMS) where financial markets are still less developed.

² This study was conducted in Apala Village, Barebbo District, Bone Regency, South Sulawesi Province, Indonesia.

Beyond these, ASEAN agriculture is also facing demographic and labour-market shifts, which in combination can have important food security implications. The agricultural workforce in Southeast Asia is shrinking, from 60% of its population in 1991 to just 30% in 2020 (Stads et al., 2020). This is in part because of an increase in the urbanisation in the region, increasing from 23% urban population in 1960 to 61% in 2020 (World Bank, 2022). The ones who are moving out are likely to be younger and more educated, such that there is a significant upward trend in the aging population in agriculture within Asia (Rigg et al., 2020); for instance, within Thailand, there is an upward trend of farmers aged 65 and above (Poungchompu, 2012). The ones who are left to till the land are also likely to be less educated as well; in the Philippines, for instance, the average farmer has only a fourth-grade education (Pangilinan, 2015).

KEY ENTRY POINTS FOR DIGITALISATION IN BOOSTING SUPPLY CHAIN RESILIENCE TOWARDS FOOD SECURITY

In order to boost the resilience of food value-chains amidst the ongoing challenges raised above, this chapter explores the potential for digitally enhancing food supply chain resilience and food security in ASEAN through the utilization of digital technologies.

To explain the relevance of digital technologies, we begin by describing the value-chain in agriculture, which includes all of the activities that are required before the food products ultimately reach consumers (Figure 3.1). The key element of the agricultural value-chain is the farming or food production phase. which includes planting, crop growth, and crop harvesting. Farmers also exercise a degree of decision-making on the amount of inputs (e.g., seeds, fertilizers, pesticides) they need to purchase for the next farming season, and also in renting farming assets that are needed for boosting the productivity of production; these determine the potential productivity levels of farmers. Farmers also need to source financing (whether through their own revenues or through loans/grants) to be able to purchase the required inputs or to rent the required farming assets, as well as getting insurance from companies to prepare for unfavourable market or weather conditions. After the farming process, the value-chain in agriculture proceeds to the **post-production** phase, which includes processing the crops produced by farmers to prepare them for future consumption; storage of the crops; and wastemanagement for farming refuse (e.g., rice husks). The final phase is the marketing phase, where farmers' goods are brought to the companies that aggregate farmers' produce for wholesale trading or further processing (aggregators or offtakers), and getting the products to the consumers (whether through markets, grocery stores/commissaries, or restaurants).

An important note on **Figure 3.1**, is the colour scheme utilized for the agriculture value-chain. The green colours represent the actual food production process, while the orange colours represent elements which are part of the supplychain of food production, in gathering the inputs, and storing/selling the products, and the blue colour reflects the financing aspect, which primarily refers to the sourcing of financing and insurance for crops too. Some of the elements of the value-chain cannot be exclusively categorized as either farming, supply chains or finance. For instance, there are financing elements in the supply chain processes of selling the products and of getting them to consumers, so we have outlined these in blue colour. Moreover, one of the elements in farming, on purchasing inputs and renting machinery, includes both decision-making by farmers, as well as supply-chain and financing aspects, so it is green in colour but outlined in blue and orange.



Figure 3.1: Value-Chain in Food and Agriculture

The digital technologies for agriculture are summarized in **Figure 3.2**, and elaborated on further in the succeeding sections; we have similarly applied the colour scheme of green (production/farming), orange (supply-chain) and blue (financing) in classifying technologies by respective value-chain components. Based on this value-chain approach, the **key entry-points** for digital agriculture technologies, based on the three key value-chain perspectives, are:

Figure 3.2: Digital Technologies in Agriculture, by Digital Entry Point (Production, Supply Chains, Finance)



Source: Authors

- Digital Technologies in Agricultural Production ("Agtech"): Digital technologies offer opportunities to help farmers address these trends of climate impacts on farming productivity, through "smart farming practices," which we detail further in our technology framework. Additionally, the use of digital technologies to improve agricultural productivity within countries also contributes to increasing the resilience of supply chains against shocks, that is, their capacity and capability to absorb external shocks. This results from the increased regional and national production, which then leads to reduced reliance on producers from outside the region.
- 2. Digital Technologies in Agricultural Supply Chains ("Blockchain"): Digital technologies can allow for "shortening" the supply chain, by allowing farmers to market directly to consumers, while at the same time ensuring the safety and quality of food products through the use of traceability technologies. This further contributes to reducing the uncertainties faced by farmers in marketing their products, by giving them market information which they can leverage to better tailor their products to the needs of the growing regional population.

3. Technologies for Financial Digitalization ("Fintech"): Finally, providing digital financial access to farmers allows for better integrating them into the digital economy, and allowing for a more stable agricultural practice. These can potentially allow for transformation of smallholder farming practices, because greater financial access allows them to utilize better inputs (in the form of fertilisers, seeds, pesticides, organic inputs, as well as crop varieties which are more resistant to droughts, floods, pests and diseases).

DIGITAL TECHNOLOGIES IN AGRICULTURAL PRODUCTION ("AGTECH" OR SMART FARMING)

Digital technologies in agricultural production offer ways of countering the negative impacts of climate change on food production, by boosting agricultural productivity with a data-driven approach, and also to improve use of inputs (**Figure 3.3**).

The impact of a data-driven approach can be best understood from a crop science perspective (Van Ittersum et al., 2013). Each crop cultivar has its own potential yield, or the highest achievable yield in the respective agroclimatic zone, but, each farmer will have their own set of challenges specific to his area, which prevents him from reaching the potential highest achievable yield, whether from pests and diseases, water, nutrient insufficiency, or combinations of these, such that the actual yield is oftentimes lower than the potential highest yield (Van Ittersum et al., 2013) (Figure 3.4). The solution is for each farmer to adopt the necessary technologies to address these challenges (Figure 3.5). The lowest yields are when farmers apply minimal intervention, such as simply planting the seeds and relying on rainfed systems and the base or extant nutrients in soils. For instance, within Indonesia, a recent study has shown that the actual rice yields were only 40%-64% of the potential achievable rice yields across 24 weather and farming stations that covered areas of similar ago-climatic zones (GYGA, 2021; Montesclaros, Babu and Teng, 2019). In contrast, the highest yields are achieved by farmers applying the appropriate pest-reducing methodologies, irrigation to address water insufficiency, and the fertilisers to boost nutrients.

Based on a report by the UN FAO (Sylvester, 2019) the role of digitalization is in allowing for identifying the relevant challenges faced by farmers, prescribing the best potential practices, and implementing these evenly. This is summarized as "precision farming" which "combines sensor data and imaging with

real-time data analytics to improve farm productivity through mapping spatial variability in the field" (Sylvester, 2019: 2). During the growth stages of plants, **Ground ("In-Situ") Sensors and Remote Sensing technology** are needed in gathering ground-level information on the growth rate of plants, the environmental conditions, and farmer practices. These may include "soil health scans, monitor crop health, assist in planning irrigation schedules, apply fertilizers, estimate yield data and provide valuable data for weather analysis," and "track(ing) crop growth stages, weeds, compaction, storm damage" (Sylvester, 2019: 2).





Source: Authors

Next, **Crop Analytics** technologies are needed in processing this data to identify the best possible practices to apply. For instance, they can leverage analytics tools like 1) "Normalized Difference Vegetation Index (NDVI) maps, which can differentiate soil from grass or forest, detect plants under stress, and differentiate between crops and crop stages"; 2) "infrared, multispectral and hyperspectral sensors (to) analyse crop health and soil conditions precisely and accurately"; 3) Crop health assessment/monitoring through combinations of NDVI, Crop-Water Stress Index (CWSI) and the Canopy-Chlorophyll Content Index (CCCI), and 4) High generation orthomosaics (satellite images) for converting "multispectral images into accurate reflectance and index maps, such as NDVI, and uses red, green and blue (RGB) images"(Sylvester, 2019: 4). These can also

provide inputs into **Pest and Disease Management**, to allow for optimal pesticides, herbicides and fertilizers (Sylvester, 2019).

To make data useful, it must feed into the decisions made by farmers on how much inputs to purchase and on the types of inputs to get, in the form of **Farmer Advisory Services**. This may come in the form of "Farm Management Software, Sensing & IoT" (Ag data capturing devices, decision support software, big data analytics) (AgFunder, 2020). In turn, **Automation and Machinery** are needed in helping the farmer to implement the identified best possible practices to apply, that are drawn from data analytics, to allow for "precision variable rate application of liquid pesticides, fertilizers and herbicides" (Sylvester, 2019). Some of these smart farming assets may include using **Drones** for consistent application of fertilizers or using **smart irrigation** to allow for timely and water-efficient irrigation methods, or even **smart seeders** which determine the optimal depth of planting according to the seeds' traits. AgFunder's report also includes Farm Robotics, Mechanization & Equipment (On-farm machinery, automation, drone manufacturers, grow equipment) (AgFunder, 2020).

Digital applications are not limited to crops but apply to fisheries/aquaculture and livestock as well. Appendix 1 of this report provides further information on such applications.



Figure 3.4: Illustration of Yields (tonnes per hectare) Resulting from Varying Practices

Figure 3.5: Illustration of Yields (tonnes per hectare) Resulting from Varying Practices



Source: Authors; Illustration is derived/modified from Van Ittersum et al., 2013.

DIGITAL TECHNOLOGIES IN AGRICULTURAL SUPPLY CHAINS ("BLOCKCHAIN")

The impacts of climate change on agricultural production are worsened by the marketing challenges in getting farming inputs to farmers, and farmers' products to consumers. This is because of inefficiencies in marketing, which can be observed in some countries and subnational areas where farmers are receiving a disproportionately smaller share of revenues relative to the effort they put into growing crops, as highlighted earlier. Such problems can be remedied if farmers are able to access consumers and sell to them directly, and to purchase inputs/rent equipment from their providers in a transparent and efficient manner. **Figure 3.6** summarises the entry-points for digital technologies in supply chains.

At the surface, **Agriculture E-Commerce** would allow farmers to sell directly to consumers (**Agri E-Commerce B2C**), or to procure inputs/machinery from providers (**Agri E-Commerce B2B and Machine Rentals**). This includes ensuring that farmers have the capacity to market their products, and to receive payments online. An equally important approach is to ensure that farmers have timely access to production inputs, given the time-sensitive nature of agricultural production.

The core problem that needs to be addressed before agricultural ecommerce can take-off, however, is that there is always the risk that farmers will not get paid for their products even after the sellers receive these, or for farmers to fail to pay the providers of farming tools/inputs like fertilizers, pesticides, machinery, etc. once farmers receive them. To overcome these, an enabling technology are **Blockchain technologies** or distributed ledger technologies. These allow buyers and sellers to simultaneously transact, so that the payments by the farmers to the input providers are deposited to an independent or third-party account; these payments are then automatically released when the inputs are received by farmers, thus making it impossible to renege from agreements. Similarly, the payments by buyers of farm products (whether companies or individual customers/consumers) to the farmers who sell these commodities, are deposited to an independent or third-party account and automatically released when the farm products are received by the buyers. Blockchain technologies therefore allow for online "marketplaces" for farmers' commodities and inputs/machines to farmers alike, with a further expansion being block-chain enabled Commodities Trading Platforms (AgFunder, 2020). Furthermore, when

engaging in transactions between farmers and equipment/input providers, or between farmers and aggregators/offtakers/ processors, farmers oftentimes have poorer bargaining power owing to their limited information availability. As such, a further important technology is **Supply Chain Analytics**, which processes historical data from previous transactions in order to give an indication to farmers as to what the fair market price is, and to who the lower-cost service providers are.





Source: Authors

A further application of digital technology is in tracking food waste and losses across the supply chain, and in ensuring quality and safety of food products purchased online. These can be enabled by **Traceability technologies** across the supply chain, including DNA fingerprinting (for genetic traceability) and stable isotope ratios fingerprinting (for verifying point of origin of meat products), and mineral element fingerprinting (for ascertaining traces of metals and chemicals, as well as determining the point of origin) and organic component fingerprinting (for ascertaining the presence of component like protein, fatty acids, etc., and further authentication of geographic origin of plants and animals) (Zhao, Li, Jin, & Pan, 2020) (Zhao et al., 2020). The same technologies can also help account for wastage across the supply chain, to make each company in the supply chain accountable for minimising wastage. Furthermore, **Waste Management Technologies** likewise further allow for either identifying solutions to extend the shelf-life of commodities (e.g., minimising moisture to prevent bacteria from forming), and also identifying ways of re-circulating some byproducts/waste into the supply chain (e.g., utilising organic compost and mulches as fertilisers).

In getting products to consumers, food retailers within logistics and distribution can further benefit from Cloud Retail Infrastructure which includes last mile delivery robots & services. They can also benefit from **Restaurant Marketplaces** or online tech platforms delivering food from a wide range of vendors); **eGrocery** or online stores and marketplaces for sale & delivery of processed & un-processed ag products to consume; **Online Restaurants and Meal Kits** i.e., Startups offering culinary meals and sending pre-portioned ingredients to cook at home, or home & cooking tech like smart kitchen appliances, nutrition technologies, food testing devices (AgFunder, 2020). Within stores, they can further benefit from **In-Store Retail & Restaurant Tech** including Shelf-stacking robots, 3D food printers, point-of-sale (POS) systems, and food waste monitoring tools (AgFunder, 2020).

DIGITAL TECHNOLOGIES FOR FINANCIAL DIGITALISATION ("FINTECH") IN AGRICULTURE

Technologies for financial digitalization (FinTech) in agriculture refers to the technologies that allow for the participation of farmers and consumers alike in the digital economy. A key technology in this regard is allowing for farmers to receive **Digital Payments** so that farmers, consumers and input providers alike may transact in a manner that does not rely on physical contact, and which is thus timelier as well since transactions can be done instantaneously (**Figure 3.7**).

Digital payments are crucial to complementing the scaling of the use of digital technologies within supply chains (including **Blockchain**, **Agri E-commerce**, **Supply Chain Analytics**, and **Machine Rentals**), because if consumers do not have access to this feature, then companies cannot sell to them. An important category in this regard is whether individuals own financial accounts in the first place. There can be gaps in financial inclusion, whether along gender, income, age, education level, and along urban-rural lines. Globally, for instance, the World Bank finds that over 1.7 billion individuals are still "unbanked" or lacking such accounts, many of whom are in Asia, Africa, and Latin America (World Bank, 2018).

A further enabler for this is the use of digital technologies for providing **Digital Payments to Individuals**, based on the World Bank's Global Findex Database (World Bank, 2018). This applies to digitised payments from governments to people (in giving social transfers like income supplements); from businesses to people (in paying employees' wages); other payments for work (in paying for the sale of agricultural products, or in self-employment). A further aspect concerns **Digital Payments from consumers to businesses** (such as utility payments, and in paying for agricultural commodities purchased through ecommerce platforms), as well as payments between people (such as **Digital Remittances**). Key drivers for this, include extent to which accounts are used for making digital payments for normal consumer purchases, in particular, how many individuals are using mobile money, debit/credit cards, mobile phones, and internet platforms, for making payments/purchases (World Bank, 2018, p. 55).

As part of digital financial inclusion, it is also important to identify patterns of resilience, through mechanisms under which people are able to save money, and whether they do so formally (e.g., through financial institutions). While this is influenced partly by account ownership, it is also defined by the presence of savings by individuals, and whether such savings rates are growing or not over time. The World Bank noted that the risk exposure within agriculture can be high, especially in cases when farmers suffer from bad harvests (World Bank, 2018). Thus, we also noted the potential for computer-aided or **"Smart" Insurance Claims Forensics** to compute losses (e.g., India) and set prices for crop/farmer insurance products.





Source: Authors

WHAT IS POSSIBLE? POTENTIAL EVOLUTION OF DIGITISED AGRICULTURE IN ASEAN

Based on our review of the existing technologies, we have identified four potential "visions" for digital agriculture in ASEAN, potentially by 2030. These were developed based on our assessment of the potential use-cases for digital technologies in ASEAN agriculture, as illustrated in the **Figures 3.3, 3.6 and 3.7**.

Outcome 1: "All Farmers Practice Smart Farming by Default"

Technologies: Big data, Mobile Data Reporting, Centralised Data Sharing, Analytics and Advisory Services

The first element of the potential future of a digitised ASEAN agricultural sector, is for all farmers in all ASEAN countries to be practicing smart farming. The logic behind this is that smart farming allows for improving the efficiency of agricultural production, by making it data-driven. Thus, we envision that all farmers are able to upload their data on their crop inputs and output (yield/productivity), which is then fed into a centralised system which calculates the optimal practices for farmers to implement. These can then be provided to farmers for their implementation, by themselves or with the use of digital technologies such as smart irrigation or drones for applying fertilizers and pesticides.

- 100% of farmers upload their data on seasonal crop performance via application, after each harvest or as soon as there are disruptions;
- In real-time, all data is automatically aggregated and analysed, to draw area-specific recommendations for maximising yields and minimising costs;
- Recommendations are given to farmers (farmer advisory) on bestpractices, for implementation.

Outcome 2: "360° Real-Time Environment Information Availability in Farms/Fisheries"

Technologies: Big data, Satellites, Drones, Remote/Ground Sensing, Analytics, Centralised Data-Sharing, Vessel Monitoring Systems

The second element of the potential future is that by default, data on disasters, pestilence, and crop performance, and IUU fishing are gathered automatically across all areas concerned within ASEAN. Moreover, it is possible that at a future point in time, agriculture is no longer dependent on government expenditures for technology upgrading. This requires that viable models and policy frameworks have been identified, to enable private sector intermediaries to alleviate farmers of disproportional costs of the adoption of these technologies, in a manner that is "win-win" for both the farmers and the private sector.

• By default, drones, satellites, and remote/ground sensing infrastructure report on disasters, pestilence, and crop performance automatically, and IUU fishing, across all areas concerned within ASEAN.

Outcome 3: "All Farming Inputs and Products are Procured through Digital Marketplaces"

Technologies: Big data, Blockchain, Online Payments, Digital Accounts/Identities, Centralised Data-Sharing

The third element of the potential future is the complete digitalisation of agricultural supply chains. This means that all farming inputs are ordered/procured in a transparent and open international online platform (including absence of product entry barriers). This requires that all farmers have digital identities, and are able to order inputs and pay online, and that all farming products are marketed on a centralised "marketplace" at the country-level and regional-level. Moreover, all farmers across all areas have access to efficient logistics infrastructure to deliver products directly to consumers. On the consumers' side, this entails that all consumers are likewise able to order and pay for food, online.

- All farming inputs are ordered/procured in a transparent and open international online platform (including absence of product entry barriers);
- All farmers have digital identities, and are able to order inputs and pay online;
- All farming products are marketed on a centralised "marketplace" at the country-level and regional-level;
- All farmers have access to logistics infrastructure to deliver products directly to consumers;
- All consumers are able to order and pay for food, online.

Outcome 4: "All Food Products Have a Digital ID for Supply Chain Traceability"

Technologies: Big data, Blockchain, Centralised Data-Sharing, Drones

The fourth element is that all products have a digital ID for supply chain traceability, to show the presence sustainable food production practices, food safety practices, or for purposes such as organic farming or Halal certification. This entails that all food items can be traced back to their ingredients' origins, and that all farming processes are traceable based on their compliance with Good Agricultural Practices (GAPs) and Good Manufacturing Practices (GMPs) for food, and where applicable, Halal Certification and Organic Certification (with further criteria to be added as needed). This also means that all farmers have the technological capacity and profit incentive to report their product origins and practices. Finally, it is envisioned that all consumers across ASEAN member states can purchase agricultural products freely within the group, and potentially with the "Plus Three" partners of China, Japan, and South Korea. Some attributes are:

- 100% of food items can be traced back to their ingredients' origins, and based on their compliance with pre-defined practices;
- 100% of consumers can purchase agricultural products freely within ASEAN member states, and potentially with +3 / other partners.

STATE OF DIGITALISATION IN ASEAN AGRICULTURE: ADOPTION, POLICIES AND CHALLENGES

Despite the potential for digitalization in supporting agricultural production, supply chains and financing, as described in the preceding section **(3.4)**, it has been previously observed that there is a wide gap in digital technology and artificial intelligence adoption among ASEAN countries, which in turn prevents the transformation of the region's economic competitiveness (Loh, 2020). While the potential for increasing digitalization applies to all the sectors of ASEAN economies, it is significant to the agricultural sector too. The insufficiency of the application of smart farming is hinted by the slowdowns in productivity growth in the farming sector over the past decades (UN FAO, 2021), for instance. In fact, the application of novel technologies like digitalization to upgrade agriculture amid climate change, in meeting the food demand for Asia's growing populations, offers an SGD 800 billion opportunity that countries in Asia can potentially seize (Temasek, PwC, Rabobank, 2019).

This aligns too with ASEAN's 2016-2025 Vision and Strategic Plan for ASEAN Cooperation in Food, Agriculture and Forestry, where the first strategic thrust is to "enhance quantity and quality of production with sustainable, 'green' technologies, management systems, and minimise pre- and postharvest losses and waste" (ASEAN, 2020a, p. 9). These initiatives further feed into the following Broad Strategies under the ASEAN's Comprehensive Recovery Framework (ACRF) from the Pandemic (ASEAN 2020b), such as Broad Strategy 1: Enhancing Health Systems: "enhance capacity of public health services to enable health emergency response including food safety and nutrition in emergencies." (p.7); Broad Strategy 2: Strengthening Human Security: "to enhance social protection, and to strengthen food security, food safety and nutrition for the vulnerable groups" (p.7); Broad Strategy 3: Maximizing The Potential of Intra ASEAN Market and Broader Economic Integration: "to further increase intra-ASEAN trade and investment to strengthen our supply chain resilience and regional value chains" (p.8): Broad Strategy 4: Accelerating Inclusive Digital Transformation: "promoting e-commerce and digital economy" "digital connectivity, the use of ICT in education, and digital transformation of MSMEs" (p.8); and Broad Strategy 5: Advancing towards a More Sustainable and Resilient Future: "systemic change... for a

sustainable and resilient future... in all dimensions, particularly in investment, energy, agriculture, green infrastructure, disaster management, and sustainable financing" (p.9).

RESEARCH METHODOLOGIES APPLIED

We conducted an assessment of the current state of utilization of digital technology in ASEAN Member States (AMS) for improving the agricultural productivity and enhancing the resilience of food supply chain. The objective is to leverage this analysis in proposing future policy directions at country level as well as regional level. We further seek to identify potential policy priorities moving forward, for technology adaptation and desirable policies, which would become input for the ASEAN guidelines for digital agriculture. The research approach (**Figure 4.1**) taken in this study is to draw information from four key sources, namely, a) the Focus Group Discussion (FGD) during the First Knowledge-Sharing Workshop, where participants were asked to share the key technologies that they currently have in their countries; b) interviews which we have conducted with private sector and other experts; and c) literature reviews and online databases; and d) findings from a questionnaire which is circulated across members of ASEAN Sectoral Working Groups (a snippet is shown in **Appendix 2**).



Figure 4.1: Research Methodologies Applied

Key Databases Reviewed

We reviewed several databases, namely, the Grow Asia Digital Directory (Grow Asia, 2021), the AgFunder AgtriFoodTech Report on ASEAN (AgFunder, 2020) and the GSMA Digital Agriculture Maps (GSMA, 2020a) to account for the provision of digital agriculture services in production, supply chains, and finance. The findings are summarised in **Table 4.1**. We complemented this with the GSMA's Mobile Connectivity Index (GSMA, 2020b) and the World Development Indicators (World Bank, 2022) to account for challenges in ICT infrastructure, as well as the World Bank's Financial Development Index (World Bank, 2018) and the International Monetary Fund's (IMF's) Financial Access Survey (IMF, 2020) to provide further information on digital financial access (both before and during the COVID-19 pandemic, and in urban and rural areas, pre-pandemic).

• **Grow Asia Digital Directory:** The purpose of this database was to provide investors and agribusinesses access to the range of solutions available in the field, ranging from farmer training to traceability and even lending (Grow Asia, 2021). It contains close to seventy agricultural digital agriculture solutions for smallholder value chains, which are active in Asia, and in our analysis. To link this survey to the objectives of our study, we have focused on technologies available in ASEAN, and the survey also further distinguishes the countries where these companies are operating. This allows for determining gaps in the

provision of digital agriculture across countries within the region, i.e., which countries are "underserved" by digital agriculture companies. This directory is rather expansive in that it is not particularly targeted at mature solutions, but also contains solutions that are in preliminary stages, but which nonetheless hold potential scalable impact on smallholder farmers.

- AqFunder's "Agrifoodtech Investment Report": This report focused on the countries where technologies were developed or domiciled. In comparison to the Grow Asia database, the AgFunder database is limited in that it does not yet include the countries of operation of the said companies. Nonetheless, its value-addition lies in how it complements the Grow Asia database by including companies which are in their early-stages of venture financing, allowing for including companies which were not part of the Grow Asia database. These similarly possess the potential for scalable impact in addressing the unmet demands for agricultural technologies within their own countries. Additionally, as far as the service offerings are concerned, AgFunder's curation of available technologies today are more "downstream" or supply-chain focused, relative to the Grow Asia database, as it includes more activities like e-groceries and online restaurant and meal kits, supply chain intelligence, and restaurant bookings, and business-to-business (B2B) e-commerce among food companies. It nonetheless also includes some "upstream" or farm-related technologies such as drones and imagery and farm-waste processing, although these appear less prominently relative to "downstream" technologies. One can therefore observe that compared to the Grow Asia database, which focuses on technologies for growing food, the AgFunder database focuses more on supply chain interventions, even including supply chain intelligence and traceability technologies. Our findings are summarised in Table 4.1 below.
- GSM Association's (GSMA) database known as "Digital Agriculture Maps" (DAMS):. The purpose of this database was to present a "window into the digital agriculture landscape to help industry practitioners and potential investors understand key trends and emerging opportunities" (GSMA, 2020: 4). The DAMS database contains information on over seven hundred digital agriculture services, which were identified as "active" of 20th January 2020. These were grouped differently from the previous services; in particular, they were grouped according to "use-cases", or applications of digital technologies, namely, "digital advisory," and "agri digital financial services; "agri e-

commerce" and "digital procurement" which provide farmers with access to markets, and "smart farming" which provides farmers with access to farming assets or technologies. Therefore, in spite of differences in the grouping of technologies, the DAMS database provides a further set of lenses to complement those provided by the Grow Asia and AgFunder databases.

World Bank's Financial Development Index (FINDEX) This database . presents the variations in digital financial access among individuals at the highest level of detail. In particular, it considers the variations across gender, education, age, and urban and rural areas. The limitation to this database was that it was it was only available for 2017, as no further survey by the World Bank was conducted since then. This prevents analysis of the broader adoption of digital finance and e-commerce across countries during the crucial COVID-19 period. As such, the fifth database we referred to was the International Monetary Fund's (IMF) Financial Access Statistics (FAS), which contained data during the period of 2020, when COVID-19's impacts could already be felt. This database was limited in that the reporting was not consistent across ASEAN countries, but we nonetheless provide comprehensive figures based on data availability for reporting countries. Finally, we leveraged the World Development Indicators database and the GSMA's Mobile Connectivity Index, to draw further information on the scope and guality of internet access among individuals. A limitation of these surveys was that while they captured the share of individuals with access to electricity at the urban-rural level, they did not have information on variations on internet access across these levels. We thus triangulate our analysis with the World Bank's FINDEX database to extrapolate the variance in the adoption of digital technologies at the rural and urban levels.

Focus Group Discussions and Online Surveys with Government Officials/ASEAN Sectoral Working Groups

Findings from the focus groups and survey respondents can be found in **Figure 4.2 in Appendix 6.** Two knowledge-sharing workshops were conducted over the course of the ERIA's project, 'Enhancing Food Supply Chain Resilience and Food Security in ASEAN with Utilization of Digital Technologies.' These were attended by members of ASEAN's Sectoral Working Groups (ASWG) on (Crops, Fisheries/Agriculture and Livestock) and ASEAN Technical Working Group on Agricultural Research and Development (ATWG-ARD), in order to draw insights and feedback from ASEAN members of respective ASWGs and the AWTG in

identifying the key challenges in developing a digitised agricultural sector. During the First Knowledge-Sharing Workshop hosted by ERIA, ASEAN Secretariat and SEARCA, the NTS Centre co-facilitated the working group session for Group 1 to draw out the relevant technologies being practiced based on the knowledge of government officials and others who formed part of the first working group. We have documented relevant parts of these discussions during the workshops hosted by ERIA, while keeping the names of individuals anonymised/confidential.

We also followed this up with a survey with participants in the previous knowledge-sharing fora (anonymised), to develop a better understanding of issues faced on-ground. The survey questionnaire was divided into three key sections. This survey was shared with the participants of the FGDs, building on the descriptions of the technologies shared in the FGDs. The first section sought to identify the key sectors where digital technologies were used within each country. For the digital technologies in production, we focused on sensors (satellites and remote sensing, drones, ground sensors), data analytics for data, farmer advisory/management services, and automation in farming/fishing. For the supplychains, we focused on traceability, centralised data sharing, and the ability of farmers to participate in e-commerce business-to-business (B2B) and businessto-consumer (B2C). Finally, for digitalisation in financing, we focused on the ability of consumers to purchase products online and make digital payments as well. The survey concluded with a section asking about technology-specific policies in place, as well as the challenges surrounding specific agricultural technologies. The names of all individuals surveyed have been kept confidential. Responses were received from all ASEAN countries except for Cambodia, in which case, publicly available information reports were used to provide some additional insights. In the case of Singapore, FGD insights were supplemented with interviews with onground practitioners beyond the ASWGs.

Expert Interviews

We conducted interviews with experts in the field of digitalisation in agriculture, with the objective of identifying potential root causes of the challenges to scaling up ASEAN digitalisation in agriculture, and of identifying policy directions to address them moving forward. These comprised of individuals from the digital financing sector, multinational sector, innovation agencies/catalysts, "offtakers" or aggregators, the non-profit/international sector, and an individual who has had broad experience in strategic marketing and commercialisation, with a lengthy career in both the private and public sector. The names of the individuals have

been anonymised except for cases when the individuals were willing to share their identities. Detailed findings are presented in **Appendix 5**.

FINDINGS ON STATE OF DIGITALISATION IN PRODUCTION (AGTECH)

This section presents our finding that the majority of the Agtech applications (i.e., digitalisation in production) in ASEAN are focused on crops, although there are initial efforts in applications to the fisheries/aquaculture sector. Government representatives have cited challenges including the lack of technical and technological expertise in utilising novel technologies like drones, as well as the high costs of these technologies. There is also limited application of real-time sensors within agriculture, owing to limited internet access, high startup costs, and high costs of maintaining the data infrastructure and of analysing the data. Furthermore, automation is not yet the common practice in agriculture within the region, owing to challenges such as budgetary constraints and the lack of farmer training in using automated equipment. There is also no centralised data sharing framework within the region, nor within countries, which drills down to the farmer level; in general, data-sharing is only happening through macro-level reports on the agricultural sector, at the country-level.

Database Analysis Findings

Across all technologies, data shows that the majority of digital applications in production among ASEAN member states focus on **farming advisory services**, namely on how to maximise yields with better production practices based on digital information. This also provides information on how to engender climate-smart practices within farms with some companies even providing solutions that are linked to weather and remote-sensing/IOT technologies. Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Brunei and Vietnam all have more than one company providing this service. Some of these companies are focused purely on farmer advisory, including Crop Base (Malaysia), Greenway, Hub and Htwet Toe (Myanmar) and GREENCoffee (Vietnam). Across all farmer advisory services, the country which has the largest number of companies providing this service is Indonesia, followed by Vietnam and the Philippines.

While there are many companies providing solely farmer advisory services, the majority of these companies are in fact providing integrated services, whereby farmer advisory services are linked to other services. Integration within digital production technologies can be observed in the linkage of farmer advisory services to **farmer management services**, where the focus is not just on the farm technologies but on maximising farmer revenues and profits as an enterprise. This
is applicable in the case of SIPINDO (Indonesia). The Grow Asia database likewise includes FarmApp, although this for African countries. In the case of Agrio (Indonesia and Vietnam), farmer advisory services are linked to pest and disease management as well.

In some cases, farmer advisory services are also linked to digitalisation in supply chains. Farmer advisory services are linked to traceability solutions, in the case of MyCrop (Indonesia), FarmCloud (Indonesia, Cambodia and TaroWorks (Philippines, Cambodia and Philippines). Indonesia). and GeoTraceability (Indonesia, Malaysia and Vietnam). They are also linked to supply chain intelligence, in providing farmers with connections to high-value markets, and to those which recognise the value of organic certification, such as in Farmerlink (Philippines) and beyond ASEAN, SmartRisk (India). Alternatively, it can be linked to digital agriculture trading, in the case of Golden Paddy (Myanmar, Vietnam). Moreover, some farmer advisory services are linked to digitalisation in financing, or fintech applications in the case of TaniFund and Eragano (Indonesia), Ricult (Laos), Cropital (Philippines), and Agribuddy (Thailand); this applies also to mySmartFarm (Philippines and Vietnam) although this is still under trial. It is also linked to insurance, in the case of Weather Index Based Insurance for Smallholders (Indonesia, Myanmar and Cambodia).

Our database analysis also shows that almost all ASEAN countries have one provider each, for either **remote sensing, drone technologies, or groundsensors**. There is one provider for remote sensing in Indonesia, Malaysia, Myanmar, the Philippines, Thailand and Vietnam. Similarly, there is one provider for drones and imagery in Indonesia, Malaysia, Singapore, Thailand and Vietnam. As far as ground-sensors and IOT are concerned, there are four providers in Vietnam, and there is one provider each in Indonesia and in the Philippines. However, companies providing drone analytics are only available in Singapore and in the Philippines. Moreover, both sensing and data analytics technologies appear to be less prevalent in the case of Brunei, Cambodia and Laos, although this could also be because they are under-reported.

Findings from Focus Group Discussions and Online Survey

Majority of the implementation of satellite and remote sensing technologies lie in crops, although there are some exploratory initiatives in aquaculture too. During the FGD, respondents from **Thailand**, shared that the government has its own GIS system, "GIS Agro 4.0," for managing agricultural zoning area and evaluating crops health in real time, across economically important crops such as rice, corn,

sugarcane, and cassava. The government likewise has its own tool for agricultural zoning, Agri Map, also focusing on economically important crops. Finally, Thailand is exploring Mobile applications for animal disease prevention and business regulation, using the DLD 4.0 and E-Smart Plus applications, to help farmers control animal diseases and to prevent illegal livestock businesses. Across **Cambodia**, **Laos**, **Myanmar** and **Vietnam**, participants shared that they have early-warning systems for crops and nutrient forecasting for crops. They are likewise leveraging digital technologies for crop and agriculture zoning.

The databases covered in this analysis were rather mute when it came to **Brunei**. As such, the focus group discussions provided complementary in this regard. Participants from Brunei also shared during the FGD that their key initiatives involved the use of sensors for zone monitoring of their crop fields. They also provided farmers with farm advisory services on fertilizer application and irrigation. The use of drones in Brunei is primarily for the purpose of monitoring crop growth. In the case of **Singapore**, participants added the use of startup incubation services for developing sensor technologies; as such, the development of sensors is not directly government-led, but rather, government-supported. Multitiered vertical farming systems are also being implemented in aquaculture and crop growing; to some extent, these systems include some smart farming aspects given that the vertical farming systems are manmade systems where water use is directly controlled by the farm owners. However, it is uncertain to what extent they are utilising automation in the crop growing and aquaculture growing processes.

Unlike Singapore, Malaysia during the study period was still in the early stages in utilising vertical farming and indoor farming, also known as "Plant Factories." Malaysia likewise has pest and disease surveillance programs, which support the spraying of pesticides. Nonetheless, they also shared about the use of agricultural drones for the purpose of area-mapping, and the use of remote-sensing and GIS in monitoring plant areas and activities, as well as soil-mapping. The government is also promoting precision-farming, through smart fertigation and using internet-of-things (IoT) systems, which leverage sensors. Based on the online surveys conducted, we found that there is a need for e-government policies and sufficient and stable internet access.

Some countries have supportive laws and regulations for farmers; for instance, Malaysia has its National Agrofood Policy 2.0 (2021-2030)³ and 12th Malaysia Plan (2021-2025), which are focused on the transformation of the agricultural sector in line with the Industrial Revolution 4.0 (IR4.0) and Sustainable Development Goals (SDGs) 2030. While in some countries, this is supported by international and local NGO partnerships, the shared challenges include the high price for satellite and remote sensing services, and the low resolution of the satellite output and camera-resolution from unmanned aerial vehicles (UAVs) like drones. There is also lack of expertise in the technology and data management among extension officers and farmers.

As far as drones are concerned, survey respondents shared the presence of data-protection policies (Indonesia), as well as basic network inspections, e.g., high voltage lines (Lao PDR). Some financial/technical support is provided (Myanmar), and it is applied mostly for crops, and less for aquaculture/fisheries (Thailand). Flying drones requires approval from aviation agencies, and the airspace can be restricted in some cases (Thailand, Malaysia). In the Philippines, drones have been piloted at the central/national level, but further budgetary support is needed in distributing drone technologies at the sub-national regional levels (Philippines). Challenges shared by respondents include the lack of expertise in the technology and data management system among extension officers and farmers; lack of technical expertise to oversee the drone and image/data processing; the need to ensure safety in all aspects; and the high cost of popular drones in the market.

As far as ground sensors are concerned, some financial/technical support is provided for ground and in-situ sensors in Myanmar. Digital technologies are used also for monitoring/surveillance of fishing vessels, in particular, vessel-monitoring systems (Thailand), as a means to prevent IUU fishing activities. Sensors are likewise being applied to crops and aquaculture (Thailand). This system is already in development process in some countries, from the perspective of providing budgeting (Philippines), and with the involvement of Meteorological

³ Malaysia's National Agrofood Policy (2021-2030), also known as NAP 2.0, focuses on "embracing modernisation and smart agriculture, strengthening domestic market and producing export - oriented products, building talent that meet the demand of the industry, advancing towards sustainable agriculture practices and food systems as well as creating a conducive business ecosystem and robust institutional framework". Source: Statement by H.E. Mr. Syed Mohd Hasrin Aidid, Permanent Representative of Malaysia to the UN, at the Second Committee of the 76th Session of the United Nations General Assembly on Agenda Item 26: Agriculture Development, Food Security and Nutrition. New York, 6 October 2021. https://bit.ly/3JyXATf.

Department (Malaysia). Key challenges include the lack of knowledge and skills of users; expensive equipment such as spectroradiometer or hand-held thermal sensor for crop monitoring; limited internet access for some farmers; and high startup costs for procurement, and high costs as well for maintenance and data analysis.

In data analytics, extension services applied are mostly traditional crop advisory and livestock planning services. There is also some technical and financial support provided by international organisations (Myanmar). However, there is a need to develop legal frameworks for enabling data analytics activity. R&D investments are needed in developing machine learning or deep learning on specific algorithms to solve problems on remote sensing approach. Another challenge is in ensuring sufficient internet connection and bandwidth in some farm areas. Thus, while governments promote agricultural, forestry and fishery extension activities, there is a need to encourage private sector participation in this activity.

Automation in agriculture is not yet a common practice. In many countries, the norm is for manual processes in agriculture. There is a need for financial support with low interest rate for farmers, coupled by supportive rules and regulations in this regard. In Thailand, there are trials for automation in aquaculture, i.e., automatic image alert for control soft shell of crab, and in fisheries try to deliver to knowledge of intelligent shrimp farms. There is also some private sector involvement in Thailand. A key in technology adoption for small scale farmers is to make it affordable at the small-scale level, and for support in covering cost of procurement and maintenance. This is because mostly, available automation technologies have high scale requirements to be viable, which means high investment requirement in terms of infrastructure and production technology, relative to the investment capital in agriculture at the country-level. Further challenges lie in small average land size of household and short land lease terms, which make farming automation unattractive investment propositions. Survey respondents have cited further inadequacies in the form of budgetary constraints, and the lack of training for farmers to implement this initiative.

Finally, as far as centralised data sharing is involved, the base data sharing within governments is currently based on the statistics published on government databases and websites. In Thailand, there are initial stages of big data farming, while in Malaysia, the Malaysia Geospatial Data Infrastructure (MyGDI) has been initiated, as a government program to develop a geospatial data

sharing infrastructure between data provider agencies and users. Interestingly, this allows for a smart partnerships on information sharing and collaboration between agencies in developing further geospatial products faster, more cost-effectively and efficiently. Its National Geospatial Centre (PGN) coordinating the MyGDI program, and has developed various geospatial information sharing platforms to support and facilitate management planning and decision- making process by related sectors. However, there are difficulties in other countries in building a shared, public, transparent database, and in stipulating the responsibilities of users.

Table 4.1: State of Digital Technology Adoption per ASEAN Country, in Number of Providers of Each Type of Technology ("Red" = underserved sector)

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Di	gital F	roduc	ction T	echno	ologies	(AgT	ech)			
Remote Sensing (GA)	0	0	1	0	1	1	1	0	1	1
Drones and Imagery (GA)	0	0	1	0	1	0	0	1	1	1
Drone Analytics (GA)	0	0	0	0	0	0	1	1	0	0
Food Biotech (AF)	0	0	0	0	0	0	0	2	1	0
IoT (GA)	0	0	1	0	0	0	1	0	0	4
Management Farmer (GA)	0	0	5	0	4	0	2	0	2	3
Advisory Farmer (GA)	0	4	10	0	2	4	7	0	3	9
Pests and Diseases (GA)	0	0	1	0	0	0	0	0	0	1
Soil Testing (GA)	0	0	0	0	0	0	0	0	0	0
Digital Advisory (GSMA)	NA	3-4	5+	0	1	5+	3-4	NA	1	5+
Smart Farming (GSMA)	NA	0	3-4	0	1	1	0	NA	1	2

Note: GSMA: GSM Association; GA: Grow Asia, AF: AgFunder Source: Authors , based on public data in respective database

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Digital Supply Chain Technologies (Blockchain)										
B2B E-Commerce (AF)	0	0	2	0	0	0	0	0	0	1
B2C Ecommerce (AF)	0	0	2	0	0	0	0	0	0	0
Supply Chain Intelligence (GA)	0	0	6	0	2	1	2	1	2	1
Traceability (AF, GA)	0	2	12	0	6	1	7	1	5	6
Hire Tractor (GA)	0	0	0	0	0	1	0	0	0	0
Trading	0	0	1	0	0	1	0	1	0	1
In-store tech (AF)	0	0	1	0	0	0	0	6	0	0
E-grocery (AF)	0	0	1	0	2	0	0	2	0	1
Restaurant Booking (AF)	0	0	0	0	0	0	0	1	0	0
Green Packaging Materials (AF)	0	0	0	0	0	0	0	1	0	0
Online Restaurant and Mealkit (AF)	0	0	4	0	1	0	0	3	0	0
Digital Procurement (GSMA)	NA	3-4	5+	0	3-4	0	3-4	NA	2	5+
Agri E-Commerce (GSMA)	NA	2	5+	0	0	0	2	NA	3-4	0
Digitalisation in Finance (FinTech)										
Financing (GA)	0	2	8	0	3	1	5	0	4	4
Digital Finance (GSMA)	NA	2	3-4	0	2	5+	5+	NA	2	2
Insurance (GA)	0	0	1	0	0	2	1	0	0	0
Mobile Payments (GA)	0	0	1	0	0	0	0	0	0	0

Note: GSMA: GSM Association; GA: Grow Asia, AF: AgFunder Source: Authors , based on public data in respective database

FINDINGS ON STATE OF DIGITAL TECHNOLOGIES IN SUPPLY CHAINS (BLOCKCHAIN)

As far as Blockchain (digitalisation in supply chains) is concerned, the key focus in the region has been on traceability, i.e., pinpointing the sources of the food products, the ingredients used, and the processes adopted in production. While governments seek to promote traceability, there is a lack of limited resources on the farmers' side, and a lack of financial incentive as well to do so. As far as ecommerce is concerned, some countries have their own systems, such as the e-Kadiwa (fish-on-delivery) system and the AGRIKonek program (for food products in general) in the Philippines, and the Agro-Bazaar online platform in Malaysia. Singapore likewise has private sector-led e-commerce, which is provided by companies, with no need for direct intervention by the government. However, for the most part, this is still in incipient stages. Even as Indonesia is potentially the largest market for e-commerce in the region, with a population of more than 270 million people, most of its e-commerce activity is still concentrated in nonagricultural products. While Singapore is leading in terms of e-commerce adoption, owing to its high level of development; its small population of less than 6 million individuals makes up a small share of the ASEAN market of more than 650 million individuals. A final point on Blockchain is focused on the digital procurement of agricultural inputs, although similar patterns can be observed as the lack of adoption of e-commerce In particular, high costs of inputs, unstable internet connections, and a lack of technology knowledge prevent farmers from accessing these technologies.

Database Findings and Analysis

The most frequent technology provided by the private sector in ASEAN, are **supply chain traceability solutions**. Indonesia is leading in the provision of this technology, with over twelve companies providing this service. This is followed by the Philippines (7 companies), while Malaysia and Vietnam are tied with six companies each. The most internationalised companies are present in over 4 ASEAN countries. These are SimpleAgri (Indonesia, Malaysia, Philippines and Thailand) and mFish (Indonesia, Myanmar, Philippines, and Thailand).

Some of the companies providing purely traceability services include neoInt (Indonesia, Malaysia and Philippines), Blockchain Advisory, Dynamic Discounting, Jupiter Chain (Indonesia, Malaysia and Vietnam), ScanTrust (Vietnam), FarmERP (Philippines and Thailand), eService Everywhere (Malaysia and Philippines), BlueNumber (Myanmar and Indonesia) and Talad (Thailand). Apart from these, there are also a few integrated solutions. Integration of traceability with digital production can be found in SimpleAgri, focusing on **farmer management tools** (Indonesia, Laos, Malaysia and Philippines) and RT Analytics (Vietnam). We have previously discussed traceability technologies linked with farmer advisory services, so we will not discuss these further here. Beyond these, there are also linkages between traceability solutions **and IoT solutions** (**including sensors**), in the case of Sat4Rice (Vietnam), which is currently in the trial phase. Beyond production, further integration can be seen in technologies that link **traceability with financing**, such as in the case of FarmForce (Indonesia, Thailand and Vietnam), and with mobile payments such as in the case of AgUnity (Indonesia).

Focus Groups and Online Surveys

Beyond these, our FGDs and surveys with government officials also showed that countries are putting in place traceability systems in fisheries through the electronic catch documentation and traceability system (eCDTS) (Philippines) to monitor activities of fisherfolk (municipal, commercial capture fisheries, aquaculture, and the processing sector). There are also traceability applications for Halal and Food Safety Certification (Brunei, Malaysia, Singapore); in Good Agricultural Practice (GAP) and Good Manufacturing Practice (GMP) (Myanmar, Malaysia); in farm products under Organic Certification Scheme (Malaysia, Singapore). Respondents from Indonesia shared licensing for capture fisheries through the Rapid Licensing Service Information System or SILAT (Indonesia). They also have Indonesia's own tool for traceability for fisheries, the STELLINA traceability information system, whose goal is to connect to all supply chain and traceability information system of fish and fishery products, in developing electronic traceability records ranging from fishing, farming, suppliers, distribution, processing, to marketing. Within Cambodia, Laos, Myanmar, and Vietnam, respondents shared they are implementing e-phytosanitary certificates and their electronic catch documentation scheme, to trace sources of illegal, undocumented, and unregulated (IUU) fish products. Finally, Singapore is interested in finding new applications of blockchain, artificial intelligence (AI) and machine learning in helping with food traceability.

However, farmers face the challenge of having limited resources to comply with such requirements. Malaysia's exploration of systems for food safety/traceability is hampered by the high cost of compliance, which deters farmers from accessing it. For example, bar code systems require farmers' own volition to participate and utilise their own resources in doing so as well. This need for parallel efforts among farmers was also echoed by Brunei and Singapore. Respondents also shared the need also for trainings on maintaining field records, and in further harmonising standards. These include measures that allow for transparency in managing and monitor the process and in assuring consumers of the origin and quality of the products, while at the same time to help prevent commercial frauds in meeting the needs of domestic and international consumers.

For **E-commerce**, the Philippines likewise has its own system, Electronic KADIWA or e-Kadiwa, and ISDAlivery (Fish on Delivery), which is an online buying and selling platform for seafoods, to help agrifisheries. Another application is the AGRIKonek platform, which connects buyers to local producers. It also has a farmer dashboard platform that enables agripreneurs to manage their inventory and control production cost online. Within Singapore, e-commerce among farmers is currently being provided by the private companies like Redmart which delivers food to consumers. In Malaysia, the government has its own e-commerce platforms, such as the Agro-Bazaar Online platform. AMS participants shared farmers' use of social media applications for marketing their products, although the imperative remains to expand rural internet access.

In **Digital Procurement of Inputs**, most countries have basic banking and electronic payment systems in place. Some are providing soft loans to support farmers in input procurement. Information on the government procurement processes involved is also made transparent /detailed on government website in the case of Malaysia, under the Government eProcurement policy, as well as on the Ministry / Government Agency website under the tender / quotation category. However, there are challenges in high costs of inputs, in unstable internet network services, and in the insufficiency in technology knowledge among farmers. Interviewees raised the need for policies that reduce taxation and fees for agricultural input procurement. Some have noted that there is potential to leverage green credits, green bonds, green taxonomy in agriculture sectors, in promoting digital procurement.

FINDINGS ON STATE OF DIGITAL FINANCIAL ACCESS (FINTECH)

On the part of Fintech (digital financial access), results presented in this section show that the country with the greatest number of companies providing digital financial services is Indonesia, followed by the Philippines, and with Thailand and Vietnam tied in third place. Missing from the databases were some later-stage companies, such as RedMart in Singapore which was cited during the interviews. Higher-income countries in general have a larger share of their population using the internet to make purchases, in particular, Singapore and Malaysia. There has also been growth in Fintech use amid COVID-19, in terms of the number of mobile and internet-based transactions, the number of registered mobile transactions, and the number of transactions relative to the population (i.e., transactions per 1,000 adults). However, there have been constant challenges in digital equity, as can be seen in lower Fintech use in rural areas relative to urban areas, or by older and less educated segments of the population relative to younger/more educated segments, based on the World Bank's Financial Development Index (FINDEX). A further challenge is a lack of consistent international monitoring of progress in financial digitalisation in the region; for instance, while the World Bank's Financial Development Index (FINDEX) was able to highlight the inequities in Fintech access, this database has not been updated since 2017. Moreover, during the FGDs, the participants shared that the default is still to engage in basic banking and electronic payment systems, rather than to migrate towards digital and mobile payments.

Database Findings

Across digital financial technologies, Indonesia is the strongest, with over seven companies providing this service, followed by the Philippines with 4 companies; Thailand and Vietnam are tied in having 3 companies each. The company, iAPPS, is the most internationalised, with operations in Indonesia, Myanmar, the Philippines, and Thailand. This is followed by Smartfarms Network Pte Ltd which has operations in two countries, even if it is just in trial.

When we assessed the gaps by type of technology within the region, we have identified that based on the Grow Asia Digital Directory (**Table 5.1**), one of the technology gaps is in using mobile payments. For instance, the company "AgUnity" provides smartphones to farmers, which have supply chain traceability features as well through blockchain technology to allow for recording contracts that farmers make for selling their crops. In combination, these allow for greater transparency in markets as well as fairer prices across farmers. It also helps keep

track of losses along the supply chain, given the company's analysis that up to 50% of crop value vanishes between harvest and point of sale.

To understand these trends, we refer to opportunities and challenges in digital financial access based on data from the World Bank Financial Development Index (FINDEX) and International Monetary Fund's Financial Access Survey (FAS).

Growth in Digitalisation in Finance amid COVID

COVID-19's timing was rather fortuitous for several countries in Southeast Asia, considering the rapid state of digitalisation in the region. By the end of 2020, there was a significant upsurge in the number of mobile banking transactions, for instance, in Malaysia, Thailand and Indonesia where data is available, while Myanmar shows improvement from 2018 to 2019 (**Figure 4.2**). Malaysia had over thirteen million transactions in 2019, which increased to close to 20 million by end. Within Indonesia, where the number of mobile transactions fell from 2018 to 2019, there has also been an increase from 3.5 million in 2019 to close to five million in 2020. In terms of the value of these transactions (**Figure 4.3**), Vietnam and Indonesia are likewise leading, with USD 40 billion and USD 27 billion worth of mobile transactions globally, followed by Thailand (USD 57 million) and Malaysia (USD 929 thousand). There is only 2019 data for Myanmar, although based on 2019 data, the country had more than USD 150 million worth of mobile and internet banking transactions.

Figure 4.2: Number of mobile and internet banking transactions (during the reference year, for commercial banks only)



Source: Adapted from International Monetary Fund (2021). 'Financial Access Survey', IMF Website, https://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C (accessed 17 September 2021).

Figure 4.3: Value of mobile and internet banking transactions (during the reference year, for commercial banks only)



Source: Adapted from International Monetary Fund (2021). 'Financial Access Survey', IMF Website, https://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C (accessed 17 September 2021).

In terms of the number of registered mobile money accounts, Indonesia is leading with over 432 million accounts in 2020, which increased from 292 million

accounts in 2019; Thailand likewise increased from forty-two million accounts in 2019 to 63 million accounts in 2020 (**Figure 4.4**). There is an important distinction, however, between the number of registered accounts, and the number of accounts which are active (**Figure 4.5**). For instance, while Cambodia has 9.5 million mobile money accounts, only half of 4.25 million accounts were active in 2020. Moreover, no data is available on the number of active accounts in 2020 in Myanmar and the Philippines, although 2019 figures show that compared to the forty-two million registered mobile accounts in the Philippines, only 9 million of these were active that year, or practically one fourth of the total registered accounts. Similarly, in Myanmar, out of the total 2.1 million registered mobile money accounts in 2019, only 854 thousand were active that year.

Finally, as far as the number of mobile transactions are concerned per person, it is highest in Malaysia. Within Malaysia, there were over eight hundred thousand transactions per 1,000 adults in 2020, a significant increase from 550 thousand in the 2019. Thailand follows Malaysia, with 157,000 transactions per 1,000 adults. Relative to these, and in spite of the larger number of transactions in Indonesia and Vietnam, such transactions are small relative to their total population. In fact, these two countries had fewer than 30,000 transactions per 1,000 adults.



Figure 4.4: Number of registered mobile money accounts

Source: Adapted from International Monetary Fund (2021). 'Financial Access Survey', IMF Website, <u>https://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C</u>

(accessed 17 September 2021).



Figure 4.5: Number of active mobile money accounts

Source: Adapted from International Monetary Fund (2021). 'Financial Access Survey', IMF Website, https://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C (accessed 17 September 2021).

Figure 4.6: Number of internet and mobile money transactions, per 1,000 adults



Source: Adapted from International Monetary Fund (2021). 'Financial Access Survey', *IMF Website*, https://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C (accessed 17 September 2021).

Challenges in Digital Equity and in International Progress Monitoring for Financial Digitalisation

In spite of the progress in e-commerce, however, data is still not widely available across all 10 ASEAN member states in relation to e-commerce transactions. The data highlighted above, was mostly lacking for Brunei, Laos, Singapore, in terms of the number of internet and mobile transactions and the number of registered and active mobile accounts. Furthermore, the region had a significant degree of discrepancy and digital inequity, in terms of use of e-commerce services across countries, represented by the blue column in **Figure 4.7.** While Singapore has the highest degree of integration by individuals in the digital economy, with 90% of individuals 15 years and above having made or received digital payments in the past year. This is followed by Malaysia, at 70%, and Thailand at 62%, based on data from the World Bank's Financial Development Index (FINDEX).

Beyond inter-country differences, **Figure 4.7** also shows that within countries, there was also a significant degree of urban-rural discrepancy in the use of e-commerce; the use of digital payments in rural areas is represented by the grey column. Thailand has the highest degree of such divide, given that the country-wide use of digital payments is 62%, and yet, the rural use of digital payments was only 37%; therefore, Thailand has an urban-rural divide in digital payments of 25%, represented by the red line. This is computed as the difference between the country-wide % share of individuals having made online digital payments, and the rural % share of individuals. After Thailand, Malaysia and the Philippines have the second largest divides, with 17% difference between country-wide digital payment use and rural digital payment use. (Since Singapore is a city-state, we did not include the rural areas in the figure, hence, an urban-rural gap of 0% in digital payment use).



Figure 4.7: Inter-country and urban-rural disparities in e-commerce: Persons who made or received digital payments in the past year (% of people 15 years and older)

Source: Summarised from World Bank (2018), , Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution, Washington, D.C.: World Bank. https://openknowledge.worldbank.org/handle/10986/29510 (accessed 17 September 2021).

Further challenges lay in education. For instance, **Figure 4.8** shows that significant education-related disparities in the use of the internet to access online accounts. Similarly, the age profile of the individual is important, with younger generations being better able to adapt to the digital economy. For instance, **Figure 4.9** shows significant discrepancies in using the internet the access financial accounts between individuals aged twenty-five and above, and those aged 15-24.

Figure 4.8: Share (%) of population using the internet to access financial accounts, for people aged 15 years and above, by level of education.



Source: Summarised from World Bank (2018), , Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution, Washington, D.C.: World Bank.

Figure 4.9: Share (%) of population using the internet to access financial accounts, for people aged 15 years and above, by age.



Source: Summarised from World Bank (2018), Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution, Washington, D.C.: World Bank.

Many of the ASEAN countries still have a low rate of e-commerce penetration, given that as of 2017, only Singapore has a high level of e-commerce

penetration, at 48%, which is greater than China's, at 45%. Following Singapore is Malaysia, at 34% (**Figure 4.10**). These divides have important implications on the agricultural sector, where there is a trend of aging among farmers (Rigg et al., 2020), and where the average education level among farmers is likewise lower than in services and industrial sectors owing to rapid urbanisation levels and job migration to industrial and services sector jobs which have higher education requirements. A further challenge lies in the availability of information. The FINDEX report by the World Bank shows the greatest lest level of detail, accounting for discrepancies within countries. However, this database has not been updated since 2017.



Figure 4.10: Share (%) of population who used internet to buy something online in the past year, for people ages 15 years old and above

Source: Summarised from World Bank (2018) Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution, Washington, D.C.: World Bank.

Findings from Focus Group Discussions and Surveys

As far as **receiving digital payments** is concerned, the default is still to engage in basic banking and electronic payment systems, and not yet digital/mobile payments. Key challenges lie in the unstable internet connections, as well as low levels of technology knowledge on the part of farmers. A potential best-practice in encouraging collaboration between the Bank and payments industry, is to improve and widen the access to the payments infrastructure; in Malaysia's case, these allow for identifying and removing barriers to greater adoption of electronic payments, and for providing the necessary support to ensure the smooth transition to electronic payments to farmers.

While digital marketing can offer farmers better prices for their products, some countries face the challenge of having only local brands, with weak linkages, information infrastructure and skills in some areas. A possible middle-way or interim approach is to leverage cooperatives in securing higher prices for products, with support from the local Chamber of Commerce and Industry (Lao PDR), and in developing smallholder production agreements (Lao PDR). There are also Agricultural Facebook groups to help market products (Lao PDR). On one hand, unstable internet access is a challenge. Another challenge is the low level of appreciation of digital marketing among farmers, which requires training courses for online marketing for farmers; these are currently more popularly provided by the private sector (Thailand). To scale up digital marketing adoption among farmers, there is a need for systematic market demand and value-chain interventions. For instance, in Malaysia, policies and activities are managed by the Federal Agricultural Marketing Authority (FAMA) (Malaysia). However, there is a need to improve knowledge and skills for farmers based on agriculture extension; to improve institutions, legal regulations to ensure transparency, and to rationalise economic policies such as taxes, green credits, green bonds, agricultural bonds, and eco-labels in a manner that allows for win-win solutions between farmers and consumers.

CRITICAL ANALYSIS OF KEY ISSUES TO DIGITISED ASEAN AGRICULTURAL SECTOR

In this section, we conduct deeper analysis to dissect the key issues surrounding the task of enhancing food supply chain resilience and food security with the utilization of digital technologies. These are drawn from the interviews which the authors conducted, integrated with the findings in this report. As earlier discussed, we conducted interviews with experts in the field of digitalisation in agriculture, with the objective of identifying potential root causes of the challenges to scaling up ASEAN digitalisation in agriculture, and of identifying policy directions to address them moving forward. These comprised of individuals from the digital financing sector, multinational sector, innovation agencies/catalysts, "offtakers" or aggregators, the non-profit/international sector, and an individual who has had broad experience in strategic marketing and commercialisation, with a long career in both the private and public sector. The names of the individuals have been anonymised except for cases when the individuals were willing to share their identities. The key issues are summarised in Figure 5.1 below.



Figure 5.1: Overview of Key Issues

Source: Authors

KEY ISSUE 1, SMALLHOLDER FINANCING: CAPITALISATION CHALLENGES OF SMALLHOLDER FARMERS

One among the key concerns shared was the capitalisation challenges faced by smallholder farmers. This has to do with the lack of consolidation in farming enterprises across the agricultural sector, as shared by our interviewee from a multinational crop solutions provider (Mooney, 2018).⁴ For instance, Mikolajczyk et al. have estimated that there are over 100 million smallholder farmers in Southeast Asia (2021: 12). The lack of consolidation among farmers can be gleaned from a comparison with the markets further upstream in agriculture; for instance, in 2018, four multinational companies (MNCs) controlled majority (67%) of the markets for seeds, and also controlled majority (70%) of the markets for agrochemicals (Mooney, 2018: 4-5). According to our interviewee, this lack of consolidation in agricultural markets implies that each farmer has a smaller amount of capital to leverage in adopting digital technologies in agriculture, in comparison to more consolidated industries such as multinational companies that provide inputs and other more consolidated sub-sectors in agriculture.

The lack of consolidation in agriculture makes the farming sector increasingly reliant on external sources of financing in adopting digital technologies. In some countries, this role can be played by governments that have the capital to invest in digital agriculture adoption; for instance, Singapore has an Agri-Food Cluster Transformation Fund of SGD 60 million (USD 44 million) which it provides to farms directly for digital agriculture as well as other productivity-enhancing technologies (Tan, 2021). In stark contrast, the governments of lower-income ASEAN member states do not have as much leeway to provide this support. During a previous workshop hosted by ERIA in 2018 on "Roadmaps for Disaster Resilience and Climate Change Adaptation," for instance, Cambodia's Ministry of Agriculture, Forestry and Fisheries (MAFF) shared a financing gap for climate change adaptation in agriculture of over USD 187.1 million (Montesclaros, Teng and Babu, 2019), based on the country's Draft Road Map (for) Climate Change Adaptation. Similarly, while Laos, Myanmar and Vietnam representatives did not present any budgets for climate change financing during the workshop, the general sentiment was that the financing gap was also relevant to them too during the said workshop.

⁴ The interviewee holds a global position in helping foster the digital capacities within Asian agriculture within a multinational crop solutions provider that is among the top 4 providers globally.

While there is potential to draw greater international support to finance digital technology adoption to boost farming productivity amidst climate change, it is noteworthy that financing gaps exist even in spite of regular applications by lower-income countries for international grants and loans to make their agricultural sectors more resilient to environmental changes. Moreover, within South and Southeast Asia, the short-term total financing needs for smallholders amounts to USD 68 billion, but the current funding available is only USD 22 billion, leaving a 68% funding gap for short-term financing, and a much larger gap was reflected in long-term financing needs of USD 59 billion, reflecting a 98% funding gap (ISF Advisors, 2019: 10).

Consequently, the onus in boosting investment in adopting digital technologies is increasingly on the private sector. In fact, across our databases surveyed, a commonality in perspective is that the scalability of digitalisation innovations in agriculture depends on the ability of digital agriculture startups to secure venture capital financing.

For ASEAN digital technology providers to draw financing, however, it is important to consider the "unit economics," as shared by our interviewees from the international venture capital sector.⁵ From a venture capitalist's standpoint, there are "economies of scale" in agriculture, whereby the profitability for a particular agricultural innovation increases as its scale or user base grows. This is based on fundamental economics: the marginal cost of an additional good produced and sold become smaller as the total size of goods produced and sold become larger. Therefore, technologies should be able to demonstrate to venture capital providers their potential for scalability, in order draw private investment.

For instance, Wefarm is a peer-to-peer social media platform that provides farmers with advice on what types of inputs to use, such as fertilizers and pesticide. Apart from social media, it can also deliver its services through SMS or text message too ("Wefarm SMS") and not just online; moreover, its website shows that the product is free for farmers to use. "The platform enables farmers to share knowledge, and access a marketplace of trustworthy retailers" (WeFarm, 2021). These build up towards Wefarm's online "Wefarm marketplace" which connects farmers to retail input providers, emphasising the importance of trust, i.e., products are recommended based on feedback by the peer farmer community, thus

⁵ This company has published the annual AgFunder Agrifoodtech report since 2014, which was a seminal report in driving the growth of the market for investing in agricultural technologies. Agfunder has also developed the ASEAN Agtech report, in 2020, which was cited earlier.

providing a potential profit pathway for the digital solution provider. Wefarm engages input retailers, which are able to access thousands of Wefarm members in their own areas, after joining the Wefarm community; these have the potential to become new customers. WeFarm was able to scale up to 2.4 million farmers to date (offices in Uganda, Kenya, Tanzania, and the UK). The large size of its community of users, in turn, provides it with greater "buyer power" or buyer bargaining power, to afford greater quantities of inputs at lower prices, thus offering a further potential profit pathway for the solutions provider without placing additional burdens on farmers.

 Another example is DeHaat, an app developed by an Indian startup that is engaged in contract growing, where institutional purchasers agree to buy the farming produce at pre-agreed price. This app links farmers to institutional buyers and organise farmers to help foster new production contracts. With its business model, it is now serving over 210,000 farmers in Indian states of Bihar, UP, Jharkhand and Odisha, and providing over 3,000 agricultural inputs (Skrinath, 2021).

Assessing the potential scalability and "investment worthiness" of digital technology products however depends on the specific contexts (whether across countries, or within countries) where these products are to be launched. Applied to the ASEAN context, governments would therefore have an interest in understanding the value-chains for agricultural technologies, to allow them to identify appropriate value-chain interventions so that they can scaling up technology provision and distribution, and in turn, draw greater financing from venture capital financing providers.

KEY ISSUE 2, SMALLHOLDER FARMER ATTITUDES: CULTURAL AND TRUST BARRIERS IN PROMOTING DIGITAL ADVISORY SERVICES

A further insight is the challenge of government extension services to adequately deliver on digital agriculture, based on an interview with an innovation catalyst.⁶ Historically, technology extension in food and agriculture production have been well resourced through government extension agencies such as state departments of agriculture. However, the landscape for agricultural businesses, including digital businesses, is now increasingly complex as technology domains converge across agtech, foodtech, fintech, medtech and others.

Private provision of advisory services can also facilitate the extension and adoption of new innovative technologies weighed against best practice standard and good agricultural practice. In addition to production efficiency and profitability, extension is increasingly sought for sustainability and environment production systems, as is being witnessed in the emergence of regenerative farming practices. In addition, downstream business opportunities lie in enterprise restructuring, vertical integration of processing and waste stream management, and in sustainable approaches to traditional crop protection programs. These create opportunities in storage, logistics and supply chain innovations as well as upcycling crop and processing waste. Other solutions may come in arranging regional distribution funds, or in allowing for lean inventory systems so that companies can re-stock efficiently.

The task, therefore, is to identify new and efficient ways to expand knowledge exchange and engagement of emerging service providers. For example, drone-based agronomic services support efficient fertilizer-and crop protection application services that reduce operator exposure and environmental overspray. Drone manufacturers in China such as DJI and XAG, among many others, provide precise application while also bringing important mapping and consolidated production data together. However, given the great diversity and ingenuity across hundreds of millions of smallholder family farmers today, scaling production efficiency and investing in innovation and scale is interwoven with a

⁶ The innovation catalyst interviewed works with enterprises in navigating complex environments and solving core challenges with three key criteria - speed, cost, and impact. It provides open-innovation processes, working with a global network of international domain experts to scout, match, and scale innovative solutions with a clear business case. It is also connected to a range of accelerator programs and support emerging startups through these programs. It supports scaleups in strategy and team development, market entry, commercial scaling, and capital raise activities.

strong cultural overlay of family, food, and community cultures. Thus, it is important to identify community elders or leaders who are willing to be open to sharing good agronomic practices that support community development.

A further challenge, is that of gaining traction through "trust" by farmers, as shared by another interviewee from a multi-stakeholder partnership platform that catalyses action on inclusive and sustainable agricultural development in Southeast Asia. The expert shared insights from a previous report by Grow Asia on the "digital adoption curve" for farmers, from (Stage 1) face-to-face interactions with their individual suppliers, customers and lenders, to (Stage 2) telephone calls for making orders/sales; (Stage 3) peer group dialogue through small group chats via Whatsapp, Line and Facebook Messenger; (Stage 4) using web search, video streaming and online messaging to find new transaction partners and negotiate farm orders (also referred to as the "active discovery" stage); and (Stage 5) actually using applications for conducting trading, finance, and disease recognition (referred to as the "digital service engagement" stage) (Voutier, 2019). Their interviews with farmers in Indonesia, Vietnam and Myanmar showed that majority of farmers interviewed, were using telephone calls (stage 2), followed by peer group dialogue (stage 3), video streaming/messaging (stage 4), and that the smallest share went to digital service engagement (stage 5).

Therefore, it is important to gain the trust of farmers. The previously cited Grow Asia report shows, for instance, that common across all stages is the importance farmers place on lines of trust within the community. The report also showed that digital service engagement (stage 5) depends on farmers' adoption of earlier stages of using social media (stages 3 and 4). The challenge, therefore, is to get more farmers to move into stages 3 and 4, before stage 5 can be reached.

One potential approach to enable the adoption of digital advisory services, is to build on a pre-existing network of trust within the community, such as the current one which includes agents or middlemen. Currently, traders and retailers are already leveraging village-level collectors/distributors as agents in maintaining relationships of trust with farmers. Such agents can be tapped in engendering greater openness of farmers to digital advisory services in agricultural production. This provides an "offline" approach to government extension that complements the "online" approaches discussed previously, for a combined "online-offline" approach to extension services. This is not entirely new; for example, the organisation "Mapan" in Indonesia (acquired by Gojek), makes loans to groups of women in rural areas, through village chiefs or some other agents in the community who have authority. These chiefs/agents are tapped to help pool the money of the individuals, to be able to buy tools for members of the said pool.

KEY ISSUE 3, TRADE AND E-COMMERCE: SPORADIC AND INSUFFICIENT SCALING UP OF E-COMMERCE IN AGRICULTURE

Our database analysis showed that agricultural Business-to-Business (B2B) and Business-to-Consumer (B2C) e-commerce is still weak in Southeast Asia, mostly being available in Indonesia and in Vietnam, based on the AgFunder database. The GSMA shows that whereas agricultural e-commerce is present in Cambodia, Indonesia, the Philippines and Thailand, it is not available in majority of the ASEAN member states. Furthermore, there is a large discrepancy in the number of internet and mobile money transactions across countries, with Malaysia having close to eight hundred thousand transactions per 1,000 population, while Thailand had only 157 thousand, and Vietnam, Indonesia and Myanmar had below fifty thousand; no data is available for the remaining countries. Focus group discussions also revealed that the default was still to engage in basic banking and electronic payment systems, and not yet digital/mobile payments. Therefore, the data shows that the region is still left wanting in drawing more participation of farmers to digital supply chains.

In contrast, our interview with the Executive Director for Sustainability and Agricultural Impact at the world's (and China's) largest e-commerce company, with over 788 million active users, showed the potential for boosting e-commerce adoption. While we cited this company earlier to show that e-commerce companies can provide a funding source for digital technology adoption, we focus here on its "bread-and-butter" of e-commerce. This is greater than other applications, such as Wefarm, which has to 2.4 million farmers using its peer-to-peer social media application (with offices in Uganda, Kenya, Tanzania, and the UK) (WeFarm, 2021) or India's DeHaat which has a reach of 210,000 farmers in Indian states of Bihar, UP, Jharkhand and Odisha (Skrinath, 2021). To understand how this feat was achieved, one important aspect of the said model is on the customers' or consumers' side, whereby the company segments cities according to e-commerce use. It identifies cities which fall in the "sweet spot" of being underserved by ecommerce applications, but at the same time, are rife with potential for ecommerce. Within China, it grouped cities into tiers of economic and political importance, from the highest tier 1 (Beijing, Shanghai, Guangzhou and Shenzhen with nominal urban GDP (or NUGDP) of greater than USD 130 billion), followed by tier 2 (such as Chengdu, Wuhan, Chongging and Foshan, with NUGDP of USD 17-130 billion), to tier 3 (such as Leshan, Ziyang, Yongzhou and Yulin [Shaanxi], with NUGDP of USD 3-17 billion) and the lowest, tier 4 (Gongzhuling, Meishan,

Zhaotong, Liuan and Linfen, with NUGDP of less than USD 3 billion). From this grouping, it then selected the under-served cities, in particular, the tier three cities from which are drawn majority of its loyal users. The reason these were under-served, was that it was only in the past decade when logistics infrastructure and smartphone penetration started to increase in the said rural cities, that e-commerce also started in these cities.

Compared to China, however, systems within Southeast Asia are still fragmented, as shared by our interviewee, who has had broad experience in strategic marketing and commercialisation, with a long career in both the private and public sector. Yet, based on the interview with the e-commerce platform developer/provider, it is precisely the under-served markets that hold promise and potential for becoming e-commerce clients. Rather than relying on a dominant ecommerce provider, our interviewee who had both public and private sector experience shared that an alternative model could lie in developing online "marketplaces" within the region. This will require parallel changes in the systems, beginning with national level programs for digital commerce and marketing in food, followed by an international level, in allowing for cross-border food trade using ecommerce. This marketplace provides networking benefits to farmers, in turn creating a "networking effect." This insight was based on the interviewee's observation that, during the pandemic, there was an increase in firms marketing their products through Facebook. A popular example is allowing for auctions to occur online, wherein online auctions can be created for marketing seafood, like fresh imported food, which is already ongoing in several ASEAN states.

ASEAN-wide implementation of this agricultural e-commerce implies treating ASEAN as an aggregated market of producers and consumers, and allowing for a similar approach which allows farmers to engage consumers from overseas directly, just as China had done at the national level. Therefore, within the complex matrix of producers and consumers globally, an ASEAN-wide implementation can present a positive "disruption" to cross-border trade, if it enables direct purchases from farmers. From this perspective, it is important to consider the basic factors of demand and supply, in enabling an ASEAN-wide approach to happen. On the demand side, consumers in higher-income countries like Singapore are already significantly digitally integrated, but they account for a small market. At the other extreme are larger-population, lower-middle-income countries like Indonesia, which is likely the biggest market in Southeast Asia; yet most products traded via e-commerce in Indonesia are mostly generic ecommerce products (i.e., manufactured products), with food e-commerce having smaller prominence, from our interviewee's viewpoint. As such, even if Singapore

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presents a market for food e-commerce, it is not sufficient to draw majority of the producers in the region to integrate digitally. There is therefore scope for arbitrage in e-commerce adoption across states of varying levels of economic development within ASEAN. This can be impactful too, since it is only when majority of the consumers in ASEAN are digitally integrated to undertake e-commerce services in the food sector, that majority of the farmers will also follow-suit.

KEY ISSUE 4, INFORMATION AND COMMUNICATIONS TECHNOLOGIES AND INTELLECTUAL PROPERTY: LACK OF INTER-OPERABILITY ACROSS DIGITAL APPLICATIONS

The high or prohibitive cost of digital applications is a key challenge that prevents farmers from accessing this technology. A further insight from our interviews, is that this high cost is in part a result of fragmentation in digital data services within ASEAN. On one hand, the advantage of open/outdoor digital applications like ground sensors and satellites is that data is widely available. The ubiquity of data emanates from the diverse capabilities across multiple companies, which have their own programming modules for analytics and providing recommendation modular.

However, the diversity of providers increases the cost to farmers of utilising these services in combination. For instance, while the same satellite data can be used for many different functions, the trouble is that farmer will need to shoulder the cost of procuring data from one sensors/satellite company, and to pay another company for processing this data to provide useful insights for the farming practice (e.g., seed selection). The farmer will need to pay further companies for applying this information to other solutions, such as fertilizer treatments, pesticides application, and others. The result of these is that farmers can be "locked" into using the services of individual providers, and making it expensive for farmers to exploring other data providers.

For instance, in the Philippines drones are being rolled out across multiple regions, each able to cover up to two hundred hectares in 30 minutes, with the help of the UN FAO (UN FAO, 2018b). Drones capture both RGB and near-infrared images. This is being done under the FIELD program of the Department of Agriculture, with support by the UN FAO. Potentially, the information can be used to provide vegetation index information, for comparing plant growth (i.e., photosynthetic activity), and through this, identify areas where there are potential crop and pest infestations; training is being provided to specialists in the UN FAO and in the Department of Agriculture. For this to be used by farmers, there will have to be providers of the said data analytics. However, donor funding alone will not be sufficient, nor sustainable, nor ideal, for serving the over 9.72 million individuals working in the agricultural sector, according to the 2020 Selected Statistics on Philippine Agriculture.

- The same logic would apply to Brunei's use of sensors for monitoring rice fields, applied to three hundred hectares in its major rice producing region; at the moment, the challenge is to raise the uptake by farmers of these technologies as well as in implementing recommendations from farm advisory services.
- Similarly, this logic would apply to Malaysia, where agricultural drones are being explored for area-mapping, alongside remote-sensing and GIS in monitoring of planting areas and activities and soil-mapping, as well as precision-farming for smart fertigation using IOT and sensors/monitoring. These approaches are still in their early stages of exploration/piloting, but the prospects for their scalability, will depend on the market mechanism that incentivises private individuals to provide data analytics services at scale.

On the other hand, niche solutions today cannot allow technology developers to engage farmers as their customer as well, since farmers need packaged end-to-end solutions; otherwise, they will not be motivated to adopt the technologies. What is needed, is for greater consolidation in the industry for providing digital technologies. A further challenge is that there is no universal "Application Programming Interface" (API), which allows multiple data applications to "talk" to one another. This is because, as earlier discussed, the market for providing data services to farmers is still fragmented, with many operators competing to become the market leader, or the operator that caters to all the market's needs.

Therefore, the ideal is that farmers and companies should have the freedom to access multiple data analytics solutions. To achieve this, it will require creating an eco-system, where farmers have a choice, and freedom to operate across multiple applications. Farmers should have freedom to access raw data, and to choose service providers for such. Policy-makers have the potential to enforce this kind of concept. For instance, this problem has to some extent been resolved in the United States, with companies like Bayer (an input/crops solutions provider) and John Deere (an equipment provider) already having a shared platform for agricultural data, allowing farmers to connect the data of different partners together. This is akin to an enterprise resource planning (ERP) system, which "integrates all aspects of a production-based or distribution business, aligning financial management, human resources, supply chain management, and manufacturing or distribution with the core function of accounting" (G2.com, 2021).

This example of a functioning ecosystem for data is available in the United States, and this approach is how this system is generally driven in big markets, based on our interview with an established multinational crop solutions provider. However, this success is not easily replicable in the case of ASEAN, since such information sharing does not typically occur. This is because multiple companies in the value-chain of data provision are still trying to own proprietary data and intellectual property (IP). This makes it challenging to "corporatize" farming innovations. While multinationals are already trying to create eco-system partnership agreements at the corporate level, and while most companies have a similar vision of developing a country-wide or region-wide "ERP," the problem comes in data sharing when negotiating terms and conditions.

As such, the need for a centralised platform for data sharing is never greater than today, as this could enable automated financing and accounting, and also allow them to consolidate soil and satellite data; this also allows for extracting data together, and for visualising this data on the same platform.

KEY ISSUE 5, INFRASTRUCTURE: DISPARITIES IN ENABLING INFRASTRUCTURE FOR DIGITALISATION

The fifth underlying issue is the lack of enabling infrastructure for digitalisation, based on the GSMA's Mobile Connectivity Index (MCI). This database is not focused on agriculture, although it provides insights on the differences in information and communication technology (ICT) infrastructure across ASEAN countries, which enable digital agriculture services. Selected "Enabling Infrastructure Indicators" are presented in **Table 5.1**.

A critical enabling infrastructure is access to electricity, and data suggests that there is 90-100% access to electricity across ASEAN countries, with the exception of Myanmar (63%). A further indicator is access to the internet, which reflects that all ASEAN countries have 90-100% internet access, at least for 2G networks, including Myanmar (95%). It may at first seem illogical that Myanmar has 95% access to the internet even as only 90% of its population has access to electricity. This highlights a key caveat to these indicators, in particular, that they are not geographically representative. In other words, just because 90-100% of the population has access to the electricity, this is not to say that 90-100% of the country's land area has access to the electrical grid.

A further discrepancy lies in the quality of internet access, where further discrepancies across the ASEAN region are revealed, as shown in **Table 5.1**. This includes international internet bandwidth per internet user, where Brunei, Singapore and Malaysia have the highest bandwidths per user (index scores of 83-100). Following these two are Indonesia, Thailand and Vietnam, with bandwidth index scores of 71-80, and even lower bandwidths can be seen in Cambodia and the Philippines, with index scores of 51-60. Finally, countries with the lowest bandwidth index scores are those below 50.

We also referred to the number of secure internet services per 1 million people, where even Singapore as the best performing country in ASEAN has an index score of only approximately eighty. The rest of the countries have index scores below 70, with Brunei and Vietnam having index scores of 61-70, and Indonesia, Cambodia, Malaysia and Thailand having scores of 51-60. The lowest scores, below 50, can be seen in Laos, Myanmar and the Philippines.

Another important indicator for quality of internet access, is the number of Internet Exchange Points (IXPs) per ten million people, which are needed for stable internet connections. Data shows that across most ASEAN countries, Singapore has a high density of IXPs with an index score of 95.54; in contrast, for the rest of the ASEAN region, IXPs are very low in density, with scores below 15.

	Percentage of population covered by 2G networks	Percentage of population covered by 3G networks	Percentage of population covered by 4G networks
Brunei Darussalam	99.06	95.94	85.00
Indonesia	98.71	95.00	95.00
Cambodia	99.00	90.00	93.00
Laos	94.00	78.00	43.00
Myanmar	95.15	90.00	71.89
Malaysia	96.30	95.00	93.00
Philippines	99.00	93.00	80.00
Singapore	100.00	100.00	100.00
Thailand	98.00	98.00	98.00
Vietnam	99.70	95.00	95.00

Table 5.1: Key Statistics from the Mobile Connectivity Index (MCI)

	Percentage of population with access to electricity	International internet bandwidth per internet user	Secure Internet Servers per one million people	Internet Exchange Points (IXPs) per ten million people	
Brunei Darussalam	100.00	86.69	67.56	NA	
Indonesia	98.40	72.35	57.49	5.37	
Cambodia	90.91	54.09	52.58	11.03	
Laos	97.76	41.48	43.78	12.68	
Myanmar	63.73	34.24	37.37	1.68	
Malaysia	100.00	83.07	56.56	8.54	
Philippines	94.47	51.31	44.14	2.52	
Singapore	100.00	100.00	79.75	95.53	
Thailand	100.00	70.94	59.25	5.22	
Vietnam	100.00	75.70	60.99	2.83	

Source: Summarised/Tabulated from GSMA (2020b), Mobile Connectivity Index Database 2019, https://www.mobileconnectivityindex.com/ (accessed 17 September 2021).

There are also significant urban-rural divides in access to electricity, which are captured in the World Development Indicators (WDI) database for Myanmar (37% difference between urban and rural areas), Cambodia (11% difference), Philippines (5% difference), Indonesia (3% difference), and Laos (2% difference), as shown in **Table 5.2**. While data is not available on similar urban-

rural divides regarding internet access and internet bandwidths, similar divides can be expected given that stable internet connections require, minimally, stable access to electricity. In the next section, we return to these urban-rural divides in access to internet services, by referencing geographic divides in using the internet to access their financial accounts in the next section.

	Access to e	Urban-Rural		
	Country	Urban	Rural	Difference (%)
Brunei Darussalam	100	100	100	0
Cambodia	92	100	89	11
Indonesia	99	100	97	3
Laos	98	99	97	2
Malaysia	100	100	100	0
Myanmar	66	92	55	41
Philippines	95	98	93	5
Singapore	100	100	100	0
Thailand	100	100	100	0
Vietnam	100	100	100	0

Table 5.2: Urban-Rural Differences in Access to Electricity

Source: Adapted from World Development Indicators Database, World Bank (2021). Note: Urban-Rural Differences are calculated as <u>%ShareUrban-%ShareRural</u>.

Therefore, disparities in the utilisation of digital technologies in agriculture are partly driven by infrastructure gaps, including access to electricity which shows significant rural-urban divides especially in the case of Myanmar and Cambodia (based on the World Development Indicators database). Comparable rural-urban data are not available for internet access. Although most countries are well as far as the share of the population covered by 2G networks (i.e., 64 kbps), gaps are revealed when it comes to access to 3G networks (up to 2mbps) and 4G networks (200 mbps-1gbps). Myanmar is lagging behind the rest of ASEAN in 4G network coverage, while Laos is lagging in both 3G and 4G network coverage. In terms of international internet bandwidth per internet user, Cambodia, Laos, Myanmar are the Philippines are lagging with a score of less than 55 out of 100. In terms of the number of secure servers per 1 million population, almost all ASEAN countries have scores below 60, with the exception of Singapore which scores 79. The biggest gaps can be seen in the number of internet exchange points, where Singapore has a score of 95, compared to scores below 15 for the rest of ASEAN.

POLICY RECOMMENDATIONS FOR DIGITALISATION IN ASEAN AGRICULTURES

This section provides policy recommendations to address the key issues raised in the previous section, which ASEAN Sectoral Working Groups in agriculture can explore further, at the regional level and also the country-level. A summary of the key issues, matched accordingly with policy recommendations, is presented in Table 6.1 below, while the remainder of this section provides further detail to each of the policy recommendations.

KEY ISSUES	POLICY RECOMMENDATIONS
Smallholder Financing: Capitalisation Challenges of Smallholder Farmers	1. Conduct Crop-Market-Area Value-Chain Assessments and Private-Sector Consultations
	2. Develop a Consortium of Private and International Financing Providers for Supporting Digital Transformation
Smallholder Farmer Attitudes: Cultural and Trust Barriers in Promoting Digital Advisory Services	3. Encourage ASEAN Member States to Explore Combined "Online-Offline" Modes of Delivering Agricultural Extension Services
Trade and E- Commerce: Sporadic and Insufficient Scaling Up of E-Commerce In Agriculture	4. Develop an ASEAN Platform for Cross- Boundary E-Commerce in Agriculture (APCEA).
	 Integrate Digital Traceability Requirements into ASEAN Food Safety Regulatory Framework (AFSRF).
	 Develop Targeted Information Campaigns on the Importance of e-Commerce Services in the Agricultural Sector to Target Consumers and Farmers.

Table 6.1: Overview of Policy Recommendations in Addressing Key Issues

Information and	7. Develop A Harmonised Standard for Data
Communications	Applications in Agriculture (HSDAA) and an
Technologies and	ASEAN Platform for Data Applications in
Intellectual	Agriculture (APDAA)
Property: Lack of	8. Integrate Data and Intellectual Property
Inter-Operability	Protection and Security in Agriculture within
Across Digital	ASEAN Framework Agreement on Intellectual
Applications	Property Cooperation
Infrastructure: Challenges in Enabling Infrastructure for Digitalisation	9. Encourage Country-Level Plans in Mapping Out "First-to-Last" Mile Travel Routes and Digital Connectivity, to Enable E-Commerce.

Source: Authors
POLICY RECOMMENDATIONS FOR SMALLHOLDER FINANCING: ADDRESSING CAPITALISATION CHALLENGES OF SMALLHOLDER FARMERS

POLICY RECOMMENDATION 1: CONDUCT CROP-MARKET-AREA VALUE-CHAIN ASSESSMENTS AND PRIVATE-SECTOR CONSULTATIONS

The first policy recommendation is for ASEAN to encourage countries to conduct value-chain assessments for digital agricultural technologies. This should assess the viability and scalability of business-models of existing technology providers (including farmer's adoption and profitability), focusing on specific crops and markets/countries/areas of interest. This is given the insight that there are sectors which are still under-served by digital technologies.

- Disparities in Access across ASEAN: Across the ASEAN countries, our database analysis reveals that digital farmer advisory services are strongest in Indonesia, provided by over 10 companies, while in Brunei, Laos and Singapore, they are less prevalent, based Grow Asia's Digital Directory. Therefore, these three countries present potentially underserved sectors as far as this technology is concerned. Similarly, there is only one provider of remote-sensing technologies in Indonesia, Malaysia, Myanmar, the Philippines, Thailand and Vietnam, while there is no such provider in the said database for Brunei, Cambodia, Laos and Singapore. Drone imagery providers are only present in Indonesia, Laos, Singapore, Thailand and Vietnam, but absent in the rest of the ASEAN countries. For drone analytics services, only the Philippines and Singapore have companies providing this service, while the rest of the countries do not. Therefore, these present the key underserved digital technology sectors in the respective countries.
- Disparities in Use of Digital Farming: Olam's reports shows that it is mostly the higher-valued crops that are provided digital products. For instance, the Olam Farm Information System (OFIS), a tool which allows its field staff to "collect data, record GPS data points for farms and social infrastructure, manage training activities, and track all 'first mile' transactions including financing, input distribution, and crop purchases" (Olam, 2019) is only available for higher-value commodities like coffee and coca in most of the countries which Olam services with OFIS. Similarly, Olam's digital buying

platform, "Digital Origination," is only provided to Cocoa and Coffee growers in Indonesia, and to pepper growers in Cambodia. To provide end-to-end digitisation of the entire procurement operation, Olam has also developed its Olam Traceability App. However, this used mainly on peppers in Vietnam, and coffee in Indonesia. Finally, Olam's "Smart Factories," which are digital technologies for transforming the food manufacturing process, are only offered in Singapore (cocoa), Malaysia (dairy), Indonesia (sugar) and Vietnam (cashew). Across all products, it was only in Thailand, that the rice crop was serviced by digital technologies, in particular, the OFIS tool (OLAM, 2019).

These "Crop-Market-Area" (CMA) value-chain assessments can potentially be outsourced to the private sector or to academia, in collaboration with national and local government bodies. This should include consultation with the private sector as well, on challenges they face in entering specific markets, or in scaling up technology provision and distribution (whether in terms of market challenges or institutional barriers). Private actors to be consulted may include off-takers (e.g., Nestle), as well as technology providers for sensors/drones/satellites, data analytics, automation, and e-commerce services. These assessments should also be crop-specific and market-specific, and should be supported by assessments of electricity and internet access in key rural agricultural production areas, which are potential areas for focused infrastructure investment in the future.

POLICY RECOMMENDATION 2: DEVELOP A CONSORTIUM OF PRIVATE AND INTERNATIONAL FINANCING PROVIDERS FOR SUPPORTING DIGITAL TRANSFORMATION

Farmers by themselves will not adopt technologies, unless incentivised to do so. Beyond venture capital, further sources of financing lie in e-commerce providers, off takers or aggregators, as well as input providing companies. In the case of companies providing e-commerce solutions, for instance, it has been previously shown in China's experience, that such an approach can provide a significant boost to farmers' earnings.

• E-commerce Providers as Partners and Sources of funding: Pin Duo Duo is the largest e-commerce platform in China, in terms of the number of users, as of 2021, even if it started only in 2015 and listed on NASDAQ in

2018. According to media news from Techcrunch, it is valuation is at USD 63 billion, rivalling JD.com, which is the largest retailer in China, at USD 68 billion. While PDD is best known for its innovative use of "gamification" as a way to attract and engage its e-commerce users, we analyse it now as an e-commerce platform that has activities in agriculture, rather than as a gamification-using platform. What is striking is PDD's scale of impact. Since it started tapping agriculture in April 2019, it has engaged approximately 12 million farmers and 600,000 merchant users in China, with farm sales of USD 21 billion in 2019 alone.

There is likewise potential to tap into input providers as well as aggregators or "off takers." This refers to the companies that purchase products in bulk from farmers, through companies like Nestle, Pepsi, Cargill, Olam, and Bungee, which have presence in ASEAN. Off takers engage in contract farming with farmers, which provides farmers with stability of demand for their products, at pre-agreed prices to ensure profitability. Off takers can give farmers guaranteed sales of their products, in exchange for their adoption of technologies. This leaves farmers more time to focus on improving production methods, rather than worrying about selling profitably. This method may also be suitable in the case of Southeast Asia, wherein middlemen can still be engaged in the process, as local agents in helping promote the adoption of technologies.

- Input Providers as Partners and Sources of Funding: The Bayer Crop Science Company, which is among the top global input solution providers, has also launched competitions for research proposals through its "Grants4Ag" (Grants for Agriculture) program, and provided funding support to winners of the competition too.
- Offtakers as Partners and Sources of Funding: Olam International, a key off taker in the ASEAN region, has provided training in good agricultural practices to over 142 thousand farmers, and training in soil practices to over 70 thousand farmers, through the use of digital platforms for farmer engagement, earning it the "Impact Award" during the Innovation Leader's 2020 Impact Awards.

Beyond these, there are actors currently who are playing their individual roles in promoting digital agriculture for climate adaptation and yield-improvement purposes in the region, through bilateral/ international cooperation (USAID, Aus Aid, GIZ, JICA). However, while having more such

initiatives are helpful, the region can further benefit if these interventions are better rationalised and prioritised. This stresses the need to address unnecessary duplications in the initiatives. Solutions to problems have already been uncovered in each of the individual projects being implemented, and a potential way forward is to rationalise the deployment of capital, in order to avoid such redundancies. These dialogues can build on ongoing regional platforms such as APEC/ ASEAN+3 / +6 and other meetings.

Therefore, ASEAN can develop a consortium of private (e-commerce platform providers, input-providers and offtakers) and international (bilateral/multilateral/regional) actors, to enable them to play supportive roles within agriculture, including in bridging the funding gaps for adopting digital agriculture applications. Consultations may be initiated with the private sector, to identify particular constraints they face in engaging the region in their interventions with farmers. This consortium can further engage in benchmarking and best-practice sharing with other countries where agricultural clusters are more effective, such as the United States, to find out how to engage more farmers in dealing with the private sector.

POLICY RECOMMENDATIONS FOR SMALLHOLDER FARMER ATTITUDES: ADDRESSING CULTURAL AND TRUST BARRIERS IN PROMOTING DIGITAL ADVISORY SERVICES

POLICY RECOMMENDATION 3: ENCOURAGE ASEAN MEMBER STATES TO EXPLORE COMBINED "ONLINE-OFFLINE" MODES OF DELIVERING AGRICULTURAL EXTENSION SERVICES

The next policy recommendation is for ASEAN to encourage its member states to explore combined "online-offline" modes of delivering extension services in promoting smart farming/data sharing. The "online" aspect of increasing technology adoption, is to leverage applications developed by the private sector, including social media applications, while the "offline" aspect includes leveraging farmer peer-to-peer networks for best-practice sharing in getting the trust of farmers. This entails leveraging cooperatives, village heads, and village-level collectors or distributors of crops, in encouraging farmers to adopt better technologies.

Such an approach can significantly help in furthering the **ASEAN Guidelines on Promoting the Utilisation of Digital Technologies for ASEAN Food and Agricultural Sector**, which were endorsed by the Forty-Third Meeting of The ASEAN Ministers on Agriculture and Forestry (October, 2021). The goal will therefore be to help farmers to develop an appreciation of how technology adoption benefits them. For instance, some consumers and offtakers/institutional purchasers place higher value on farmers who adopt traceability technologies, and prioritise buying from farmers who provide information on product origins. If this can be communicated to farmers, this may yet allow them to perceive the incentive or opportunity of accessing more markets by applying traceability technologies.

The offline-online approach can tap on the complementary expertise and resources of local actors, including the private sector, local universities/research centres, government, and farmer cooperatives. Local universities/research centres can provide providing technical support and knowledge on growing crops and in the use of existing technologies. Governments can provide operational support, policy incentives, guarantees, supervision and management/coordination roles in expanding the uptake of e-commerce technologies. Finally, farmer cooperatives can play critical bridging roles, by organising farmers, and creating organisations for developing their farming practice as businesses, whereby cooperatives can eventually develop their own capital sources for future investment in productivity-enhancement and technology adoption.

POLICY RECOMMENDATIONS FOR TRADE AND E-COMMERCE: ADDRESSING SPORADIC AND INSUFFICIENT SCALING UP OF E-COMMERCE IN AGRICULTURE

POLICY RECOMMENDATION 4: DEVELOP AN ASEAN PLATFORM FOR CROSS-BOUNDARY E-COMMERCE IN AGRICULTURE (APCEA).

In addressing sporadic and insufficient scaling up of e-commerce in agriculture, ASEAN can explore developing an **ASEAN Platform for Cross-Boundary E-Commerce in Agriculture (APCEA)**. Traditional modes of trading are mostly based on business-to-business dealings. Even if these are aided by digital communication technologies (e-mail messages, etc.), they are still based on traditional approaches to sourcing information in searching for sellers. In contrast, a regional digital platform for cross-border retail trade will allow for importers to more easily sift through the exporters offering a particular product, in order to obtain higher quality and lower-cost agricultural products.

To some extent, the problem of limited information flows for agricultural traders is addressed by social media platforms today, whereby the companies organise live auctions for farmers to sell their agricultural products locally, i.e., social media marketing. However, these only involve information exchanges, while the facilitation of sales and transactions is still done sporadically. There is therefore potential to "evolve" the existing social media-based product promotions, into actual digital e-commerce, in particular, in developing an ASEAN online platform or marketplace. In this manner, such transactions will occur less sporadically, and consumers can benefit from larger network benefits through a greater diversity of product offerings at the international level.

Currently, there is already an **ASEAN Agreement on Electronic Commerce or AAEC** (signed in Hanoi, Vietnam in January 2019). However, this simply promotes the use of e-commerce across countries, without proposing to develop a regional platform for conducting these. Moreover, the agricultural sector is not a particular focus of the said agreement, being excluded from the explicit areas for cooperation among countries (Article 6, Cooperation, AAEC). Nonetheless, the **APCEA** can build on the recommendations of the AAEC, in developing national-level regulatory frameworks (Article 12); in promoting paperless trading, electronic authentication (e-signatures), online consumer protection, cross-border information transfer, and online personal information protection (Article 7); cyber security (article 8), electronic payments (Article 9); national and international logistics (Article 10), stakeholder involvement (Article 11); and transparency in publishing information in relation to the AAEC (Article 13). Beyond the AAEC requirements, the APCEA will further require collaboration with the private sector in either tendering for the development of such a platform, or in partnering with existing platforms should any be interested in providing this service for ASEAN member states.

POLICY RECOMMENDATION 5: INTEGRATE DIGITAL TRACEABILITY REQUIREMENTS INTO ASEAN FOOD SAFETY REGULATORY FRAMEWORK (AFSRF).

Another important element in developing the APCEA is the need to incentivise farmers to use digital traceability applications. This is because without traceability, an APCEA can lead to greater potential for food fraud and food safety risks, as this will lead to a significant growth in the number of transactions to investigate and approve. This therefore requires integrating traceability requirements into established international ASEAN food standards, in particular, the **ASEAN Food Safety Regulatory Framework (AFSRF)**. Currently, these standards focus only on food safety, and not yet on sustainability criteria or on the requirement of full disclosure of ingredients and processes. By integrating these latter components, the region will benefit in that this will in turn incentivise value-chain actors to adopt sustainability and transparency practices.

Interestingly, once this problem of bringing majority of farmers closer to consumers through e-commerce is solved through the APCEA, it will also address the challenge of getting farmers on-board in adopting e-commerce and traceability as well. From a farmer's perspective, engaging these technologies helps them to sell more, and there are also associated benefits in terms of the information they get from the market, assuming there is telecommunications and logistics infrastructure in place to allow for digital market transactions to occur. Therefore, creating the APCEA provides a strong "push" for e-commerce adoption, by increasing the likelihood that there are buyers for food produced by farmers. This in turn, helps ensure that farmers are able to recover the costs of investing in the technologies. The APCEA addresses this, and the marketplace helps in doing this in the most economical manner. One way to do this, is to catalyse an existing marketplace, to move towards food. So, what is key is to find existing e-commerce providers, and catalyse them to create an agri-food marketplace.

POLICY RECOMMENDATION 6: DEVELOP TARGETED INFORMATION CAMPAIGNS ON THE IMPORTANCE OF E-COMMERCE SERVICES IN THE AGRICULTURAL SECTOR TO TARGET CONSUMERS AND FARMERS.

The adoption of digital payments is currently skewed towards younger populace, and also towards those with greater education levels, as shown by the World Bank database. There is therefore a need for ASEAN member states to employ targeted technology promotion campaigns that address older and less educated consumers. Similarly, the benefits of e-commerce need to be communicated to farmers as well. Government extension services should include provision of information and further support to farmers, in digitally adapting their food businesses to the new normal; these include providing entrepreneurial education, enabling receiving mobile payments, and disseminating information on current e-commerce platforms.

The roll-out of these initiatives should focus on getting early wins by prioritising agricultural e-commerce roll-out on "low-hanging fruits" within countries, namely: cities with sufficient logistics and telecommunications infrastructure; with high smartphone penetration; and with high e-commerce activity in non-food sector. The priority is thus to replicate the success of e-commerce in the non-food sector and applying this to the food sector.

POLICY RECOMMENDATIONS FOR INFORMATION AND COMMUNICATIONS TECHNOLOGIES AND INTELLECTUAL PROPERTY: ADDRESSING LACK OF INTER-OPERABILITY ACROSS DIGITAL APPLICATIONS

POLICY RECOMMENDATION 7: DEVELOP A HARMONISED STANDARD FOR DATA APPLICATIONS IN AGRICULTURE (HSDAA) AND AN ASEAN PLATFORM FOR DATA APPLICATIONS IN AGRICULTURE (APDAA)

The ASEAN Leaders' Statement on Advancing Digital Transformation in ASEAN (October, 2021) gave a strong push to digitalisation of economic sectors within the region. However, a lasting challenge in this regard, has been the high cost of digital services in agriculture, which has in part contributed to the slow uptake of digitalisation in this sector. In this regard, ASEAN should consider developing a platform where farmers can connect all different partners' data together. This can be achieved by having a **Harmonised Standard for Data Applications in Agriculture (HSDAA)**, that can provide a uniform categorisation of data and data applications, which allows for more systematic data retrieval and use. This will ideally be a common language across applications, so that the multiple digital technologies available today can be inter-operable and standardised as well. This helps private companies too, in facilitating their assistance to farmers, as it would allow them to compare multiple digital service providers, and to identify the best service provider for the job. Achieving this requires parallel infrastructure and standardisation, within the ICT sector.

• Within agriculture, for instance, there is already a universal and standardised "BBCH-scale," in classifying plants according to the same growth stages (Meier, 2001). This provides a "decimal code system," divided into principal and secondary growth stages, and is based on the cereal code system (Zadoks, Chang and Konzak, 1974). The said scale, allows for identifying interventions, and for standardising approaches within the industry, such as in seed treatment; leaf development; vegetation; and post-harvest/storage treatment, etc.

The HSDAA can potentially address the fragmentation in the market for providing data services to farmers, so that even as technology providers compete to take market leadership in data applications, they do so in a manner that builds on one another's complementary strengths and data gathered. This allows for creating an "eco-system of digital solutions" with detailed classification of technologies, and a **digital master list and ID of**

all products in the market. If all of the products should have unique ID, then this can be used to develop a common industry language; in turn, the nomenclature can be digitised within agriculture, giving each an "ID." In the long-term, this makes it more manageable to ensure that at a later stage in supply chain optimisation, those data can be directly transferrable across applications.

An important consideration in developing the HSDAA is the need for ASEAN as well as the public sector, to collaborate with the private sector in developing an inventory of computer languages used across data applications. This can be followed through by conducting working groups sessions for harmonising these languages, to allow for better interoperability across them. These can be supported by a consortium or alliance of digital technology developers which benefits all companies even if some of the companies may have more advanced/progressive technologies.

A potential further evolution of the HSDAA is to develop an **ASEAN Platform** for Data Applications in Agriculture (APDAA), which provides a universal "Application Programming Interface" (API), which allows multiple data applications to "talk" to one another. This can resemble an enterprise resource planning (ERP) system, which "integrates all aspects of a production-based or distribution business, aligning financial management, human resources, supply chain management, and manufacturing or distribution with the core function of accounting" (G2.com, 2021). If farmers have such an ERP, it could enable automated financing and accounting, and allow them to get soil and satellite data together, and also collaboratively extract and visualise data on the same platform. This combination of a bottom-up approach (HSDAA) and top-down approach (APDAA) can build ASEAN Leaders' Statement the on Advancing on Digital Transformation in ASEAN (October, 2021), that was raised earlier, with a focus on digital transformation in the agricultural sector.

POLICY RECOMMENDATION 8: INTEGRATE DATA AND INTELLECTUAL PROPERTY PROTECTION AND SECURITY IN AGRICULTURE WITHIN ASEAN FRAMEWORK AGREEMENT ON INTELLECTUAL PROPERTY COOPERATION

A potential barrier to developing a platform for interoperability across multiple applications, is the failure to address data protection for farmers and technology developers alike. This can disincentivise farmers from sharing their information on their crop performance and yields, as it can impact on other aspects of the farming business and of their dealings with their competitors. It can also disincentivise technology developers if it exposes their industry secrets.

As such, it is important to complement the HSDAA and APDAA with intellectual property (IP) protection and security guidelines and norms. Therefore, there is a need to introduce a segment for IP protection in such collaborative initiatives, as the region adopts global intellectual property standards which conform to the World Intellectual Property Organisation (WIPO) and to the Patent Cooperation Treaty (PCT) to which ASEAN is already signatory. In particular, provisions should be added to the **ASEAN Framework Agreement on Intellectual Property Cooperation**, with a focus on enabling data-sharing across multiple digital agriculture platforms and applications.

POLICY RECOMMENDATIONS FOR INFRASTRUCTURE: ADDRESSING CHALLENGES IN ENABLING INFRASTRUCTURE FOR DIGITALISATION

POLICY RECOMMENDATION 9: ENCOURAGE COUNTRY-LEVEL PLANS IN MAPPING OUT "FIRST-TO-LAST" MILE TRAVEL ROUTES AND DIGITAL CONNECTIVITY, TO ENABLE E-COMMERCE FROM INPUT PROVIDERS TO FARMER, AND FROM FARMERS TO CONSUMERS.

A further pre-requisite to allow for digital marketplaces to emerge, is the need for efficient logistics channels from both the transport infrastructure and the internet and telecommunications perspectives. Therefore, focused investments are required in developing such channels. One among these channels is from input providers to farmers, where the ideal is that farmers are able to decide on which input provider to source their fertilizers, pesticides, etc. from, in a manner that is not limited by the logistics infrastructure in the country. The other channel is from farmers to consumers, where the ideal is that consumers are able to decide on which farmer to source their inputs from, without being bound by geographical areas.

ASEAN member states should therefore be encouraged to map out these routes from their subregional areas to the consumers. In doing so, they allow for a competitive market from the perspective of input sales and delivery to farmers, and food sales and delivery to consumers. This mapping will thus be the basis for longer-term infrastructure projects. A gradual approach can be taken, prioritising areas closer to the centre, and gradually moving outwards to more far-flung areas.

CONCLUSION: ENHANCING THE UTILIZATION OF DIGITAL TECHNOLOGIES IN AGRICULTURE TOWARDS ACHIEVING A FOOD SUPPLY CHAIN RESILIENCE AND FOOD SECURITY IN ASEAN

This report has discussed the state of digital utilisation in agriculture in ASEAN. Over the course of the NTU/RSIS teams' interactions with the ASEAN Sectoral Working Group on Crops (ASWGC), ASEAN Sectoral Working Group on Fisheries (ASWGF), ASEAN Sectoral Working Group on Livestock (ASWGF), and the ASEAN Technical Working Group on. Agricultural Research and Development (AWTG-ARD), an important challenge observed was that the attention given digital agriculture is still nascent. This is understandable since digital agriculture emerged only in the 21st century alongside the Fourth Industrial Revolution. As such, the application of digitalisation to the food and agricultural sector remains to be esoteric to some of the participants, and requires further elucidation.

In this regard, this report has elucidated "digital utilisation in agriculture," from the perspective of value-chains. In particular, it has provided a categorisation of digital technologies in agriculture, based on the three key entry points for digitalisation in agriculture along the food and agriculture value-chain, namely: digital technologies in agricultural production ("Agtech"), in agricultural supply chains ("Blockchain"), and in digital financial access ("Fintech"). This proposed categorisation can potentially serve as a point of reference for future policy developments in ASEAN, given the nascent and relatively recent attention given to digitalisation in the agriculture sector. Based on the review of literature, this report has also provided a potential trajectory or evolution of digital agriculture in ASEAN, across the three facets. This includes a future where "all farmers practice smart farming by default" and where there is "360° real-time environment information availability in farms/fisheries", on the Agtech aspect; and "all food products have a digital ID for supply chain traceability" on the Blockchain and Fintech aspects.

To ascertain how far ASEAN is from these envisioned futures for digital agriculture, this report also provided a landmark consolidation of key existing databases on the adoption of digital technologies in the region, integrated with focus group discussions with members of the ASEAN Working Groups mentioned above. Based on these, it identified the key gaps within the region across these categories.

AGTECH (DIGITALISATION IN PRODUCTION)

Most of the digitalisation in agricultural production has been focused on crops, with some early efforts in applying this to the fisheries/aquaculture sector. Key challenges include the lack of technical and technological expertise in utilising novel technologies like drones, as well as the high costs of these technologies. There is also limited application of real-time sensors within agriculture, owing to limited internet access, high startup costs, and high costs of maintaining the data infrastructure and of analysing the data. Neither is automation the common practice in agriculture within the region, owing to farmers' budgetary constraints, and their lack of training in using automated equipment. There is also no centralised data sharing framework within the region, nor within countries, at the farmer level; rather, there are only macro-level reports on the agricultural sector, at the country-level.

BLOCKCHAIN (DIGITALISATION IN SUPPLY CHAINS)

While governments seek to promote traceability within Blockchain applications (digitalisation in supply chains), there is a lack of resources on the farmers' side, and a lack of financial incentive as well to do so. Moreover, some governments have initiatives to promote e-commerce, such as the e-Kadiwa (fish-on-delivery) system and the AGRIKonek program (for food products in general) in the Philippines, and the Agro-Bazaar online platform in Malaysia. A private sector-led approach has been taken in Singapore. However, for the most part, these are still in incipient stages. Similar patterns apply to the digital procurement of agricultural inputs. Key challenges included high costs of inputs, unstable internet connections, and a lack of technology knowledge that prevents farmers from accessing these technologies.

FINTECH (DIGITAL FINANCIAL ACCESS)

Higher-income countries in general have a larger share of their population using the internet to make purchases. While there has also been growth in Fintech use amid COVID-19, there have been constant challenges in digital equity, as can be seen in lower Fintech use in rural areas relative to urban areas, or by older and less educated segments of the population relative to younger/more educated segments. There is also a lack of consistent international monitoring of progress in financial digitalisation in the region; for instance, while the World Bank's Financial Development Index (FINDEX) was able to highlight the inequities in Fintech access, this database has not been updated since 2017. Moreover, the default is still to engage in basic banking and electronic payment systems, rather than to migrate towards digital and mobile payments.

This report has further dissected the key drivers of these gaps in application of digital technologies, based on further expert interviews and analysis of databases. Five key issues identified fall under the following areas: 1) smallholder financing (capitalisation challenges of smallholder farmers); 2) smallholder farmer attitudes (cultural and trust barriers in promoting digital advisory services); 3) trade and e-commerce (sporadic and insufficient scaling up of e-commerce in agriculture); 4) information and communications technologies and intellectual property (lack of inter-operability across digital applications) and 5) infrastructure (lack of enabling infrastructure for digitalisation).

Finally, this report concludes with a call for regional strategies that address these key issues, which should be customised according to respective country contexts. This report has provided nine key policy recommendations. Notable among these are the development of a consortium of private and international financing providers supporting digital transformation; developing an ASEAN Platform for Cross-Boundary E-Commerce in Agriculture (APCEA); integrating traceability requirements into established international food standards, in particular, the ASEAN Food Safety Regulatory Framework (AFSRF); develop a Harmonised Standard for Data Applications in Agriculture (HSDAA) and an ASEAN Platform for Data Applications in Agriculture (APDAA); and Integrate Data and Intellectual Property Protection and Security in Agriculture within ASEAN Framework Agreement on Intellectual Property Cooperation.

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APPENDIX 1: DIGITAL APPLICATIONS IN AQUACULTURE, FISHERIES AND LIVESTOCK

Under fisheries, there are opportunities for digital technologies in improving the management of fisheries, including the collection of data on fish stocks, monitoring fishing activity, and improving the enforcement of existing regulations and agreements, especially in addressing illegal, unreported and unregulated (IUU) fishing, as captured in a report published by the OECD (Payrat, 2017). Foremost among these are collaborative monitoring, control, and surveillance (MCS) tools. First are i) Vessel Monitoring Systems (VMS), to map the spatial distribution of fishing vessels and calculate their fishing intensity. These are complemented by ii) Automatic Identification Systems (AIS), which leverage networks to track and report other ships within close proximity, without giving out the position of the ships that track them. Given the short range of 40 nautical miles for AIS transponders, this can be aided by iii) optical and radar satellite imagery, such as those managed by the European Space Agency in collaboration with the European Marine Safety Agency, as some ships are able to avoid detection via VMS and AIS. Furthermore, iv) Electronic Logbooks and Electronic Reporting Systems (ERS) aid in keeping track of fish catches (in terms of both origin and volume) and the types of gear used. The v) use of GSM smartphones that are equipped with VMS transceivers to help collect data from fishing vessels, and to transmit this to satellite operators, for improving the monitoring data in VMS and AIS.

Beyond these, there is also scope for vi) big data storage, sharing and analytics, although the common issue is the lack of a common language for this, and the scope, i.e., the ability to compile information in one place. viii) blockchain technologies can also be used for tracking origin data for the seafood industry, such as in the Earth Twine-Stratis Platform. viii) Smart weighing systems at sea can allow for weighing fish even as ships are in motion, and these can be integrated with ix) radio frequency (RF) id tags for tracing fish boxes back to their points of origin. x) drones can also be used to aid in fish stock assessments, whether it be aerial, surface, or underwater. For instance, the European Maritime Safety Agency (EMSA) is coordinating with a private French company, CLS, in tracking IUU fishing and smuggling activity. Furthermore, xi) electronic monitoring (EM) and on-board survey cameras can be leveraged to help identify fish that are unintentionally caught, i.e., the wrong species, or the wrong size. Finally, it is important to ascertain if xi) a Fish Monitoring Centre (FMC) exists, which integrates the information gathered using the technologies above, and interprets the data, to improve policy development and implementation (Payrat, 2017).

A sub-section within fisheries, is aquaculture (Bostock, 2009). The

management of aquaculture can also be improved through digital technologies, sensors and monitoring tools, including: i) automated counting or estimation of fish stocks, through infrared beams across pipe openings and sonar systems; ii) use of bio frames and stereo vision camera systems for the estimation of weight and biomass of fish for feed management; iii) underwater cameras to regulate the response of fish to feed; iv) sensors (infrared beams or sonar) to detect waste feed; v) environmental control systems for regulating temperature, current and oxygen; vi) the use of tags (external visual tags, RF tags, telemetry tags and passive integrated tags or PITs, for instance) for tracking individual fish in breeding programmes. In stock management, there are opportunities for electronic resource planning (ERP) systems, such as vii) computer-based stock management systems, which leverage digital information for planning feed and harvests; viii) the use of databases for storing and easy access to data; and ix) decision-support tools like environmental modelling tools, geographic information systems (GIS), riskassessment and hazard-analysis tools, market models for demand estimation, and business plan development tools. In quality management, there are also x) quality management tools, for aligning with ISO and Hazard Analysis Critical Control Point (HACCP) standards, as tools in quality management. Important too are xi) traceability systems to record information like location, feed/medicine and chemical inputs applied, storage temperatures, etc. An example of this can be in the use of RF id tags that allow for automatic input of information, and xii) network linkages for linking information from multiple sources.

Under livestock, a report by Deloitte (2017) shows the way by which smart farming within the livestock sector can allow for improving the efficiency of land- and water-use, reducing pollution and emissions, improving logistics, and even reducing antibiotic use from livestock production. First, i) precision-feeding can allow for optimising the feed intake of animals and maximising animal growth rates too, through tailor-fitted nutrient compositions, aided by ii) artificial intelligence for generating insights from data collected; iii) smart waste management, whereby the intelligent collection of data allows for the identification of key waste sources across the supply chain, aided by iv) cyber-physical systems (CPS) and internet of things (IoT) applications that allow for decentralised and automated decision-making; v) big data analytics for tracking consumer preferences and consumption patterns, to aid in enterprise resource planning. There is also potential for vi) information sharing platforms to help optimise logistics and distribution processes for feeds into farms, and for farm products into markets, aided by vii) cloud computing platforms to allow for data storage and processing across large numbers of users. There are also technologies for viii)

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animal health and welfare monitoring, through cameras, image recognition software, and wearables for livestock, and through **ix)** environmental monitoring through drones. These can also allow for the creation of new jobs along the supply-chain, through better data stewardship among farms.

APPENDIX 2 SNIPPETS FROM ONLINE SURVEY

Image: Second construction <th< th=""></th<>
II. Specific Challenges Faced in Each Technology, and Policies Implemented
1. Satellite Data and Remote Sensing: What are the supportive policies and particular challenges faced in adopting these technologies, if any?
Your answer
2. Drones: What are the supportive policies and particular challenges faced in adopting these technologies, if any?
Your answer
3. Ground (In-situ) Sensors for Sensing/Monitoring: What are the supportive policies and particular challenges faced in adopting these technologies, if any?
Your answer
4. Traceability of products: What are the supportive policies and particular challenges faced in adopting these technologies, if any?
Your answer

5. Automation of Farming Processes (e.g. seeding, fishing, etc.): What are the supportive policies and particular challenges faced in adopting these technologies, if any?

Your answer

6. Software/Data Analytics for Analysing Data from Drones/Satellites/Ground Sensors: What are the supportive policies and particular challenges faced in adopting these technologies, if any?

Your answer

7. Farmer Advisory for Crops: What are the supportive policies and particular challenges faced in adopting these technologies, if any?

Your answer

8. Centralised Data Sharing: What are the supportive policies and particular challenges faced in adopting these technologies, if any?

Your answer

9. Farmers' Digital Procurement of their Inputs (e.g. feeds, fertilizers, machinery): What are the supportive policies and particular challenges faced in adopting these technologies, if any?

Your answer

10. Farmers' Receiving Digital Payments for their Harvest: What are the supportive policies and particular challenges faced in adopting these technologies, if any?

Your answer

11. Farmers' Marketing their Products Online: What are the supportive policies and particular challenges faced in adopting these technologies, if any?

Your answer

APPENDIX 3 LIST OF PRODUCTS/COMPANIES IN ASEAN WITH TECHNOLOGY CLASSIFICATIONS

	Product Offered	Technology Classification
1	Alternative Data Credit Score and Verification, LenddoEFL	Finance
2	Drones for Agriculture, Poladrone	Drones and Imagery; Management Farmer
3	SimpleAgri, SimpleAgri	Management Farmer; Traceability
4	Slide, iAPPS	Finance
5	Data analytics, Eaglesensing	Supply Chain Intelligence
6	mFish, Eachmile Technologies	Traceability
7	FarmCloud, Koltiva	Traceability; Advisory, Farmer
8	TaroWorks, TaroWorks	Traceability; Advisory, Farmer
9	GeoTraceability, GeoTraceability	Traceability; Advisory, Farmer
10	Farmforce, Farmforce	Traceability; Finance
11	neoInt, iConcept Software Services	Traceability
12	Blockchain Advisory, Dynamic Discounting, Jupiter Chain (In Trial), JEDTrade	Traceability
13	eService Everywhere, SourceTrace	Traceability
14	Golden Paddy, Impact Terra	Advisory, Farmer

	Weather Index Based	Advisory, Farmer
45	Insurance for Smallholders,	
15	Syngenta Foundation	
16	Agrio, Saillog	Advisory, Farmer
17	FarmAI, ListenField	Advisory, Farmer
10	mySmartfarm (In Trial)	Advisory,
18	Smartfarms Network Pte Ltd	Farmer; Finance
10	SatSure Sparta, SatSure	Insurance;
19		Remote-Sensing
	Advance Al driven analysis,	Remote-Sensing;
20	Adatos	Supply Chain
20		
21	Sustainable Coffee	Supply Chain
21		Intenigence
22	Cadasta Platform, Cadasta	Supply Chain
		Intenigence
22	FarmERP Vishwaam Info, Toch	Traceability
23		
24	Bluenumber, Bluenumber	Traceability
	Telio	B2B E-
25		Commerce
	Relali	B2B E-
26		Commerce
27	Seppure	Nano Technology
28	AlPallate	
29	SinGene	
30	Trax	In-store tech
31	Warung Pintar	In-store tech
32	Mobikon	In-store tech
33	Zeemart	In-store tech
34	Perx Technologies	In-store tech

35	Tinvio	In-store tech
36	Eatsy Technologies	In-store tech
37	Limakilo	E-grocery
38	HappyFresh	E-grocery
39	Glife Technologies	E-grocery
40	SignatureMarket	E-grocery
41	Mekhala Living	E-grocery
42	Kamereo	E-grocery
43	Fore Coffee	Online Restaurant and Mealkit
44	Kopi Kenangan	Online Restaurant and Mealkit
45	Grain	Online Restaurant and Mealkit
46	Yummy Corp	Online Restaurant and Mealkit
47	dahmakan	Online Restaurant and Mealkit
48	abillion Veg	Online Restaurant and Mealkit
49	Wakuliner	Online Restaurant and Mealkit
50	Bubays	Online Restaurant and Mealkit
51	Kedai Sayur	Upstream B2C Ecommerce

52	Eden Farm	Upstream B2C
52		Lcommerce
53	Hoow Foods	Ingredients/ Ing
		intornatics
F 4	Entobel	Ingredients/ Ing
54		Informatics
55	Rice Exchange	Trading
50	RWDC Industries	Green Packaging
56		Materials
	QueQ	Restaurant
57		Booking
	TerraView	Drones and
58		Imagery
	Aerodyne Group	Drones and
59		Imagery
	ATEC Biodigesters	Farm Waste
60		Processing
61	Shiok Meats	Food Biotech
62	Alchemy Foodtech	Food Biotech
	ralali	B2B E-
63		Commerce
64	JuiceInnov8	Food Biotech
	SIPINDO	Management
65		Farmer
	LuckNow (In Trial	Management
	Sam's), International	Farmer
00	Corporation	
07	Digital Farm Development	Management
67	Plan, Grameen Foundation	Farmer
	Crabifier (In Trial), De La Salle	Management
68	University	Farmer
	MimosaTEK	Management
69		Farmer

70	RT Analytics	Management Farmer
71	DDFN (In Trial), Fefifo	Management Farmer
72	MyCrop, MyCrop Technologies	Advisory Farmer
73	Htwet Toe, Village Link	Advisory Farmer
74	GREENCoffee, ICCO Cooperation	Advisory Farmer
75	ImPACT (In Trial). Pessl Instruments	Advisory Farmer
76	Green Way, Greenovator	Advisory Farmer
77	TaniFund	Advisory Farmer
78	Agrimedia	Advisory Farmer
79	Cropital Cropital, Enterprises Corporation	Advisory Farmer
80	Eragano, Eragano Agritech	Advisory Farmer
81	CropBASE, Crops For The Future	Advisory Farmer
82	Agribuddy	Advisory Farmer
83	LISA, 8Villages	Advisory Farmer
84	Farmerlink, Grameen Foundation	Advisory Farmer
85	Ricult, Ricult	Advisory Farmer
86	Talad, Talad Holding Corporation Ltd.	Advisory Farmer
87	N-Frnds, N-Frnds	Finance
88	Agribuddy, Agribuddy	Advisory Farmer
89	CROWDE, CROWDE	Finance

	Tanijoy, In Trial,	Finance
90	Tanijoy	
	DDFN (In Trial), Fefifo	Management
91		Farmer; Finance
	Agrimedia, Agrimedia	Advisory Farmer;
92		ЮТ
	Sat4Rice (In Trial), Nelen &	IOT
93	Schuurmans	
94	AgUnity, AgUnity	Payments
	HARA, HARA	Supply Chain
		Intelligence;
95		Trading
	Akvo Flow, Akvo Foundation	Supply Chain
96		Intelligence
	Next Billion Agri Marketplace,	Supply Chain
97	Next Billion	Intelligence
98	ScanTrust, ScanTrust	Traceability
99	Tun Yat, Tun Yat	Hire Tractor
100	iFarms, iFarms, Inc.	Drone Analytics

Source: Adapted from AgFunder (2021) and Grow Asia (2021) databases

APPENDIX 4 MAP OF STRATEGIC PRIORITIES FOR A DIGITISED ASEAN AGRICULTURAL SECTOR

The 2nd Knowledge-Sharing Workshop on Promoting the Utilization of Digital Technologies for the ASEAN Food and Agricultural Sector (April 2021) provided some guidelines for increasing the adoption of digital technologies across the region. However, among the comments raised by the participants was the need to prioritise across the different objectives. We interpret this as saying that there has to be a clear "theory of change" or logical sequence for achieving the goals set forth, at the beginning of the workshop.

With this in mind, we provide here a strategic perspective on the draft guidelines complied by ERIA, which is illustrated through a **Strategy Map** with hopes that this provides this theory of change or logical sequence. This is not a roadmap, since it does not provide a chronological sequence to achieving the vision; rather, it only elucidates the different perspectives that need to be considered in achieving the envisioned outcomes.

KEY OUTCOMES

The key outcome to be achieved, is the increase in the adoption of digital technology adoption across ASEAN. This is captured below:

• Scaled-up Breakthrough Innovation and Digital Adoption in Agriculture. This outcome includes the objectives captured in the following envisioned futures for a digitised ASEAN agricultural sector: "All Farmers Practice Smart Farming by Default,""360° Real-Time Information Availability in Farms/Fisheries", "All Farming Inputs and Products are Procured through Digital Marketplaces", and "100% of Products Have a Digital ID for Supply Chain Traceability".

Potential Strategy Map for Enabling a Digitised ASEAN Agricultural Sector



The "story" or narrative to understand this map, is described further below, where insights were drawn from draft inputs from the 2nd Knowledge-Sharing Workshop that were shared by SEARCA and ERIA
KEY DRIVERS OF THE OUTCOME

There are five key drivers that can allow for the achievement of the envisioned outcomes, namely, Transformation of Government Extension Services; Private Sector Engagement; Engagement and Partnership with Local Capacity Builders; Financing to Farmers; and Best-Practice Sharing across the Region.

- **Transformation of Government Extension Services in Agriculture**: The foremost drivers are the governments themselves, through the extension services they provide. The following are the points from the draft guidelines, which we compile under this driver.
- **Private Sector Engagement**: Since not all digital technologies come from government but also come from the private sector's initiative, the other key driver is the private sector. Engaging the private sector would entail the following:
- Engagement and Partnership with Local Capability Builders: A further means of expanding the number of farmer-users of digital technologies, is through effective engagement and partnership with local capability builders, like government, private sector, universities, and farmer cooperatives.
- **Financing to farmers:** The provision of financing to farmers on-ground also provides an avenue for addressing the bottlenecks to technology adoption. This differs from multilateral financing, whose goal is to draw more financing into the country; in contrast, financing to farmers focuses on the manner of providing this financing directly to farmers.
- **Best-practice sharing across the region**: Building on the complementary expertise of different countries, as shown in Chapter 3 of this report, the fifth driver is best-practice sharing across the region.

Support / Enabling Environment

The key drivers above will not be sufficient, if an enabling environment is not present which allows for greater technology adoption and cross-technology communication. This is captured by the three supporting objectives below.

• ICT, Electricity, and Logistics Infrastructure: Across all the drivers above, a key pre-requisite is the presence of supportive infrastructure, in the form of roads, as well as telecommunications infrastructure.

- Enabling Business Environment and Regulatory Environment: Equally important to the hard infrastructure, are the softer infrastructure formed by the business and regulatory environments which allow technologies to enter.
- Secure, Transparent and Interoperable Market for Data Service Provision: A further strategy is to give farmers the Freedom to Operate across multiple data service providers. This requires a secure, transparent, and interoperable market for data services that the private sector provides.

Financial Resource Management

To get the initiatives above going, the government will need to mobilize and manage its financial resources effectively, as captured by the two resourcerelated objectives below.

- Strategic Use of Government Resources: The first role of perspective is the strategic use of public resources. This eliminates redundancies and the crowding out of private initiative as a result of too much government intervention, and in turn, allows the government to provide more resources into those areas where such investments cannot be viably provided by the private sector.
- Activating Private, Regional and Multilateral Resources: Private, regional, and multilateral resources are critical to supplementing the government's resources and allowing for a broader degree of impact.

APPENDIX 5 DETAILED NARRATIVE FORM OF POLICY INSIGHTS FROM EXPERT INTERVIEWS

How can digital agriculture adoption ASEAN be scaled up? This was the key question that prompted our interviews with experts, in developing a better understanding the challenges uncovered from our technology assessment which were mostly from the government perspective. Therefore, we conducted expert interviews focused on the private sector perspective, where potential approaches moving forward were identified. We present our insights here in narrative format, and revisit these findings when we provide our policy recommendations in the succeeding sections.

1. Interview 1: Developing Scalable Models for E-Commerce: Interview with E-Commerce Platform Provider

The interviews began with an international e-commerce platform for agricultural products in Asia. The purpose of this interview was to understand the role of e-commerce in agricultural development. Prior to the interview, the interviewee shared a case-study conducted by Singapore Management University, which was discussed during the interview.

This company is among the largest e-commerce platforms in Asia, in terms of the number of users as of 2021, even if it started only in 2015 and listed on NASDAQ in 2018. According to media news from Techcrunch, it is valuation is at USD 63 billion. While the company is best known for its innovative use of "gamification" as a way to attract and engage its e-commerce users, we analyse it now as an e-commerce platform that has activities in agriculture, rather than as a gamification-using platform.

What is pertinent about this first company, is in its scale of impact. Since it started tapping agriculture in April 2019, it has engaged approximately 12 million farmers and 600,000 merchant users in China, with farm sales of USD 21 billion in 2019 alone. While this company is not to the only one engaging in e-commerce, far exceeding any other model in Southeast Asia or even in Asia. This is greater than other applications, such as Wefarm, which has to 2.4 million farmers using its peer-to-peer social media application (with offices in Uganda, Kenya, Tanzania, and the UK) (WeFarm, 2021) or India's DeHaat which has a reach of 210,000 farmers in Indian states of Bihar, UP, Jharkhand and Odisha (Skrinath, 2021). Thus, the extent to which this company has scaled its user base presents a success story that can potentially be replicated by ASEAN countries.

Segmenting Markets and Identifying "Low-Hanging Fruits" for Agricultural E-Commerce Markets

To understand how this feat was achieved, we discuss the two key sides of the company's model. We will begin with the "customers" side, focusing on "city" segmentation. It identified cities which fell in the "sweet spot," i.e., being underserved by e-commerce applications, but at the same time, rife for ecommerce.

- It grouped cities in its target market, China, into tiers of economic and political importance, from the highest tier 1 (Beijing, Shanghai, Guangzhou and Shenzhen with nominal urban GDP or "NUGDP" of greater than USD 130 billion), followed by tier 2 (such as Chengdu, Wuhan, Chongqing and Foshan, with NUGDP of USD 17-130 billion), to tier 3 (such as Leshan, Ziyang, Yongzhou and Yulin [Shaanxi], with NUGDP of USD 3-17 billion) and the lowest, tier 4 (Gongzhuling, Meishan, Zhaotong, Liuan and Linfen, with NUGDP of less than USD 3 billion).
- 2. From this grouping, it selected the under-served cities, in particular, the tier 3 cities from which are drawn majority of its loyal users. The reason these were under-served, is that it was only in the past decade when logistics infrastructure and smartphone penetration was started to increase in the said rural cities.

A key lesson for ASEAN, from the demand or customer/buyer side, is that it is important for the cities to have sound logistics infrastructure and a high penetration of smart phone users. In the case of the rapidly urbanizing ASEAN region, there is much room for e-commerce to grow, including in the field of agricultural supply chains.

Therefore, the policy implication of the company's successful market segmentation, is that given limited resources, ASEAN should also identify and prioritise the cities or areas where there is sufficient 1) logistics infrastructure, 2) telecommunications infrastructure, and 3) penetration rates of mobile accounts as well as mobile and internet purchases, are sufficient. These cities serve as "low-hanging fruits," where the private sector can be involved in building that linkage between consumers and farmers.

Engaging in Quad-Partnerships with the Private Sector, Research Institutes, Local Government Units, and Farmer Cooperatives

The other aspect of company's success, was in how it engaged farmers to engage in e-commerce. The company analysed the market, and found that for a farmer to reach consumers, the original farmgate price of RMB 0.5 per kilogram of vegetables, would increase to RMB 4 per kilogram of vegetables by the time the crop reaches the consumer. By allowing for this direct linkage from farmers to consumers, farmers were empowered to be able to sell their crops for RMB 1 per kilogram of vegetables using the company's app.

This provides an attractive proposition to both farmers and consumers, as consumers can obtain the same vegetables at a lower price, and farmers can also obtain higher sales, compared to those who go through the traditional marketing routes.

One of the challenges commonly faced across ASEAN countries is in engaging farmers to adopt the applications available in the market. The company provides an example of how this can be done. In the company's case, it trained 500,000 farmers in using its application, including the use of e-modules. Apart from these, the company also plays the role of data integrator and analyst for the 12 million farmers that are using their app, providing recommendations on the kinds of crops to farm, even in terms of the varieties within each crop, in order to maximise their sales and revenues, and the prices at which crops can be sold.

These interventions take away the need to train farmers in business analysis, and instead allows them to focus on what they do best, which is farming. In doing so, farmers can then spend more of their time in thinking about the best production methods to adopt, without worrying about not being able to sell their crops at a profit. The company provided over USD 2.2 billion in marketing assistance, and USD 413 million in cash subsidies, in 2019 alone.

This makes way for the next intervention of the company, which was in helping farmers to upgrade their productivity. The company partnered with local agronomic research institutes, in providing technical support as well as providing knowledge on how best to grow crops. It also partnered with local governments in providing operational support, as well as policy incentives, operational guarantees, supervision, and management.

Finally, on the side of farmers, there was a need to form cooperatives, especially for poorer farmers. This was to enable farmers to manage sales by

cooperatives, and to help with business development as well. In fact, the focus of the company was on the poorest farmers, who were identified by government as living in extremely poor areas. The objective, within this cooperative model, is for the company to no longer need to do as much in helping farmers in the future, but rather, for the cooperatives to be selfsustaining business units that are able to make decisions for developing the cooperative farming enterprise by themselves.

The key insight for ASEAN, from the interviewed company's experience, is that initiatives that help farmers adopt new technologies and practices, can be rapidly scaled if the appropriate business model is applied, and if there is sufficient private sector incentive to enter. This means that the resource capacity shortage issues that were formerly identified as hindrances, need not be binding constraints, since the private sector can step in and serve farmers, who are "under-served" in terms of e-commerce. However, for this to happen, governments should provide businesses with the freedom to operate, as such.

2. Interview 2: Developing "Marketplaces" to Innovate Ecosystems: Insights from Interview with Professional with Extensive Background in Private/Public Sector

We conducted a further interview with an individual who has had broad experience in strategic marketing and commercialisation, with a long career in both the private and public sector, who shared that an alternative model of getting this done, was to develop an online "marketplace" within the region.

The Importance of Scaling ASEAN Digital E-commerce Use

Unlike the previous interviewee, which was an established company in providing e-commerce services, with significant volumes, and group purchases to boot. The problem is that within Southeast Asia, not all countries have an eco-system approach that engages smallholder farmers. Therefore, thinking about ASEAN-wide implementation of this technology implies treating ASEAN as an aggregated market of producers and consumers, and allowing for a similar approach which allows farmers to engage consumers from overseas directly, just as China had done at the national level. Within the complex matrix of producers and consumers globally, an ASEAN-wide implementation implies a positive disruption to cross-border trade, if it enables direct purchases from farmers.

From this perspective, it is important to consider the basic factors of demand and supply, in enabling an ASEAN-wide approach to happen. On one hand, the demand side, there are countries like Singapore which are already significantly digitally integrated, but they account for a small market. This means that even if Singapore presents a market for food e-commerce, it is not sufficient to draw majority of the producers in the region to integrate digitally. At the other extreme are countries like Indonesia, which is probably the biggest market in Southeast Asia in terms of both population and level of development. However, most products traded via e-commerce in Indonesia are mostly generic e-commerce products (i.e., manufactured products), with food e-commerce having smaller prominence. In this regard, it is only when majority of the consumers in ASEAN are digitally integrated to undertake ecommerce services in the food sector, that majority of the farmers will also follow-suit.

"Evolving" a regional Marketplace for agricultural products out of the current social media promotion activities

Systems within Southeast Asia are still fragmented, meaning it will require parallel changes in the systems for firstly, marketing food at the national level, and secondly, for marketing food at the international level, in allowing for cross-border food trade using e-commerce. This is akin to creating a marketplace, which provides networking benefits to farmers, in turn creating a "networking effect." For example, during the pandemic, there was an increase in firms marketing their products through Facebook. A popular example is allowing for auctions to occur online, wherein online auctions can be created for marketing seafood, like fresh imported food.

However, this is for the most part only happening sporadically, whereby the people doing these live auctions are still just individual companies, rather than cross-country and country-wide initiatives. Moreover, it remains at a low technology level, meaning, it only involves exchanging information, and has not yet moved into sales and actual transactions being done digitally. There is therefore potential to "evolve" such digital/social media marketing and promotion, into actual digital e-commerce, i.e., in developing an online marketplace.

Interestingly, once this problem of bringing majority of farmers closer to consumers is solved through the marketplace, it also addresses the challenge of getting farmers on-board. From a farmer's perspective, engaging in food e-commerce helps them to sell more, and there are also associated benefits in terms of the information they get from the market. Following PinDuoDuo's model also provides additional benefit to consumers in terms of "groupons" or group discounts, assuming there is telecommunications and logistics infrastructure in place to allow for such transactions to occur.

Therefore, creating such a "marketplace" provides an "offtake" or in other words, increases the likelihood that there are buyers for food produced by farmers. This in turn, helps ensure that farmers are able to recover the costs of investing in the technologies. The marketplace addresses this, and the marketplace helps in doing this in the most economical manner. One way to do this, is to catalyse an existing marketplace, to move towards food. This implies working with existing e-commerce providers, and catalysing them to create an agri-food marketplace.

3. Interview 3: Identifying Scalable Approaches for ASEAN: Insights from an Interview with a Multinational Crop Input Provider

Our next interview was with a multinational crop input provider. The interviewee, holds a global position in helping foster the digital capacities within Asian agriculture within the company.

The Need to Provide Integrated Solutions so that Solutions are Scalable

The interviewee agreed that the benefit of an e-commerce model, as exemplified in the first interview, is that it allowed for minimising the marketing uncertainties for farmers. In turn, this allows farmers to focus on the production side instead. Furthermore, partnering with an e-commerce company allows for a significant influx of capital to farmers.

However, while this feat being attempted by multiple startups within ASEAN, it is still only in the initial stages, and in a very fragmented market. The interviewee felt that it is unlikely that ASEAN startups will reach the same level of scale, as was achieved by the first company interviewed, given that ASEAN startups have a smaller amount of capital. Therefore, the challenge is in replicating the model in terms of scale, across ASEAN.

The interviewee stressed the lack of consolidation among farmers, by comparing them to input providers, which are in fact the most consolidated within the agricultural sector, with the top 5 companies already occupying majority of market share globally. In contrast, markets further downstream, in production (i.e., farmers) and off taking, are relatively fragmented. As such, the production and supply chain side will need to rely on venture capital, unlike the upstream markets which have their own capital.

Another challenge is that providers of digital technologies to farmers are still spread out and fragmented, with many choices for modular solutions, and each actor trying to become the platform player that take cares of end-to-end solutions for all farmers. The problem with such a fragmented market, is that they cannot provide a critical mass of offerings and have limited capabilities.

On the other hand, if the focus is on scaling only the niche solutions available today, it will be challenging to engage farmers as customers as well, since farmers need packaged end-to-end solutions; otherwise, they will not have motivation to adopt the technologies. What is needed, from the viewpoint of the expert, is greater consolidation in the industries that provide digital technologies. A key insight for ASEAN, based on this interview, is that while governments are taking incremental approaches today in identifying or testing scalable solutions, such approaches may have limited scope for drawing farmers to participate in them. This is because farmers need integrated solutions that allow for gathering the data and providing actionable insights and information that are useful to farmers.

For instance, in the Philippines drones are being rolled out across multiple regions, each able to cover up to 200 hectares in 30 minutes, with the help of the UN FAO (UN FAO, 2018b). Drones capture both RGB and near-infrared images. This is being done under the FIELD program of the Department of Agriculture, with support by the UN FAO.

Potentially, the information can be used to provide vegetation index information, for comparing plant growth (i.e., photosynthetic activity), and through this, identify areas where there are potential crop and pest infestations; training is being provided to specialists in the UN FAO and in the Department of Agriculture.

For this to be used by farmers, there will have to be providers of the said data analytics. However, donor funding alone will not be sufficient, nor sustainable, nor ideal, for serving the over 9.72 million individuals working in the agricultural sector, according to the 2020 Selected Statistics on Philippine Agriculture.

The same logic would apply to Brunei's use of sensors for monitoring rice fields, applied to 300 hectares in its major rice producing region; at the moment, the challenge is to raise the uptake by farmers of these technologies as well as in implementing recommendations from farm advisory services. Similarly, this logic would apply to Malaysia, where agricultural drones are being explored for area-mapping, alongside remote-sensing and GIS in monitoring of planting areas and activities and soil-mapping, as well as precision-farming for smart fertigation using IOT and sensors/monitoring. These approaches are still in their early stages of exploration/piloting, but the prospects for their scalability, will depend on the market mechanism that incentivises private individuals to provide data analytics services at scale.

Therefore, a market mechanism for providing the said data analytics is required if this is to be scalable. Otherwise, there would not be sufficient incentive for the data analytics providers to operate at a scale that is commensurate to the number of farmers and areas that need to be served. Only such a package that integrates both sensor technologies and data analytics providers, will likely be taken up by farmers.

Engaging "Off takers" for an Additional Push in Terms of Capital

The e-commerce model described in our first interview, provided farmers with the market incentive to adopt new technologies, including digitalisation. This is important since farmers by themselves are not likely adopt these technologies, unless incentivised to do so. As earlier discussed, e-commerce solutions are one way to move forward in incentivising farmers. The problem is that the market for providing e-commerce products, is still very fragmented. An alternative way to move forward, is to tap into aggregators or "off takers." This refers to the companies that purchase products in bulk from farmers, through companies like Nestle, Pepsi, Cargill, Olam, and Bungee, which have presence in ASEAN.

Off takers engage in contract farming with farmers, which provides farmers with stability of demand for their products, at pre-agreed prices to ensure profitability. Just like the e-commerce-supported model, off takers can give farmers guaranteed sales of their products, in exchange for their adoption of technologies. This leaves farmers more time to focus on improving production methods, rather than worrying about selling profitably. This method may also be suitable in the case of Southeast Asia, wherein middlemen can still be engaged in the process, as local agent in helping promote the adoption of technologies. The only difference is that the one promoting the uptake of new technologies, will be the off takers, rather than a major e-commerce provider latter being absent in Southeast Asia). This is also in agriculture (the beneficial, and provides a parallel alternative to the e-commerce-supported model, since off takers such as Nestle, Pepsi, Cargill, Olam, and Bungee, are already consolidated as businesses/multinational companies, and already have some presence in ASEAN. Therefore, their impacts on farmers are synonymous with having a major e-commerce provider, since they have sufficient capital to support farmers, and the only difference is that these off takers are the ones who aggregate the commodities and sell them after processing. Unfortunately, agriculture in ASEAN is not as consolidated yet as it is in countries like the United States

Therefore, the key insight for ASEAN, is 1) the need to engage in discussions with private sector off takers to enable them to play supportive roles within agriculture, including in bridging the funding gaps in this regard. Consultations may be initiated with the private sector, to identify particular constraints they face in engaging the region in their interventions with farmers. Another insight is 2) the need to engage in benchmarking and best-practice sharing with other countries, such as the United States, to find out how to engage more farmers in dealing with off takers.

Providing farmers with the "freedom to operate" across multiple data service providers

A further challenge is that there is an imperfect market, in terms of information that farmers have on existing applications. If we look at applications that are open field or outdoor field, the advantage is that it is relatively easy to get the data through IoT sensors.

However, the challenge in outdoor farming is that IoT sensoring is very expensive. There are many such companies that have their own analytics modular and recommendation modular. Instead of allowing farmers to find new solutions, they are trying to enclose farmers within their own digital solutions, i.e., potentially preventing or hindering farmers from exploring other providers.

For instance, the same satellite, can be used for many different functions. The trouble is that the farmer needs to pay a satellite company for getting the data, and another agent for processing it to provide insights on one aspect of farming (such as seed selection), and yet another agent for further insights, such as fertilizer treatment. The ideal, is that farmers and companies are given the freedom to access data analytics solutions.

Thus, the challenge is to really create an eco-system, where farmers have a choice, and freedom to operate across multiple applications. Farmers should have freedom to access raw data, and to choose service providers for such.

Policy-makers have the potential to enforce this kind of concept. For instance, the United States has solved it somehow. Companies like Bayer (an input provider) and John Deer (an equipment provider) already have a similar platform that they share. These are the platforms where farmers can connect all different partners' data together. It is generally an ERP or enterprise resource planning (ERP) system, which "integrates all aspects of a

production-based or distribution business, aligning financial management, human resources, supply chain management, and manufacturing or distribution with the core function of accounting" (G2.com, 2021).

A bottom-up approach can therefore be explored. At the multinational corporate level, multinationals are already trying to create those eco-system partnership agreements. This is not an easy area, because everybody is still trying to own proprietary data and intellectual property (IP). It is still difficult to "corporatize" farming innovation. While many companies have a similar vision of developing such an "ERP, the problem comes in data sharing when negotiating terms and conditions.

If farmers have such an ERP, it could enable automated financing and accounting. That way, they can also get soil and satellite data together. They can also extract data together, visualise them on the same platform. This system is rather available in US, and this is how this system is driven in big markets.

Unfortunately, in ASEAN, we do not have such an ERP for farmers yet, which prevents farmers from having the freedom to operate across multiple applications. There is therefore a need for a consortium or alliance, to get this going. Even if some of the companies may have more advanced/progressive ideas. Need to be common platforms interoperable across companies. Even if we do not have one multinational company doing this, a bottom-up approach can be taken, in encouraging partnerships across multiple companies, in supporting this common vision of "data for all."

Developing a Standard Application Programming Interface

A further challenge is that there is no universal API or "Application Programming Interface," which allow multiple data applications to "talk" to one another. This is because, as earlier discussed, the market for providing data services to farmers is still fragmented, with many operators competing to become the operator that caters to all the market's needs.

For instance, there is already a universal "BBCH-scale," in classifying plants according to the same growth stages (Meier, 2001). This provides a "decimal code system," divided into principal and secondary growth stages, and is based on the cereal code system (Zadoks, Chang and Konzak, 1974). The said scale, allows for identifying interventions, and for standardising approaches within the industry, such as in seed treatment; leaf development;

vegetation; and post-harvest/storage treatment, etc.

Similar to the BBCH-scale, there is potential to develop a common language across applications, so that the multiple digital technologies available today can be inter-operable and standardised as well. This helps private companies too, in facilitating their assistance to farmers, as it would allow them to compare multiple digital service providers, and to identify the best service provider for the job. Achieving this, this requires parallel infrastructure and standardisation, within the ICT sector.

The goal, therefore, is to allow one digital solution and another to talk to each other. This is not possible, if applications are not categorised; for instance, one solution can help in fertilization activity as fertilization as opposed to nutrition management.

The problem is, while we do want to have a common language, there is scant coordination on creating the standard. If the objective is to digitalise farming, there is a need to identify key digital technologies and standardisation of mechanisms.

Such an "eco-system of digital solutions" will mean having detailed classification of technologies, and a digital master list and ID of all products in the market. If all of the products should have unique ID, then this can be used to develop a common industry language. If all languages and names can be digitised within agriculture, giving each an "ID," then we will no longer need a "master data currency" to speak of. By developing such a framework, it is possible to ensure that at a later stage in supply chain optimisation, those data can be directly transferrable.

The key implication for ASEAN, therefore, is the need to create an integrated solution to the problem of inter-operability across farmers. This will allow all the partners to do simple "plug and play," with solutions able talk to each other, and with systems able talk to each other.

4. Analysis of Documents: Insights from a Global "Offtaker"

Further insights are drawn from documents of a key off taker in ASEAN region. This company won the "Impact Award" for developing a digital platform that empowers smallholders and improves incomes, reaching out to 70,000 farmers across 12 countries, during the Innovation Leader's 2020 Impact Awards. It won this award for its mobile app e-commerce application for farmers.

Off takers usually buy from local buying agents, or middlemen who buy from farmers and sell to the off takers. In contrast, the app allows the company to buy directly from the farmers. Apart from this service, the app also provides agronomy and information services such as weather forecast, sharing the prices of commodities, thus making the farming business more transparent to farmers. This app can be used in smart phones, but there are also features which can be tapped using older fashioned "feature phones" via SMS. For those farmers who have neither smart phones nor feature phones, they can go to village head instead who can help with coordinating the purchase. In these cases, local buying agents are still tapped to help buy from the farmers.

Beyond this, the company also has further applications, such as its Farmer Information System, which provides data on farms, such as socioeconomic factors, and uses these to develop farmer development plan for farmers. It also uses the GPS points of farms, to help manage training activities, and further, helps in managing all "first-mile" transactions, like farmer financing and input distribution. Through these, the company is able to come up with agri-advice in the form of a business model for the farmer. This is then placed in the hands of the field staff, who give to farmers to use as a guide. This helps too, in helping promote practices for sustainability and traceability (OLAM, 2021).

There are further applications which the company has, including their Digital Supplier Engagement app, which helps local buying agents, in their transactions with farmers and the buying agents. In some jurisdiction, cannot buy directly from farmers. Olam also has a Digital Warehouse app, to help in synchronising and balancing different information that comes from the solutions mentioned above. These can then be linked to Olam as a company, to allow it to identify how it can better assist farmers and their local buyers and middlemen. Further applications are included in the 2019 Olam Insight report (OLAM, 2019). For instance, Olam has is using drones for image analytics; sensors for irrigation; sensors to look at health of the plant. It has also developed an app for plantation workers to track their productivity and make it convenient to report anomalies around the plantation. This allows them to take a photo to show to agronomists of Olam, who then go down to diagnose crop issues and provide advice.

The company also has an E-commerce portal, to reach small and medium

businesses. This is being used for selling nuts, coffee, and spices (chilli, garlic, onions) in Vietnam, Indonesia, and Australia; in Singapore, there is a B2C or business-to-consumer app, branded "RE" which allows for assessing the sustainability of the production process, across the whole supply chain. Olam likewise has its Olam Market application, for distributors. In Ghana and Nigeria, it is using these to help distributors sell crops to consumers. They also have applications for distributors to do the ordering, the direct inventory, invoice, all digitally, including the packaged food business.

In agri-processing, the company also has an "operational excellence manager" application within its factories. This started with 4 factories in 2016, which has grown to over 100 factories, to get them in standard operational excellence or OE systems. These use sensors to detect when the machinery requires maintenance, and weightage to do certain processing, within 3-5% confidence interval, and for even lower intervals.

Finally, the company has digitised its bills and letters of credit, in order to make its business paperless. This is primarily driven by banks, together with other ecosystem players. It is still working to get more processes to go paperless, for as long as it is allowed by governments.

Identifying Underserved Markets for Private Sector Intervention

We now turn to the issue of reach, and scale. If such solutions are already available, why have they not reached very single country?

For instance, our analysis of Olam's reports shows that it is mostly the highervalued crops that are provided digital products. For instance, the Olam Farm Information System (OFIS), a tool which allows its field staff to "collect data, record GPS data points for farms and social infrastructure, manage training activities, and track all 'first mile' transactions including financing, input distribution, and crop purchases" (Olam, 2019) is only available for highervalue commodities like coffee and coca in most of the countries which Olam services with OFIS. Similarly, Olam's digital buying platform, "Digital Origination," is only provided to Cocoa and Coffee growers in Indonesia, and to pepper growers in Cambodia.

To provide end-to-end digitisation of the entire procurement operation, Olam has developed its Olam Traceability App. However, this used mainly on peppers in Vietnam, and coffee in Indonesia. Finally, Olam's "Smart Factories," which are digital technologies for transforming the food manufacturing process, are only offered in Singapore (cocoa), Malaysia (dairy), Indonesia

(sugar) and Vietnam (cashew). Across all products, it was only in Thailand, that the rice crop was serviced by digital technologies, in particular, the OFIS tool (OLAM, 2019).

Therefore, the key insight is that in terms of private sector intervention, it is natural for private entities to prioritise higher value crops. What is needed, then, is for ASEAN countries to provide support to private sector entities, through their local government units. This calls for an analysis of which sectors are under-served by the private sector, to allow for identifying where government can best step in.

5. Interview 4: Insights from Interviews with Multi-Stakeholder Partnership Platform

Beyond largescale actors, we also saw the need to understand the challenges faced by smallholder farmers. In this regard, we interviewed was with the Innovation Lead of a multi-stakeholder partnership platform that catalyses action on inclusive and sustainable agricultural development in Southeast Asia.

Engaging "online-offline" approaches in promoting digital advisory services

Oftentimes, projects and initiatives that provide assistance to smallholder farmers are seen as acts of benevolence or charity to aid less developed sectors. While this view is socially beneficent, the impact of such projects can be limited if they do not have business models that allow for scaling this type of assistance, in manner that is financially sustainable.

One among the digital technologies, is the provision of advisory services to farmers through digital media like social media and farmer-focused applications. Such initiatives can help improve the productivity of farmers since they provide them with the needed knowledge to calibrate and optimise their practices, such as fertilizer application.

Government's assistance, in helping farmers to adopt these technologies, falls under the purview of government extension services. One among the bottlenecks in driving the adoption of digital advisory technologies, is that farmers do not easily buy into such initiatives.

Oftentimes, a supply focused approach looks at the infrastructure challenges to allowing for the adoption of digital technologies. In contrast, the "digital

adoption curve" shows that even if technologies are accessible, farmers may still not venture into applying them. This framework is therefore helpful in understanding what factors might help farmers to adopt digital advisory services and applications more frequently.

In this regard, the interviewee shared insights from a previous report by Grow Asia on the "digital adoption curve" for farmers, from 1) face-to-face interactions with their individual suppliers, customers and lenders, to 2) telephone calls for making orders/sales; 3) peer group dialogue through small group chats via Whatsapp, Line and Facebook Messenger; 4) using web search, video streaming and online messaging to find new transaction partners and negotiate farm orders (also referred to as the "active discovery" stage); and 5) actually using applications for conducting trading, finance, and disease recognition (referred to as the "digital service engagement" stage (Voutier, 2019). Their interviews with farmers in Indonesia, Vietnam and Myanmar showed that majority of farmers interviewed, were using telephone calls (stage 2), followed by peer group dialogue (stage 3), video streaming/messaging (stage 4), and that the smallest share went to digital service engagement (stage 5).

The take-away drawn by from this, common across all stages, is the importance farmers place on lines of trust within the community. It also shows that digital service engagement (stage 5) depends on farmers' adoption of earlier stages of using social media (stages 3 and 4). The challenge, therefore, is to get more farmers to move into stages 3 and 4, before stage 5 can be reached.

One possible approach to enable government extension services to drive this adoption of digital advisory services, is to build on a pre-existing network of trust within the community, such as the agent model, whereby traders and retailers leverage village-level collectors/distributors, who maintain relationships of trust with farmers already. This therefore provides an "online-offline" approach to government extension.

This is not foreign. For example, this is being done by the organisation "Mapan" in Indonesia (acquired by Gojek), which makes loans to groups of women in rural areas, through village chiefs or some other agents in the community who have authority. These chiefs/agents are tapped to help pool the money of the individuals, to be able to buy tools for members of the said pool.

In the case of ASEAN, a combined "offline-online" approach to extension services is encouraged. The "online" channel relates to farmers adopting social media, so that information can reach them faster. The "offline" approach refers to leveraging village-level collectors or distributors of crops, in encouraging farmers to engage in digital modes of interaction, and eventually, in digital service engagement.

6. Interview 5: Insights from Interviews with Venture Capital Firm

We conducted an interview with the founder of an international venture capital firm. Unlike other venture capital firms, the firm interviewed started as an insight-generating company, which has published the annual AgFunder Agrifoodtech report since 2014. This seminal report has helped drive the growth of the market for investing in agricultural technologies, including digital technologies, by sharing information on the investment activity and growth potential of this sector. The company also developed the ASEAN Agtech report, in 2020, cited earlier.

The Importance of "Unit-Economics" and Market Size

A key insight shared by the interviewee was the importance of "unit economics." An underlying concept that is needed to understand this, is the "economies of scale," whereby the marginal cost of an additional good produced and sold, becomes smaller as the total size of goods produced and sold become larger. This implies that the profitability of a business, per unit and as a whole, increases as its scale increases.

Venture capital firms are therefore on the lookout for scalable digital agricultural solutions, from the business perspective. Products, by themselves, are not "investment worthy" without an understanding of the broader context of those products. It is all the same supply chain, and the journey between farm and plate can take multiple different routes. The first key insight therefore is that market size is important. By "market," this refers to the farmers who demand a particular digital solution. In this regard, there is no point in supporting or investing in a digital solution, if there is no demand for it. How to bridge that route, and get the end-goal, is the challenge that agricultural startups will face.

Take, for instance, e-commerce. In the ASEAN context, the scale of impact of e-commerce company is smaller than the impact and financing that can be

brought by aggregators. This refers to companies that pool vegetables for serving a large group of consumers. The interviewee cited some examples which have been able to achieve traction. For instance, Wefarm is a peer-to-peer social media platform that provides farmers with advice on what types of inputs to use, such as fertilizers and pesticide. This has built traction to up to 2.4 million farmers to date. Similar to Olam Direct, it can also be via SMS too ("Wefarm SMS") and not just online; moreover, its website shows that it is free for farmers to use. "The platform enables farmers to share knowledge, and access a marketplace of trustworthy retailers" (WeFarm, 2021).

Another interesting aspect of Wefarm is that it offers an online "Wefarm marketplace" which connects farmers to retail input providers, emphasising the importance of trust, i.e., products are recommended based on feedback by the peer farmer community. Moreover, Wefarm also engages input retailers, wherein after joining the Wefarm community, they are able to access thousands of Wefarm members in their own areas who have the potential to become new customers. The community's size, in turn, provides them with greater "buyer power" or buyer bargaining power, to afford greater quantities of inputs at lower prices. Its offices are in Uganda, Kenya, Tanzania, and the UK.

A further example cited by the interviewee is DeHaat, an app developed by an Indian startup that is engaged in contract growing. This app links farmers to institutional buyers, and organise farmers to do this. The purchasers then agree to buy the produce at the agreed price. This is serving over 210,000 farmers in Indian states of Bihar, UP, Jharkhand and Odisha, and providing over 3,000 agricultural inputs (Skrinath, 2021).

The key to the success of these solutions, is in their ability to make the "unit economics" work. This means that each component of delivery is costed effectively so that the actors playing that role are able to make a profit.

For this to happen, scale is important, in particular, a large enough market of farmers and/or retailers and/or consumers using the application, and the ability of app providers to get access to that market. For instance, in the case of distribution, one has to get that price balance right, to being able to bring in the food, and to be able to distribute the food.

A potential role of governments in ASEAN, is therefore to provide support so that smaller companies can grow and draw sufficiently high profits, to enable a rapid scaling up of their product offerings in the future. Therefore, the perspective is philosophically different from a multinational company's perspective. The objective, in this case, is to allow for technology to be applied in a way that is equitable, even to companies.

Helping Identify Ways for Firms to Value-Add

If one differentiates Grab company which delivers food, from applications like Hello Fresh and Marley Spoon, a key difference is that the latter provides further value addition in terms of ready meals and recipes. This provides additional convenience which the consumer and the purchaser are willing to pay for.

A further value-addition can be in the aggregation of products. Logistically, it is easier to centralise, by aggregating goods into large warehouses, and then selling them later on. This differs from the "off taker" model, since no additional processing is required; rather, it is simply a role of aggregation of farmer products, and distribution to consumers. These value-add, because farmers do not have the ability to organise the distribution of their products, such that a central repository is required; this in turn frames the value-addition of the aggregator.

For these to happen, there is a need to for an actor to create that market for farmers, whether the task is simply putting the fruits and vegetables in a box to package them for delivery, storing the products, etc. This has to make business sense for the farmer, giving them a decent price for their products. It should also make business sense to the aggregator to do this. What is important is that to create that virtuous loop, with farmers, intermediaries, and consumers, all getting what they want.

The challenge for ASEAN will therefore be in accessing and engaging farmers, multiple actors in the supply chain, and consumers. Engaging farmers alone can be a challenge when one considers the smart phone adoption rate among farmers. A potential role for ASEAN is thus in identifying these choke points which prevent companies from accessing farmers, intermediaries, and consumers.

7. Interview 6: Insights from an Innovation "Agency"

A further interview was conducted with the founder of an innovation agency and ventures group that applies a challenge-led innovation process to solving challenges for medium to large food and agricultural production and processing enterprise across APAC. The interviewed company works with enterprises in navigating complex environments and solving core challenges with three key criteria - speed, cost, and impact. It provides open-innovation processes, working with a global network of international domain experts to scout, match, and scale innovative solutions with a clear business case. Beanstalk is connected to a range of accelerator programs and support emerging startups through these programs. Commercial solutions however typically come from scaleup SME's who are in "post-accelerator" stages, who have raised professional capital and secured commercial offtake agreements. The interviewed company supports scaleups in strategy and team development, market entry, commercial scaling, and capital raise activities.

Understanding the complex challenges in growing AgriFoodTech startups and scaleups

The interviewee shard that historically, technology extension in food and agriculture production have been well resourced through government extension agencies such as state departments of agriculture. However, the landscape for agricultural businesses, including digital businesses, is now increasingly complex as technology domains converge across agtech, foodtech, fintech, medtech and others. Beanstalk plays a role in bridging solutions, sitting at the interface between investors, innovators, and industry. This is coupled with an increase in smallholder service providers across Southeast Asia, where in-field decision support in agronomy, irrigation, harvest, and marketing are leveraged with existing good agricultural practice from across the region. This function is undertaken by distributors and retailers, cooperatives and independent operators. Alternatively, it can be provided by government agencies and select university extension services.

Advisory services can also facilitate the extension and adoption of new innovative technologies weighed against best practice standard and good agricultural practice. In addition to production efficiency and profitability, extension is increasingly sought for sustainability and environment production systems, as is being witnessed in the emergence of regenerative farming practices. In addition, downstream business opportunities for enterprise restructuring, vertical integration of processing and waste stream management, and in sustainable approaches to traditional crop protection programs. These open opportunities in storage, logistics and supply chain innovations as well as upcycling crop and processing waste. Other solutions may come in arranging regional distribution funds, or in allowing for lean inventory systems so that companies can re-stock efficiently.

There is great diversity and ingenuity across 450 million smallholder family units throughout Asia and Africa. Here, **scaling production efficiency and investing in innovation and scale is interwoven with a strong cultural overlay of family, food, and community cultures.** While these are not necessarily going to be the drivers of a global innovation agenda, it is important to identify community elders or leaders who are willing to be open to sharing good agronomic practices that support community development.

The task, therefore, is to identify new and efficient ways to expand knowledge exchange and engagement of emerging service providers. For example, drone-based agronomic services support efficient fertilizer-and crop protection application services that reduce operator exposure and environmental overspray. Drone manufacturers in China such as DJI and XAG, among many others, provide precise application while also bringing important mapping and consolidated production data together.

Government agencies support with extension trials comparing different varieties for yield, disease and insect resistance and nutritional profiles. Whereas cooperatives provide for consolidated harvests and better leverage in marketing to millers and traders for better returns.

A key issue across the ASEAN region with fragmented supply chains and lack of investment in infrastructure (transport, storage, and cold chain) is last-mile logistics. Getting inputs in the hands of farmers and produce to market remains a major challenge

Focusing on Challenges, Outcomes, and Impact rather than "Technology"

Focusing exclusively on a technology, rather than prioritising the challenge, can lead to significant redundancies in long cycle production systems such as agriculture. In many cases developed solutions readily available across adjacent markets, and adaptable for the ASEAN region to tap. The priority is to develop a solid business case for adoption and scaling of available solutions, while keeping in mind the diversity in agronomic practices in ASEAN,

and not being distracted by the technology itself

Across the Mekong Region there are rice-based cultivation systems that are susceptible to climate change These require advances not just in alternative chemistry profiles but also in adaptive production systems (e.g., shrimp/rice, fish/rice) and alternative varieties that can withstand prolonged flooding and saline intrusion. IRRI along with commercial rice breeders has been instrumental in this endeavour. Advances in integrated regional (cross-border) insect monitoring systems (e.g., <u>RapidAIM</u>) also have potential to improve an effective integrated pest management response to endemic pests such as brown hopper, which can cause significant damage to rice crops across the region.

In contrast, horticulture (vegetables, fruit, and plantations) is driven by a shorter cycle cash-based market economy, and subject to large market swings that can significantly impact farmer returns. This requires long-term investment in supply chain/cold-chain infrastructure to consolidate supply. A recent increase in demand from consumers around food safety and sustainable cropping practices is driving development of traceability solutions that support provenance and brand loyalty. From a nutrient-density perspective, there is also an increased awareness around combined health and safety features of certain functional foods, and specifically nutrient density in hyperlocal production systems compared with long cycle harvest/imported produce.

A better understanding of where technology is accessed, used, and communicated is critical in advancing food production systems. The Vietnamese Government has a long-established program of subsidised machinery distribution to drive mechanisation and labour efficiency. Respected publicly funded research and extension institutions such as the Cuu Long Delta Rice Research Institute in Southern Vietnam, along with the extension resources of the Plant Protection Department (PPD) are key in this respect. Leveraging digital tools for effective extension across large numbers of smallholder farming production units presents a unique opportunity to engage effectively. Grouping smallholder farmers into geographic production units across homogenous cropping systems, connecting with key service providers and government extension agencies, and forming cooperative trading and marketing structures brings both economies of scale and options for extension.

One key opportunity across the ASEAN region is to focus resources on key challenges that have measurable impact across adjacent production systems. Engaging a range of key stakeholders from farmers to service providers and industry is key in extension and adoption.

Engaging Multilateral Partners to Drive Efficient Deployment of Resources

There are many sources of external project funding across multiple Government and Non-Government agencies, and in particular focused in countries such as Vietnam that require support for innovation and technology. Most are well meaning, many are ineffectual. One key criticism is the lack of coordination across various organisations and opaque focus in addressing key challenges between organisations. In many cases this results in duplication of activities with only limited sustainable impact, driven by funding and grant cycles.

Coordination in focus and resources is critical. Best practice examples include AgResults, a long cycle funding program across multiple leading aid agencies that prioritises challenges and uses prize-based competitions to drive adoption and create sustainable agricultural markets. Graft Challenge Vietnam 2021 (www.graftchallenge.com) is a post-accelerator program focused on meeting specific industry designed production challenges in Vietnam by matching scaleup SMEs with commercial collaboration partners. It is funded by CSIRO Aus4Innovation, AusAID and supported by MOST (VN Ministry of Science and Technology) and delivered by Beanstalk.

Other groups such as Grow Asia, focused across the ASEAN region, have well established in-country partnerships with industry groups and ready access to smallholder farmer organisations and production grouping.

The proposal, therefore, is to breathe oxygen into multilateral actions by taking a step back and asking, "what challenges are we trying to fix, and where are we deploying our resources?" This can mean dialoguing with partners, such as from Aus Aid, US AID and GIZ, and getting them to come together and try to get this in the same direction, while eliminating redundancies.

Moreover, larger farm sizes, do not necessarily equate to economies of scale. Some activities can be time-saving but not necessarily drive productivity. There is need for support-earning centres for good agricultural practice. Consolidating resources, prioritising focus, and engaging a multidialogue approach across aid agencies will drive scalable outcomes with impact. Extension of existing good agricultural practice should take priority over developing new technologies and systems. Government agencies can play a critical role in this process.

8. Interview 7: Interview with an Innovation "Catalyst"

A further interview conducted, was with the Co-Founder of an innovation "catalyst." This company seeks to "accelerate innovation to solve big problems and develop opportunities through Open Innovation with corporations, government, startups, and communities," looking at areas such as food and agriculture, smart cities, health, sustainability, and data and artificial intelligence (Padang, 2021).

The Importance of Understanding Diversity of Farmer Behaviour

The first insight drawn, is that each country will have its own unique set of challenges. For instance, the data showed that Singapore and Indonesia were the largest destinations for Agtech investment; yet farmers in Singapore and Vietnam are vastly different. In the case of Singapore, for instance, the "farm to fork" problem is not so much a problem, as it is easier to get farmer produce direct to consumers. In contrast, in Vietnam, a rice farmer is dealing with different situations. For instance, there can be inconsistent adoption of, and access to smart phone technology. Therefore, the approaches to use, need to be different from crop to crop, and from country to country.

In developing countries like Indonesia, for instance, social media like Facebook, and peer support/information, are more useful as opposed to downloading apps (given inconsistent smart phone adoption). Part of the problem continues to be in a lack of understanding of the behaviour of farmers as users, and in change management. Some app developers are designing apps somewhat in a vacuum, focusing more on what technology can do, than on what farmers actually need. For instance, there are subsistence farmers, who have other ambitions beyond just adopting the end products of developers; rather, their priorities can be as simple as having enough money to get their kids to school. In these cases, the aim should be to show how technologies help them improve the state of their livelihoods. Moreover, while some applications seek to remove middlemen, middlemen still play important roles in some local cases, such as in helping to facilitate the uptake of

technologies within their own communities.

Another challenge is in how to encourage frequent use of the application. This is because the number of application downloads does not necessarily mean that those farmers are using the application. This raises the need to engage local cooperatives in encouraging the use of applications, going beyond access, and into adoption; the strategic use of messaging and incentives to increase use of the application; and working within existing village structures and gatherings to encourage farmers to utilise the apps. This is because the alternative, of going farmer-by-farmer, can be a very expensive process.

Within ASEAN, critical questions need to be asked about farmer behaviour. What apps have they signed up to, which ones are they actually using. What is the problem they (farmers) want to address, and what types of information do farmers need? Is the market price fair and does it ensuring that farmers equally benefit from the use these new technologies? The idea is to go at it from crop to crop, and from market to market.

The low hanging fruit may be in increasing the adoption of common coops where there are massive farmers already in the group, as well as is in leveraging digital technologies to help extension workers to do their work better. There also has to be a business model that allows for applications to reach a critical mass of users.

Developing the Business Ecosystems for Agricultural Startups

Providing assistance to companies is also important. In some areas, it is not as easy to incorporate, thus hindering the entry of potential companies that can help catalyse the adoption of new technologies. This also requires sufficiently incentivising SMEs and large companies alike to digitalise, to innovate, thus allowing for driving growth through innovation. In some countries, these can be in the form of export development grants, to cover marketing activities across Southeast Asia.

Much can be learned as well from within the region, and part of the challenge is in helping to replicate successful business eco-system approaches. For instance, there are booming start-up scenes in Indonesia, as well as in Singapore, the latter having a hub strategy of attracting technology hubs. These models too, are something which can be exported, but the challenge lies in helping other countries in developing supportive business eco-systems for startups. At the same time, it is important to ask what startups are valueadding to the innovation process for farmers, in order to consolidate efforts and avoid redundancies.

Within ASEAN, there is room for food diplomacy, in using food technology as a diplomatic tool. This can help to forge stronger ties across the region, if countries which are ahead in terms of technology development (e.g., Singapore's push for alternative proteins) can help the rest of the region in boosting their own productivity and in creating new food baskets and new food sources to import from.

Identifying "Cold Spots" where Connectivity is Missing

In most countries, basic internet connectivity is shown to be already present when reported at the national level. However, sites where there is sufficient connectivity. The challenge is that it is not always in places where there is data access, that the majority of production is also being done. A critical priority is thus to assess what percentage of the population are using feature phones as opposed to smart phones.

Within ASEAN, the 2017 World Bank Findex asked respondents about whether they made or received digital payments in the past year, data showed that the urban-rural gap was approximately 28% to 75%. (The gap was measured as the difference between rural areas and the country-level data, divided by the country level data). Even if published statistics reveal that majority of country populations have access to the internet as shown by the GSMA's database on access to 3G network services, a significant share of agricultural producers may still face interrupted or insufficient access to the internet.

This divide in access to digital payment services, is also linked to access to electricity. On one hand, across most countries (except Myanmar), access to electricity at the country level is defined as being 92%-100%. However, in Cambodia, Indonesia, Lao, Myanmar and the Philippines, the share of the rural population with no access to electricity is higher than that of the urban population. Moreover, a significant share of firms interviewed by the World Bank for their Enterprise Surveys, also shows that electricity is still a major constraint to many of the firms studied: 14.5% of firms in Indonesia, 17.6% in Lao PDR, 19.6% in the Philippines, and 23.7% in Thailand.

Therefore, there is an urban bias to country-wide statistics on access to electricity and the internet. With a growing share of populations becoming

urbanised, the measurement of "internet access as a % of total population" is likely to under-represent individuals in rural areas.

Within ASEAN, this therefore raises the need for more research that provides information on internet access as a share of the land area (rather than as a share of the population), especially in rural areas.

APPENDIX 6 KEY POLICIES AND CHALLENGES FACED BY ASEAN MEMBER STATES IN ADVANCING DIGITALISATION IN AGRICULTURE

Table 4.2: Findings: Key Policies and Challenges Faced by ASEAN Member States in Advancing Digitalisation in Agriculture

Digitalisation in Production					
	(\$	Satellites, Drone	s, Sensors, Automati	on and Data Analytics)
	1. Satellite Data and Remote Sensing	2. Drones	3. Ground (In-situ) Sensors for Sensing/ Monitoring	4. Automation of Farming Processes (e.g., seeding, fishing, etc.)	5. Software/ Data Analytics for Analysing Data from Drones/ Satellites/ Ground Sensors
Brunei	Policy: Brunei Vision 2035 Dynamic and Resilient Economy. Agricultural sector to be transformed, in line with Fourth Industrial Revolution (IR 4.0) (Roslan, 2021).			Policy: 1. License conditions provided by government. Challenges: 1. Costs, 2. internet network services 3. technology knowledge	
Cambodia	Policy: 1. Agricultural Sector Master Plan 2030 (ASMP 2030) (Ministry of Agriculture, Forestry and Fisheries (2020). Comment: 1. Private sector provided, used for environmental scanning, mapping, meteorology (Aruna Technology, 2022).	Policy: 1. Drone Use Policies are in place. 2. ASMP 2030 Challenges: 1. Convincing farmers to try the new technology as they are unfamiliar with it (Sovanny, 2019).	Policy: 1. ASMP 2030 Comment: 1. Private sector provided, used for environmental scanning, detecting land movements, etc (Aruna Technology, 2022).	Policy: 1. ASMP 2030 Comment: 1. Private sector provided technologies for smart irrigation (Hong, 2019).	Policy: 1. ASMP 2030 2. Agricultural Big Data Platform (ABDP), under Ministry of Agriculture, Forestry and Fisheries (MAFF). (Sorn, 2020). Comment: 1. Private sector provided technologies.

Indonesia Po 1. N Str. the Mir Agr 202 202 (Mi Agr 202 202 202 (Mi Agr 202 202 202 202 202 202 202 20	Dicy: Medium Term rategic Plan of e Indonesian nistry of griculture 2020- 24 (MTSP-MA 20-2024). linistry of griculture, 20).	Policy: 1. Government provides data protection regulations. 2. MTSP-MA 2020-2024	Policy: 1. MTSP-MA 2020-2024	Policy: 1. MTSP-MA 2020- 2024	Policy: 1. MTSP-MA 2020-2024 Challenges: 1. Limited internet access in farm areas.
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Table 4.2: Findings: Key Policies and Challenges Faced by ASEAN Member States in Advancing Digitalisation in Agriculture (Continued)

Digitalisation in Production (Satellites, Drones, Sensors, Automation and Data Analytics)						
	1. Satellite Data and Remote Sensing	2. Drones	3. Ground (In-situ) Sensors for Sensing/ Monitoring	4. Automation of Farming Processes (e.g., seeding, fishing, etc.)	5. Software/ Data Analytics for Analysing Data from Drones/Satellit es/Ground Sensors	
Lao People's Democratic Republic	Policy: 1. Satellite Imagery and weather station data is provided by meteorological department via a mobile app.	Policy/Support: 1. <u>JIRCAS</u> project for drones (In 2018-2019, sub-component). 2. Basic network inspections, e.g., <u>high voltage</u> <u>lines</u> .	Comment: 1. Potentially, there have been testing/pilot projects from ACIAR,FAO,UNDP,A DB,NGOs etc.	Policy: 1. Utilising irrigation and hydropower reservoir to maintain safe water levels (Ministry of Agriculture and Forestry, 2015).	Policy: 1. Limited policy apart from National Agricultural Library Information System (Global Forum for Rural Advisory Services GFRAS, 2022).	
Malaysia	Policy: 1. National Agrofood Policy (NAP) 2.0 (2021- 2030); 2. 12th Malaysia Plan (2021-2025) are focusing on the transformation of this sector in	Policy: 1. NAP 2.0 (2021-2030) and 12th Malaysia Plan (2021- 2025). 2. Drone flight activities are currently bound by Civil Aviation Regulation 2016 (MCAR) Regulation 140-	 Policy: 1. NAP 2.0 (2021-2030) and 12th Malaysia Plan (2021-2025). 2. Policies under the Malaysian Meteorological Department. Challenges: 1. Expensive 	Policy: 1. NAP 2.0 (2021-2030) and 12th Malaysia Plan (2021-2025). Challenges: 1. Engendering Technology adoption for small scale farmers.	Challenges: 1. Develop machine learning or deep learning on a specific algorithm to solve problems on remote sensing approach	

line with the Industrial Revolution 4.0	144. Challenges:	equipment such as spectroradiometer or handheld thermal	2. Need for affordable	
(IR4.0) and	1. Lack of	sensor for crop	small-scale	
Sustainable	expertise in the	monitoring;	machinery and	
Development	technology and	2. Not all farmers	automation;	
2030.	management system among	internet and startup	3. High cost of procurement	
Challenges: 1.	extension officers	(procurement,	and	
Data from	and farmers;	maintenance and	maintenance.	
satellite and	2. Lack of	data analysis)		
remote sensing	technical			
are expensive;	expertise to			
2. Resolution of	process the			
the satellite	drone and			
output and	image/data			
camera-	processing;			
	5. Need to			
3 Lack of	all aspects			
expertise in the	un aspecto			
technology and				
data				
management				
among				
extension				
officers and				
farmers.				

Table 4.2: Findings: Key Policies and Challenges Faced by ASEAN Member States in Advancing Digitalisation in Agriculture (Continued)

	Digitalisation in Production						
	(Satellites, Drones, Sensors, Automation and Data Analytics)						
	1. Satellite Data and Remote Sensing	2. Drones	3. Ground (In-situ) Sensors for Sensing /Monitoring	4. Automation of Farming Processes (e.g., seeding, fishing, etc.)	5. Software/Data Analytics for Analysing Data from Drones/ Satellites/ Ground Sensors		
Myanmar	Comment: 1. Need E government. Challenge: 1. Limited Wi- Fi and internet connection	Comment: 1. Financial and technician support.	Comment: 1. Financial and technician support.	Challenges: 1. Need financial support with low interest rate for farmers with rules and regulation.	Policy: 1. IT technician and financial support is provided by international associations.		
Philippines	Policy: 1. International and local NGO partnerships. Challenges: 1. Budgetary constraints.	Policy: 1. Drones have been piloted at the national level, and next phase is regional distribution of drones. Challenges: 2. Budgetary constraints.	Policy: 1. System in development process. Challenge: 2. Budgetary constraints.	Comment: 1. Manual process in place: no automation yet.	Comment: 1. No analytics yet: Challenges: 1. Budgetary constraints.		
Singapore	Comment: 1. Not in use yet for outdoor agriculture, unlike in other sites like tracking heat. Challenges: 1. Need to reach economies of scale.	Policy: 1. Laws and on drone usage, e.g., cannot use near certain places like airport, military facilities (where most of farmers are). Challenge:	Comment: 1. Currently in use for both traditional and indoor/vertical farming. 2. Tracking the following: a. Green House Temperature, Relative Humidity, Oxygen, CO2 level, Light Intensity (LUX); b. Water: Ph Level,	Policy: 1. Loans/grants in adopting technologies; basic equipment (e.g., Agri-Food Cluster Transformation Fund, SGD 60 M). Challenge: 1. The system is not automatic yet, in reacting to the sensors, "auto-	Challenge: 1. To find the correlation between outputs and the environmental factors; learning/growing knowhow. 2. Agriculture has high capital requirements. As countries have their own unique		

 Need to meet economies of scale; Most of facilities are under cover, not enough land to make technology viable. Airspace control issues, airspace is restricted. As for manned aircrafts for crop surveillance, challenges are: a. high manpower and costs, b. high specificity of skills and equipment c. not domestically available. 	EC level c. Fisheries: Oxygen Level Challenge: 1. Sometimes equipment failure (faulty), e.g., giving wrong data, not calibrated properly; sometimes too sensitive, or not sensitive enough. 2. While humidity and water level monitoring are in use in hydroponics sites, it is not as much used in traditional farming.	rectification".(e.g., automating blinds). So, rectification still relies on human means. (e.g., PH level calibration). 2. The sector can be helped by tailoring policies specifically for an "infant" industry that is not yet economically significant in size, to allow for scaling technology adoption in this sector. 3. Needs more understanding, education of farmers to help farmers make sense of data, and make data pragmatic and actionable. 4. Needs more pragmatic consideration of costs. 5. To expand the use of technologies, so that farmers can have surplus/ reserves to allow them to be more entrepreneurial. 6. Proof of Concept and Scalability takes	agriculture circumstances, even in traditional farming, this can be skewed towards countries with larger plantations, 3. While digital farming systems are essential, for traditional farmers, these are less relevant, especially if space is limited.
4. As for manned aircrafts for	monitoring are in use in hydroponics sites, it is not as	in this sector. 3. Needs more understanding,	is limited.
crop surveillance, challenges are:	much used in traditional farming.	education of farmers to help farmers make sense of data, and make data	
a. high manpower and costs		pragmatic and actionable. 4 Needs more	
b. high specificity of skills and		pragmatic consideration of costs.	
equipment c. not domestically		5. To expand the use of technologies, so that farmers can	
available.		have surplus/ reserves to allow	
		entrepreneurial. 6. Proof of Concept	
		time.	
		1. Currently used for farm factories,	
		transporting seedlings within farm.	
		2. Currently used for watering, nutrient	
		harvesting of material.	
		3. Mostly indoor or hydroponic or	

vertical farm
systems.
4. To achieve both
economic and food
security goals, urban
farming can grow
further through
policies that facilitate
the use of unused
spaces, like
rooftops, and of
green spaces like
parks. out there, but
to help farmers
embrace technology

Table 4.2: Findings: Key Policies and Challenges Faced by ASEAN Member States in Advancing Digitalisation in Agriculture (Continued)

	Digitalisation in Production (Satellites, Drones, Sensors, Automation and					
	1. Satellite	2. Drones	3. Ground	4. Automation	5. Software/Data	
	Data and Remote Sensing		(In-situ) Sensors for Sensing/ Monitoring	of Farming Processes (e.g., seeding, fishing, etc.)	Analytics for Analysing Data from Drones/Satellites/ Ground Sensors	
Thailand	Policy: 1. Laws and regulations for farmers. Comment: 1. There is supportive policy for agriculture crop but for aquaculture is initial stage for predict the area crop only.	Policy: 1. Laws to control to use drone in Thailand. Need to get approval from aviation agency when drone is needed. Comment: 1. No data of using drone for fisheries and aquaculture.	Comment: 1. Potential to adopt for aquaculture and fisheries such as we use VMS to monitoring the vessels for fisheries and use ground sensers for predict the crop of aquaculture.	Policy: 1. Initial stages in aquaculture, using automatic image alert for control of soft shell of crab in the southern part of Thailand. 2. DOF trying to deliver knowledge of intelligent shrimp farms too.	Comment: 1. Not in particular use.	
Vietnam	Challenges: Lack knowledge and skill of user.	Policy: Institution and regulations of national security. Challenges: High cost and low popularity of drones in the market	Challenges: Need to improve knowledge and skill of user.	Comment: Need to have a large scale and commensurate investment in terms of infrastructure and production technology. Challenges: 1. Small country-level capital to invest in agriculture. 2. Small average land size of household. 3. Short land lease term.	Challenges: Data approach and legal framework.	
4. Items 1-3 result						

in unattractive						
investment in						
science and						
tochnology and						
in high tooh						
in nigh-tech						
agricultural						
products.						
5. Inadequacies						
in research.						
technology						
transfor						
o. Limited numan						
resources.						

Table 4.2: Findings: Key Policies and Challenges Faced by ASEAN Member States in Advancing Digitalisation in Agriculture (Continued)

	Digital Proc (Farmer Centra Sh	isation in duction r Advisory, lised Data aring)	Supply Chains and Financial Digitalisation (Traceability, and Farmers' Digital Procurement, Farmers' Digital Payments, and Farmers' Digital Marketing			
	6. Farmer Advisory for Crops	7. Centralised Data Sharing	8. Traceability of products	9. Farmers' Digital Procurement of their Inputs (e.g., feeds, fertilizers, machinery)	10. Farmers' Receiving Digital Payments for their Harvest	11. Farmers' Marketing their Products Online
Brunei			Policy: 1. Government provides License Condition for adopting the traceability of products. Challenges: 1. internet network service 2. Need support from the operators.	Challenges: 1. Costs 2. internet network services 3. technology knowledge	Challenges: 1. Costs 2. internet network services 3. technology knowledge	Challenges: 1. Costs 2. internet network services 3. technology knowledge
Cambodia	Policy: 1. ASMP 2030 2. ABDP (MAFF)	Policy: 1. ASMP 2030 2. ABDP (MAFF)	Policy: 1. ASMP 2030 2. Exploring developing an agricultural product monitoring system; ABDP (MAFF) (Sorn, 2020). Comment: 1. Private sector provided traceability	Policy: 1. ASMP 2030 2. <u>CamAgri</u> <u>Market mobile</u> <u>application</u> (connect producers, brokers and consumers on a single platform to facilitate transaction) (MAFF) (The Star, 2020).	Policy: 1. ASMP 2030 2. <u>CamAgri</u> <u>Market mobile</u> <u>application</u> (MAFF)	Policy: 1. ASMP 2030 2. <u>CamAgri</u> <u>Market mobile</u> <u>application</u> (MAFF)

			(Farmlink, 2022).			
Indonesia	Policy: 1. MTSP- MA 2020- 2024	Policy: 1. MTSP- MA 2020- 2024	Policy: 1. MTSP-MA 2020-2024 Challenges: 1. Limited resources of smallholder farmers.	Policy: 1. MTSP-MA 2020-2024	Policy: 1. MTSP-MA 2020-2024	Policy: 1. MTSP-MA 2020-2024

Table 4.2: Findings: Key Policies and Challenges Faced by ASEAN Member States in Advancing Digitalisation in Agriculture (Continued)

	Digitalisation in Production		Supply Chains and Financial Digitalisation			
	Centralised Data Sharing)			Farmers' Digita	I Payments, and	rement,
	6. Farmer Advisory for Crops	7. Centralised Data Sharing	8. Traceability of products	Farmers' Digi 9. Farmers' Digital Procurement of their Inputs (e.g., feeds, fertilizers, machinon)	ital Marketing) 10. Farmers' Receiving Digital Payments for their Harvest	11. Farmers' Marketing their Products Online
Lao People's Democratic Republic	Policy: 1. Some advice is given by Department of Extension and Agro- Processing (DEAP)\ Ministry of Agriculture and Forestry (MAF).	Policy: 1. Data is sharing is at the macro- level, i.e., sharing of publications, and sharing of general agricultural statistics on Lao Statistical Bureau website.	Policy: 1. MAF partnership with TE- FOOD focusing on traceability and food safety (TE-Food, 2019).	Challenge: Power is partially available in rural areas (GFRAS, 2022).	Comment: 1. Farmers engage in smallholder production agreements. Challenge: 1. Power is partially available in rural areas.	Policy/ Program: 1. " <u>Made in</u> Laos" program 2. " <u>Agri-Sell</u> online platform (Facebook).
Malaysia	Policy: NAP 2.0 (2021-2030) and 12th Malaysia Plan (2021-2025).	Policy: 1. Malaysia Geospatial Data Infrastructure (MyGDI), a program initiated by the government to develop a geospatial data sharing infrastructure between data provider agencies and	Policy: 1. NAP 2.0 (2021-2030) and 12th Malaysia Plan (2021- 2025). 2. Malaysian Good Agricultural Practices (myGAP) for traceability of farm products. 3.	Policy: 1. Government eProcurement (although focused on government procurement process), Ministry of Finance website. 2. Ministry / Government Agency website under the tender /	Policy: 1. Collaboration between the Bank and payments industry to a. improves and widen the access to the payments infrastructure. b. Identify and remove barriers to greater adoption of electronic	Policy: 1. Policies and activities under Federal Agricultural Marketing Authority (FAMA).

users.7	Malavsian	quotation	navments	
2. National Geospatial Centre (PGN) (coordinator for MyGDI program), has developed various geospatial information sharing platform to support and facilitate management planning and decision- making process by	Organic Certification Scheme (myOrganic)	category. (Note: Currently, focused on government procurement.)	c. provides the necessary support to ensure the smooth transition to electronic payments.	
making				
process by related				
sectors.				

⁷ Through this infrastructure, a smart partnership on information sharing and collaboration between agencies was established to further promote development of geospatial products faster, more cost-effectively and efficiently.

Table 4.2: Findings: Key Policies and Challenges Faced by ASEAN Member States in Advancing Digitalisation in Agriculture (Continued)

Digitalisation in Production (Farmer Advisory, Centralised Data Sharing)			Suppl (Traceability, Digital Pa	y Chains and F and Farmers' D yments, and Fa	inancial Digitalis)igital Procurem armers' Digital M	sation ent, Farmers' larketing)
	6. Farmer Advisory for Crops	7. Centralised Data Sharing	8. Traceability of products	9. Farmers' Digital Procurement of their Inputs (e.g., feeds, fertilizers, machinery)	10. Farmers' Receiving Digital Payments for their Harvest	11. Farmers' Marketing their Products Online
Lao People's Democratic Republic	Policy: 1. Extension advisors and teams by government Challenges: 1. Unstable internet access.	Comment: 1. Well established website and link by government.	Challenges: 1. Need trainings on field Record GAP and GMP for farmers by govern.	Comment: 1. Well established banking system and electronic payment system.	Policy: 1. Well established banking system and electronic payment system. Challenges: 1. Unstable internet access.	Comment: 1. Systematic market demand and value chain process. Challenges: 1. Unstable internet access.
Malaysia	Comment: 1. Manual process in place: no automation yet.	Policy: 1. Macro-level regional data submitted to central database.	Policy: 1. Electronic catch documentatio n and traceability system (eCDTS system) in place	Comment: 1. No policies as of yet: no automation in place	Comment: 1. Managed by banks and private entities: no automation yet.	Policy: 1. e-KADIWA online marketing platform.
Singapore	Comment: 1. Private- sector provided mobile app to alert about situations (tracking/ monitoring function).	Policy: There are currently farm networks active. Comment: Data sharing among farmers is not yet actively in practice.	Policy: 1. There is a barcode system in place to trace the tracing of sources of recalled products by retailers. This enables	Comment: Likely, typically, traditional business-to- business dealings, based on relationships, rather than blockchain.	Challenge: 1. Current platforms focus on larger players, but these are less accessible to smaller farms. As such, smaller farms	Policy: 1. There is an association for farmers, SAFEF, to educate farmers. Challenge: 1. Consumers may not necessarily

		No platform	traders to filter	still sell	have a sufficient
	Challenge:	exists yet,	unsafe food	predominantly	understanding
	1. Not yet full	that are	sources.	in	about how the
	accuracy.	comparable to		supermarkets	products are
	since still	IRRI's rice	Challenges:	rather than	actually being
	have to go	nlatforms for	1 There are	direct to	farmed what
	nave to go	instance	differences in	concurror	are being used
		instance.		consumer.	are being used,
	on-ground to	a			elc.
	rectify.	Challenges:	testing		
		1. Sensitivity to	between		2. Investment
		sharing of data	domestically		capacity is
		on practices.	produced		dispersed into
			products and		smaller farmers.
		2. Culture of	foreign-		
		being secretive	produced, i.e.,		3. Unpredictable
		private.	imports are		supply of
			tested in		commodities
		3 While there	batches while		(i.e. whether
		is a farm	for local farms		consumers will
		network there	audits can be		shift from
		is no collective	done on a per		imported to
		aroup to	form basis		domostio
		group to	lann basis.		domestic
		promote			products).
		snaring of	2. Traceability		
		information.	of seeds will		4. Consumer
			be needed		acceptance of
		4. Concerns	too.		increased prices
		over sharing of			of sourcing
		data, market	3. Relatively		local. The
		information.	initial stages,		Singapore
			but spurred by		consumer is
			issues of		price-sensitive.
			adulterated		The pull for
			food		technologies
					has to be the
					consumer and
					their willingness
					to new the price
					to pay the price.
					Commercia
					Comment:
					1. People
					usually assume
					local and foreign
					goods are the
					same, and act
					based on price
					rather than
					quality/safety.
					. , ,
					2. There is a
					need to change
					management
1				1	management

	systems.
	3. Farmers need to be educated on the potential for blockchain, and helped to adapt their systems too.
	4. There are well-established supply chains for the larger retailers in Singapore, from imported to domestic growers

Table 4.2: Findings: Key Policies and Challenges Faced by ASEAN Member States in Advancing Digitalisation in Agriculture (Continued)

Digitalisation in Production			Supply Chains and Financial Digitalisation					
	(Farmer Adviso	ry, Centralised	(Traceability, and Farmers' Digital Procurement,					
	Data Sh	aring)		Farmers' Digital	Payments, and			
				Farmers' Digit	al Marketing)			
	6. Farmer	7. Centralised	8. Traceability of	9. Farmers'	10. Farmers'	11. Farmers'		
	Advisory for	Data Sharing	products	Digital	Receiving	Marketing		
	Crops			of their Inputs (e.g., feeds, fertilizers, machinery)	Digital Payments for their Harvest	their Products Online		
Thailand	Policy: 1. Crop planning assistance is provided. In livestock sector, there are staff offices, volunteers for livestock and smart farmers that can help, inform and disseminate knowledge and technologies to the other farmers. Comment: 1. "Iust actual	Policy: 1. Initial stages of building up linkage for big data. Comment: 1. Mixed opinion, as some say not in practice yet.	Policy: 1. Laws and regulations particularly IUU case. Comment: 1. Just the initial stage, ongoing research on applying blockchain to Traceability of fisheries products.	Policy: 1. Soft loan to support for group of farmers. Comment: 1. Mixed opinion, as some say not in actual practice yet.	Comment: 1. There are currently (private) providers of these services 2. Mixed opinion, as some say not in actual practice yet.	Policy: 1. Provided training course on online marketing to the farmers. Comment: 2. Still in process on side of government, but already popular in private sector.		
Vietnam	1. "Just actual crop planning." Policy: Government provides agricultural, forestry and fishery extension activities, and encourages private sector participation.	Challenges: Building a shared, public, transparent database and stipulating the responsibility of users	Comment: 1. Need for measures to manage and monitor food production process, to be transparent, 2. to help consumers rest assured to use products of	Policy: 1. Reduce tax and fee; 2. Develop the green credits, green bonds, green taxonomy in agriculture sectors	Challenges: 1. "Local" brand, week linkage, information infrastructur e and skills for some farmers.	Challenges: 1. Need to improve knowledge and skills for farmers based on agriculture extension; 2. Perfecting institutions, legal regulations to ensure transparency,		

clear origin	amending
and	economic
guaranteed	policies such
quality,	as taxes,
	green credits,
3. and at the	green bonds,
same time to	agricultural
help prevent	bonds, eco-
commercial	labels
frauds and to	
meet the	
needs of	
domestic and	
international	
consumers.	

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Professor Mely Caballero-Anthony, is Professor of International Relations at the S. Rajaratnam School of International Studies (RSIS), Nanyang Technological University, and holds the President's Chair for International Relations and Security Studies. She is also the Head of the RSIS Centre for Non-Traditional Security (NTS) Studies and Associate Dean (External Engagement).

Prof. Anthony's research interests include regionalism and multilateralism in Asia-Pacific, human security and non-

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Prof. Anthony has led a number of global and regional research projects on international security and global governance. She has served as the Secretary-General of the Consortium on Non-Traditional Security Studies in Asia since 2008 and is a member of the International Climate Security Expert Network. She was Vice President at-large of the Governing Council of the International Studies Association (ISA) and was member of the ISA's Global South Task Force from 2018-2021. From 2013-2017, Prof Anthony was a member of the UN Secretary-General's Advisory Board on Disarmament Matters (ABDM) and served as its chairperson in 2016. She is also a member of the Asia-Pacific Leadership Network on Nuclear Non-Proliferation (APLN). She was Director of External Relations at the ASEAN Secretariat from 2011-2012.

ABOUT THE CENTRE FOR NON-TRADITIONAL SECURITY STUDIES (NTS CENTRE)

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