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Transforming Philippine Agri-Food Systems with Digital Technology: Extent, Prospects, and Inclusiveness

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Abstract

This study presents a rapid assessment of digital technology's adoption in Philippine agriculture and its implications for smallholder farmers. Modernization of agriculture, a perennial goal in agricultural policy, is increasingly linked with digital technologies, as outlined in the Philippine Development Plan (PDP) and underscored by Industry 4.0's transformative impacts on markets, trade, and manufacturing. Digital agriculture offers significant potential benefits, including enhanced productivity, market access, and sustainability. However, it also presents the risk of exacerbating the "digital divide," potentially leaving vulnerable rural populations further behind.

The assessment explores the current application of digital technologies in agricultural value chains, the prospects for further adoption, and whether these technologies are benefiting the most vulnerable farmers and fisherfolk. Findings reveal that, while certain digital agriculture components like advisory apps and online retail networks are widespread, others remain in early development or at prototype stages. Government priorities and stakeholder interest (farmers, fisherfolk, agribusiness companies) suggest promising prospects for the expansion of digital agriculture tools, including decision support systems and online marketplaces.

The study also identifies strategies to bridge the digital divide, such as community organizing, development of rental markets, and investments in rural connectivity. Key policy recommendations include harmonizing government data and advisory services, creating a single government portal for digital agriculture, integrating digital solutions into farm management, expanding decision support for diversification and climate resiliency, and establishing a centralized e-commerce platform. Emphasizing the importance of government-led initiatives, the study advocates for exploring public-private partnerships to enhance the commercialization and accessibility of digital agricultural technologies.

Keywords: digital agriculture, agri 4.0, precision agriculture, smart farming, e-commerce, fintech, digital divide

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Transforming Philippine Agri-Food Systems with Digital Technology: Extent, Prospects, and Inclusiveness[1]

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1. Introduction

Rationale

Modernization of agriculture and fisheries has been an elusive and perpetual goal of agricultural development policy (Briones, 2023). Chapter 5 of the current Philippine Development Plan (PDP), on *Modernizing Agriculture and Agribusiness*, identifies digital technology in several strategies for agriculture and agribusiness modernization (National Economic and Development Authority [NEDA], 2023). The potential of information and communications technology (ICT) is demonstrated by the Fourth Industrial Revolution, or Industry 4.0, that has expanded markets, promoted trade, and transformed manufacturing processes (Lamberte et al. 2019). Digitalization is now beginning to affect the agri-food system. Considering these trends, PDP Chapter 5 identifies the strategy of *Improve physical and digital infrastructure* under Outcome 2: "Access to markets and agriculture, fisheries, and forestry (AFF) enterprises expanded". The strategy involves: integrating and improving inter-operability of AFF information systems; strengthening capacity of farmers and fisherfolk in using mobile and web-based platforms; as well as implementation of AFF digitalization projects, such as the National Farmers and Fisherfolk Registry System (NFFRS). Digital technology opportunities are highlighted as well in the areas of finance, insurance, and land administration.

Digital agriculture leads to economic benefit through increased productivity, efficiency, market opportunity, and environmental sustainability. Already, smallholders' access to information, inputs, and markets, are improving with the spread of mobile technologies, remote-sensing services, and distributed computing. However, the "digital divide" risks worsening inequities between urban and rural areas, further leaving vulnerable populations behind (Trendov et al. 2019). Given this strong interest from government and other stakeholders in digital technology in agriculture, as well as its concerns over the equity of its benefits, the following policy questions are most relevant:

- What are existing applications of digital technologies in the agricultural value chain in the Philippines?
- What are the prospects of further adoption?
- Are the benefits from these new technologies reaching the most vulnerable farmers and fisherfolk?

Aims and scope of the study

This study undertakes a rapid assessment of existing and potential adoption of digital technologies in Philippine agriculture, and implications for smallholders. The assessment aims

[1] The authors, who serve as PIDS Fellow II, Supervising Research Specialist, and Research Analyst II, extend their gratitude to Ms. Junalyn T. Bayona for her invaluable assistance during the data collection phase of this research study. For correspondence, you may email the authors at: rbriones@pids.gov.ph, igalang@pids.gov.ph, and jlatigar@pids.gov.ph.

to addressing the foregoing research questions, as follows: a) determining the extent to which digital technologies are being applied in agricultural value chains; b) evaluating prospects for further adoption; c) assessing the degree to which small-scale farmers and fisherfolk benefiting from the digital technologies.

The rest of this paper is organized as follows: Section 2 describes the conceptual framework and study method. Section 3 reviews previous research on the policy questions. Section 4 provides a background on the Philippine agriculture and digital economy. Section 5 presents findings of the study on extent, prospects, and inclusiveness, of digital agriculture. Section 6 concludes with a summary and policy implications.

2. Conceptual framework and method of the study

Problems and solutions for Philippine agriculture and agribusiness

The PDP diagnoses an array of interrelated problems affecting Philippine agriculture and agribusiness. These include: Low farm/labor productivity; low access to credit and insurance, particularly among smallholder primary producers; unsustainable farming practices; weak export performance; weak investments in the AFF sector; inadequate infrastructure; fragmentation of agricultural lands; and high vulnerability to multidimensional shocks. To address these problems, PDP Chapter 5 proposes desired Outcomes and associated strategies as follows:

Outcome 1: Agriculture, forestry, and fisheries (AFF) production enhanced:

- Diversify farm and non-farm income
- Consolidate/cluster farms
- Create and facilitate adoption of improved technology
- Improve access of primary producers to production requirements (e.g., land, water, renewable energy, and credit)

Outcome 2: Access to markets and AFF-based enterprises expanded

- Create opportunities for the participation of primary producers in value adding of AFF products
- Improve physical and digital infrastructure
- Protect local AFF against unfair competition and supply/price manipulation

Outcome 3: Resilience of AFF value chains improved

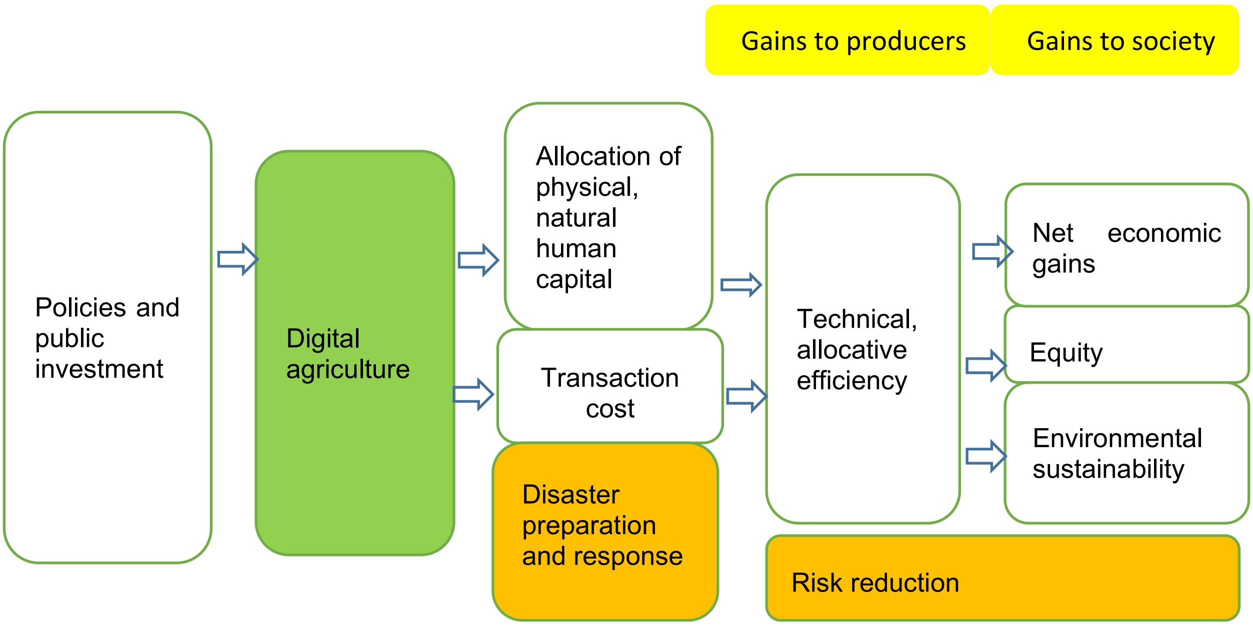
- Create and adopt climate- and disaster-resilient technologies
- Strengthen local food systems
- Develop and mainstream early warning systems/anticipatory mechanisms
- Integrate climate and disaster risks in AFF planning and programming

ICT offers a pathway towards achieving PDP Outcomes. "Information" is defined as *what is conveyed or represented by a particular arrangement or sequence of things* (Oxford Languages, 2023). More broadly, information may be seen as coded in digital symbols and conveyed through electromagnetic waves. With digitized symbol manipulation comes unimaginable information processing capacity enabled by modern electronics. With better data and processing of information, greater efficiency can be realized throughout the agricultural value chain, from the production of inputs and services, to farming, processing, logistics, and distribution to consumers. *Digital agriculture* refers to “ICT and data ecosystems to support the development and delivery of timely, targeted information and services to make farming profitable and sustainable while delivering safe nutritious and affordable food for ALL.” (International Crops Research Institute for the Semi-Arid Tropics [ICRISAT], n.d., par. 4) It represents both a technological transformation in itself, as well as a means to accelerate agricultural innovation.

Benefits from digital agriculture

The pathways to benefits from digital agriculture are summarized in Figure 1, adapted from Schroeder et al. (2021). Digital agriculture is relevant for allocation of physical, natural, and human capital, for transaction cost in coordinating across the value chain (i.e. searching cost for matching supply and demand; and monitoring and enforcement of contracts.) As an immediate gain to producers, application of digital technologies can improve technical and allocative efficiency; there are also potential gains to society by net economic benefits in the value chain; improved equity by increasing access to goods and services; and environmental sustainability by avoiding excessive input use and extraction of resources, Lastly, disaster preparation and response (an extension over the original Schroeder et al. [2021] schema) is another pathway to realize gains to producers and society through risk reduction.

Figure 1: Pathways for digital agriculture to benefit producers and society



Source: Adapted from Schroeder et al. (2021)

Decision support systems: Decision Support Systems encompass various information systems tailored for agricultural and environmental contexts. They offer comprehensive resource profiling, risk assessment, and critical data to guide planning, disaster response, and the allocation of investments. The deployment of such systems can significantly enhance the efficacy of public services.

Agricultural production applications: Digital agriculture is often enabled by devices that are either embodied in agricultural machinery and equipment or else disembodied and deployed by human users, such as smartphones or tablets. **Information/advisory services**, and other tools of **e-extension**, is a more cost-effective way to reach more farmers with new technologies, training, and advice. **Precision agriculture** and **smart farming** are characterized by the collection, processing, analysis of temporal, spatial, and individual data which are combined with other information to handle variations in field management and perform precise machine action (Food and Agriculture Organization [FAO] 2022).

Fintech: Financial technology, or Fintech, refers to "advances in technology that have the potential to transform the provision of financial services, spurring the development of new business models, applications, and processes, and products" (World Bank 2022, p. 10). By increasing the efficiency of financial intermediation, fintech may benefit farmers with improved access to finance.

E-commerce: The deployment of online platforms for matching demand with supply, and arranging payments and logistics. These platforms may benefit buyers and suppliers by better matching of supply and demand, leading to narrowing of intermediation, opening up new markets, reducing transaction costs, and improving price discovery.

Protection of ecosystem services: The reduction of input use and waste, enhanced environmental monitoring, and promotion of sustainable farming practices, all ensure a more reliable and sustained flow of ecosystem services from soil, water, biodiversity, and the like.

Method of the study

This study relies on rapid appraisal techniques to obtain qualitative answers to its research questions. The first major source of information is a desk review of relevant data, and research reports and scientific papers. Qualitative data collection methods used by the study are focus group discussions (FGDs) and key informant (KI) interviews. This study employed chain referral methods, namely, snowball sampling. This entails identifying key informants and/or documents to name one or two individuals from the population, who are then asked to recommend others who may be interested to participate. The process is repeated, and the sampling grows with each interview until saturation is reached. Snowball sampling is commonly used in social sciences to study populations that are hard to find or access such as those that are small and scattered (Bernard, 2016).

In this study, the use of snowball sampling is particularly crucial due to the challenge of identifying respondents from an undefined population. There is no comprehensive listing of institutions or agencies actively employing digital technologies in agriculture. This complexity is compounded by the diverse range of technologies in use and the variety of stakeholders in the agri-food system, which include producers, distributors, retailers, and consumers, each potentially employing different digital tools and approaches. Thus, traditional sampling methods are less effective, making snowball sampling an ideal strategy to reach a representative group of respondents in this fragmented and evolving field.

The key stakeholders to be covered in the rapid appraisal are: Government actors in digital agriculture; private companies and social enterprises engaged in digital agriculture, whether agribusiness or tech companies; and farmer organizations. These stakeholders have their respective engagement with the key digital technologies; for instance, tech and agribusiness companies engage in e-commerce, e-extension, and smart farming. Other companies, together with farmers and farmer organizations, as well as consumers, serve as clients of these digital technologies and its users.

The assessment of extent of adoption entails a review of secondary data on technology usage, supplemented by FGD and interviews with key informants who possess local insights into the uptake of digital technologies. Assessment of prospects is limited to a five-year horizon, based on two considerations: a) Benefits derived from adoption; and b) Factors influencing the pace/rate of adoption. The common idea is that the greater the benefits from adoption, the greater the incentive to adopt. However, there may be obstacles for benefits of a technology to scale. Lastly, assessment of inclusiveness examines whether there are any systemic biases against certain types of farmers, especially those that are more marginalized. These aspects are further explored in the subsequent literature review.

3. Review of past studies

Extent of adoption

There is evidence of widespread adoption of some types of digital agriculture in developed countries, but very limited uptake in developing countries. Precision agriculture started in the 1980s in the USA when field mechanization was integrated with global positioning system (GPS), geographic information system (GIS), and remote-sensing technologies (Robert, 1999 as cited in Serraj and Pengali 2019). In Japan, farmers had been using unmanned helicopters for chemical application (e.g. pest control and pesticides in rice, soybean, and wheat fields) since early 1980s. Other early adopters are Australia and New Zealand which adopted precision agriculture not just in crop management, but also in rangeland and livestock management (Huang and Brown 2018, as cited in Serraj and Pengali 2019). Since then precision agriculture has spread throughout the developed countries. Lowenberg-DeBoer and Erickson (2019) summarized adoption estimates as follows:

- Widespread adoption in developed countries on GPS and related geographic information systems
- Slow adoption of variable rate technologies even in developed countries: for instance, variable rate fertilization does not exceed 20 percent of farms even in North America

On the other hand, in developing countries, there has been very little use of precision agriculture on non-mechanized farms in the developing world. One reason is that very few precision agriculture technologies are cost-effective on non-mechanized medium and small farm common in these countries (Loweberg-DeBoer and Erickson, 2019).

Similarly for site-specific nutrient management digital tools (SSNM-DT), most of the experts surveyed in Sida et al. (2023) believe these digital tools have not been widely adopted in developing countries. Up to 54 percent of experts estimated adoption rate at under 1 percent of farmers. The biggest adoption barrier is technical; usually, only agricultural extension workers (AEWs) actually use the tools to generate recommendations, which are then relayed to farmers.

While solid data is seldom available, broad-brush characterizations are common; for instance, Voutier and Woo (2021) identify three waves of technology advancements that occurred. The first involves mobile communication, owing to increased mobile phone penetration in rural areas in the 2000s. By 2015, the second wave of agribusiness digitization had begun, as entrepreneurs adopted digital solutions along the agri-food value chain, such as monitoring of farms using satellite data. On-going is the third wave, involving digital payments by farmers, digital trading and lending platforms, hardware innovations for smallholder farmers, and digital farmer advisory services. The third wave is heavily dependent on private sector investment, especially in technology start-ups. As of 2021, tech start-ups in smallholder agri-technology in the Philippines numbered 18, compared with 27 for Singapore and 51 for Indonesia, although at par or better than Viet Nam (18), Malaysia (14), and Thailand (14) (Voutier and Woo 2021).

Factors determining adoption

Despite the favorable outcomes measured, various intervening farmers determine actual pace and extent of adoption. Ruzzante et al. (2021) assesses various theories of agricultural technology adoption against the evidence. Theories of agricultural technology adoption may be categorized into three "paradigms": the *innovation-diffusion paradigm* points to information as the key constraint to adoption, leading to a range of adopter categories from innovators and early adopters to laggards. The *economic constraints paradigm* posits that technology adoption is the outcome of utility maximization subject to constraints; differences in resource endowments account for adoption patterns. Lastly the *adopter-perception paradigm* incorporates subjectivity in assessing constraints and opportunities, within a cultural and institutional context . Hence for instance, the economic constraints paradigm can better explain why farm size matters compared with the innovation – diffusion paradigm, inasmuch as large farm size may enable economies of scale associated with agricultural innovation. However, adoption factors such as caste, social networks, etc., are better accommodated in the adopter-perception paradigm.

Ruzzante et al. (2021) conduct a meta-analysis of adoption studies for major new agricultural technologies in developing countries, namely: natural resource management (e.g. crop rotation, intercropping, organic farming); improved varieties (e.g. high yielding maize); chemical inputs (e.g. pesticides); and mechanization/infrastructure (e.g. groundwater pump, laser land leveling). They find that education, farm size, access to credit, land tenure, contact with extension agents, and membership in farmers' organizations, all positively influence the adoption of most of the new technologies. The same effects are found for digital agriculture, with additional variables such as: ease of using technology, supporting institutions and services, compatibility of different brands and models, cost of equipment, possibility of renting equipment, presence of regulations for reduced input use; other farmer characteristics such as familiarity with computer usage and willingness to take risk; and social milieu (Say et al. 2018).

Readiness for digital agriculture is typically greater, the higher the average income of an economy. Based on these and related adoption factors and other indicators, several country assessments of readiness for digital agriculture are compiled in Briones and Jiang (2023), covering India, Pakistan, Thailand, and Viet Nam. Readiness indicators are computed for upstream, production, downstream, and general development and digitization aspects of the agricultural value chain, and qualified as Low, Medium, and High. Degree of readiness upstream is mixed, though Indonesia tends towards the Medium-Low end and Thailand at the High-Medium end. Downstream factors range from Medium-Low for India and High for Thailand. Lastly, enabling factors for development and digitization range from mostly Low to Medium for India, up to Medium-High for Thailand, with Vietnam and Indonesia at the intermediate stage.

The Philippines, however, is not included in Briones and Jiang's (2023) analysis. A separate assessment by Camacho et al. (2022) evaluates the readiness for Agriculture 4.0 within Philippine agricultural research and development organizations. Their ratings are, in order of increasing readiness: Level 1 – Awareness; Level 2 – Conceptualization; Level 3 – Creation; and Level 4 – Innovation. Of the 187 organizations assessed, only 2 are at the Innovation level (most ready), while 76 (41 percent) are at the Creation level; the remainder (58 percent) are at the least ready levels.

Impact of adoption

While precision agriculture tools have had measurable impacts in developed countries, similar evidence for developing countries is sparse. Owing perhaps to a longer history and experience with precision agriculture, benefits have been better researched and quantified in developed countries. For example, digital soil mapping-enabled adoption of YieldProphet in Australia has led to an estimated net present value of AUD 26.1 million, with benefit-cost ratio of 3.2. Meanwhile, users of SoilWaterApp (also enabled by digital soil maps) affirmed benefits from the app, with 47 percent believing it helped better monitor soil and water, 43 percent had increased knowledge about water storage and losses, and 30 percent had led to more efficient use of soil/water (Grundy et al. 2020).

In developing countries, however, evidence on outcome and impact in developing countries is sparse. Grundy et al. (2020) examined regional scale application of digital soil mapping in Cabulig River Watershed in the Philippines, a mountainous area covering 220 sq. km. The resulting soil atlas was the basis of developing a land use plan as well as location-specific land management packages. However, impact assessment of this initiative has not been done.

At the input provision stage, Paudel et al. (2023) found that laser land leveling (LLL), a precision technology that can do away with these water holding structures in rice fields, entail high cost, though a survey of Nepali farmers found that those in the top quantile by acreage were willing to pay an average 45 percent more than the market price for service. As for e-extension, a meta study finds the transmission of agricultural information through mobile technologies boosted yields in sub-Saharan African and India by an average of 4 percent (Fabregas et al. 2019). Meanwhile the odds of adoption of recommended inputs increase by 22 percent. Fabregas et al. (2023) compile the following additional examples from several previous studies:

- Six experimental evaluations of text extension services in Kenya and Rwanda found that farmers receiving texts were 19 percent more likely to follow the advice.
- Several video-based interventions for farmers were found to have improved knowledge and farmer practices (as self-reported), although measured impacts on crop yields have been mixed.
- Weather forecasts affect farmer investment, and accurate forecasts increase farm profitability.

Digital tools for site-specific nutrient management (SSNM-DT) have failed to scale despite past applications showing favorable impacts on productivity, economic, and environmental outcomes. Sida et al. (2023) based on a survey of key informants, examined expert opinions on effects of the aforementioned digital tools on adopters (Table 1). Impact on yield and environment are overwhelmingly positive, while a majority of farmers had experienced a positive economic impact. Negative effects are relatively rare, except for environmental effects, while neutral effects are observed by a considerable number of farmers for economic impact.

Table 1: Key informant opinions on impacts of SSNM-DT

	Yield	Economic effects	Environmental effects
Negative	4.8	3.2	17.9
Neutral	20.6	41.9	11.0
Positive	74.7	55.0	71.2

Source: Sida et al. (2023).

Use of the internet has been found to have a significant positive impact on farmer income, access to markets, and to finance in some countries. For surveyed farmers in Ghana, internet use increased farm and household income by 20 percent and 15 percent, respectively; the impact was measured using an endogenous switching regression model and probit models were employed to achieve the aims of the study to account for selection bias (Siaw et al. 2020). For surveyed wheat growers in Pakistan, mobile phone and internet technology usage (MPITU) has been found to be associated with higher incomes of rural farmers. Active MPITU increased agricultural revenue by more than 36 percent, with also positive impact on off-farm income. A major channel of income increase was the greater efficiency of selecting sales channels. Propensity score matching and Heckman regression were applied to control for selection effects (Siaw et al. 2020).

For rural China, household data for Henan and Shanxi provinces were analyzed to isolate the impact of e-commerce. Adoption of e-commerce significantly increased farmers' selling price, although it also increased marketing cost (as farmers now undertake numerous functions previously performed by intermediaries). In turn, adoption of e-commerce is driven by education level, smartphone use, off-farm employment, and social capital. These variables were used to adjust for the endogeneity bias using endogenous switching regression (Liu et al. 2021). Similarly, a survey of farmers in China found that e-commerce adoption, with controls for endogeneity (using propensity score matching and difference-in-differences), is associated with a significant increase in sales income. However, income effects differ across locations and household characteristics (Li et al. 2021).

Not all countries, though, yield definitive evidence. Despite widespread use of mobile phones, mobile phone ownership has had no statistically significant effect on the level of farmgate price received by farmers in Ethiopia, except for wheat (Tadesse and Bahigwa 2015). Similarly, a survey of Kenyan farmers found that although over 80 percent of farmers use mobile money, only 15 percent utilize it for agriculture-related payments. Less than 1 percent of farmers use mobile loans for agricultural investments (Parlasca et al. 2022).

The "digital divide"

Digital divide refers to a "range of inequalities between social groups, genders, age groups, and rural and urban areas, both within and across countries (International Institute for Applied Systems Analysis (IIASA) 2019 as cited in Schroeder et al. 2021, p. 35)." It arises from heterogeneity across farm households with respect to adoption factors, creating differential access to digital technologies for agriculture, thereby skewing the incidence of benefits from the technology.

A critical divide relates to farm size. FAO (2022) examined the barriers to inclusive adoption of agricultural automation and digital technologies by small-scale farmers. Drawing from 27 case studies, the most significant challenges include (i) low levels of digital literacy, particularly in rural areas, (ii) inadequate infrastructure, such as limited connectivity and lack of electricity access, and (iii) financial limitations. In general, asset endowments tend to correlate with early adoption of ICT (Schroeder et al. 2021). Similarly, ICT literacy among smallholder farmers tends to be low. For instance, Alant and Bacare (2021) find that even the most basic smartphone use competencies elude smallholders, based on a survey in South Africa. ICT literacy tended to be greater for better educated farmers, as well as younger farmers and, as a corollary, those with fewer years of farming experience.

4. Philippine agriculture and the digital economy

Philippine agriculture and the Filipino farmer

Agriculture remains a sizable contributor to gross domestic product (GDP), with largest contributions coming from rice, livestock, poultry and egg, and support services. According to the Philippine Statistics Authority (PSA), in 2022, Gross Value Added (GVA) in agriculture had reached PHP 2.1 trillion in current prices, about a tenth of total GDP (Table 2). The crops together sum up to less than half of GVA (46.4 percent), while capture and raising of animals account for 41.9 percent. A sizable and rising portion of agricultural GVA comes from support services.[1] Among the crops, the largest share is contributed by palay at 17.0 percent; the share has been declining though from 18 percent back in 2020. Capture and farming of animals has been seeing a rising share, as has support services to agriculture.

The Department of Agriculture (DA) (2021) conducted a Baseline Study based on a survey of farmers and fisherfolk listed in the Registry System for Basic Sectors in Agriculture (RSBSA). According to this study, there are about 6.05 million farmers and 0.9 million fisherfolk in the country (Table 3). Farmers and fisherfolk are predominantly male (72.6 percent of the total).

Table 2: GVA in agriculture, current prices (PHP billions)

	2020	2021	2022
GVA, total	1,828	1,954	2,103
Shares in GVA (%):	100.00	100.00	100.00
Palay	18.07	17.69	16.98
Corn	4.75	5.33	6.02
Coconut	4.39	4.66	4.66
Sugarcane	1.53	1.35	1.80
Other crops	21.76	19.64	16.94
Livestock and other farmed animals	16.19	17.09	17.82
Poultry and egg	10.29	10.31	11.23
Fishing and aquaculture	12.29	12.70	12.82
Support services to agriculture	10.63	11.15	11.67
Forestry and logging	0.11	0.07	0.06

Source: PSA (2023a).

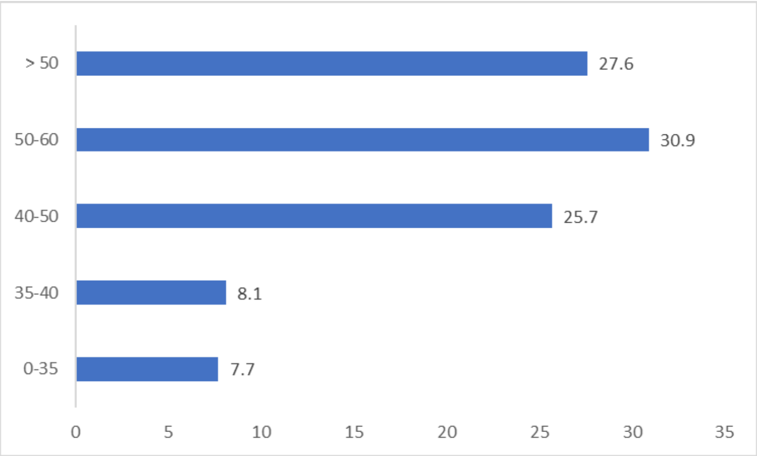
Table 3: Estimated number (in thousands) and shares of farmers and fisherfolks, 2021

	Farmers		Fisherfolk		Total	
	Number	%	Number	%	Number	%
Female	1,708	28.2	197	21.9	1,905	27.4
Male	4,341	71.8	702	78.1	5,042	72.6
Total	6,049	100.0	899	100.0	6,947	100.0

Source: DA (2021).

Farmers and fisherfolk tend to be older and less educated than the average workers. Figure 2 confirms the commonly held view that farmers and fisherfolk are mostly older workers. Nearly three-fifths are aged 50 and above, while those aged below 40 account for only 16 percent of farmers and fisherfolk. Those between 40 and 50 years comprise the remaining 26 percent.

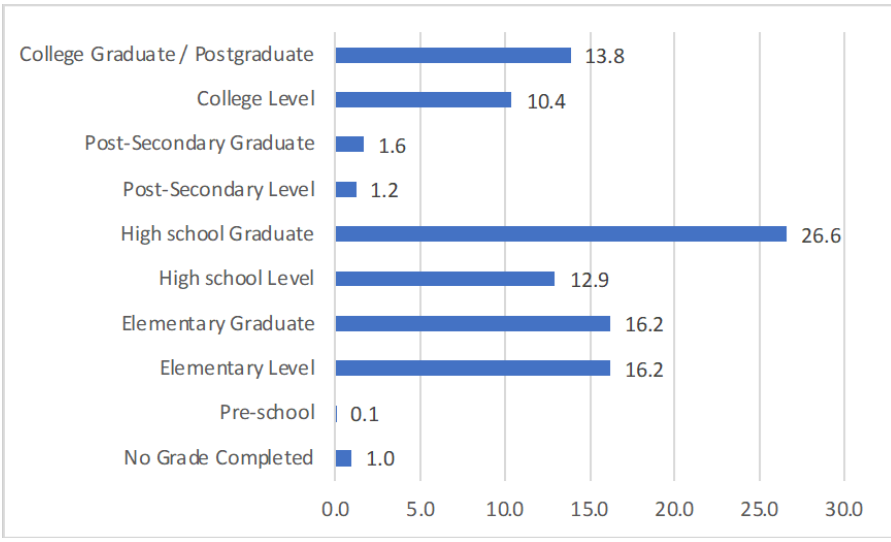
Figure 2: Distribution of farmers and fisherfolks by age range (%)



Source: DA (2021).

In contrast, in July 2021 the Labor Force Survey found that 65.5 percent of employed persons were aged under 45 (PSA, 2022). Likewise, only 27.0 percent of farmers and fisherfolk had advanced beyond secondary school in terms of highest educational attainment (Figure 3). Those with secondary schooling are the largest group accounting for 39.5 percent of farmers and fisherfolk. More than one-third has had only primary schooling or lower.

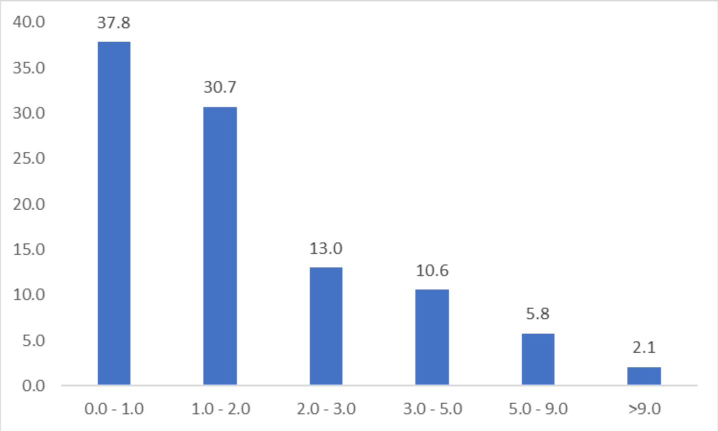
Figure 3: Distribution of farmers/fisherfolk by educational attainment



Source: DA (2021).

Most farmers in the country are cultivating small plots of land, with the largest share farming less than one ha. Figure 4 documents the problem of fragmentation of the country's agricultural lands. About 38 percent cultivate less than one ha; a remarkable 68.5 percent cultivate not more than two ha. Only 7.9 percent cultivate more than five ha.

Figure 4: Distribution of farmers by farm size attainment

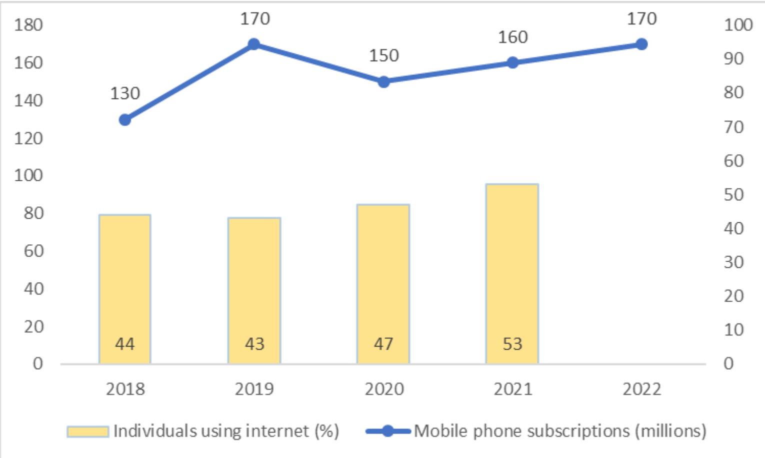


Source: DA (2021).

Digital usage and digital economy in the Philippines

Usage of digital technologies has exploded in the past few years. The number of mobile phone subscriptions had already reached 170 million in 2019, compared with the population then at 110 million, and 31 percent greater than the figure just the previous year (Figure 5). With the coronavirus disease of 2019 (COVID-19) pandemic, subscriptions dropped to 150 million, but have since recovered to its peak level by 2022. Internet penetration has likewise increased as a share of the population, beginning from 44 percent in 2018, up to 53 percent in 2021.

Figure 5: Indicators of ICT penetration, Philippines, 2018 - 2022



Source: International Telecommunications Union (ITU): https://datahub.itu.int/query/

Most households in the Philippines have ICT access, though rural households are at a distinct disadvantage. The National ICT Household Survey of 2019 (Albert et al. 2021) provides more details about household ICT access. The survey found that 75.3 percent of respondents own a cellphone, while 79.0 percent had used a cellphone in the past 3 months. A breakdown of selected indicators by urbanity is available from the survey (Table 4).

Table 4: Access to ICT of Filipino households, 2019 (%)

	Urban	Rural	Total
Used internet in the last 3 months	57.3	36.1	46.9
Has internet connection at home	23.6	11.4	17.7
Owns computer	30.0	17.3	23.8
Use of computer at home, by type:			
Laptop	67.3	63.4	65.9
Desktop	29.0	16.9	24.7
Tablet	36.6	44.7	39.4
Internet connection, by type of service:			
Fixed, wired broadband	62.8	36.4	54.4
Fixed, wireless broadband	21.8	23.5	22.3
Mobile broadband	15.5	38.8	22.9

Source: Albert et al. (2021).

Only 46.9 percent of households had used the internet in the last 3 months; the proportion rises to 57.3 percent in urban areas. Meanwhile only 17.7 percent of respondents had internet access at home, with the share rising to somewhat 23.6 percent in urban areas, but only 11.4 percent for rural areas. About 30.0 percent of urban households owns a computer, but the low 17.3 percent share among rural households pulls down the national average to 23.8 percent. Among those with computer access at home, the main form of access is the laptop computer, although urban households have the edge in terms of laptop access (67 percent) compared with rural households (63 percent). The form of home internet access with the largest share is fixed wired broadband at more than half of households (54 percent) with a much larger share for urban households versus rural households (63 versus 36 percent).

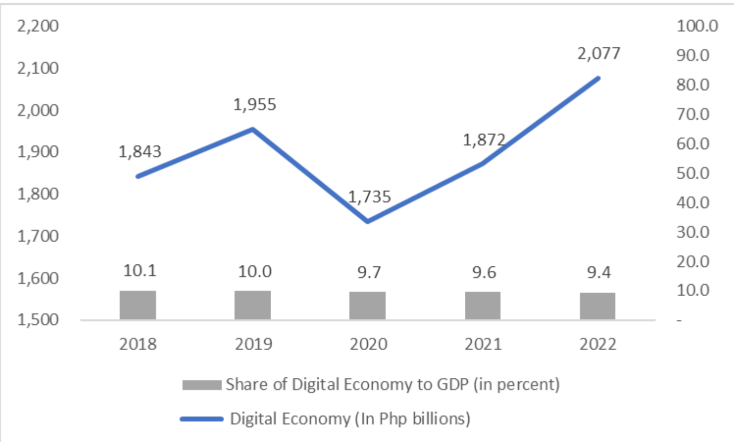
Among households with internet connection, a majority use the internet for work/business, although less than half of rural home internet users do so. The dominant form of usage of the internet is for social media (i.e., connecting with friends and family), with nearly identical shares of over 90 percent among rural and urban households with connection (Figure 6). The next most common usage is for entertainment, this time with urban households exhibiting larger share (71 percent), versus rural households (60 percent). The next largest usage is for school work, with nearly identical shares (about 65 percent) for urban and rural households. Usage for work or business is done by a majority of households, but a greater share of urban households uses the internet for this purpose.

Figure 6: Proportion of households, by usage of internet connection at home (%)

Source: Albert et al. (2021).

Digital economy accounts for about a tenth of the economy although its GDP share has remained stagnant. The PSA (2023b, par.2) uses the term "digital economy" to refer to "digital transactions covering digital-enabling infrastructure, e-commerce, and digital media/content". Since 2018, digital economy has been rising in terms of current GVA, but not steadily (Figure 7). As with mobile phone subscriptions, there was a marked drop ion 2020, followed by a recovery to 2022. As a share in GDP, however, digital economy GVA has shrunk slightly, from 10 percent of GDP in 2018-19, to just 9 percent of GDP in 2022.

Figure 7: Digital economy GVA and share in GDP, current prices, 2018-2022



Source: PSA (2023a).

Philippine agriculture and digital technology

Digital technologies are increasingly being adopted by all establishments, including AFF establishments, though the latter tend to lag behind overall average trends. PSA establishment data cover agricultural, fisheries, and forestry (AFF) establishments, which are categorized as formal establishments. Table 5 compares AFF with establishments for the entire country, based on annual sample surveys. By 2017, nearly all establishments in the country (98.2 percent) use computers and communications equipment, up from 92 percent in 2010. The proportion is somewhat lower for AFF establishments (87 percent in 2017).

Table 5: Digital economy indicators, Philippines and AFF establishments, shares in total

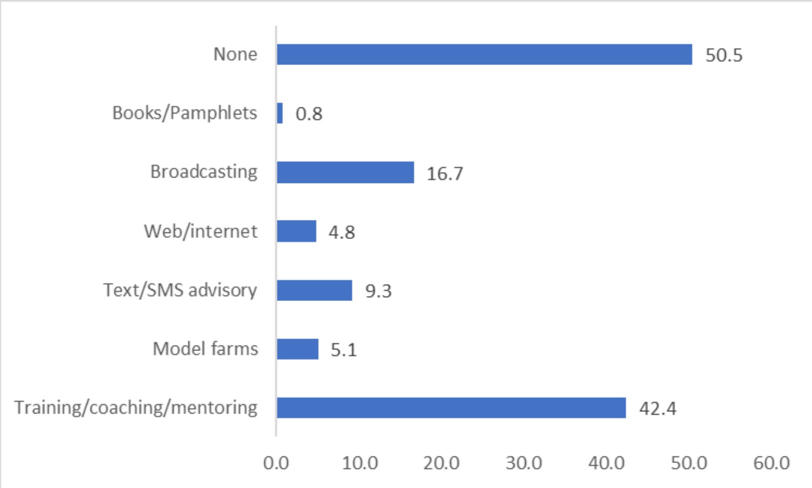
	2010	2013	2015	2017
With computers and communication equipment				
Philippines	92.4	95.7	96.1	98.2
AFF	85.7	86.1	84.2	87.4
With internet access				
Philippines	78.3	92.2	93.4	95.3
AFF	56.2	74.8	69.2	74.1
With web presence				
Philippines	24.7	25.5	32.8	33.2
AFF	5.4	4.3	5.9	13.0
With e-commerce via internet				
Philippines	17.1	14.4	14.2	17.7
AFF	10.4	9.0	11.1	12.1
Employees using computer routinely at work				
Philippines	31.9	35.4	42.0	44.0
AFF	4.3	5.8	13.1	15.2
Employees with internet connection routinely at work				
Philippines	20.7	28.5	34.5	37.5
AFF	2.2	3.4	8.6	13.3

Source: PSA (2023a).

There was also a relatively rapid increase in the share of establishments with internet access from 2010 to 2017, from 78 percent to 95 percent. However, for AFF establishments, the share with internet access started out with a low base (56 percent), ending with a higher share by 2017 (74 percent), but lower than the internet access share for all establishments. This lag is likewise observed for *having a web presence*, *conducting e-commerce via the internet*, and *employees with internet connection routinely at work*. The relatively low shares for AFF establishments are likely to be higher now than in 2017, before the COVID-19 pandemic, although to date more recent figures are not available.

Only a small percentage of farmers and fisherfolk receive information needed for their farm/aquafarm activities. The Baseline Study also asks respondents: *"In 2019, where did you get information you need in your farm/aquafarm activities?"* About half had no source of information (Figure 8). Among those with information, the most common is training/coaching/mentoring at 42.4 percent of the total; next is radio/television at 16.7 percent; only 9.3 percent receive information by Short Message Service (SMS), while under 5 percent get information from the internet.

Figure 8: Shares in total farmers and fisherfolk, by source of information needed for farm/aquafarm activities, multiple response (%)



Source: DA (2021).

5. Findings of the rapid assessment

Decision support and computer enabled systems

Extent of adoption

Government agencies in agriculture are increasingly computerizing their management and information systems. Examples of computerization among agriculture-related agencies abound. The following list is far from exhaustive:

- Within DA, procurement of fertilizer handout has been converted into a voucher scheme with computerized records, based on a digital RSBSA.
- Farmer and fisherfolk enterprises are also being registered in the FFEDIS (Farmer and Fisherfolk Enterprise Development Information System).
- The Philippine Crop Insurance Corporation (PCIC) has shifted to computer assisted personal interviews (CAPI) to collect information about insured farmers and about indemnity claims.
- The Bureau of Agriculture and Fisheries Engineering (BAFE) offers Geographic Information System for Agricultural and Fisheries Machinery and Infrastructure (GEOAGRI), an online portal that consolidates, stores, processes, and analyses GIS-based data of the Farm-to-Market Road Projects of the Department and other road projects of National Government Agencies (NGAs) and Local Government Units (LGUs).

A number of decision support systems exist to serve government agencies, LGUs, and other stakeholders, partly driven by the need for a more climate-resilient agriculture. Table 6 presents some examples of decision support systems adopted by government and used by other stakeholders. Under DA, PhilRice has introduced platforms like the Philippine Rice Information System (PRISM), PalayStat System, RiceLytics, the Pest and Disease Risk Identification and Management system, Climate-Smart Maps, and the Data Analytics Center.

Also under DA is the Climate Resilient Agriculture Office, which is leading a number of initiatives to address climate vulnerability in agriculture and among farming communities:

- The National Color-Coded Agricultural Guide (NCCAG) Map is a digital tool that shows the suitability of the country's land area to 21 economically important crops, as well as the state of climate change vulnerability of these areas. Launched in 2017, it is now undergoing updating for re-launch this 2023.
- The Climate Information Services (CIS) offer online and printed advisories for farming and fishing at two horizons/levels: seasonal climate forecasts at the regional level, and ten-day forecasts at the municipal level. An Agro-climatic Advisory Portal (ACAP) is currently under development to automate the provision of CIS and enable online dissemination for every region.

Table 6: Examples of decision support systems

Name	Description
Philippine Rice Information System (Prism)	A system that relies on satellites to monitor rice crops, offering timely and reliable information about rice production through the use of remote sensing, crop modeling, and information and communication technology (ICT), enabling better-informed policy and planning decisions.
Pest and Disease Risk Identification and Management (PRIME)	Its goal is to identify the risk factors for pest outbreaks and suitable management strategies and tactics for minimizing crop losses.
Smarter Approaches to Reinvigorate Agriculture as an Industry in the Philippines (SARAi)	An action-research program, funded by Department of Science and Technology (DOST) - Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD), that creates tailored crop advisories for rice, corn, banana, coconut, coffee, cacao, sugarcane, soybean, and tomato. These advisories emphasize the integration of local weather information and drought predictions into farming practices.
DOST's Advance Science and Technology Institute (ASTI) - Remote Sensing and Data Science (DATOS)	A Help Desk which intends to generate and relay crucial disaster data to pertinent agencies and primary end-users, enhancing the efforts of current governmental bodies and initiatives. DATOS synthesizes and incorporates previously supported and current DOST projects, as well as various techniques from Geographic Information System (GIS), Remote Sensing (RS), and other Data Science domains.

Source: Authors' compilation.

Meanwhile, under DOST, is Project SARAi, which began as a DOST-funded initiative 8 years ago, with over PHP 420 million allocated for its two phases. Currently, it is implemented by the UPLB and 11 other State Universities and Colleges (SUCs) and six national government agencies. Aimed at climate-proofing agriculture in the country, SARAi integrates modern technologies to deliver timely and pertinent information. Initially focused on coffee, coconut, banana, cacao, rice, and corn, it expanded to include tomato, soybean, and sugarcane in its second phase (2018 – 2021). The project combines data from various sources: Sentinel's satellite data, weather insights from AWS, Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), and DOST Advanced Science and Technology Institute (ASTI), along with agronomic, market, and economic information. The

Project currently maintains the SARAi.ph portal, which continues to offer cropping advisories, remote sensing data, and weather monitoring data. It ensures that the data is updated regularly, with intervals ranging from 6 to 10 days.

The Drought and Crop Assessment Forecasting (DCAF), closely observes a drought index tailored for the Philippine environment. Additionally, there is the Soil Suitability Map, which, compared with DA's National Color-Coded Agri Guide map, offers more detailed suitability levels and colors. This map, enriched with BSWM data from the group's ground truthing, is web-based due to its memory-heavy nature for mobile apps.

SARAi has also ventured into real-time weather monitoring through the Automatic Weather Station (AWS). They have set up their own AWS devices, covering a 20 km radius on flat terrains. However, due to the considerable distance between stations, data from other sources remains essential. Each AWS device, valued at PHP 400,000 and owned by DOST, can record data on precipitation, wind velocity, radiation, humidity, temperature, and soil moisture. Some of its limitations include the need for a signal, an annual subscription of PHP 10,000 per unit, and a monthly load worth PHP 300. The readings are then sent to SARAi and subsequently shared on their platform. Moreover, SARAi has partnered with SUCs to supervise the AWS installations.

Prospects

Prospects for further utilization of decision support systems are excellent, although the high cost of some applications may limit features of some systems. Decision support systems are primarily developed and applied by government. Given the strong policy interest in e-governance and adopting digital agriculture, the prospects for further utilization are favorable. The results of decision support interventions are also well received by beneficiaries. For instance, the geomapping of farm plots under various projects such as Rice Crop Manager Advisory Service (RCMAS) and Digital Clustered Rice Farming (DCRF) has led to more accurate crop management (i.e. better implementation of crop recommendations, which are typically on a per ha basis). Likewise, the income diversification thrust of Adaptation and Mitigation Initiative in Agriculture (AMIA) village projects has led to great interest in the beneficiary community to continue with the project and expand their involvement in it.

A continuing obstacle, however, is the high cost of some services, that need to be absorbed by government. For instance, a subscription to a proprietary satellite land use mapping service costs upwards of USD 3 million per year. Certainly, government subscription provides bargaining power and cost-sharing, although licensing arrangements may limit number of users within the subscription.

The decision support systems across multiple agencies may not offer harmonized recommendations. It has been noted that crop suitability maps available in NCCAG and SARAi exhibit some inconsistencies in specific locations. This may lead to unnecessary confusion on the part of users (e.g. LGUs or farmers), and induce hesitation in fully embracing these tools.

Inclusiveness

Benefits of decision support systems appear to be inclusive. The government is clearly resolved to utilize these systems to serve the marginalized groups, especially those most vulnerable to climate change. Hence, such systems appear to be highly inclusive. The Climate Resilient Agriculture Office (CRAO), for instance, adopts the Climate Risk Vulnerability Assessment (CRVA), a systematic method for assessing climate risk at the provincial level. To date, CRAO has prepared 63 CRVAs. Among the priority provinces is Albay, where CRVAs were have been conducted for various municipalities, narrowing down to Tiwi, Pio Duran, and Rapu-Rapu. Within Tiwi, prioritization was done to identify vulnerable barangays, leading to the identification of Barangay Joroan.

In Joroan, the AMIA project implemented a participatory rural appraisal, in cooperation with the Joroan Farmers and Fisherfolk Association (JFFA). Based on the appraisal, several livelihood initiatives were identified, and funding realized through linkages with other government agencies. These initiatives include chicken egg laying (600 heads), vegetable hydroponics, and a community processing center, the latter being directly funded by AMIA.

Lack of internet connectivity in remote rural areas may prevent the spread of benefits, though it is being addressed by various government programs. The problem of low internet connection (Section 4) is due to some areas simply having no access to the internet. Outcome 3 of the National Broadband Plan (Department of Information and Communications Technology [DICT], 2017) is "More places connected," which entails several strategies, including: a) Leverage the use of satellite and emerging technologies; b) Establish the Philippine Integrated Infostructure, including provide demand-responsive domestic connectivity. Consistent with this Plan, the Cooperative Development Authority (CDA) has implemented a satellite-based internet connectivity project covering 58 sites identified in collaboration with DICT in various rural areas throughout the country. The project is aimed at cooperatives (mostly in agriculture), with the primary aim to enabling them to file all their registration and renewal papers online (towards CDA target of 100% online registration and renewal for Philippine cooperatives). CDA covers the equipment and a one-year subscription (at PHP 10 - 12,000 per month). The total cost of the project was PHP 14.4 million covering 58 sites (averaging about PHP 250,000 per site on average). However, few cooperatives have indicated commitment to continue the subscription once the subsidy ends, even though the service provider offers income-generating opportunity through the sale of access vouchers. For example, in areas with *Piso* WiFi available, the vouchers are uncompetitive by comparison.

Information and advisory services

Extent

Numerous information and advisory apps are available, but are not yet widely adopted, with one significant exception. Examples of digital information and advisory services for the Philippines are summarized in Table 7. For rice farmers, about 31 percent have been found to use ICTs as tools for rice cultivation, according to the 2016-2017 Rice-Based Farm Household Survey (IRRI 2017). In particular, RCM has generated 2.66 million fertilizer recommendations in the Philippines from 2013 to early 2021 with an estimated uptake of 30 percent (Chivenge et al. 2021). As for the other apps, based on the data provided by PhilRice, the number of users of AgriDoc App, e-Damuhan, and Binhing Palay apps (as of July 2022) are 1,061, 3,236, and 8,268 users, respectively. Other than rice, an online knowledge bank has been developed for the pili nut, namely PILI NICER (https://pili-nicer.parsu.edu.ph/). However, feedback from one user is that the amount of information available is very sparse; the website developers admit that the latest research is not yet online as they are awaiting completion of the publication process before uploading on the site.

Table 7: Examples of digital information and advisory services

Name	Description
Rice Crop Manager Advisory Service (RCMAS)	A web- and Android-based platform for field-specific information on crop and nutrient management to increase yields and income of rice farmers, based on site-specific nutrient management (SSNM) principles.
Precision and Digital Agriculture Center (PreDiCt)	A Central Luzon State University (CLSU) center which hosts facilities and technologies such as spatial variability for soils, a greenhouse, field monitoring systems, irrigation canals, farm machines, microclimate monitoring equipment, and fabrication tools.
AgriDoc App	A mobile rice farm management application tool which allows users to record day-to-day major farming and management operations and monitor rice crop growth.
Binhing Palay App	A mobile app catalog of released rice varieties in the Philippines.
e-Damuhan app	A mobile app that uses artificial intelligence technology for weed recognition. It provides descriptions of weeds and recommendations on how to manage them.
WateRice	A project which developed ICT and IoT-based tools for improving decision making on water and weed management, recommended best practices for rainfed environments, and introduced mechanization for land leveling and planting to improve water productivity."
Agricultural Training Institute (ATI) e-extension	Offer self-paced online certified courses on different production technologies on crops, livestock and poultry, fisheries, sustainable agriculture; as well as social technologies. These courses are developed by the ATI in collaboration and consultation with subject matter specialists from research and development institutions, other government agencies, state colleges and universities, and private sector.
FarmSmart	In training, farmers are introduced to tech tools for quick information access, and they also learn basic mobile media and social marketing skills to increase income and expand their reach in local communities and online platforms. A collaboration between Smart Communications, Inc., and ATI, it targets both young and seasoned farmers to help bridge the digital divide (Smart Public Affairs 2021).
Fresh Depot (Aboitiz Group)	A pilot project between Fresh Depot and Mankayan's Manpat-A Farmers Association of Benguet. The first phase is a pilot site of its innovative modular, solar powered, onsite cold storage unit to reduce postharvest losses from prolonged land transport. The second phase of Fresh Depot entails digitizing information on farmers' land, planting practices, pre-harvest and harvest. Fresh Depot collaborated with several international agri-tech players, including Cropin Technology Solutions, to provide farm monitoring services and communications solutions connecting farmers, agri-businesses and field officers (Lagare 2023).

Source: Authors' compilation.

Other agencies have also developed information and advisory apps. One of the advisory apps developed under SARAi is SPIDTECH (Smarter Pest Identification Technology). This technology enables partners to send in reports on pests and diseases. By utilizing this information, SPIDTECH can identify hotspots for pest and disease incidences and use the accumulated data to forecast their spread, providing an early warning to farmers. The system applies a facial recognition algorithm and uses a comprehensive database from the National Crop Protection Center (NCPC). After one year of deployment in Google Play Store, SPIDTECH registered 2,755 users located in 78 provinces, of which 51.3 percent were farmers, the rest being students, AEWs, researchers, and private companies (Guiam et al. 2020).

Information services are assisting rice farmers to upgrade and standardize crop management practices in one province of the Philippines. The DCRF Project, initiated in June 2023 in the province of Albay, engages a private sector partner that deploys its proprietary expert system, to inform and monitor rice production in the project area. Actions of rice producers are all monitored in real-time using satellite remote sensing, which is able to read crop growth indicators on every 10 days.

Rice producers are those who are part of a farmer cooperative who agreed to participate in and met the requirement of DCRF. Conceptualized in December 2022, the provincial LGU was responsible for vetting project proposals for modernizing rice farming, as well as participating cooperatives, to identify appropriate project areas and partners. Loan finance for rice production is sourced from the Development Bank of the Philippines (DBP) under the Rice Competitiveness Enhancement Fund (RCEF) financing window. The project will run for three years (six cropping seasons). By the end of the six seasons, the farmer cooperative will take over management of the DCRF, including free use of the proprietary system.

As learning modality, e-extension is slowly gaining wider acceptance. When e-extension was first introduced in 2007, there was initial reluctance among AEWs. By 2023 though, there are now 76 courses available online, which have already produced 170,000. According to implementors, graduates affirm that the training certificates are well recognized in their job applications.

Prospects

While impact evaluations are rare, some advisory services have been found to be beneficial to adopting farmers. Among these SSNM-DTs, the Rice Crop Manager (RCM) in the Philippines has been the subject of an impact evaluation (ASCEND, 2020). Using propensity score matching to control for selection effects, the study found that treatment farmers earned PHP 10,000 per ha per season more than control farmers. For those who recall actually receiving an RCM recommendation, the impact goes up to PHP 16,669.

Meanwhile, SPIDTECH was found to achieve 77.3 - 89.5 percent accuracy. An initial usability survey of 24 cacao farmers in Laguna and 48 coffee farmers in Cavite found that 94.44 percent of the respondents are willing to use the application and 97.22 percent are willing to recommend the application to other farmers (Guiam et al. 2020).

Accurate weather information has the potential to increase the efficiency of different farming practices and reduce the waste from various agricultural inputs. AMIA has installed Automatic Weather Stations (AWS) at the municipal level, providing area-specific, 7-day weather advisory. AMIA beneficiaries agree that their training has equipped them to make use of these advisories for optimal timing in applying fertilizers, planting crops, harvesting, and going to sea to fish.

Project SARAi also deploys AWS in their project sites to improve the accuracy of local weather information by 40-50 percent and increase the frequency of information delivery through constant updates. In justifying increased provision of these information beyond the SARAi sites, a contingent valuation study estimated the willingness-to-pay of farmers in Dingle, Iloilo as a way to measure the economic value of improved information. The study finds that farmers are willing to make a one-time payment of PHP 233.55 for the weather information improvement. Sex, educational attainment, farming years, and farming practices of the farmers are also important determinants of willingness-to-pay (Lacson et al. 2020).

Other apps have received less favorable feedback. Some AEWs found that apps such as the AgriDoc were tedious to use due to considerable demands on amount and accuracy of data entry. Moreover displays were typically in English. RCM by contrast is relatively simple and straightforward to use, with SMS advisories available in Filipino. In their municipality, more than half are using RCM.

Preliminary estimates of DCRF crop management system experience suggests favorable impact on the ground. At the time of the FGD, few farmers under DCRF had already harvested. One of these were interviewed for this study. He claimed that he managed to follow the DCRF package of technologies indirectly. He clarified that he actually followed the program prescribed by the seed company (the same one certified by DCRF). Before DCRF, his typical harvest was 2.9 tons per ha (wet palay); at PHP 14 per kg, he would gross PHP 70,000. After deducting expenses, net income was around PHP 30,000. In his most recent harvest (October 7), he harvested 95 cavans per ha, paid a price of 21.80 per kg, equivalent to gross of PHP 120,118. Only PHP 35,000 expenses for a profit of PHP 85,000, about 183 percent increase. Experiences like this have spread by word-of-mouth; there is now widespread interest among farmers in surrounding communities to sign on to DCRF. Around two thousand hectares of palay farms are scheduled to be covered by 2024 (the next cropping season), with potentially 5,000 hectares in total throughout Albay in subsequent cropping seasons.

Inclusiveness

Users of PhilRice advisory services for farmers are mostly male, aged 21-40, college graduates, and more likely to reside in Luzon. PhilRice embedded user profiling in their apps to have a better sense of user statistics (Table 8).

Table 8: Demographics of users by PhilRice app (as of July 2022)

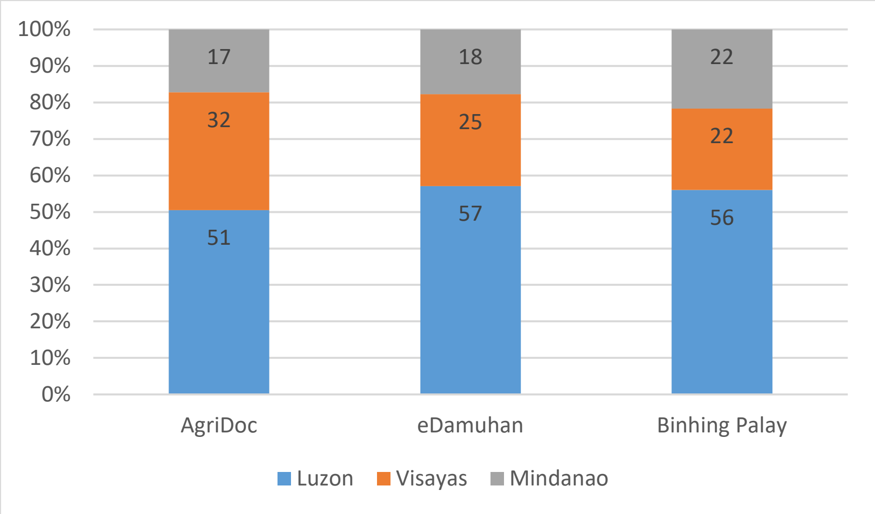
	AgriDoc App	e-Damuhan	Binhing Palay
Total number of users	1,061	3,236	8,268
Shares in total users (%)			
Males	58	54	61
College graduates	74	75	69
Farmers	55	40	57
Extension workers	23	19	19
Farmers aged 21-40	62	55	60

Source: PhilRice.

Most registered users are males (54-61%), aged 21-40 (55-62%), college graduates (69-75%), and they are either farmers (40-57%) or AEWs (19-23%). In terms of spatial distribution, the top three provinces where users of AgriDoc and e-Damuhan reside are Occidental Mindoro, Nueva Ecija and Iloilo. For Binhing Palay, the top three provinces are Nueva Ecija, Isabela, and Pangasinan. Across the three apps, majority of users reside in Luzon, with Visayas users account for one-fifth to one-third, and the remainder in Mindanao (Figure 9).

Aforementioned numbers may be underestimating extent of usage owing to information spillovers within the household, but this requires engagement of young people in farming. According to some AEWs, many older farmers are being assisted by younger household members in the use of advisory apps. Hence the characteristics of actual users may differ from those of registered users. Note that if young people are absent in the household due to migration, or disinterest in farming, older farmers may be unable to access the latest apps.

Figure 9: Geographic location of users by PhilRice app (as of July 2022)



Source: PhilRice.

Owing to advanced age of many farmers and low levels of digital literacy, app usage depends on the frequency and quality of agricultural extension service. Advisory services may end up increasing the efficiency of extension service delivery of LGUs. This was the case for RCMAS, which received large funding from the National Rice Program to incentivize extension workers to achieve coverage targets (i.e. 100 farmers per AEW per cropping).

Unfortunately, without support from national commodity programs local dissemination efforts may fall short owing to budget constraints. In some instances, extension workers do not have ample financial support, such as transportation allowance to visit farmers. Even in LGUs that are highly agricultural, the number of AEWs are too few compared to the number of farmers that need to be served. AEWs are also hampered by a low number of permanent appointments, with job orders being common. The type of appointment, compensation and benefits also have an effect on AEWs' quality of monitoring and mentoring of farmers.

LGUs have no monopoly on providing extension service. Farm technicians can also be deployed by private companies. In the case of DCRF, all the computer system interaction is handled by professionals, while monitoring and information services are delivered by company technicians. These make up for the lack of facility of some farmers with digital applications.

Obstacles to scaling up digitally enabled crop management include upfront financing requirements and management costs. New technologies may require larger outlays of working capital for inputs (i.e. seeds, fertilizers, equipment services), reflected in high upfront financing. High cost of satellite services, software development, farm technician salaries, etc. may entail high overhead cost for computerized farm management. In the case of the DCRF, the management is PHP 52 million per year for the 5,000 ha, which is part of the upfront financing cost. For the initial 2,000 ha, PHP 20.8 million has already been shouldered by DBP.

Clustering of farmers is one way to share in the management fee, giving rise to economies of scale. However, not many cooperatives may have this size of membership, nor the organizational maturity to run a fairly sophisticated, computer-enabled farm management scheme.

Agricultural automation/smart farming

Extent of adoption

The policy environment endorses mechanization using smart farming technologies. The DA is at the forefront of mechanization based on smart farming. For instance, DA Memorandum Order (MO) No. 16 (Series of 2021) under the previous administration promotes the use of agricultural drones towards the transformation of Philippine Agriculture. This effort is continued by the current administration, as evidenced by MO No. 13 (Series of 2023), which provides for drones for fertilizer application, seed sowing, and spraying; and for topographic surveys, mapping, structural safety inspections, crop health monitoring, and agricultural surveys. The policy also encourages the use of Laser Land Levelling (LLL) technology as part of precision/smart farming, aiming to facilitate clustering and consolidation.

Large agribusiness companies are at the forefront of adopting smart farming. Outside of government, it is the large companies that can readily absorb the high investment costs of automated agriculture. Examples of large company investments are the following:

- **Del Monte Philippines**: began a smart farming technology pilot project in 2018, which boosted their on-going precision farming efforts. Smart farming is being used to identify target pesticides more effectively or boost nutrient levels in particular areas (Del Monte 2018).
- **Syngenta Philippines**: two new pesticides were developed in 2021 for the purpose of drone application of crops. One pesticide targets rice bugs, while the other targets the fall armyworm. Aside from pesticide application, the company also deploys drones for crop monitoring, area mapping, and image capture of crops, to assist farmers in crop management (PhilStar 2021).
- **Denso Philippines**: Normally known for its air-conditioning business, it has recently opened a hydroponic smart agri-tech farm in Ibaan, Batangas. The PHP 60 million farm produces high value vegetables and fruits (Cahiles-Magkilat 2023).

At least one individual large farmer was able to invest in some smart farming technologies, with government support. One farmer we visited in Benguet has invested in a smart irrigation system for his 4 ha farm. He was supported by DOST Small Enterprises Technology Upgrading Program (SETUP) 4.0, which aims to assist Micro-, Small and Medium-sized Enterprises (MSMEs) enhance their information and communication technology (ICT) infrastructure. The assisted enterprises are given three years to return the funds they received, interest-free, and are granted a one-year grace period (DOST Region VI 2023).

Several government R&D projects have developed smart farming technologies, most of which are at pre-commercialization stage. For instance, PreDICt of CLSU has developed auto furrow irrigation system, indoor agriculture with sensors, controllers, and monitoring equipment. They also have drones and 3D printers for customizing parts and for their equipment. The mobile solar pump that was developed is perceived positively by farmers as a cost-saving innovation.

Likewise, DOST's Advance Science and Technology Institute (ASTI) has developed ROAMER, an autonomous robot equipped autonomously traverse plantations and, through AI, pinpoint plants potentially afflicted with diseases, and mitigate their proliferation, without incurring high labor cost. With a P24.7 million budget, this pilot project, initiated in June 2021, is anticipated to be operational by June 2024 (Chua 2023). In another DOST-supported project, UP Mindanao is now conducting research towards developing an AI system for automatic sorting of *durian* by ripeness, quality, and type. It is intended to replace manual grading, a time-consuming and subjective process.

Prospects for adoption

Many of the technologies may take years before reaching commercialization. Commercialization of new agricultural technologies is typically a convoluted process with several determinants of success, including the amount of external assistance, availability of expert services, and clarity of intellectual property (Chernova et al. 2019). Although the policy environment for private sector engagement and commercialization is already in place, thanks to the Philippine Technology Transfer Act of 2009 (RA 10005), current digital technologies are still in nascent or, at most, in incubation stage.

Portable systems have an excellent outlook for widespread use among the farmers on a fee-for-service basis. Equipment that has been manufactured into relatively small and mobile units, such as hand tractors, mechanical seeders, combine harvester-threshers, is now increasingly used on a fee-for-service basis. There is every reason to believe that the uptake of drone seeders, drone sprayers, automated tractors, etc. will also increase under a similar payment modality, as long as pricing is competitive with existing methods. For instance, estimates from Bayer Crop Science indicate that a drone rice seeding service is only PHP 3,000 per ha, compared with manual transplanting which costs at least PHP 11,000 per ha (Bayer Crop Science n.d.).

Inclusiveness

Fixed systems such as smart irrigation may entail large upfront investments, thereby excluding most smallholder farmers. Unlike portable equipment, fixed systems such as smart greenhouses and smart irrigation must be installed on-site. Hence the adopting farmer is compelled to absorb the investment cost, which is usually beyond the financial means and/or risk appetite of small farmers. Alternatively, a cluster of farmers may divide the investment cost among themselves; however, this requires the consolidation of multiple farm operations under a single facility, along with its attendant transaction costs.

Fintech in agriculture

Extent

Fintech has only recently been introduced in the country's financial and regulatory landscape. In 2020, most Securities Exchange Commission (SEC)-registered fintech companies were engaged in virtual currency issuance, remittances, credit and finance, and lending (Quimba et al. 2023). In the context of agriculture, two examples are found for the Philippines (Table 9). Both fall under the regulatory regime of SEC, under Memorandum Circular (MC) No. 14 (Series of 2019): Rules and Regulations Governing Crowdfunding.

One crowdfunding platform has assisted 1,600 farmers since 2015. The Cropital website introduces production ventures of various farmers, and invites users to invest in these ventures based on the description provided, and the financing requirement. The minimum investment per farm is PHP 5,000, with a maximum of PHP 15,000 (in increments of PHP 5,000). The investment can be made in an e-wallet, or via bank deposit. The return is a fixed percentage of the net profit of the farm. Cropital collects a 5 percent platform service fee up front. Since its founding in 2015, the company has raised PHP 100 million, assisting 1,600 farmers residing in 10 provinces (Cropital n.d.).

To minimize risk to lenders, Cropital has partnered with PhilGuarantee and PCIC. It also actively supports its farmer-partners by providing technical assistance and production monitoring. Interaction with farmers is mediated through farmer organizations, as Cropital does not deal with individual farmers.

As part of its P2P (peer-to-peer) lending, Cropital has had to develop a comprehensive profile of farmers it is serving. A spin-off of this activity is a credit scoring service, developed with support from DOST. It is now another revenue generating activity of the company.

Table 9: Examples of fintech in agriculture

Name	Description
Cropital	A crowdfunding platform that helps finance its partner farmers and at the same time provides an alternative medium for investments to prospective investors.
FarmOn	Likewise a crowdfunding platform that acts as an investment gateway, assisting users in identifying and supporting projects with high potential. At present, the platform features projects under three main categories: (1) Farming, (2) Technology and Mechanization and, (3) Farm Produce Procurement and Franchising (FarmOn n.d.).

Source: Authors' compilation.

Prospects and inclusiveness

Cropital offers a rate of return for lenders at about 3-5 percent per cropping (5-6 months duration). Note that the financial product carries a disclaimer that returns on investment are not guaranteed, as Cropital needs to collect from farmers to pay back its investors. About 85 to 87 percent of farmers pay their lenders on time; of those who are delayed in repaying, another five percentage points will eventually pay over the next three months. A remaining eight percent are the delinquent borrowers, who have typically undergone some unexpected setback which is preventing them from completing repayment, despite coverage by crop insurance (PCIC) and credit guarantee (PhilGuarantee).

There are no statistics available on annual growth of agricultural credit via fintech. The geographic scope of Cropital offers a clue about prospects for this business model: previously Cropital had reached farmers in Bohol, Samar, Leyte, but they have returned to focus on Central Luzon and Ilocos Region, mainly in Nueva Ecija, Pangasinan, and Bulacan. High cost and high climate risk among less productive farmers in Visayas have compelled them to scale back the geographic scope of operations. The small number of farmers served, and the lack of new players in the fintech space, suggest a stagnant outlook for agricultural fintech.

The borrower-clients of Cropital are all rice farmers, farming small plots (5 ha and below), with relatively low levels of risk as gauged by their credit scores. Farmers are not required to have smartphones, or even be digitally literate, to engage as borrower-clients. What they need to demonstrate are characteristics and behaviors that mark them out to be reliable borrowers (unfortunately, owing to its proprietary nature, we were unable to gain access to the credit scoring methodology). They are currently restricted to rice farming as diversifying to other agricultural activities (e.g. other crops, livestock) entails gathering considerable amounts of new information to gauge risk and return.

E-commerce for agriculture

Extent

A variety of online platforms are actively offering market matching functions for agricultural goods or processed agricultural products. Table 10 lists some examples of online platforms which include agri-food products. The various platforms may be categorized as follows:

- *Online marketplace*: offers an online platform for market transaction, from order placing, to payment, and product delivery. Shopee.ph and Lazada.com.ph are well-known examples.
- *Online retail:* a site/app that allows buyers to interact electronically with a retailer to place orders, make payments, and arrange delivery, e.g. shopsm.com for SM Supermalls. The retailer is responsible for procuring goods for sale, whether by traditional means, or also by an online platform.
- *Hybrid*: functions as an online marketplace but lacks one or two of the key features enumerated above, such as onsite payment and delivery arrangement; these elements of the transaction are performed offsite.
- *Online market information:* A website/app that provides information about merchants and suppliers, but otherwise lacks facility for placing orders making payments, ensuring delivery, except in direct interaction with the merchant. An example is Facebook Marketplace.

Table 10: Examples of e-commerce for agri-food product suppliers

Name	Description
Agrabah	A multipurpose online platform that connects farmers and fisherfolks by giving them access to buyers, allowing them to move their goods from farmer to market with ease, and giving them access to quickly-vetted credit.
Agro-digital Philippines	A multipurpose online platform that digitizes the food value chain starting from capturing and forecasting demand, consolidating production and storage, and finally facilitating fulfillment. The model revolves around organized small holders.
ANI Express	The web- and mobile-based portal of AgriNurture Inc. (ANI) offering the delivery of a wide range of products including rice, fruits, and vegetables.
Co-opBiz	An e-commerce platform by CDA that provides cooperatives, particularly micro and small, a free space for selling and promoting their products for domestic and international markets.
Facebook Marketplace	A marketplace feature of Facebook.com, which allows: search for items to buy; and message buyers/sellers to arrange transactions. Facebook plays no role in facilitating or managing transactions (Target Internet n.d.).
GoLokal	A market access platform provided by DTI to the Philippines' micro, small and medium enterprises (MSMEs) for market incubation and brand testing
Lazada	Online shopping platform, owned by Lazada Group, a global e-commerce corporation, recognized as one of the prominent players in Southeast Asia, had amassed over 10,000 third-party sellers by November 2014 and attracted 50

Name	Description
	million active buyers as of September 2019.
Livegreen International	A social enterprise engaged in the production, processing, and distribution of fresh and Organic Certification Center of the Philippines (OCCP)-certified organic vegetable produce. Aside from its displays in brick-and-mortar supermarkets under the brand "Organicus," it also utilizes online platforms in selling its produce.
Mayani	An online agri-fisheries value chain platform that directly sources fresh produce and agricultural products.
Onestore.ph	An online marketplace for buying and selling of variety of goods i.e. food, vintage goods, and handmade products, among others.
Pili Marketplace	Pili Marketplace was launched in February 2021 under the PILI NICER project of the Bicol Consortium for Agriculture and Resources Research and Development (BCARRD), with funding from DOST.
Rural Rising	Website offers a marketplace to place orders for delivery within Metro Manila and adjacent towns and cities, or where door-to-door services (Lalamove, Grab, etc.) are available. As of May 2023, Rural Rising has moved over 2,000 tons of produce, helped 4,500 farmers nationwide, and fostered a community with over 40,000 members (Golangco 2023).
Session Groceries	Company located in the famous Session Road of Baguio City, it links over 2,000 partner farmers spread across Benguet, Cavite, Ilocos, Mindoro, and Pangasinan to customers with its online marketplace. For every sale made, 30 percent of the profit goes directly to the farmer (Gonsalves n.d.).
Shopee.ph	Shopee Pte. Ltd Singaporean multinational company specializing in e-commerce. In 2021, it held the status of being the primary e-commerce hub in Southeast Asia, recording 343 million monthly visitors. Furthermore, it extended its services to connect buyers and sellers in East Asia and Latin America seeking online transactions.
shopsm.com	The online store of SM including Savemore, the leading supermarket of the Philippines by number of stores
Zagana	An online platform that sources fresh produce and frozen food from local farmers.

Source: Authors' compilation.

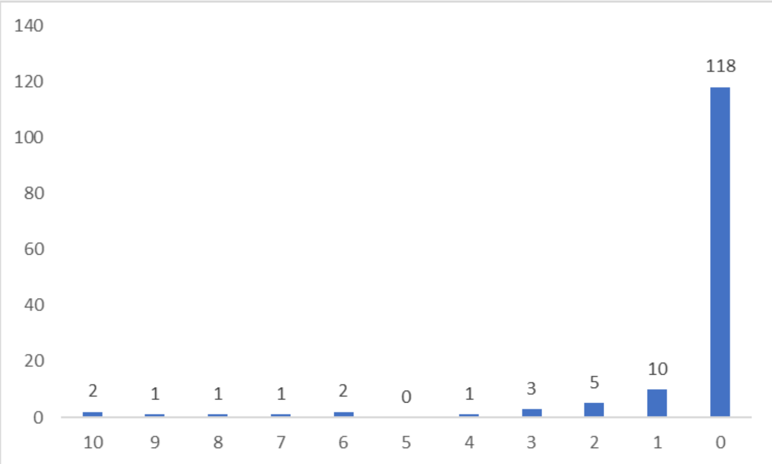
The use of e-commerce for food retail, including farmgate purchasing, has likely exploded since 2020 due to the Covid19 pandemic lockdowns. Like e-commerce in general, food e-commerce has also seen significant growth during the Covid19 pandemic. There are indications that this has penetrated to the farm level, i.e. several formal farm enterprises had shifted to online selling, with sales even going up upon shifting to online retail, often in partnership with the DA's E-Kadiwa program (FAO, 2021).

Online market information systems and hybrid platforms seem to offer a narrow marketing channel for farmers and food processors. An example of an online market information system is GoLokal.dti.gov.ph. Another example is Pili Marketplace (pilimarketplace.parsu.edu.ph), which hosts 22 merchants. We interviewed J. Emmanuel Pastries, the largest pili processor in Bicol Region, who has not sold any pili through Pili Marketplace.

A hybrid platform, meanwhile, is CoopBiz.ph, which allows buyers to place orders and arrange logistics, but does not accept payments. Moreover, order placement requires further off-site communication between merchant and buyer (by email or messaging service). According to

CDA, CoopBiz.ph started as an online market information system, but secured few merchants. They opted to add features and relaunched the website last 2021. The renovated site allowed them to invite more merchants, up to the 144 cooperatives now in the online store. However, they do not accept fresh food, only processed and packaged food. The website itself tracks the number of cooperatives by number of sales made (Figure 10).

Figure 10: Number of cooperative merchants, by number of sales through coopbiz.ph, 2021-present



Source: CoopBiz.ph

Figures shown in the chart are likely an underestimate as transactions consummated offsite are omitted. Nonetheless the figures are striking; only 2 cooperatives have made ten sales; both are cacao farming cooperatives based in Davao City. Only 1 cooperative (selling handicrafts from Ilocos Region) has made 9 sales. Ten cooperatives have made just 1 sale, and 118 cooperatives (82 percent) have made no sales.

Online marketplaces are a minor marketing outlet for a few established SMEs and cooperatives. Biao Agrarian Reform Beneficiaries Cooperative (BARBCO), one of the top sellers in CoopBiz.ph, also sells through Shopee.ph. While their total sales through CoopBiz does not exceed PHP 6,000, they sell an average of 30 kg per month (cacao beans) through Shopee. Even this amount is miniscule compared with their annual sales of about 100 tons in a year, mostly through brick-and-mortar stores. A larger share of sales (but still only 5 percent) is coursed through online marketplaces, in the case of J Emmanuel Pastries.

Online retail seems to be linking more farmers to markets, whether directly or indirectly, compared with the other platforms. The Magsige Multipurpose Cooperative (MPC) is engaged in multiple businesses, including garment manufacture, brick-and-mortar retail outlets, finance, job contracting, coffee manufacturing, and sale of agricultural products. Their main product offering is garments, of which up to 50 percent of sales is done through their website. However, only miniscule amounts of coffee and other food and beverage products are sold online, with the bulk being disposed of through their traditional outlets.

Meanwhile, Mayani has managed to reach over 139,000 organized smallholder farmers and fisherfolks in Mayani's grassroots network. They distribute to over 20,000 retail customers and more than 230 commercial stores, including supermarket giants Robinsons Retail, WalterMart, Merry Mart, luxury resort City of Dreams; international fast food brand Bon Chon, as well as Manila Doctor's Hospital, Wildflour, Yellow Cab, Turks, and Caramia. Driven by a social enterprise mission, Mayani was founded in 2019 with just one supplier, the Malarujatan Family Farm Association (MAFFA), in Lian, Batangas. Since then, they have reached out to farmers all over Luzon.

They transact by anticipating demand from both online and direct orders from institutional buyers, as well as anticipating supply from harvest and production of client associations/cooperatives. They adopt a policy of pricing based on their prevailing prices, though they can offer more than the usual farmgate price, subject to a 30 percent net income for the farmer on top of estimated production cost. Delivery is done by Mayani using third party logistics as well as their own vehicles.

Prospects

Online market information systems offer little additionality over other marketing platforms and are therefore not a growth area. New market information systems are simply entering an already crowded space for online market information. They offer little additional value compared to established options, such as social media, and already established websites (e.g. Carousell). Without additional features, merchants may not find it attractive to join online market information systems. Hence, for instance, DA's ekadiwa.gov.ph, which was active during the pandemic, has gone offline following the economic recovery.

Growth of online retail and online marketplaces is promising, though the latter is limited by high commission fees. The additional features are available from online marketplaces, such as Shopee and Lazada; according to BARBCO, they will be much more incentivized to engage actively in CoopBiz if the site could replicate the convenience of these established apps. On the other hand, these platforms do charge a commission fee, about 12 percent according to BARBCO.[2] This fee can be avoided if the enterprise developed its own online retail store, though it would have to shoulder a web development cost, as well as pay the fees of third-party payment and logistics providers.

For online retail, B2C will remain a small market segment owing to delivery fee, while B2B could potentially become a mainstream mode of procurement. Food is a daily consumption item, which consumers may still find useful to physically visit stores and decide on purchases on the spot over the foreseeable future. The relatively high share of delivery cost in small purchases more than offsets the convenience of online shopping. On the other hand, B2B transactions are typically in bulk, hence delivery cost can be driven down to a small proportion of the purchase cost. Retailers and food service establishments may therefore rely increasingly on online procurement for their raw material and inventory needs.

Inclusiveness

Clustering of farmers and fisherfolk into organizations such as cooperatives is essential to joining the e-commerce space. No individual farmer we observed was able to sell directly to an e-commerce enterprise. Farmers typically had to be part of an association or cooperative; the farmer-owned enterprise then either transacted with the e-commerce company, or itself engages in e-commerce.

Larger agri-coops with greater amounts of inventory will be more motivated to sell online. Online retail (through one's own website) is a matter of scale: smaller agri-coops with low levels of inventory will likely eschew the high cost of e-commerce development; larger agri-coops with more inventories at hand will be more willing to expand markets through an online store.

E-commerce-linked enterprises are able to include small farmers, women, other marginalized groups, and even communities without internet access. Among the Mayani supplier enterprises, 38 percent of the members are women. Approximately 50 percent are below forty years old based on profile of FGD participants. At least one IP community (among the Aeta of Zambales) are supplying ube to Mayani. While 70 percent have some ability to use digital technology, the internet is not the main medium for communication owing to weak signal and lack of data access. Instead, Mayani staff make direct farm visits in order to transact with and ensure delivery from their suppliers.

Inclusiveness limited by the sheer proportion of farmers and fisherfolk still in the unorganized informal sector. DA (2021) finds that 67.3 percent of farmers and fisherfolk are members of an organization (farmers organization, livestock and producer organization, fisherfolk organization, or other agricultural organization/association). However, as this figure is drawn from RSBSA, it may be unrepresentative of the population. Songco (2023), on the other hand, finds that just 20 percent of farmers are members of an economic organization. This is more consistent with Annual Poverty Indicators Survey data for 2020, which finds that only 16.0 percent of families in rural areas were members of cooperatives (any type, not necessarily agri-cooperative). The national figure is just 12.3 percent (PSA, 2021).

6. Conclusion

Summary

The most widespread elements of digital agriculture landscape are selected advisory apps and online retail networks; other elements are at early or even prototype stages. In the Philippines, digital agriculture is still far from being a majority choice of farmers and other stakeholders in the agri-food system. Applications such as fintech, and some types of automated agricultural equipment, are at an early stage of development, or even at prototype stage prior to commercialization. Rather, the more commonly observed elements are online retail and farm advisory apps (most notably, RCMAS).

The following elements of digital agriculture are more likely to be at or moving to the mainstream within the next five years: decision support; computerization of public services; online advisory and extension services; crop management and monitoring systems; portable equipment; online retail; and online marketplaces. In the medium term, government priorities and willingness to allocate budgets underpin the are healthy prospects for wider dissemination for decision support and computerization of public services. Meanwhile, on the demand side, there is strong interest among stakeholders, such as farmers, fisherfolk, and agribusiness companies, in information, advisory and extension services, as well as portable equipment such drones, sensors, lasers for land leveling.

Very real concerns about the digital divide related to farmer age, education, assets, and rural connectivity, can be bridged through community organizing, development of rental markets, provision of traditional extension services, and investments in last mile connectivity. The literature and our rapid assessment have confirmed the reality of the "digital divide" in rural Philippines. However, the rapid assessment also indicates that there are workarounds to bring farmers in despite their advanced age, lack of education, low digital literacy, lack of rural connectivity, and lack of assets. These are: organizing into large farmer-owned enterprises; investing in shared facilities; fee-for-service transactions for portable equipment; visits by farm technicians to bridge farmers to digital tools; and public-private-farmer partnerships.

Policy implications

The rapid assessment supports PDP strategies related to digital tools in agriculture. The following draws out additional policy implications for agricultural policy on digital agriculture, based on the rapid assessment.

1. **Ensure that a single data set and advisory underpins the various decision support systems used by government.**

Rapid assessment of government agencies has uncovered some conflicting data and advice from decision support systems deployed by different agencies, e.g. crop suitability. At root there may be a lack of agreement about land and climate characteristics, base maps, parcel maps, and other relevant information. Government must initiate a process of harmonization, first by convening regional technical working groups (TWGs), with representatives of DA, DENR, DOST, and SUCs. When discussing tenure issues, then Department of Justice, Department of Agrarian Reform, and, , where applicable, the National Council for Indigenous Peoples, should also be included. Second, outputs of these TWGs may be discussed in validation workshops initially at the regional level, but ultimately at the national level for standardized mapping. Achieving effective collaboration among multiple agencies, each with its own mandate, culture, and priorities, can be challenging. As a possible solution, a high-level steering committee may be established to oversee the harmonization process. This committee should have representatives from all key agencies to ensure buy-in and facilitate smoother coordination.

2. **Provide a single portal linked to all the online sites and apps for digital agriculture developed by government.**

The proliferation of farm advisory apps may at first sight appear unnecessarily confusing to the various stakeholders. However, the type of information required, the way the information is conveyed, and the interface with users with different needs, may justify the variety of apps and websites now available (and potentially more in future). The solution to proliferation may be to simply create a single government portal which links to the various advisory tools provided by government. The portal should catalog and describe each linked advisory tool to guide potential users to the one most relevant for their needs. It seems most appropriate for the portal to be hosted by DICT; however, each government app should contain a cross-link to the central portal.

3. **Integrate digital solutions to standardizing farm management in the DA's clustering and consolidation program, based on formation and capacity building of large cooperatives.**

The DA is currently undertaking a farmer and fisherfolk clustering program. DA must now consider digital agriculture as a technological solution to centralizing and standardizing production and management practices to optimize production within these clusters. Furthermore, to ensure economic viability and sustainability, clusters may need to cover thousands of hectares (compared with the current 100 ha guideline), all under a single cooperative. This will entail a program of consolidation of numerous small cooperatives and associations into larger groups, with an aggressive campaign of recruiting currently unorganized farmers and fisherfolk. Expansion of fewer cooperatives to cover a greater share of the farm population enables the absorption of high overhead costs from hiring professional and technical staff needed to run sophisticated management operations. The assumption here is that current cooperatives are open to the idea of merging or forming a larger collective, such as a group or federation. Nonetheless, a significant hurdle lies in persuading current officers and Board members to give way to a possibly new set of leaders upon merger and expansion who will assume responsibilities within this expanded organization. Possible ways to address this issue would be: i) Phased Integration Approach: Rather than an abrupt merger, a phased approach to integration can help in smoothing the transition. Start with joint projects or shared services between cooperatives before fully merging. This approach can help members and leaders to build trust and understand each other's strengths and weaknesses; ii.) Rotational Leadership Systems: To address concerns about representation and power dynamics, a rotational system for key management roles can be established; iii) Democratic Decision-Making Process: Ensure that the process of determining which management officers will lead the larger organization is transparent and democratic; and iv) Conflict Resolution Mechanisms: Merging different groups can lead to conflicts, particularly regarding leadership and management roles. It would be helpful to establish clear conflict resolution mechanisms and channels for members to express concerns. This could involve setting up a neutral committee or hiring a mediator to help resolve disputes.

4. **Pursue diversification and climate resiliency by expanding decision support systems, and diversified knowledge portals and advisory services.**

Recommendation 3 focuses on clustering and consolidation around single crops. However, the agri-food system encompasses a variety of production activities. Diversification supports resiliency to climate and economic shocks, as well as opens opportunities for improving livelihoods. Digital agriculture enables also diversification through decision support systems, and through knowledge portals and advisory services encompassing crops beyond rice and monocrop agriculture. Implementing this recommendation entails proposal and approval of projects for developing decision support systems and knowledge portals, advisory apps, etc., covering a wide range of commoditie sand livelihood systems systems (such as coconut intercropping, rice-legume rotation, etc.) These projects may be undertaken within DA, and other agriculture-related agencies such as SUCs and DOST-PCAARRD. SARAI and PILI NICER have already initiated this process but much more funding space should be allocated for these inititatives.

5. **Offer a centralized e-commerce platform catering to MSMEs, incorporating agri-food products, and functioning as an online marketplace.**

Unlike farm advisory apps, the proliferation of e-commerce platforms under different government agencies is inefficient given that success of an online marketplace depends on the same set of prerequisites, namely: attractive product advertising; ease of use; convenience in terms of payment and logistics; and delivery assurance. These can all be achieved more cost-effectively under a single platform. Government participation in such a platform is justified by their support for development of MSMEs and agri-cooperatives.

The natural host of such a platform will be the DTI, which already has a market information system (GoLokal) that can be grown into an online marketplace. Additional justification for government intervention, as well as the role of the private sector in the platform, is dealt with in the next two recommendations below. The challenge to implementing this recommendation is to persuade various agencies already engaged in e-commerce to merge their efforts and systems with those of DTI; DBM may need to enforce this by making budgeting and approval conditional on e-commerce consolidation.

6. **Realize agri-food system upgrading through e-commerce by investing in traceability, food safety, registration and certification, and good agricultural practices.**

Another reason why government may be interested to support such an online marketplace is to enforce upgrading of value chains within an e-commerce ecosystem. In the case of agri-food products, merchants should be properly registered, and required to source from GAP-certified farms; processed food should be compliant with FDA food safety requirements; other certifications may be included as applicable (e.g., halal). The marketplace can also institutionalize traceability for food products. Such quality assurances will likely draw demand to the marketplace. However, high standards may limit the ability of smaller or less-equipped merchants to participate. One possible solution to this is to offer support programs for small-scale producers to meet the required standards, such as subsidies for certification costs or training in quality management systems. Another challenge would be on monitoring and enforcement. Continuously monitoring compliance and enforcing standards can be resource-intensive. To address this, it would be useful to utilize technology for monitoring, such as AI for compliance checks. Implement a reporting system where consumers can report non-compliance.

7. **Government support for digital agriculture should explore entry points for private sector participation, e.g. joint development, operation, licensing, and similar partnerships.**

The consolidated online marketplace recommended above need not be entirely government-run; private participation may be invited in the development and operation of the platform, while government focuses on quality and delivery assurance. Resort to proprietary software is one option for such partnership; however, note that there are any number of open source e-commerce software that may be utilized. The Open Network for Digital Commerce initiative of India may be a model that can be emulated for this purpose.

Similarly, commercialization of smart farming applications, automated equipment, and the like, should also be spun off to the private sector. Whereas the legal framework for such commercialization has already been established under RA 10005, further review and study may be undertaken to identify and address bottlenecks to public-private partnership in commercializing outputs of public R&D. Moreover, aligning the interests of the public sector and private partners, especially regarding profit motives versus public service, is crucial. To address this potential issue, there should be clear agreements and contracts that outline the roles, responsibilities, and expectations of each party. Ensure that public interest remains a primary focus, with mechanisms in place to prevent exploitative practices.

8. **Aside from assisting smallholder farmers, skills enhancement programs should also target the landless agricultural workers.**

The high rate of underemployment in the Philippine agricultural sector, with one-fifth of workers underemployed since 2006, underscores the need for targeted policy measures (Briones 2017). As the sector undergoes modernization, there is an increasing need for upskilling or retooling, particularly for those agricultural workers who might face job displacement due to technological advancements. Addressing the skill gaps and productivity issues in this sector is crucial. Policies should concentrate on skill enhancement and training programs specifically designed for agricultural workers. By improving their technical competencies and adaptability to modern agricultural practices, these initiatives aim to boost their employability and productivity in the sector.

The development and implementation of the Pre-Employment Enterprise Based Training (PET) Programs in Agriculture Qualifications by the DA and PCCI-HRDF is a significant step in this direction (PCCI-HRDF n.d.). These programs are specifically designed to address the skills gap and boost the productivity of agricultural workers, thereby enhancing their employability in a sector that is rapidly evolving due to technological advancements. A parallel action to the development of PET Programs is the establishment of an agricultural training council, originally proposed by Philippine Chamber of Commerce and Industry-Human Resources Development Foundation (Padin 2016). This council, envisioned to be composed of employers, employees, and industry organizations, is aimed at ensuring the agricultural workforce's skills are aligned with the current and future needs of the industry. Such a council would play a crucial role in overseeing and guiding the upskilling and retooling programs offered by the Agricultural Training Institute (ATI) and the Technical Education and Skills Development Authority (TESDA), tailoring them to effectively address any skills gap among agriworkers. As the industry incorporates more advanced technologies, it is crucial that workers are not only versed in traditional agricultural methods but are also adept in the use and maintenance of these new, high-tech machines and computer applications.

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[2] The figure is much higher than what is advertised in the Shopee website. It may cover all fees and charges such as delivery fee, payment processing, etc.