



A Factsheet Series

Digitalisation in Agriculture

Digitalisation in agriculture refers to the deployment of digital technologies in farming and the entire food system and value chain—from the development of seeds, deployment of drones, on-farm sensors and internet of things (IoT) devices in the production process, automation of farm management and digital advisories to online transactions of farmers, creation of online marketplace for buying and selling of produce and links with consumers. In its essence, digitalisation in agriculture is a business model which monetises data collected from farmers and their farms and throughout the value chain which creates new forms of extraction of labor, knowledge and resources.

Digitalisation is accompanied by new forms of technologies, knowledge regimes and even legal regimes. It is not just about technological change; it is also an epistemological change - the way we understand “legitimate” agricultural knowledge and how they are measured, quantified, collected and monetised. The deployment of sensors, drones, automation and softwares are underpinned by a belief that the natural world can be measured, quantified, controlled, manipulated and commercialised.

Digitalisation of Agriculture in Asia

Beyond industrialised countries where digitalisation in agriculture was mostly developed, tested and deployed, Asia as a continent has been a logical market for expansion of new digital tools and technologies in agriculture. Home to the so-called “tiger economies”—namely South Korea, Singapore, Hong Kong and Taiwan—whose economic leaps were mostly triggered by technological and industrial innovations in particular in

electronics and communications that served as backbone for digitalisation in agriculture in these countries and in the rest of the region. Taiwan is home to the world's largest producer of computer microchips for consumer products. South Korea has strong industries in manufacturing of microchips, automobiles and electronic products. Singapore and Hong Kong have robust industries and hubs to financial and investment companies. These industries are important pillars in the deployment of digital technologies in Asia's farms.

Public Policies on Digitalisation in Agriculture

Unlike in the Global North where large private players in agriculture and technology are in the forefront of the push for digitalisation for profit, governments in the Global South play critical roles in facilitating the takeover of food and agriculture by private actors. Digitalisation in agriculture in Asia has been accompanied by significant policy changes in most countries where "digital transformation" of their economies has become a common feature of national development plans in the past decade. In the food and agriculture sector specifically, promoting digitalisation as a means to boost agricultural productivity, increase farm incomes, promote efficiency in the value chain and address the climate crisis are echoed in government policies. Some of these national policies and programmes in agricultural digitalisation are described below:

Country	Relevant Policies to Digitalisation of Agriculture
Bangladesh	<ul style="list-style-type: none"> • 2022: Smart Bangladesh 2041 • 2024: National Agricultural Data Infrastructure (NAgDI)¹ • 2024: Farmers (Krishak) Smart Card initiative²
India	<ul style="list-style-type: none"> • 2020: Agristack • 2025: Digital Agriculture Mission³ • 2024: Namu Drone Didi Scheme

1 *Namu Drone Didi*, static.pib.gov.in/WriteReadData/specificdocs/documents/2024/nov/doc2024114428601.pdf.

2 "Digital Agriculture Mission: Tech for Transforming Farmers' Lives." *Press Information Bureau Delhi*, 4 Sept. 2024, www.pib.gov.in/PressReleaselframePage.aspx?PRID=2051719&%3breg=3&%3blang=2®=3&lang=2.

3 "Empowering Agriculture through the Creation of Digital National Farmer Registries: South Africa, Mozambique and Bangladesh Gain Insight from the KIAMIS Experience in Kenya." *Food and Agriculture Organization of the United Nations*, 20 May 2024, www.fao.org/agroinformatics/news/news-detail/empowering-agriculture-through-the-creation-of-digital-national-farmer-registries--south-africa--mozambique-and-bangladesh-gains-insight-from-the-kiamis-experience-in-kenya/en.

Indonesia	<ul style="list-style-type: none"> • 2020: National Strategy for Artificial Intelligence 2020-2045 • 2023: National e-agriculture strategy⁴
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Malaysia	<ul style="list-style-type: none"> • 2021-2030: National Agrofood Policy⁵ • 2023: Digital Agtech Program • 2021-2025: National Food Security Policy Action Plan⁶
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Philippines	<ul style="list-style-type: none"> • "Agriculture 4.0" Agenda by the Department of Agriculture • Philippine Rice Research Institute's Strategic plan from 2023-2028
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Sri Lanka	<ul style="list-style-type: none"> • National Digital Economy Strategy 2030 • Inclusive Digital Agriculture Transformation (IDAT) initiative
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Pakistan	<ul style="list-style-type: none"> • Digital Agriculture Transformation Plan 2021 • 2023: Digital Agriculture Transformation Plan • National Agristack 2025
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Bangladesh

In Bangladesh, key to the digital transformation agenda is the "Aspire to Innovate" initiative which is spearheading the building and implementation of the National Agricultural Data Infrastructure (NAGDI). In December 2023, FAO undertook a scoping mission to Bangladesh at the government's request and identified an efficient Farmer Registration and E-voucher system as a key priority area. The Farmers (Krishak) Smart Card initiative plans to register 22.7 million farm households to develop a database and enable the expansion of digital service provision in agriculture. These cards will serve as the farmers' digital identity which will enable government officials to digitally monitor the personal details and the farming needs of the farmers. The claimed benefit of these cards is that it will enable the Department of Agriculture to take immediate action in responding to the needs of the farmers and communicate with them more effectively. FAO also has a digital village initiative which enables smallholder farmers to access e-services from the government and private sector.

4 "Indonesia Announces E-Agriculture National Strategy." *FFTC Agricultural Policy Platform (FFTC-AP)*, 1 Mar. 2023, ap.fftc.org.tw/news/3298.

5 <https://www.kpkm.gov.my/en/agro-food-policy/national-food-security-policy-action-plan-2021-2025>

6 <https://www.kpkm.gov.my/en/agro-food-policy/national-agrofood-policy>

There are 60 digital villages across Barishal, Rangpur, and Cox's Bazar. The villages are run by producer organisations which facilitate marketing of produce and bulk procurement of agricultural inputs.

India

India's Ministry of Agriculture and Farmers' Welfare announced the AgriStack in 2021 which is a collection of technologies and digital databases proposed by the Central Government, and as defined by the government is a digital foundation being set up with the aim of making it easier to get stakeholders, which are mostly private actors, to "improve agriculture" using data and digital services by making high quality/really crucial data easily accessible to create new services using the data. Agristack aims to enable "easier access for farmers to cheaper credit, higher-quality farm inputs, localised "advice" (which is not really advice, it is a prescription or a dictation from the machine to the farmer undermining their autonomy and rights) and more informed and convenient access to the markets." In 2021, the Government started signing memorandum of understanding (MoU) with private and transnational corporations for this purpose, many of which have not been made public. These have been signed with Microsoft, ESRI India Technologies, AWS, Star Agribazaar, Patanjali Organic Research, JIO Platforms, ITC Limited, Cisco Commerce India, NC-DEX e-Markets Ninjacart AI Unit of National Entrepreneurship Network (Wadhvani AI) And Pixxer.

At the center of Agristack is a farmer registry which is to be compiled by state governments but stored with the Center and linked to the farm land record of the farmers. The government is preparing a farmer database by linking the land records of farmers across the country. The data related to PM Kisan, Soil Health Card and Pradhan Mantri Crop Insurance Scheme, available with the government, have already been integrated. The government says that it is being built by taking publicly available data (as said in Lok Sabha) but the very activity of collecting data by reaching out to farmers through various digital platforms including apps, taking data from the department and putting it together is a massive effort.

Indonesia

Indonesia has an "e-agriculture national strategy" to utilise data to benefit smallholders. According to the strategy, by 2027, Indonesia will have a database for farmland and farmers, a digital early warning system for agriculture-related disasters, and systems for agriculture data collection and analysis. The strategy aims to create a data collection platform (DCP) that can collect agriculture data from various sources to facilitate the implementation of digital solutions.

In July 2025, Nezar Patria, the Deputy Minister of communication and digital affairs, stressed the role of artificial intelligence (AI) and data in transforming Indonesia's agricultural sector. The Ministry is speeding up the expansion of digital infrastructure in rural areas and promoting digital literacy and working closely with universities like Gadjah Mada University (UGM) to advance research, training, and the development of technology-based solutions for agriculture. In February 2021, Indonesia's Ministry of Agriculture signed an MoU with Microsoft "to empower smallholder farmers with technology-oriented solutions that will help them increase income using ground-breaking, cloud-based technologies, machine learning and advanced analytics."

Malaysia

Malaysia's government promotes digital agriculture primarily through the National Agrofood Policy (DAN 2.0) and related initiatives under the National Food Security Policy Action Plan and the National Digital Economy and Fourth Industrial Revolution Council (MED4IRN). The Malaysia Digital Economy Corporation (MDEC), under the Ministry of Digital, serves as the implementing agency for the digital agriculture technology (Digital AgTech) initiative.

The Digital AgTech program began in November 2023, aiming to modernise agriculture through the use of technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) across all key agricultural subsectors including crops, livestock, and aquaculture. Over 600 Digital AgTech systems have been implemented nationwide, reaching over 30,000 agropreneurs who have been trained in digital technology adoption. Key goals include increasing productivity by up to 20%, raising income by up to 20%, and reducing operating costs by up to 30%. Efforts focus on real-time data-driven agricultural technology to enhance competitiveness, food security, and efficiency. Programs like Jelajah Malaysia Digital (JMD) promote AI integration into agriculture within states such as Kedah and Sabah, covering various crops and aquaculture sectors. Additional projects leveraging IoT and AI with significant investment value continue to be deployed to strengthen technology adoption.

Pakistan

In 2023, Pakistan introduced its Digital Agriculture Transformation Plan to digitalise agriculture through artificial intelligence, smart devices, and precision agriculture. The National Climate Change Policy (NCCP) 2021 and National Adaptation Plan (NAP) 2023 emphasise advancing climate-smart agriculture through technology. The Punjab Agriculture Policy also encourages the adoption of modern farming tools, such as soil moisture sensors, GPS, and drones. Similarly, in the Gilgit-Baltistan Climate Change Strategy and Action Plan-2017 (Revised-2023) and Agriculture Policy-GB, 2018 promotes the adoption of precision agriculture.

In 2021, Pakistan launched its first-ever digital agriculture community network project called "Digital Dera." Located at Chak 26-SP in the Pakpattan region of Punjab, Digital Dera serves over 1,500 farmers across rural areas by providing solutions to farming challenges through access to the latest agricultural technologies and services. Digital Dera functions as an innovation lab for agriculture and food security, where AgriTech startups and investors from across Pakistan can test their products in a real farming environment. The facility is equipped with high-speed internet and offers capacity-building sessions in the local language, empowering farmers with digital knowledge and internet connectivity to integrate them into the digital economy.

In 2025, Pakistan began working on its "National Agri Stack" to build digital infrastructure for its agriculture sector to boost farmer access to credit, subsidies and markets. This initiative, similar to India's Agristack is led by Pakistan's Ministry of Information Technology and Telecommunication (MoITT) in collaboration with the Ministry of National Food Security and Research (MNFSR), the Land Information and Management System (LIMS) and the Special Investment Facilitation Council (SIFC). This will create

a digital ID for every farmer by integrating land and farmer data, and an online hub where farmers can access services. The farmer ID will have personal details of the farmer and will enable the government, banks and agri companies to target their subsidies, loans, crop insurance, weather updates and market prices.

Philippines

The Department of Agriculture has openly embraced the technological transformation of the Philippine agriculture sector through its "Agriculture 4.0" agenda, which aims to digitalise the country's agricultural and fishery sector through the use of "modern technologies like hydroponics, genetic modification, blockchain, drones, powerful data analytics, and nanotechnology". The agency has set a PHP2.5 trillion plan to modernise agriculture. In 2018, the country inaugurated its first state-funded smart farm as part of the Smart Plant Production in Controlled Environments (SPICE) project, supported by the Department of Science and Technology. The SPICE project aims to deploy electronics, sensors and automation to promote controlled environments for farming. The Philippine Rice Research Institute envisions digital transformation as a key part of its strategic plan from 2023-2028, with a budget allocated for the same. The institute is developing a rice integrated crop management system called PalayCheck, and aiming to set up a Big Data Analytics Center, along with having developed apps that help farmers identify weeds, analyse soil fertiliser requirements, and inform farmers on rice varieties.

Sri Lanka

Sri Lanka's National Digital Economy Strategy 2030 prioritises agricultural digitalisation for crop management at the field level and promotes the adoption of digital agriculture among SMEs. It highlights universal, affordable, high-speed broadband access as a way to bridge the digital divide, especially in underserved areas, promoting the building of digital infrastructure, boosting digital literacy, and workforce with digital skills.

In July 2025, the Sri Lankan Government launched the Inclusive Digital Agriculture Transformation (IDAT) initiative in partnership with the Gates Foundation. This initiative aims to utilise data and technology to improve decision-making and service delivery for smallholder farmers, focusing on modernising agriculture, enhancing rural livelihoods, and building climate resilience. It also aims to increase investments towards the development of digital infrastructure, enhance digital literacy, and for the provision of digital services such as credit, insurance, advisory, and post-harvest management. The strategy promotes building capacity across the agriculture value chain for effective technology adoption and introduces modern agriculture technologies to increase yields, improve water management, optimise fertiliser use, and enhance soil health. It emphasises adopting interoperability standards to facilitate information exchange within the agriculture ecosystem while ensuring data quality, privacy, and security.

IDAT is built around five strategic levers: Information security, interoperability of data systems, digital infrastructure development, innovation facilitation, and institutional governance to support real-time data collection, analysis, and use for policymaking

and farm management. The program collaborates with universities, research institutions, and private sector actors like telecom companies, companies operational across the Agri value chain, Agri-tech companies. Through agri-tech incubators supporting startups to develop, test, and scale technologies.

International Push

The Food and Agriculture Organization (FAO) has a digital village initiative in Bangladesh which enables smallholder farmers to access e-services from the government and private sector. There are 60 digital villages across Barishal, Rangpur and Cox's Bazar which are run by producer organisations that facilitate marketing of produce and bulk procurement of agricultural inputs. In 2022, FAO and a2i conducted a baseline survey to assess the readiness of the villages for digital adoption under the Digital Village Initiative. FAO also collaborated with the International Telecommunication Union to conduct a stocktaking assessment of digital agriculture in Bangladesh to develop a digital agricultural strategy.

FAO supports the government of Vietnam's programs in promoting drone applications in rice farming in the Gia Phong commune in Ninh Binh province as the demonstration site in collaboration with Vietnam Academy of Agricultural Sciences (VAAS). This includes assessing drone use for direct rice seeding, identifying challenges limiting the adoption of this technology, conducting field trials on two hectares of demonstration plots to showcase drone effectiveness, capacity building of stakeholders, training cooperatives members (smallholder farmers), service providers, government bodies, and researchers on drone technology in rice farming.

FAO, in close collaboration with the Center of Agricultural Data and System Information (CADIS) of the Ministry of Agriculture (MoA) of Indonesia launched the agriculture digitalisation strategy for the country called an "e-agriculture national strategy" to utilise data to benefit smallholders. According to the strategy, by 2027, Indonesia will have a database for farmland and farmers, a digital early warning system for agriculture-related disasters, and systems for agriculture data collection and analysis. The strategy aims to create a data collection platform (DCP) that can collect agriculture data from various sources to facilitate the implementation of digital solutions.

The International Rice Research Institute (IRRI) and drone manufacturing company XAG have joined forces to promote digital agriculture and precision farming in the Philippines. XAG, one of the world's leading manufacturers of agriculture drones based in China, through its Philippine partner Agridom, has donated agricultural drones to IRRI to support precision agriculture and sustainable farming. The collaboration aims to accelerate agricultural automation and innovation, specifically in rice-based cropping systems, through the use of drone technology. Currently, the World Bank has 53 lending investment projects in 36 countries with 1.15 billion USD investments in Data and Digital Components related to agriculture and food systems, influencing an investment of about 10.7 billion USD.⁷

⁷ <https://gfair.network/events/world-bank-transforming-agriculture-and-food-systems-through-data-driven-digital-agriculture>

Agriculture Transnationals and Tech Companies

The largest seed, agrochemicals and farm machineries companies in the world are aggressively promoting digitalisation in agriculture in Asia. As early as a decade ago, transnational seed and agrochemical giants such as Syngenta and Bayer (and the former Monsanto that it acquired in 2018) have already projected their transformation into technology and data companies. The shift in investments of these companies on digital technologies is manifested in the changing profile of their human resources where plant breeders and mechanical engineers have given way to data scientists and software engineers. As governments of developing countries in Asia adopt policies that enable digitalisation in agriculture which opens up vast opportunities for market expansion, partnerships between transnational companies in food and agriculture and technology companies have become more visible. Syngenta forged a strategic partnership with the world's largest drone manufacturer DJI in 2019 involving the use of agricultural drones for direct seeding and application of Syngenta's proprietary seeds and agrochemicals. In early 2020, Bayer announced its own partnership with XAG, another leading drone manufacturer headquartered in China.

In Indonesia, Microsoft announced a record \$1.7 billion investment (2024-2028), towards building cloud and AI infrastructure, designed to support digital transformation and AI adoption including agriculture. In India, Microsoft has collaborated with private actors as well as research institutions like UPL and ICRISAT to develop AI-based digital agriculture tools for pest alert systems, soil health diagnostics, and farmer advisory platforms. Microsoft also signed an MoU with India's Ministry of Agriculture in 2021 for a pilot in 100 villages across 6 states, deploying AI, machine learning, and cloud platforms (via CropData) for farmer interfaces, smart agriculture, post-harvest management, and data analytics on crop patterns, soil health, and weather.⁸

Amazon has also made significant investments in digital agriculture in India through its initiative Amazon Kisan, launched in 2019, provides agronomy services to farmers.⁹ Its Smbhav venture capital fund funds startups working on making agri-inputs more accessible to farmers, providing tailored agronomy solutions to farmers to improve productivity, distribute credit and insurance to farmers or reduce food waste by building efficient farms to fork supply chains.¹⁰ The company collaborates with the Indian Council of Agricultural Research (ICAR) via an MoU to provide farmers with scientific cultivation guidance, capacity building, and marketing platforms through Amazon's network, enhancing farmer livelihoods and crop yields.

Agtech Start Ups

Digitalisation in agriculture has paved the way for the emergence of start up companies engaged in the design, development, manufacture and/or operation of digital technologies in any part of or across the agricultural value chain. These start ups are the main

8 <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1711877®=3&lang=2>

9 <https://asvf.in/amazon-reiterates-commitment-towards-an-aatmanirbhar-bharat/>

10 <https://www.aboutamazon.in/news/community/how-amazon-is-using-technology-to-improve-farmer-livelihoods-and-boost-crop-yield>

recipients of financial investment of venture capitals and private investors including sovereign funds mostly from the global North. Asian countries have consistently attracted investments in digital technologies in food and agriculture by venture capital firms. As of October 2024, the South Asian agrifoodtech sector saw a total of 3.5 billion USD (approx.) invested across 165 deals (thanks largely to China and India); East Asia witnessed an investment of 1.8 billion USD across 364 deals, followed by Southeast Asia which was far behind at attracting 287 million USD across 46 deals. The Asian countries with highest venture capital investment in food and agriculture are: India, China, Japan, Singapore, Indonesia, South Korea, Australia, New Zealand, Bangladesh and Vietnam. These countries have a robust crop of new companies, usually established by young entrepreneurs, pitching for ideas and selling innovations on digitalisation in agriculture. Some of the leading examples from across the region are below:

Country	Startup	Key Technologies
Bangladesh	iFarmer	Low-cost collateral-free financing for inputs/machinery; capacity building/training (crops, livestock, fisheries, poultry); soil testing via sensors; satellite-based advisory; farm product marketplace.
Indonesia	eFishery	Digital aquaculture platform; funding from Temasek, SoftBank (noted financial misconduct concerns).
	Lokatani (LokaFresh, LokaGrow, LokaTech)	B2B fresh produce platform; hydroponic system building; IoT monitoring for hydroponics.
	Eratani	Smallholder funding, supply chain management, crop distribution.
Malaysia	BoomGrow	Controlled environment agriculture (CEA) with modular container farms (95% less water/land/labor); funded by Gobi Partners.
	Aerodyne	Drone manufacturing, digital services (unicorn with VC funding).

Pakistan	Aqua Agro	AI for crop yields/water savings (50%); solar IoT sensors (soil moisture, temp, humidity); SMS/email/app advisories.
	Ricult	Online platform for credit, weather forecasts, price updates.
Philippines	Anihan Technologies (AniTech)	Local sensors for greenhouse/warehouse monitoring (temp, humidity); web/mobile platform with alerts.
	Mayani	Connects small farmers/fishers to consumers via online/B2B platforms.
Sri Lanka	Farmonaut	Satellite-based farm management; real-time crop health/AI advisory; precision agriculture.
Vietnam	Enfarm	AI/IoT for precision crop management.
	Techcoop	Digital payments for ag/export markets (\$70M funding, \$75M 2024 revenue targeting \$150M 2025).
	Rize Agriculture	Addresses input costs/data access for small-holders (\$14M funding, regional expansion).
India	CropIn	Traceable farms via CropIn Cloud (30M acres digitized, 7M+ farmers, 350 crops/10K varieties, 103 countries); investments from Google, Neenext, Bill & Melinda Gates Foundation.
	DeHaat	One-stop app (crop reminders, regional voice advisories, weather, mandi rates) for 1.4M farmers in 12 states.

Drones: Poster child of digitalisation in agriculture in Asia

Drones are arguably the most visible symbol - essentially a status symbol - of digitalisation in agriculture in Asia. Drones are mainly used for spraying pesticides and foliar fertilisers, initially in industrial monocrop plantations for more efficient use of chemicals and to reduce labor costs. A study by the International Food Policy Research Institute (IFPRI) found that agricultural drones in Southeast Asia have increased yields by up to 20 percent and reduced pesticide usage by 30 percent. With the introduction of smaller agricultural drones by Chinese companies namely DJI and XAG that made the technology more affordable for large and medium-scale farmers, coupled with push and incentives provided by government programs, drones have begun to spread more widely in developing countries in Asia. Drones are also being tested for direct seeding in rice farms with the intent of reducing labor costs and increasing efficiency. More sophisticated ones fitted with sensors and hyperspectral imaging systems are used to monitor farms and collect data on crops, pests and diseases, soil and water and other parameters for farm management and for providing technical advisories to farmers.

India

The Government of India has launched several key initiatives to promote the use and manufacturing of drones like the Production-Linked Incentive (PLI) Scheme which was launched to boost domestic drone manufacturing, and allocated about US\$14.39 million to incentivise local production and reduce dependency on imports. It targets positioning India as a global drone manufacturing hub under the Atmanirbhar Bharat mission. Drone Shakti Scheme encourages startups to provide drone services across sectors, including agriculture, to expand drone usage. Kisan Drone Scheme provides drones subsidised for pesticide spraying and other farm activities. The SVAMITVA Scheme in which drones are used to map village lands under this scheme, aiding land demarcation and surveys to improve land record systems. The Namu Drone Didi Scheme which is a targeted program funding 15,000 drones with an outlay of approximately US\$150 million for Women Self Help Groups (SHGs) to provide renting and service models using drones.

To protect its growing local industries in manufacturing agricultural drones, India banned the import of commercial drones in 2022, using the flimsy guise of national security and prevention of espionage by foreign elements. Strict import controls of drones are imposed, limited mostly to R&D and government uses. Drone components are importable to support local manufacturing. Importers must navigate authorisation from multiple government agencies, and comply with customs and registration requirements to operate drones legally in India.

Malaysia

Oil palm plantations in Malaysia are the first to deploy drones for pesticide spraying and fertilisation in the name of efficiency and reducing labor costs. Smaller drones are increasingly being used in food crop cultivation, in particular in rice farming primarily to reduce labor costs as farms rely on foreign workers. Government agencies encourage small-scale rice farmers to use drones in spraying pesticides and

fertilisers by hiring the services of agriculture drone operators. Several companies have sprouted to partner with manufacturers such as DJI and XAG in reselling, distributing or renting out services of agricultural drones.

■ Philippines

The government of the Philippines has been actively promoting the use of drones in agriculture through various initiatives and regulatory frameworks to enhance farming efficiency and productivity. The Fertilizer and Pesticide Authority (FPA), in collaboration with the Department of Agriculture's National Rice Program (DA-NRP), leads efforts to develop standardised protocols, operational standards, and monitoring systems for drone applications in rice farming under the Drones4Rice project. This project focuses on the precision application of seeds, fertilisers, and pesticides and aims to reduce production costs and manual labor while increasing rice yields. The FPA issued enhanced rules regulating drone use for pesticide application, ensuring the safety of users, consumers, and the environment. These guidelines apply to drone operators, service providers, pesticide companies, and research institutions. The Civil Aviation Authority of the Philippines (CAAP) governs drone registration, pilot licensing, and operational clearances, setting requirements such as weight-based registration and remote pilot licenses for commercial drone activities, including agricultural uses. The government supports subsidised access to drone services for farmers, particularly targeting farmer groups, cooperatives, and associations through voucher schemes to cover drone-assisted farming operations.

■ Vietnam

Drones are being used in Vietnam's fruit export market which has strict residue limits. Young farmers are offering drone services claiming that it reduces pesticide use by 30%, making the service cost-effective.

Impact on farmers and rural communities

Agriculture in most developing countries in Asia is dominated by small farms, diverse agricultural practices and in some cases, an ageing population and the migration of youth from rural areas. The rural areas in these countries are characterised by poverty and lack of infrastructure for phone and internet connectivity. This reality casts doubts on the promotion of digital technologies on farmers who might already be burdened with loans and find it difficult to afford these technologies. Rural literacy rate in these countries is low, and the digital literacy might be even lower. It might be counterproductive to expect farmers to become digitally savvy and use technologies that are not even proven to be beneficial for them. In contexts where there is not enough infrastructure for digital technologies to exist, where those who are being pushed towards or expected to adopt digital tools are not fully informed about the digital technology and its impacts, let alone be able to participate in its designing and assessment processes, the push towards digitalization invites scrutiny.

There is a lack of transparency regarding information from government agencies related to where the data that they collect are stored and processed, and what kind of agreements on data ownership between government agencies or agtech startups and

the commercial provider of cloud services are signed. When farmers are brought in on these digital platforms/apps to share data about their farms, their poultry and fishing practices, their land, ponds, and livestock, rarely they are informed about how the company benefits from the data shared by the farmers, let alone the prospect of sharing part of the revenue/profits the company gains from the data-sharing of farmers, and the future revenue gained from the new business strategies the collected and analyzed data leads to.

In many analyses, farmers are cast as having low productivity and not able to “keep up” with agricultural mechanization and trends. Digital technologies are mentioned as enabling higher incomes for farmers, and are therefore being pushed on to them but these actors don’t mention neoliberal and even imperialist trade policies, expansion of corporate control over agriculture, the devastating impacts of the climate crisis as the cause for low income of farmers. In the context of continued inaction on farmers’ demands regarding the devastating impact of cheap imports, any positive impact of digital technologies on farmers’ income is highly questionable. Blaming the farmers and their farms as inefficient and low productivity is mislabeling the problem and prolonging inaction regarding practices that are actually causing damage to the food sovereignty of farmers.

It is important to acknowledge that digital connectivity can lead to perpetuation of exploitative relationships. This is encapsulated in the term “adverse digital incorporation” which refers to individuals or groups in the Global South becoming included in digital systems that perpetuate existing inequalities, by enabling a more advantaged group to extract disproportionate value from the work or resources of a less advantaged group. The digital divide and digital inequality concepts frame inequalities as arising from exclusion from availability, accessibility, adoption and use of digital technology, with the narrative that those who are not part of the digital sphere are being excluded from the benefits of digital technologies. The adverse digital incorporation concept reflects on recent literature and developments, tracing how those incorporated into digital systems have been marginalised: through the commodification of resources and materials that were not traded before (i.e., traditional and local knowledge, photos and videos of cultural practices and the environment), criminal exploitation, increasing legibility to the state or other powerful actors who can access knowledge about users that can be exploited, and digital enclosures.

Despite claims of efficiency and accuracy, many digital technologies have proven to be inaccurate and are not backed by scientific studies on how they can ecologically and economically benefit smallholder farmers implementing agroecological practices. Most of these digital technologies are further entrenching the input-intensive model of agriculture as exemplified by drones being used to spray agrochemicals. Digitalisation seems to largely be benefitting private actors who are manufacturing digital technologies or designing and implementing proprietary software.

Governments hold large amounts of valuable agricultural data. The startups backed by private venture capital firms are also collecting valuable on-ground agricultural data. In many of these countries, the governments have entered into partnerships with private actors and provided them access to their agricultural data. Many startups, despite being homegrown, are dependent on investment by large transnational actors who can eventually have a say in the handling of the data collected by them. This raises questions

about national data sovereignty in which firstly, transnational private corporations have access to national agricultural data, and secondly, all of this data is in any case, being stored and analysed in cloud servers not located on national territory but largely in locations in the Global North. Digitalisation in agriculture is facilitating economic extraction by private actors through collection of farmers' personal data, agricultural trends, agrochemical and seed usage, input prices from the farmers, analysing them and then selling them back to farmers and governments.

Agricultural digitalization could further marginalize indigenous, traditional and local knowledge and practices which are often characterized as conservative, outdated and even backward in many narratives, total ignoring the fact that the agricultural biodiversity that has been feeding the world for millennia were nurtured and enriched by small-scale farmers, fishers, pastoralists and indigenous peoples. The impacts of digitalization on the environment, agriculture and the very foundations of global food security need to be thoroughly examined. Digitalization is enabled by technologies and infrastructures such as data centers that need large tracts of lands to build, require massive amount of energy and consumes enormous volume of water to operate, store, analyze and transfer data across the world. All these technologies are proprietary, owned by a handful of giant corporations in the North that are reaping profits from oligopoly in digital platforms without societal control and financialization of data extracted from people and the planet without free and prior informed consent and regulations.

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