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DIGITAL CHANGE IN SOUTHEAST ASIAN AGRICULTURE

A study of Laos, Cambodia, Vietnam, Philippines, East Timor, and Indonesia

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“THERE IS NO DOUBT THAT THE ADOPTION OF EXTENSIVE TECHNOLOGICAL SOLUTIONS HAS THE POTENTIAL TO CHANGE AGRICULTURAL PRACTICES AND MARKET FACILITATION — NOT ONLY IN THE SIX COUNTRIES STUDIED HERE, BUT GLOBALLY”

FOREWORD

By Dr. Todd Sanderson, Research Program Manager, Social Systems, ACIAR

Over the past few decades, significant progress has been made in the digitisation of financial services, the creation of market facilitation platforms, and the extension of agricultural services to farmers. These developments hold great promise, yet farmers' ability to leverage these benefits depends on various factors, including accessibility, usability, functionality, specific requirements, literacy, contextual relevance, and more. To date, a comprehensive synthesis of knowledge regarding farmers' digital needs, practices, and the consequences of introducing new technologies remains elusive.

The Australian Centre for International Agricultural Research (ACIAR) is a specialised agency established by the Australian government to support and promote international collaboration in agricultural research. ACIAR's primary mission is to contribute to agricultural development and food security in partner countries, particularly in the Asia-Pacific region, through research projects and initiatives. This includes a focus on the adoption of innovations to enhance smallholder farmer engagement with market-chains and information systems. We partnered with Finthropology to investigate the state of development of agricultural marketing and extension apps and research on digital farming in Laos, Cambodia, Vietnam, the Philippines, East Timor, and Indonesia.

The study serves as a valuable resource for gaining an overview of available applications throughout the region. Moreover, the literature review highlights a significant gap in research on user-centric design and its impact, emphasising the considerable potential for further investigation, particularly in understanding farmers' experiences and optimising designs to meet their unique needs and preferences. An intriguing aspect of the study is its examination of financial applications in agriculture, revealing a lack of specialised apps in this domain. Given the paramount importance of financial inclusion, this presents an exciting avenue for further development and exploration.

“TO DATE, THERE IS NO SYNTHESIS OF KNOWLEDGE ON FARMERS’ DIGITAL NEEDS, PRACTICES, AND THE IMPACT OF INTRODUCING NEW TECHNOLOGIES”

EXECUTIVE SUMMARY

The past few decades have seen substantial development in the digitisation of financial services, market facilitation platforms and agricultural extension services for farmers. These offer many potential benefits, but the ability of farmers to realise these benefits depends on many factors: access, usability, functionality, needs, literacy, context, and more. To date, there is no synthesis of knowledge on farmers' digital needs, practices, and the impact of introducing new technologies.

In this report we explore the state of development of agricultural extension apps and research on digital farming in Laos, Cambodia, Vietnam, Philippines, East Timor, and Indonesia, in light of the active promotion of digitisation from governments and international organisations.

We pose the following research questions:

- Where are digital services for farming most developed?
- What kinds of services are available?
- Who provides them, and who has access to them?
- How are they designed to be useful to farmers and their communities?
- What level of uptake are they achieving?
- What are their impacts?

To answer these questions, we first created an overview of agricultural extension apps in the six countries. We then performed a review of the literature (academic and other) focusing on the context of digital agriculture, digitisation of agricultural extension tools, and discussions and case studies of solutions (available, under development and speculative). We analysed the insights from these research streams to synthesise the state of knowledge.

We found 87 apps, of which 20% were available in more than one country, giving a total of 114 available solutions. The availability is concentrated in Indonesia, with less in the Philippines, Vietnam and Cambodia, and very few in Laos and East Timor. Most of the apps were developed quite recently, and we found few figures on how many farmers are using them or to what extent. Looking at different types of apps, there is a clear development from early solutions focusing on digital advisory services, with later developments in e-commerce, digital procurement and smart farming. Most recently we see the appearance of broader platforms aiming to connect the farming ecosystems and networks. We found fewer solutions in digital finance than expected, given the need for integrated payment solutions and access to credit and capital.

The findings from the literature review showed that the literature is quite scarce and focused on 1) the rollout and adoption of technology; and 2) the development of extension apps. Organisations developing apps carry out very little design research to learn about farmers' actual experience and needs, and little research is done on how farmers use these apps and integrate this use with other available tools and practices.

There are few studies on impact, but there is an awareness of what kinds of impacts may take place, including economic impact (sales, income, productivity and growth), environmental impact (climate, sustainability and wildlife protection) and equity or inclusion (better inclusion for women, low income groups and farming communities). Focus in the few studies is on economic impact.

As the literature is still scarce and quite far from farmers' experiences, it provides little guidance to identify unmet needs and little help on how best to design to meet farmers' needs and preferences. The literature does identify a number of drivers (perceived usefulness, ease of use, income, farm size, education, age, farmers' innovativeness, communities) and challenges (access, literacy, language, incentives including price, convenience, distrust and perceived risk of data loss / fraud) in technology adoption. To these, we would add sociocultural context and the use of digital tools alongside other tools (digital or not).

We recommend future research in areas such as the use of apps among different groups of farmers, the usability of apps, and the impact of use in different contexts. We particularly suggest looking into the need for financial solutions and their integration with other tools.

FIGURE 1. Agricultural apps

INTRODUCTION

The past few decades have seen substantial development in the digitisation of financial services, market facilitation platforms and agricultural extension services for farmers.[1] These include mobile access to advice from peers or experts, mobile payments, and digital analytical tools to help farm management and support more efficient value chains. In recent years, they increasingly include smart machinery like drones and sensors for data collection, and a wide range of smartphone-based applications such in e-commerce, procurement and finance.

There is no doubt that the adoption of extensive technological solutions has the potential to change agricultural practices and market facilitation — not only in the six countries studied here, but globally. Advances in data management offer the opportunity to collect, store, analyse and share very large amounts of data on aspects including yield, meteorological data, climate information, animal health, and so on. Artificial intelligence, machine learning, precision machinery and hardware such as drones can provide robust data analysis to help farmers choose the best times to sow, fertilise, water and harvest. The Internet of Things (IoT) can advance the communication of data from small sensors installed in fields or on animals, sharing (for instance) information on location, earth quality, animal health and product ripeness. Sharing data can reduce costs and tighten connections in a value chain, creating more collaboration between farmers and suppliers and/or distributors or retail customers. From a financial perspective, agricultural solutions hold the potential to make payments easier and quicker, as well as providing new credit and insurance solutions which can help overcome the need for capital.

However, digital transformation does not occur evenly, either across countries or within them. Farmers' ability to benefit from digital apps differs across income groups, education levels and cultures. In agriculture, climate challenges and issues of sustainability and inclusion provide further challenges. Perhaps most importantly, farmers' ability to benefit depends on whether they can access the necessary infrastructure, hardware and government services, including connectivity, and access to mobiles, identification and financial services. Taking advantage of smart farming, for example, will rely on access to a variety of types of data. A very important issue here is who can and will collect and share data. In some cases this will be a natural activity for national authorities. In others it could fall on private players and communities opening discussions on access.

This leaves many unanswered questions with respect to the state of digitization of farming in different Southeast Asian countries. Where are digital services most developed? What kinds of services are available? Who provides them, and who decides who has access to them? How are they designed to be useful to farmers and their communities? What level of uptake are they achieving, and what are their impacts?

In this report we explore the state of development of agricultural extension apps and research on digital farming in Laos, Cambodia, Vietnam, Philippines, East Timor, and Indonesia. In Southeast Asia, governments and international organisations have been keen to promote the digitisation of agriculture as part of broader agrarian change, helping farmers to learn best practices, access inputs, improve production techniques and gain a better position in the market.[2]

The six countries in our study are low-income to middle income countries with large rural populations ranging from around 50% in Indonesia and the Philippines to 75% in Cambodia (World Bank Data). In all the countries except Cambodia, agriculture contributes to 10-15% of GDP (more than 25% in Cambodia) but accounts for 30-40% of employment (World Bank Data). Many of those working in farming are smallholder farmers who often combine farming for household sustenance with commercial crops in low productivity farms (GSMA 2020). Access to ID for the adult population is generally high at over 90% (World Bank ID4D).[3] Internet connection is still quite low at between 50% and 75%, with mobile access somewhat higher at between 70 and 90% (Global Findex Database 2021).[4] With respect to money, cash is still the most important means of payment, ranging around 50% (where information is available) (Worldpay 2022). Only between one third and one half of the adult population has a bank account or another financial account (Global Findex Database 2021). Not surprisingly, this leaves financial literacy at a low level, at between 20 and 30% (Klapper et al. 2015).[5]

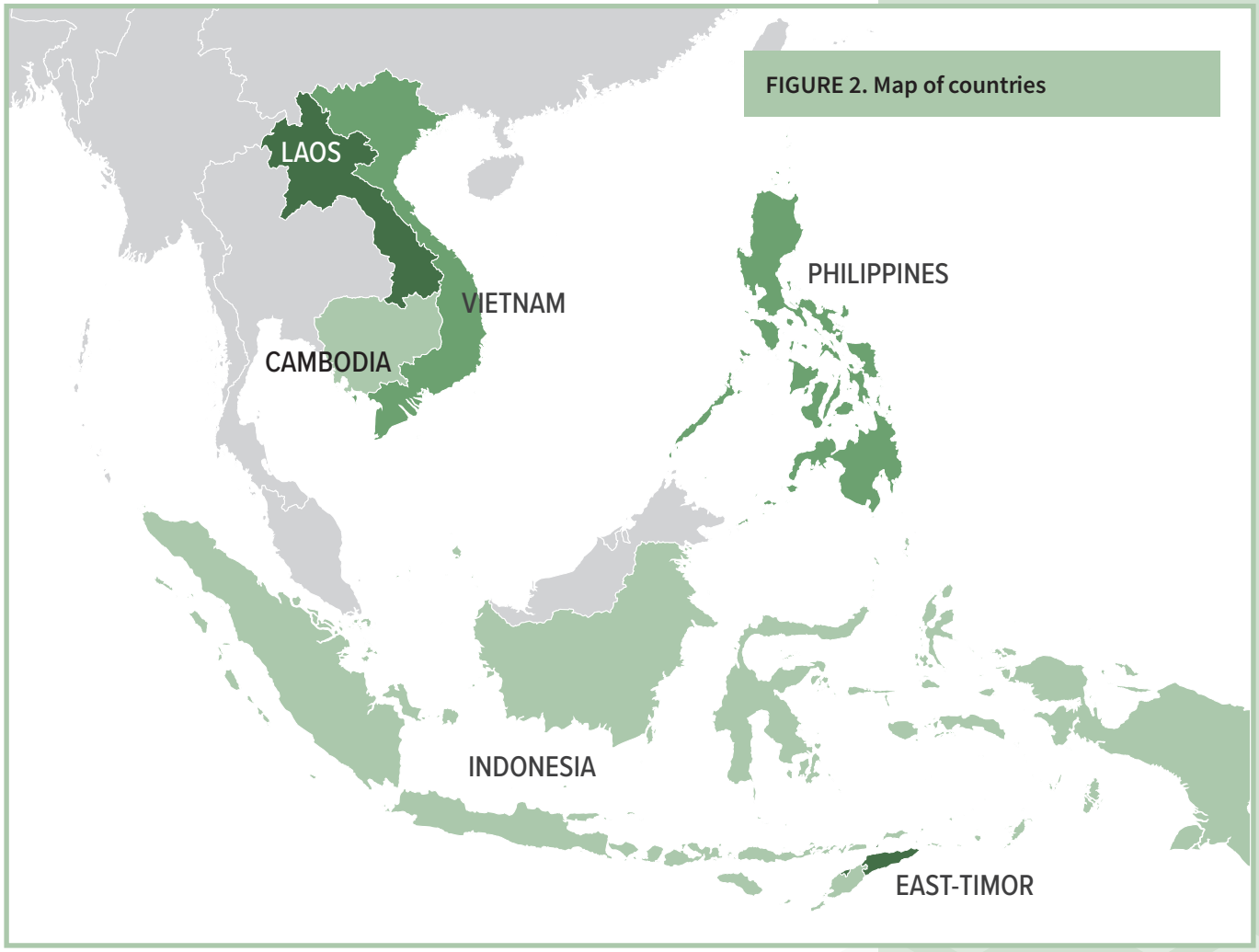


FIGURE 2. Map of countries

In this report we first present an overview of the mobile finance and market facilitation solutions available in the six countries. To assess the state of research on digital extension services we provide a literature review, focusing on the broader literature (academic and reports) on the context of digital agriculture, the digitisation of agricultural extension tools, and academic literature specifically discussing agricultural extension apps. We synthesise this research into a discussion of the state of knowledge on available apps and gaps in the research, including knowledge on farmers as users, and approaches to impact. Since much literature discusses the introduction of new tools from a perspective of adoption of technology or innovation, we provide a comment on these approaches and a critique. Finally we discuss areas for future research.

AN OVERVIEW OF MOBILE APPS FOR AGRICULTURE

We identified farming apps in the six countries in this study by searching in the literature and the two directories published by Grow Asia and GSMA.[6 7]

Our search for mobile apps in the six countries uncovered 87 services accessible via apps, most of which are very recent.[8] We were not able to find the year of founding for all the apps, but it is clear that the number of mobile apps offered to farmers in Southeast Asia is growing fast. Among the 80 apps where we were able to find the year of foundation, 11 (14%) were started in the last three years, 48 (60%) started between 2015 and 2019, and only 21 (26%) go back earlier than 2015. The oldest app, METOS (1984), which provides climate monitoring in the Philippines, is part of an Austrian organisation. This is not surprising since some of the technologies have only been broadly available after 2000.

Many of the apps are offered by very small companies. Most (60%) are national but a large number are available in several countries, either in the region or across the Global South.[9]

Many solutions build on advanced solutions like biotechnology, data analytics AI/ML, IoT software and hardware, and robotics. Their success builds on initiatives (from governments and organisations) to provide databases with meteorological information, and so on. Access is, of course, dependent on access to electricity and the Internet.

We grouped the apps according to a structure developed by the GSMA structure:

- Digital Advisory
- Agri Digital Finance
- Agri e-Commerce
- Digital Procurement
- Smart Farming

We found 6 apps in Agri e-Commerce, 27 in Digital Advisory services, 32 in Digital Procurement, 10 in Smart Farming, and 12 in Agri Digital Finance. The trend is towards a broadening of the offers across different categories (information, advice, lending, market place, etc.) to provide common platforms.

Most apps (29, or slightly more than one third) have their headquarters in Indonesia, 17 are headquartered in Vietnam, 15 in Philippines, five in Cambodia and one in each of Laos and East Timor. When we look at the availability in the six countries we found a similar picture: 46 in Indonesia, 29 in Philippines, 26 in Vietnam, 10 in Cambodia and two in each of Laos and East Timor - a total of 114 offers in-country, since 19 of the 87 apps are offered in more than one of our sample countries. It is somewhat surprising that so few apps are available in Laos and East Timor.

Many of the apps have been developed for farmers in general (33 of the 86). Five focus on fishers or aquaculture and 11 specifically target smallholder farmers. Seventeen have been developed for broader groups including traders, lenders and groups of farmers.[10] Some apps have been developed for particular crops, but most are usable for several products or across all products. The last group is the biggest: almost half the apps (42) do not target specific crops. This includes many sensor-based or drone-based apps. The most common crops are maize and rice (29 apps) and vegetables and fruits (30 apps). The rest target a broad variety of produce including pulses, livestock, coffee, cocoa, bamboo, ornamental plants, bees and aquaculture.

From the descriptions it was clear that many providers work with both national governments, universities and international organisations to develop solutions. Many are startups with ambitious goals and agendas. Some spring from cooperative initiatives to overcome crises. For example, Session Groceries in the Philippines started to help farmers find outlets for their produce following bad weather. Most seem to operate on commercial conditions - some across the whole region, the Global South or even worldwide.

The technologies in use are quite advanced, including the use of sensors, geotracing, drones and other precision tools to monitor crops and collect information as well as advanced artificial intelligence and machine learning solutions to analyse and share the information found. Many services combine cloud based services with offline apps to further reach. There is a general development of apps towards broader platforms covering more than one category.

This means that the solutions rely on access to electricity, internet and mobile solutions. But it also means that their value will increase as databases (crop data, prices, meteorological data, earth and water quality etc.) are built and shared. Within this picture it is also important to clarify whether access will be for all or restricted. An interesting case is the app LaCSA, which was started to build national data sets of meteorological information in Laos. The case clearly illustrates how many partners need to work together to provide these services combining information on wind, temperature, rainfall, agriculture types, soil, crops etc. in digital analysis (Kim et al. 2022).

We have not been able to find systematic data on the use (download or activity) of different apps. Some providers do not publish the information or publish different information (number of downloads, number of users, number of partners, number of locations reached, etc.).

Figure 3 illustrates the year in which 80 of the apps were founded. No figures were available for B2BPriceNow, Digital Farm Development Plan, Green Coffee, LuckNow, MySmartFarm, Sentrago or wowtrace.

Digital advice, data and network

This is quite a large group of applications with a total of 27, of which 21 are headquartered in the countries of study. It includes some "older" initiatives going back to 2013. This illustrates the close connection of internet and mobile device access with access to information and advice. A good example is a smartphone app called Chamka, which was built as part of an IFAD project in Cambodia. Its purpose is to help rural farmers access information, ICT and farming techniques, and it also provides the foundation for extensions with further services. Chamka is chat-based and provides connections to both suppliers and buyers.

An app in the Philippines and Vietnam, mySmartfarm, gives farmers access to a range of services on the one platform, including connecting them to suppliers and insurers, advisors and training for risk management. It thus provides small farms and communities with the basis for economies of scale and collective strength through data and network access. The platform is free for farmers.

LuckNow in Indonesia is a more advanced tool. It is a Software as a Service (SaaS) solution that helps farmers improve their land management practices through the use of IoT devices, artificial intelligence and connections to market partners. The system analyses data points such as sunlight levels, temperature, precipitation, pH, humidity, presence of pests or diseases, and more. Similarly, India-based Taroworks combines a mobile app for field workers to use for data collection with a back-end service providing analysis and information based on a Salesforce solution.

FIGURE 3. Year founded

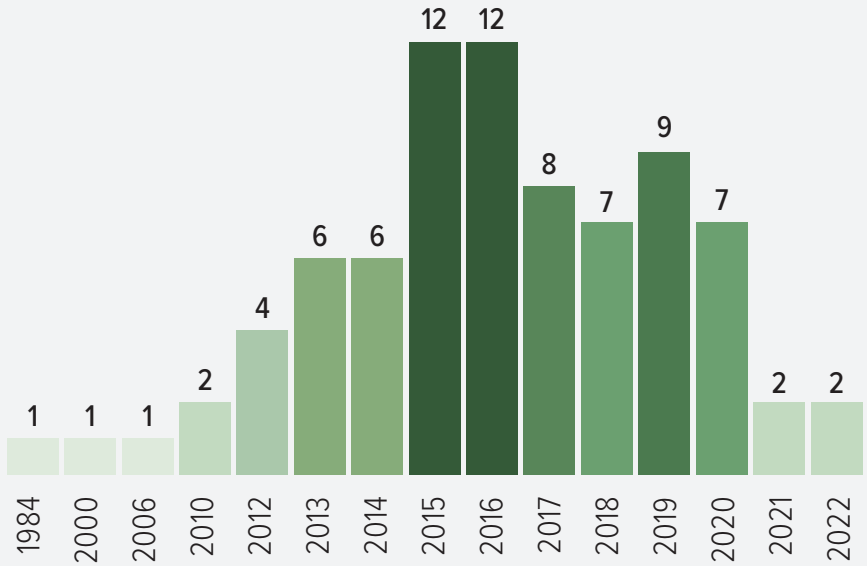
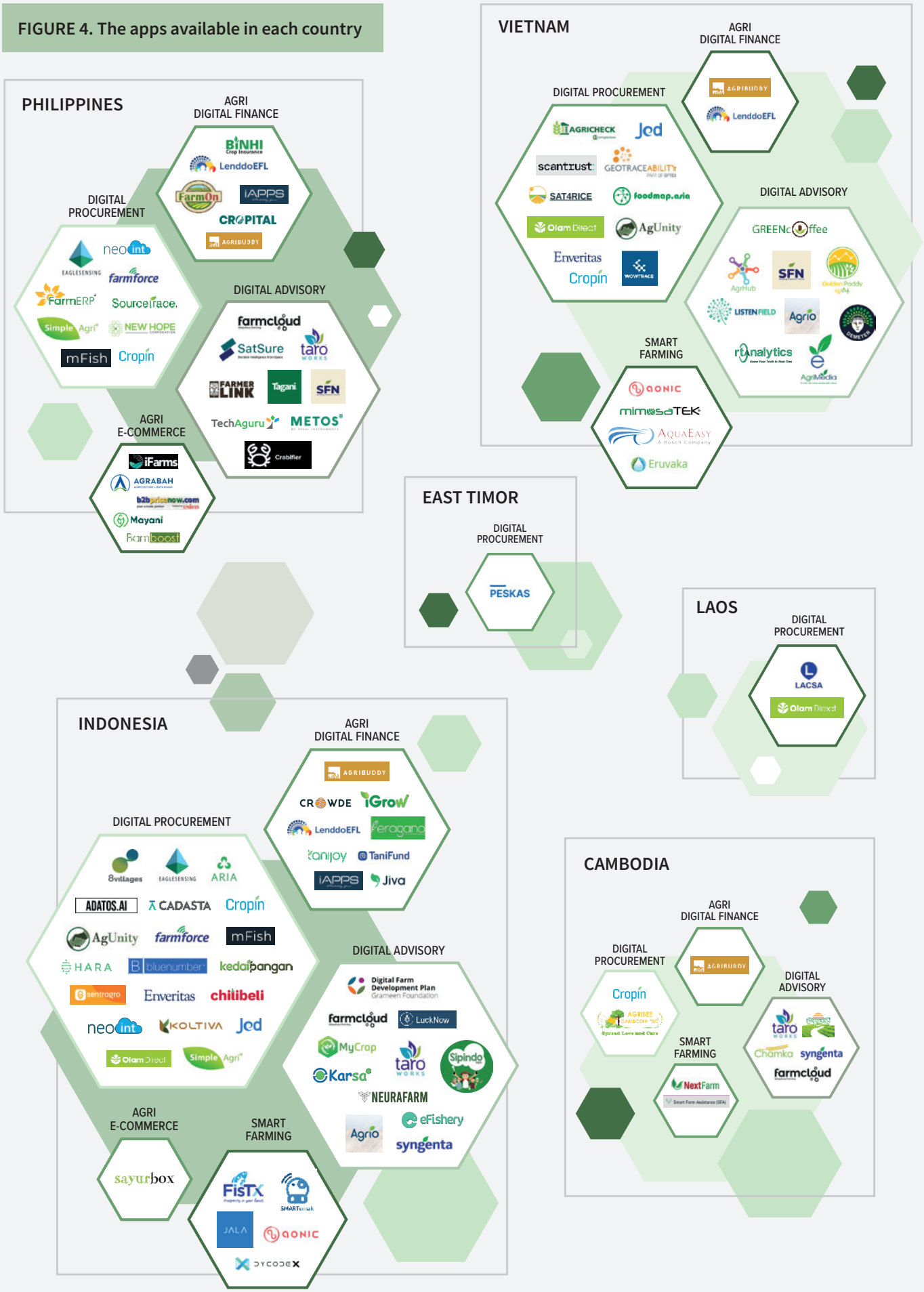


FIGURE 4. The apps available in each country



e-Commerce and access to market

Agri e-Commerce apps are predominantly designed to help farmers connect with retailers and end users. This potentially helps farmers sell at better prices in broader networks and markets, as well as reducing their dependence on middlemen and distributors. This category of services seems to be well developed in the Philippines, which is probably related to the type of produce sold (particularly fresh vegetables) and the infrastructure connecting urban and rural areas. Internet connectivity and digital literacy will be part of this picture as well.

Although digital mobile solutions offer the potential to cut out middlemen, sometimes the companies providing the service bring in middlemen to complete the links along the value chain. A good example in the Philippines is Mayani, an online shopping website that claims to have over 72,000 farmers and 13,500 B2C customers in its network. While the website does not specify how many farmers sell directly to consumers, the substantial number of B2C customers suggests that farmers are selling to retailers. Similarly, in Indonesia, Sayurbox was originally intended to connect farmers directly with consumers, but when the company realised that many farmers were not familiar with technology and sales they altered their business model to B2B (Mulia 2021).

Digital procurement and value chains

This is by far the largest group of solutions including 32 of the 87 apps found. In Indonesia there are 20 solutions available. There are 11 apps available in Vietnam, nine in the Philippines, two in Laos and a single app in each of Cambodia and East Timor. Very basically put, digital procurement solutions help digitally connect different actors in the agricultural value chain from suppliers to buyers. Digital networks create traceability of transactions. Very importantly it also helps bring connections all the way to rural areas, reaching new groups of farmers. This allows suppliers to share data, trends and offers. They also provide farmers with more information, enabling better productivity, higher yields and better prices. Most solutions are based on a SaaS solution. TaroWorks is a platform that enables agribusiness and extension service providers to connect with farmers in hard-to-reach, rural or poorly connected areas. Farmers in the field use an offline system to log farm data such as crop yields.

Some apps are specially developed to serve smallholders and support inclusion, which is reflected in their work with farmers, pricing and learning tools. Examples are FarmERP, the suite of services from 8villages, Koltiva and Sat4Rice. FarmERP stands out for covering the whole value chain, including end-consumers, providing a link to e-commerce.

Some digital procurement solutions develop platforms with additional solutions to support management (overview of cost, risk, sales, etc.) and early warning signals on weather or price developments. Bluenumber specialises in providing a digital ID to uniquely identify people, organisations, places and things and show how these are related—which is very important in more complex value chains. Some (like HARA, JEDtrade, mFish, AGUnity and SCanTrust) are based on blockchain technology. This is often an advantage where trust is low. The decentralised access to data supports traceability across partners.

Smart farming

Smart farming refers to the use of sensors, drones, satellites and other farm assets to generate and transmit data about a specific crop, animal or practice to support agricultural activities (GSMA 2020). It is mostly related to the introduction of new remote sensing equipment working with IoT to connect data collection to farming practices. As this requires capital, most of these solutions are used by larger farmers and commercial producers. This group is the smallest of the five, but is to some extent related to digital procurement solutions due to its use of traceability and data collection.

We found 10 solutions in this category, mostly available in Indonesia and Vietnam. Aonic (formerly Polardrone) offers drone solutions for monitoring, crop counting and fertilising in a number of countries. Several solutions target cattle management through sensor based tracking of animal movements and health (Dycodex and Smarternak). Others follow water quality and irrigation (Smart Farm Assistance, JALA and NextFarm). There are a number of fishing-related apps monitoring conditions (Eruvaka, FIs TX and AcquaEasy). MimosaTEK in Vietnam offers smallholder farmers management tools to build sustainable businesses.

Financial apps

Only 12 apps (13%) are in finance. Most of these are national solutions. Six are based in Indonesia; three in the Philippines. One is based in Hong Kong and two in Thailand but serve the Philippines, Vietnam and Indonesia.

The apps mainly provide capital (short or longer term) to farmers, reflecting the particular needs of farmers as is discussed in the literature. Farming is exposed to more risks than many other types of businesses, and requires special insights into climate, meteorological developments and sustainability requirements. This seems to hold back loans and investments in agriculture, for instance by commercial banks.

The loan providers fall in three major categories. Many solutions provide P2P lending platforms to help farm investors target farming projects based on relevant information. In Indonesia, these include Crowde, Tanijoy and Tanifund. In the Philippines, FarmOn provides farmers with access to P2P loans for growing particular crops.

Other apps connect credit to traditional farming practices, with suppliers and distributors allowing farmers credit for new investments in machinery or sowing with payment at harvest ("Pay-As-You-Go", or PAYG), including Eragano and JIVA in Indonesia. Loukos and Arathoon (2022) describe PAYG solutions as credit to finance the acquisition of an asset over time, typically 12 to 60 months. Credit providers are typically the solution providers. They generally require a down payment ranging from 20% to 50%, with the remainder billed in monthly instalments, often paid through a mobile money platform.

The third group of farming credit apps develop new financial solutions to build agriculture. Examples are Lenddo (Philippines) and Agribuddy (several countries), which offer new types of credit scoring. Cropital (Philippines) is an NGO-based social app offering P2P lending through a wallet. Hong Kong-based Agribuddy works with a large network of agents that offer credit data and credit assessments to partner banks.

There are some examples of microinsurance solutions, particularly crop insurance. These include IgrowAsia, JIVA and Binhi Crop Insurance. The only broader financial platform for farmers is SlideiAPPS from Thailand, which offers a variety of financial solutions. No apps offer savings and investment solutions for farmers. This could be because people use traditional solutions for these services.

“THE TECHNOLOGIES IN USE ARE QUITE ADVANCED, INCLUDING THE USE OF SENSORS, GEOTRACING, DRONES AND OTHER PRECISION TOOLS TO MONITOR CROPS AND COLLECT INFORMATION AS WELL AS ADVANCED ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING SOLUTIONS TO ANALYSE AND SHARE THE INFORMATION FOUND. ”

AN OVERVIEW OF KNOWLEDGE

Our overview of agricultural extension apps shows that there has been a substantial amount of development in recent years. This reflects a general belief among funding bodies, agricultural extension agencies and developers that digitising financial tools can bring substantial benefits to farmers. But the areas targeted vary greatly. What is the design thinking that sits behind these applications? How have farmers responded to them? What are their impacts?

There is a growing body of academic literature on digital change in agriculture. The main areas of focus have been the development of digital solutions and their implementation or adoption by farmers in selected areas. The literature studies drivers, challenges and education in relation to adoption of new solutions. It also follows development projects, often with many stakeholders including farmers, government agencies and international organisations.

Our search for literature specifically on agricultural extension apps turned up 48 relevant academic articles which we have categorised by country, year published and with regard to the type of mobile technology mentioned (following the five categories described above). We identified 27 other relevant articles, reports and tools relating to digital agriculture. Together these provide a good overview of a fast developing field across countries but also in Southeast Asia, where the potential is high because agriculture is a very important contributor to GDP, employment and exports. There is a clear connection between country size and the number of studies, with Indonesia in front but no articles on mobile development in East Timor.

The articles cover a wide range of topics in the area of agriculture and use a variety of research methods, including econometric studies (of adoption), surveys (of use), focus groups, interviews and experiments (on the development of tools).

In this section we first present a summary of the literature and how it relates to the kinds of services offered and the location of service. We then draw out key issues in the literature.

How the literature mirrors services and location

We focused on collecting literature relevant to Southeast Asia. With respect to digital services, we only collected literature for the six focus countries of our study. To understand the context of these services, we examined a range of literature, most of which was focused on Southeast Asia, though some articles had a global focus.

Digital services

We sorted the 48 papers on the implementation of digital apps according to the GSMA's groupings. It is important to bear in mind that many of these papers cross categories; for example, some papers classified as 'smart farming' could also be listed under 'digital advisory', and so on. Nonetheless, while rough, these groupings give a sense of where research is being focused.

The largest category was 'Digital Advisory', which included 20 articles. Nearly half were about apps in Indonesia (7), followed by the Philippines (3), Vietnam (3), Cambodia (3) and Laos (1). Most articles discussed information needs and delivery channels by farmers and extension agents (Bruns et al. 2022 [Cambodia]; Erlanga 2020 [Indonesia]; Hu et al. 2015 [Cambodia]; Listiana et al. 2019 [Indonesia]; Hoang 2020; Hoang et al. 2021, 2022 [Vietnam]). These included an app that helps farmers decide where to market their produce Indonesia (Dormido and Malicdem 2019), and an article on the extent to which farmers use text messaging in information gathering and sharing (Garcia et al. 2018 [Philippines]).

Some articles discussed the process of developing an app without explaining the context in which it would be used (Nurrifqhi et al 2019 [Indonesia]; Bungayong et al 2019 [Indonesia]; Lirag et al 2021 [Philippines]). A few articles focused not on specific apps, but on mobile phone use in agriculture, including how accessing information via mobile

affects prices (Shimamoto et al. 2015 [Cambodia]) and drivers to use mobile phones in agribusiness (Bounkham et al 2022 [Laos]; Mariyono et al. 2021 [Indonesia]). One further article discussed the M-Fisherman Smart Service in Kalimantan, Indonesia, which allows fishermen to request that the service's operators come to the village to perform services such as providing advice or a fishing card (Atika and Kurniasih 2018). Finally, one article discusses the development of a mobile app to disseminate information about corn management and growing techniques in the Philippines (Aribe 2019). We also found an article on developing early warning advisories for farmers for climate and weather information in Indonesia (Walker 2021).

The category 'smart farming' includes 18 articles. The majority are focused on Indonesia (7), followed by the Philippines (12), Vietnam (2), and Cambodia (2). There were no articles on Laos or Timor Leste. There were four articles on apps for plant diseases and pest management, including one in Cambodia that tested whether text messages encouraged integrated pest management (Mwambi et al. 2023) and another on plans to develop an app, e-RICE, to identify plant diseases and prescribe possible control options (Morco et al. 2017).

In the Philippines we found three articles on software and hardware that could help locate pests (Cortez et al. 2018; De Leon et al. 2017; Guiam et al. 2021). Several articles discussed apps to monitor watering and water quality, including one on the possible development of a smart irrigation system based on IoT (Badrun and Manaf 2021), another on a mobile application that can monitor the level of soil saturation in strawberry plants (Gifari et al. 2021), an app to test soil nutrients in water in Indonesia (Golicz et al 2020), and a system called Internet of Things Ponds (I-Tamb) Indonesia that uses sensors and mobiles to monitor nutrients in water (Junaidi and Kartiko 2020). Some articles covered apps to test whether it was time to plant or harvest, including rice yields in Cambodia (Onwuchekwa-Henry et al. 2022), tomato farming in the Philippines (Teogang et al. 2022), corn in the Philippines (Trogo et al. 2015) and pineapples in Vietnam (Cuong et al. 2022).

Additionally, we found one article on building an app to optimise the use of agricultural machinery in Indonesia (Desrial et al. 2019), an article about the development of a mobile poultry management system in Philippines (Batuto et al. 2020), the use of Open Data Kit (ODK) to survey of cacao farms on Panay Island in the Philippines (Pakes et al. 2019), and a discussion of a remote monitoring data collection system to predict livestock's habits based on location and auditory information in Vietnam (Ngo et al. 2020).

Our literature search turned up 5 results for agri e-Commerce. Four of these are in Indonesia, including one on supply chain management (Ariyanto 2021) and one on catfish auctions (Meyliana 2021). Another article discusses the barriers rural communities face accessing digital business systems and proposes a platform that would be a collaboration between government and digital business suppliers in Indonesia (Mukti et al. 2021). Finally, a paper by Diaz (2021) discusses the willingness of smallholder farmers in the Philippines to adopt a mobile app for marketing bamboo products.

We identified just one article on mobile financial services for farmers: a study undertaken in Cambodia on the possibilities of alternative scoring among smallholders, using a survey and a mobile application (Simumba et al. 2018). We also found only one article on digital procurement: a paper by Falgenti (2021) discussing how to design a procurement app for smallholders in Indonesia to sell produce for making palm oil. At the time of publication the app had not yet been developed. This low number of articles on procurement is particularly surprising given that we identified quite a few procurement apps.

Perspectives on digital agriculture

The second group of 27 articles and reports include broader perspectives on the use and potential of digital mobile extensions in Southeast Asia as well as in other global south contexts. We include 11 academic articles.

Eight of these articles throw a little more light on different perspectives of agricultural finance and credit, taking a broader view than only new digital tools. They include an overview of the research on microfinance (Guetierrez-Nieto and Serrano-Sinca 2019) and a more particular article on microfinance in agriculture (Saad et al. 2014). Two articles focus on microfinance debt in Cambodia (Bylander et al. 2018; Shimamoto et al. 2015) and one article on access to credit in rural Vietnam (Lihn et al. 2019). Two articles discuss mobile solutions from the perspective of financial inclusion. Kim et al. (2018) review the available literature on the topic, whereas Morgan and Trinh (2020) dive deeper into fintech and financial inclusion in Vietnam. Finally, Setiawan et al. (2021) discuss user innovativeness in Indonesian fintech. Related to this, we find one article discussing risk in agriculture, which is very important to understand the difficulties of access to capital. The final article (Glover et al. 2019) discusses frameworks for the adoption of technology. We will come back to this later.

The last 17 papers are more general reports, largely from international organisations involved in agricultural development across the globe. Most of these provide very recent (2020-2022) overviews and assessments of developments in digital agriculture, particularly in Southeast Asia or South Asia. They include GSMA's maps of agricultural apps (GSMA 2020) and the GSMA assessment of access to mobile money (GSMA 2021). GSMA also provides an evaluation of smart farming tools available in the region (Loukos and Arathoon 2022). A Brookings report on AgriTech in emerging economies provides valuable insights for the qualification of drivers, challenges and impact (Goh 2021). This is similarly the case for a Grow Asia report on inclusive

digital transformation in Southeast Asia (Voutier and Woo, 2021) and an article from the World Wildlife Foundation (WWF 2021) on the development of sustainable agriculture in the region.

Approaches to digital change in SEA agriculture

Diving a step deeper into the literature, we can throw some light on how the agricultural digital transformation in Southeast Asia is developing. Voutier and Woo (2021) describe three waves of digital solutions. The first is the development of farmer networks and connectivity through mobile communication. The app Chamka, in Cambodia, is a nice example of bringing SMS contacts to farmers. The second wave is the digitization of agricultural business, incorporating new technologies to trace the origin of the agricultural products, drive efficiencies in smallholder value chains, and so on. The third wave is the introduction of new technologies including IoT and AI.It also embeds agriculture in financial platforms for payments and credit.

Many articles discuss the development and adoption of new technologies. We therefore start this section with a short description of the main theories of technology adoption and some important critiques. In the following sections we share a few main findings from the literature in three sections. These cover drivers and challenges of adoption, impact of agricultural digitalisation and some particular perspectives on financial services.

General perspectives on technological change

Our literature review illustrates that the adoption of innovation and the adoption of new technologies are a main starting point for researchers concerned with the transformative potential of technology in Southeast Asia, particularly among smallholder farmers. Several of the articles in the literature review build their insights on two often-used perspectives on the introduction of digital tools and innovation diffusion (Setiawan et al. 2021; Morgan and Trinh 2020; Nguyen et al. 2022.) We therefore include a brief comment on these as well as a critique of them, particularly their relevance to smallholder agriculture (Glover et al. 2019).

Technology adoption is an issue discussed in many of the articles found. An article by Setiawan et al. (2021) nicely summarises some of the theoretical background developed to understand technology adoption, including the Technology Acceptance Model (TAM). TAM is quite an old model that originated in the psychological theory of reasoned action and theory of planned behaviour to describe how likely individuals are to change behaviour based on factors such as ease of use, usefulness, and characteristics of system and environment. Many extensions have been made to the model, including an article on financial literacy in Vietnam that discusses trust and mobile wallet enjoyment (Morgan and Trinh 2020). As becomes clear below, these elements form part also of the empirical issues studied in our review. Nguyen et al. (2022) analyse the propensity to adopt e-commerce solutions among farmers in Vietnam. They find that the willingness to adopt new technologies is driven by perceived usefulness and perceived ease of use. These in turn develop under the influence of the organisational and technological context.

Another often used theoretical approach develops from innovation theory developed by Rogers (2003), who often treats technology and innovation as synonyms. The theory views adoption as the decision to fully use innovation and rejection as the decision not to adopt it. The diffusion of innovation is the process by which an innovation is communicated through certain channels over time among the members of a social system, making innovation, communication channels, time and social systems key elements.

The study of human behaviour in innovation has led to critique of the thinking behind these models. Our literature review includes an article on technological change in smallholder agriculture (Glover et al. 2019) that specifically critiques two central elements: First, they point out that any new technology or innovation tends to be represented as a whole: it may actually be a combination of new tools, new routines and new contacts. Second, they criticise the dichotomic view of either adoption or non-adoption. Based on the understanding of agency, networks, institutions and affordances they develop a framework of appropriation of innovation that allows them to understand how it is taken up by different farmers. The theory includes four aspects: propositions, encounters, dispositions and responses.

These challenges to the idea that people are innovative or not, and their counterpoint that people in fact enact substantial agency in how they incorporate technologies, lines up with many of our findings in other Finthropology studies (Taylor and Broløs 2022; Broløs and Taylor 2022). Among other things, we have noted that people fill the gaps left by technological inadequacies by creating 'human bridges' or workarounds to find solutions. It also suggests that innovation is, in fact, always co-created, as suggested by several studies in the review.

Designing for farmers: drivers and challenges

Many of the articles in our review focus on the introduction of technology among groups of traders and farmers (Hu et al. 2016; Bounkham et al. 2022; Panganiban 2019; Hoang et al. 2020; Hoang et al. 2021; Coggings 2022; Wijaya et al. 2020) or identify drivers and challenges (Bruns et al. 2022; Mariyono et al, 2021; Mukti et al. 2021; WWF 2021).

An understanding of this part of digital development will depend upon an understanding of specific context and users' experience as found also by Nguyen et al. (2022).

While the literature does not provide a great deal of detail here, it does identify an overview of drivers and challenges of technology adoption. On the driver side, we can build this picture (Hoang et al. 2021; Nguyen et al. 2022; Wijaya 2020):

- Perceived usefulness
- Perceived ease of use
- Farmers' innovativeness
- Farmer communities and leadership
- Literacy of ICT tools
- Income share from farming
- Farm size
- Farmer age
- Education

There are also many challenges (Coggings et al. 2022; Hoang 2020; Hoang 2021; Hoang et al. 2022; Wijaya et al. 2020):

- Inaccessible device
- Inaccessible electricity
- Inaccessible mobile network
- Insensitive to digital illiteracy
- Insensitive to illiteracy
- Unfamiliar language
- Slow to access
- Hard to interpret
- Unengaging
- Insensitive to users knowledge
- Insensitive to priorities
- Insensitive to socio-economic constraints
- Irrelevant to farm, distrust
- Fear of data appropriation
- Fear of digital fraud

As the introduction of digital infrastructure is relatively new, we can consider overviews of drivers and challenges as a good starting point for analysing particular contexts. The development from a largely analogue industry to a new digital world served by a host of different digital and mobile tools is, however, happening at speed and through parallel changes in machinery, devices, networks, trade and analysis. To better understand these developments, we need more studies of the interplay between factors in different contexts.

What we know about reach and impact

A critical question is whether the apps discussed in this report are reaching farmers, and if so, what impact they are having on farming households and communities. Unfortunately, very little of the literature provides this kind of information.

The total literature covered includes a number of case studies, mainly on the introduction of market facilitation apps (WWF 2021; Kim et al. 2022; Hu et al. 2016; Bounkham et al. 2022; Panganiban 2019; Diaz 2021; Atika and Kurniasih 2018; Wijaya 2020). Many articles focus on the development of new solutions and do not include test results or even a specification of the target user groups. Among these are Ngo et al. (2020) Trogo et al. (2015), De Leon et al. (2017), Morco et al. (2017), Aribe (2019), Junaidi and Kartiko (2020), Gultom et al. (2017), Ariyanto (2021) and Meliyana (2021). It is not always clear from the articles exactly which groups of farmers were involved in the testing or adoption of solutions (if any).

Though there is much focus on the development and introduction of new tools, we did not find much work to explain how widely the introduction has spread among farmers in the individual countries. Only one article, on an app in the Philippines called Smarter Pest Identification Technology, includes data on downloads and users (Guiam et al. 2021). We did not find descriptions of the overall adoption of digital agricultural solutions across the different countries - just as we did not find systematic information on the number of customers or coverage of the apps.

We can relate this lack of knowledge of reach to the lack of literature on short-term or long-term impact (Shimamoto et al. 2015; Goh 2021). There is, however, an awareness of what kinds of impacts may take place, including economic impact (sales, income, productivity and growth), environmental impact (climate, sustainability and wildlife protection) and equity or inclusion (better inclusion for women, low income groups and farming communities) (Goh 2021). Where impact has been a little discussed, focus has been on potential economic impact, including access to market information technology and credit (Mariyono et al. 2021).

When looking at the impact of mobile solutions in farming there is a question of what kind of farm structures and stakeholders are involved. How are farmers working in different economies? To what extent do the different groups contribute to the economy and to employment?

One typology of types of farming structures (WWF 2021) is the following:

- Farmer-owned enterprises such as cooperatives
- Contract farming (typically with large agro businsess)
- Management contracts (tenant farming)
- Land concessions (long term leases with government or private enterprises)
- Family-owned enterprises

This clearly illustrates that access and impact can be very different depending on whether new technology is offered as a commercial solution for all, a tool (co)created for cooperatives or communities, or a tool extended by an agro-business to contractors.

Target groups for the introduction of financial solutions or market facilitation apps can be anything from individual farmers to households and particular groups (for instance, in the case of financial inclusion), farming communities, cooperatives, or whole ecosystems spanning several parts of the value chain. Future research and programs would do well to specify which groups of farmers they are targeting.

Goh (2021) provides a general framework to understand value chains moving from suppliers of seeds and farming equipment to the farmers themselves to processors, distributors, retailers and consumers. The articles illustrate that some simple apps for digital advice to farmers may be very helpful in creating new networks that help farmers escape dependance of suppliers or distributors. The e-commerce apps described above make exactly that point.

There are, of course, other stakeholders in the value chain or the broader ecosystem. These include governments and regional/local authorities and NGOs, as is clear from the literature. Yet the literature available does not provide a clear picture of who initiates the introduction of new technology or the target groups. There is no doubt that governments are important stakeholders from both a macroeconomic perspective and in relation to goals for financial inclusion and sustainability. As is clear from the several articles on programs working towards the development of farming apps, NGOs and international organisations also play an important part. Looking at the specific apps developed in different areas, it is clear that both farming communities and developers are driven by passionate wishes to create better farming possibilities. From the many international available apps, it is probable that commercial players in the supply chain could also be providers.

From the overview created through both literature and available apps, it is clear that access to information and networks is key to the development of higher agricultural productivity and earnings. Farmers' need for information is categorised nicely in an article on Cambodia (Hu et al. 2016) and confirmed for Indonesia (Mariyoni et al. 2022):

- National and international market information
- Techniques of improvement products
- Quality and safety products
- Weather forecasting
- Potential product
- Geographical potential
- Agriculture service providers

Of course, farmers also need to be able to stay in contact with friends, family and communities that can be trusted to have similar experiences and share information and advice. An interesting discussion relates to the existence and development of networks between farmers for advice, learning, and to obtain higher bargaining power in trade and supply. As pointed out by Matous et al. (2015), online contact works better when networks have been established in person. Wijaya et al. (2020) have done a qualitative study of the impact of ICT technology in rural Indonesia. They find that ICT infrastructure can definitely help build new possibilities for rural smallholders, including the development of ecological and sustainable production systems. New ways of communication and working can also help attract young farmers to stay in the communities. The study, however, highlights that human capacity and leadership are critical factors in the transformation process.

Very few articles or reports (for exceptions, see Hu et al. 2016; Bounkham et al. 2022) discuss broader user experience in different contexts or how new technological solutions are put to use among existing practices in different communities. In many papers we had difficulty identifying whether groups of farmers were involved in the research, and if so, which groups. We found no articles describing long term impact in communities or at the national level.

On digital financial services in agriculture

There is a broad literature available on developments in digital finance,[11] particularly in the Global South where the focus is often on rural areas and populations. However, there is very little that specifically discusses the development, use or impact of financial apps for farmers.

In the broader literature, a common topic is the introduction of digital payments. This literature points both to advantages (such as ease of use, transparency and security) and drawbacks (such as dependence on financial intermediaries, access issued due to location and opening hours, delays in payment). Another focus is on the introduction of new types of credit and lending.

Many of the broader reports on mobile extensions in agriculture raise the issue that farmers lack financial tools and that lack of access (particularly to agricultural credit) slows down the development of agricultural productivity and growth as well as (financial) inclusion for smallholder farmers (WWF 2021).

Finance is crucial in farming both because of high investment requirements in modern machinery and tools and because of the long timeframe between investment, sowing and harvest. Several reports point out that traditional commercial banks identify risk as a reason for being reluctant to provide capital to agriculture (WWF 2021). A study (Komarek et al. 2020) discusses different types of agricultural risk, finding that there is a lack of research and understanding of the relationship between risk, yield, productivity and income. In response, Lihn et al. (2019) point out that the picture of risk is also related to farmers' personal conditions as well as that of the household. These conditions will often drive farmers to take on semi-formal or informal loans bearing the risk of dependency and high cost (Lihn et al. 2019).

The introduction of digital finance (or fintech) is described as having the potential to create greater reach and transparency, as well as to develop new solutions that are more suited to different kinds of users, including the financially excluded. In our literature review we see two clear examples of this. Simumba et al. (2018) describe how digital development can support alternative credit scoring models better suited to serve farmers. Loukos and Arathoon (2022) discuss the development of new credit types that allow farmers to obtain credit at the time of sowing, to be repaid in later instalments at harvest (Pay-As-You-Go, PAYG), and they see these as a key enabler for farmers. From the overview of financial apps, we also identified Agribuddy as an interesting example of a combination of digital and human structures (agents covering the last mile to farmers). From a more strategic perspective, Voutier and Woo (2021) discusses what he calls "third wave digital solutions", where platforms include not only networking, advice and management but also access to digital farming tools, trading, payments and credit.

"A CRITICAL QUESTION IS WHETHER THE APPS DISCUSSED IN THIS REPORT ARE REACHING FARMERS, AND IF SO, WHAT IMPACT THEY ARE HAVING ON FARMING HOUSEHOLDS AND COMMUNITIES. UNFORTUNATELY, VERY LITTLE OF THE LITERATURE PROVIDES THIS KIND OF INFORMATION."

FINDINGS AND FURTHER RESEARCH

We set out to create a market scan of the use of mobile agricultural applications in the six Southeast Asian countries. We have created an overview of mobile finance and market facilitation products/services that are available to farmers in the selected countries, and we have reviewed a large body of literature on the context of digital farming and extension apps.

Looking at the many mobile apps available throughout the six countries, we note that:

- Indonesia and Philippines host many more than the other four countries
- Very few applications are available in Laos and East Timor
- Many apps are available in a number of countries, most often in the Asia region but to some extent also throughout the Global South or globally
- Though many providers will share the number of users or downloads (access), there seems to be no general measures of the uptake across countries or regions (actual use)

The lack of overview of the actual uptake and use of mobile extensions and the complexity of the digital transformation process in agriculture means that it is difficult to point to specific unmet needs. We do, however, find that developing the next generation solutions should include the farmers (and other stakeholders) involved. This is also an important point made in several articles and reports (Hu et al. 2016; Glover et al. 2014; Coggings et al. 2022).

Although there are a considerable number of apps in existence, little research has been done to understand farmer's needs before such tools are developed, or assess impact after they become available. The literature on farmers' different experiences with digital agriculture is scarce, and knowledge of farmers' and households' needs is limited. It is not always clear which groups of farmers are involved in development, testing or implementation. We found very little focus on how farmers actually make use of extension apps in their daily work and in relation to other available resources, including cooperative household management, personal networks and contacts, and local communities. Yet one recent study (Wijaya et al. 2022) found that human capacity is the key in the digital change.

There is a high awareness of the potential impact of a new set of tools, but studies on impact are still scarce. Instead, research focuses on access to technology, education, growth in productivity and economic outcomes. Impact on rural communities and financial inclusion are less studied.

The literature reflects initiatives (mainly by governments) to push digital development to help the growth of farming productivity, manage the risks of climate change, develop sustainable solutions, and foster financial inclusion. In these endeavours, governments are working with NGOs and international organisations to draw on existing experience.

We found very little literature on the intersection between farming and financial technology development. Given the assumed importance of financial tools for farming, this absence is notable. The particularities of agriculture have often led to the provision of specific financial solutions, and so financial solutions are focused on credit and lending. Though there are a few examples of new digital types of insurance, there is very little focus on savings or investment solutions for agriculture.

The need for capital and finance in both the short-term (credit to span the gap between sowing and harvesting) and longer-term (for investments in infrastructure, machinery and knowledge) runs clearly through most of the more general reports. Several publications also find that commercial banks are risk-averse with regard to agriculture. This leaves funding to specialised institutions and to a more informal lending system including the use of agents and other intermediaries, probably pushing up the price. Credit scoring or credit

assessment are key when it comes to risk management, including whether to assess the individual, the household, a larger community or the "farm capital" (building, land, etc,). There is great hope set on the potential of fintech institutions (including both integrated platforms with PAYG solutions and blockchain-based solutions) to fill some of these gaps with new types of data and evaluation of creditworthiness. However, it should be noted that these might need to be implemented in combination with human resources, such as agricultural communities or agents.

This focus on capital leaves broader embedded financial solutions and particularly savings and insurance as potential future use-cases. However, the lack of literature on digital financial solutions for agriculture raises the question of whether the apps are not widely used because farmers are already covered by traditional finance, or whether they are in fact under-researched. The answer could, of course, be both. However, given the general belief that digital farming apps stand to benefit farmers, even if uptake is low it would be useful to know why this is the case. Knowledge could be expanded in areas such as farmers' use of agricultural apps.

There is plenty of work to be done to better understand farmer's needs for digital solutions. First, it is important to understand farmers' current needs and practices and assess the impact of existing tools. Second, given the changes taking place in agriculture and technology more broadly, it would be helpful to undertake an analysis of future needs and use cases. Such research would better inform the development of digital farming technology and policies in both the short-term and long-term.

TABLE 1: Areas for future research

- How widespread is the use of agricultural extension apps among smallholder farmers?
- Are there particular kinds of farmers who are more likely to use the apps than others (e.g., age, gender, crop, type of farming, geographic location)?
- How usable are the apps? What kinds of advantages do they provide to farmers compared with non-digital solutions?
- What is the impact of the digitalisation of farming on smallholder farming households and rural communities?
- Are there special agricultural needs for financial solutions, or are mainstream digital tools sufficient? If so, in what areas (savings, payments, e-commerce, insurance, credit, etc.), and how should tools be integrated with platforms?
- To what extent do e-commerce platforms provide farmers with better market conditions?
- Given the changes taking place in agriculture, what kinds of future tools and use cases might be developed? Who is best placed to develop them?

ENDNOTES

1 Many of the reports reviewed later provide good insights into some of these elements (GSMA 2020; Loukos and Arathoon 2022; Goh 2021; Voutier and Woo 2021; Nogales 2022).

2 Among the six countries, Grow Asia works with Cambodia, Vietnam, the Philippines and Indonesia.

3 Data not available for Cambodia or East Timor.

4 Internet connection data not available for Vietnam and East Timor; mobile access data not available for Vietnam.

5 Data not available for the Philippines and Laos.

6 See their websites, https://directory.growasia.org/ and https://www.gsma.com/mobilefordevelopment/m4d-tracker/magri-deployment-tracker/

7 Data collection for mobile apps ended early May 2023.

8 The majority were apps in their own right; a few, such as Binhi Crop Insurance, were part of another app.

9 As far as information can be found.

10 Leaving 22 with no specified target group (own data).

11 From 2022-2027 the topic of digital finance for farmers is currently being researched by an ACIAR-funded project based at Western Sydney University; see the project website, https://www.diffproject.org/

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APPENDIX A: LIST OF DIGITAL FARMING APPS

NAME	WEBSITE	YEAR STARTED	SERVICE	SERVICES IN
8Villages	http://www.8villages.com	2013	Digital Procurement	Indonesia
AcquaEasy (Bosch)	Https://www.AquaEasy.life	2020	Smart Farming	Vietnam
Adatos	https://www.adatos.com	2015	Digital Procurement	Indonesia
Agrabah	https://www.agrabah.ph	2019	Agri e-Commerce	Philippines
Agribee	https://www.agribee.co	2019	Digital Procurement	Cambodia
Agribuddy	https://www.agribuddy.com	2015	Agri Digital Financial Services	Cambodia, Indonesia, Philippines, Vietnam
Agricheck	https://www.agrichec.net	2016	Digital Procurement	Vietnam
Agrhub	https://www.agrhub.com	2016	Digital Advisory	Vietnam
Agrimedia	https://www.agrimedia.net.au	2014	Digital Advisory	Vietnam
Agrio Saillog	https://www.saillog.co	2017	Digital Advisory	Vietnam, Indonesia
AGUnity	https://www.agunity.com	2016	Digital Procurement	Indonesia, Vietnam
Aonic (formerly Polardrone)	https://www.aonic.com	2017	Smart Farming	Indonesia, Vietnam
Aria	https://www.aria-indonesia.id	2021	Digital Procurement	Indonesia
B2BPriceNow	http://www.b2bpricenow.com	Not available	Agri e-Commerce	Philippines
Bamboostapp	https://www.facebook.com/Bamboostapp/	2022	Agri e-Commerce	Philippines
Binhi Crop Insurance	https://www2.insurance.gov.ph/Binhi Micro-Crop Insurance Program/	2016	Agri Digital Financial Services	Philippines
Bluenumber	https://www.bluenumber.org	2015	Digital Procurement	Indonesia
Cadasta	https://www.cadasta.org	2015	Digital Procurement	Indonesia
Chamka	https://www.directory.growasia.org/chamka/	2020	Digital Advisory	Cambodia
ChiliBeli		2019	Digital Procurement	Indonesia
Crabifier	https://sites.google.com/view/Crabifier?pli=1	2019	Digital Advisory	Philippines
Cropin	https://www.cropin.com	2010	Digital Procurement	Cambodia, Indonesia, Philippines, Vietnam
Cropital	https://www.cropital.com	2015	Agri Digital Financial Services	Philippines

Crowde	https://www.crowde.co	2016	Agri Digital Financial Services	Indonesia
Demeter	https://www.demeter.vn	2017	Digital Advisory	Vietnam
Digital Farm Development Plan	https://www.grameenfoundation.org	Not available	Digital Advisory	Indonesia
Dycodex	https://www.dycodex.com	2015	Smart Farming	Indonesia
Eaglesensing	https://www.eaglesensing.com	2014	Digital Procurement	Indonesia, Philippines
eFishery	https://www.efishery.com	2013	Digital Advisory	Indonesia
Enveritas	https://www.enveritas.org	2016	Digital Procurement	Vietnam, Indonesia
Eragano Agritech	https://www.directory.growasia.org/Eragano/	2015	Agri Digital Financial Services	Indonesia
Eruvaka	https://www.eruvaka.com	2012	Smart Farming	Vietnam
Farm Cloud	http://www. farmcloud.io	2016	Digital Advisory	Indonesia, Cambodia, Philippines
FarmAI	https://www.listenfield.com	2020	Digital Advisory	Vietnam
Farmerlink	https://www.grameenfoundation.org	2015	Digital Advisory	Philippines
FarmERP	http://www.Vishwaam InfoTech.com	2006	Digital Procurement	Philippines
Farmforce	https://.www.farmforce.com	2012	Digital Procurement	Indonesia, Philippines
FarmOn	https://www.community.farmon.ph Corp.	2014	Agri Digital Financial Services	Philippines
FisTx	https://www.fistx.co.id	2020	Smart Farming	Indonesia
Foodmap	https://www.foodmap.asia	2019	Digital Procurement	Vietnam
GeoTraceability	https://www.optelgroup.com/en/blog/reimagining-the-smallholder-data-producer/	2012	Digital Procurement	Vietnam
Golden Paddy Impact Terra	https://www.impactterra.com	2016	Digital Advisory	Vietnam
Green Coffee	https://www.waterwatchfoundation.com/greencoffee-vietnam	Not availablle	Digital Advisory	Vietnam
HARA	https://www.hara.ag	2015	Digital Procurement	Indonesia
IFarms.Inc	https://www.ifarms.php	2018	Agri e-Commerce	Philippines
iGrowAsia	https://www.igrow.asia	2014	Agri Digital Financial Services	Indonesia
Jala	https://www.unreasonablegroup.com/ventures/jala	2015	Smart Farming	Indonesia
JED Trade	https://www.jedtrade.com	2017	Digital Procurement	Vietnam, Indonesia
Jiva AG	https://www.Jiva.ag	2020	Agri Digital Financial Services	Indonesia
Karsa	https://karsaamarta.com/	2016	Digital Advisory	Indonesia
KedaiSayur	https://www.kedaisayur.com	2018	Digital Procurement	Indonesia
Koltiva	https://www.koltiva.com	2013	Digital Procurement	Indonesia
LaCSA	https://www.lacsa.net	2022	Digital Procurement	Laos

LuckNow	http://www.mtc-sams.com	Not available	Digital Advisory	Indonesia
Mayani	https://www.mayani.ph	2019	Agri e-Commerce	Philippines
Metos	https://www.metos.at	1984	Digital Advisory	Philippines
MFish	https://mfish.co/about/	2014	Digital Procurement	Indonesia, Philippines
MimosaTEK	https://www.mimosatek.com	2014	Smart Farming	Vietnam
MyCrop	https://www.linkedin.com/company/mycrop/about/	2016	Digital Advisory	Indonesia
MySmartFarm	Website not available	Not available	Digital Advisory	Philippines, Vietnam
NeoInt	http://www.neoInt.ai	2017	Digital Procurement	Indonesia, Philippines
NeuraFarm	https://www.neurafarm.com	2018	Digital Advisory	Indonesia
New Hope Corporation	https://www.newhopecorp.com	2017	Digital Procurement	Philippines
NextFarm	https://www.nextfarm.vn	2018	Smart Farming	Vietnam, Cambodia
Olam Direct	http://www.ofi.com	2020	Digital Procurement	Vietnam, Indonesia, Laos
Peskas	https://www.timor.peskas.org	2021	Digital Procurement	East Timor
RTAnalytics	https://www.rta.vn	2013	Digital Advisory	Vietnam
Sat4Rice	https://www.sat4rice.wordpress.com	2019	Digital Procurement	Vietnam
SatSure	https://www.satsure.co	2019	Digital Advisory	Philippines
Sayurbox	https://www.sayurbox.com	2016	Agri e-Commerce	Indonesia
Scantrust Knorr App	https://www.scantrust.com/farm-to-fork-traceability-supply-chain-awareness-and-consumer-engagement-help-knorr-regain-market-share-despite-aggressive-competitor-pricing/	2013	Digital Procurement	Vietnam
Sentrago	http://www.sentrago.com	Not available	Digital Procurement	Indonesia
Simple Agri	https://www.simpleagri.com/	2016	Digital Procurement	Indonesia, Philippines
SIPINDO	https://www.sipindo.id	2018	Digital Advisory	Indonesia
Slide iAPPS	https://www.iappsasia.com	2012	Agri Digital Financial Services	Philippines, Indonesia
Smart Farm Assistance	https://www.smartfarmassistanc.wixsite.com	2020	Smart Farming	Cambodia
Smarternak	https://www.dycodex.com	2015	Smart Farming	Indonesia
Source Trace	https://www.sourcetrace.com	2018	Digital Procurement	Philippines
Syngenta	https://www.syngentaFoundatio.org	2000	Digital Advisory	Indonesia, Cambodia
Tagani	https://www.e27.co/startups/tagani	2018	Digital Advisory	Philippines
TaniFund	https://www.tanifund.com	2017	Agri Digital Financial Services	Indonesia
Tanijoy	https://www.linkedin.com/company/tanijoy/	2017	Agri Digital Financial Services	Indonesia

Taroworks	https://www.taroworks.org	2013	Digital Advisory	Indonesia, Cambodia, Philippines
TechAguru	http://www.techaguru.com	2015	Digital Advisory	Philippines
The Lenddo Score	https://www.lenddoefl.com	2010	Agri Digital Financial Services	Philippines, Vietnam, Indonesia
Tonlesap	https://www.amkcambodia.com	2019	Digital Advisory	Cambodia
wowtrace	http://www.wowtrace.io	Not available	Digital Procurement	Vietnam

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