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Platform for
Big Data
in Agriculture

Digital Agriculture Profile

• Viet Nam

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HIGHLIGHTS

Agriculture plays a vital role in Viet Nam's economy, accounting for an average of 17% of the national GDP and employing 40% of the national workforce

The biggest challenges to agriculture are information and communication gaps that lead to inefficiency between the hubs of the agriculture value chain, including an absence of actionable decision-support systems for farmers, resulting in resource mismanagement and unnecessary expenditure

The most promising technologies for addressing these issues include smartphones (that can send and receive information), QR codes, blockchain (that connect information and data across the value chain), cloud-based solutions (that enable storage and access of data and information across varied sources), Internet of things, unmanned aerial vehicles (that facilitate gathering of data and insights at high resolution), and data analytics (that enables conversion of data to information and knowledge products)

Digital infrastructure is well established in Viet Nam; the primary constraint to digital agricultural solutions is digital illiteracy—i.e., stakeholders' inability to use digital technologies to acquire information, communicate, and solve challenges in the value chain

The public sector, nonprofit organizations, private industry, and international community all have important and distinct roles to play in creating sustainable digital agricultural solutions in Viet Nam



OVER

99%

OF VIETNAMESE ACROSS BOTH RURAL AND URBAN AREAS HAVE ACCESS TO ELECTRICITY

VIET NAM IS RANKED



3RD

IN THE WORLD IN TERMS OF AFFORDABILITY OF INFORMATION AND COMMUNICATION;

THE AVERAGE RATE FOR BROADBAND IS LESS THAN US\$3 PER MONTH

90%

OF FARMERS OWN A MOBILE PHONE, AND PER CAPITA MOBILE SUBSCRIPTION RATES ARE WELL OVER 100%



42%

MOBILE PHONE USERS HAVE 3G OR 4G CONNECTIONS,



A 36%

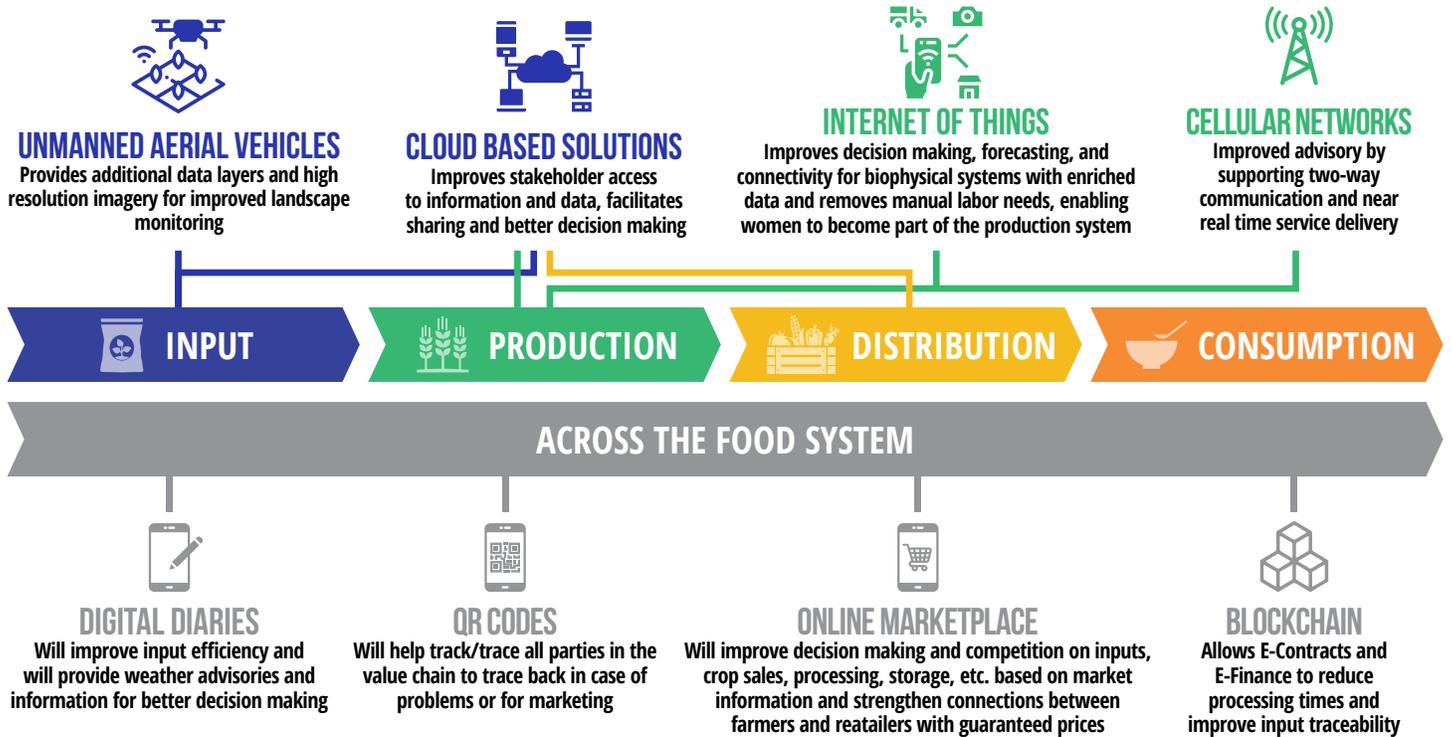
INCREASE SINCE 2015

46%



OF THE TOTAL VIETNAMESE POPULATION AND 10% OF FARMERS USE BROADBAND INTERNET

PRIORITY TECH SOLUTIONS



Introduction

As a cornerstone of economic growth and employment, agriculture has been vital to sustaining livelihoods throughout Viet Nam. However, recent years have brought about new challenges for all stakeholders within the sector as well as new investment opportunities to drive agricultural growth. Both domestic food production and the food imports: exports ratio have been on the rise since the early 2000s, resulting in improved food security and an increasing reliance on international commerce.¹ Indeed, Viet Nam is a net food exporter to Western countries, and a net importer from its Asian neighbors. The future success of agriculture in Viet Nam therefore depends on its stakeholders' abilities to adapt to, and compete in, the rapidly changing biophysical and financial environments.

Many of Viet Nam's agricultural producers currently lack the contemporary technologies and decision support tools necessary for sustaining and improving yields in a rapidly changing environment.² Other stakeholders along agricultural value chains, including input providers,

distributors, and consumers, also face substantial challenges, including excessively bureaucratic value chains and the associated costs and poor information flows across hubs.

One possible solution to addressing these challenges is digital agriculture. While the concept of digital agriculture is relatively new and still evolving, foundational technologies, such as mobile and Internet connectivity, are already available to support innovative digital solutions to the major challenges facing the Viet Nameese agricultural sector.

Digital agriculture is the use of new and advanced technologies, integrated into one system, to enable farmers and other stakeholders in the value chain to improve their products and processes.³ Integrating digital solutions into agriculture can improve efficiency by decreasing financial and labor costs, providing information to support management decisions, increasing product quantity and/or quality, reducing losses, and/or ensuring effective and sustainable use of resources. Ultimately, the transition

¹ Food and Agriculture Organization of the United Nations, "FAOSTAT," 2019.

² General Statistics Office of Viet Nam, "Results of the 2011 Rural, Agricultural, and Fishery Census."

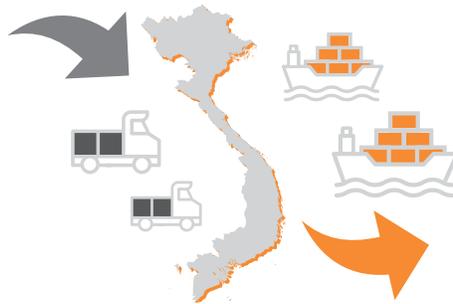
³ United Nations, "Digital Agriculture."

TOP 3 AGRICULTURAL PRODUCTS IMPORTED IN 2017

MAIZE
7,7
MILLION TONNES

WHEAT
4,7%
MILLION TONNES

SOYBEAN
1,7%
MILLION TONNES



TOP 3 AGRICULTURAL PRODUCTS EXPORTED IN 2017

RICE
5,8
MILLION TONNES

CASSAVA
3,6%
MILLION TONNES

COFFEE
1,4
MILLION TONNES

PRIMARY CROPS ACCORDING TO PRODUCTION QUANTITY

RICE
42,8
MILLION TONNES/YEAR

SUGARCANE
18,4
MILLION TONNES/YEAR

VEGETABLES
14,2
MILLION TONNES/YEAR

to digital agriculture presents a unique opportunity to spur sustainable economic growth and development by addressing agriculture's biggest challenges.

As part of the initiative on Digital Agriculture Transformation by the World Bank, this Digital Agriculture Profile for Viet Nam leverages the expertise of stakeholders to evaluate the current landscape of digital agriculture in Viet Nam, including its key players across value chains, the main barriers they face, and the potential to overcome these barriers through the adoption of innovative technologies. In identifying and prioritizing these technologies, we aim to support investors and implementers in maximizing their impact by focusing on the opportunities of highest potential. Once enabling factors are identified and understood, the mainstreaming of digital agriculture in Viet Nam can begin in earnest.

Natural Context

Economic relevance of agriculture

Over the last two decades, Southeast Asia has undergone a rapid and remarkable recovery from the financial crisis of the 1990s. Within the region, this economic turnaround has been especially apparent in the development of Viet Nam. Following a series of market-oriented policy reforms known as *Doi Moi*, Viet Nam has successfully transformed into a lower-middle income country and has emerged as one of the top economies in Southeast Asia, with a GDP⁴ of over US\$223 billion and a GNI⁵ (PPP 2011) of US\$5,857 per capita.⁶

Agriculture has played a vital role in this achievement as well as in the country's overall growth, contributing an average of 17% to national GDP and generating approximately US\$12.5 billion each year in exports.⁷ Moreover, the Vietnamese agricultural sector has exceeded that of almost every neighboring country, growing nearly 4% per annum between 2000 and 2012, and making Viet Nam a global leader in the export of agricultural commodities.⁸ Viet Nam outperforms other Southeast Asian countries in the production of rice, maize, coffee, rubber, cashew, tea, and pepper. In terms of trade, the share of agricultural commodities amounts to roughly 15% of total exports.⁹ Accelerated by its succession into the Association of Southeast Asian Nations Free Trade Area in 1995, Viet Nam is now one of the world's largest exporters of rice and coffee, and a regional leader for other staple commodities, including cashew nuts, vegetables, and rubber.¹⁰

Nevertheless, Viet Nam's exponential growth in land productivity has tapered in recent years, and the country currently trails several neighboring countries in terms of agricultural output for key commodities, including rice.¹¹ A complex, interrelated set of problems is causing this phenomenon, including the prioritization of productivity over sustainability and unsustainable farm economics resulting from overreliance on inputs. Additionally, agriculture is facing growing domestic competition from successful urban sectors, including industry and services, for resources such as labor, land, and water.

4 Gross Domestic Product

5 Gross National Income

6 The World Bank, "GDP | Viet Nam"; The World Bank, "GNI per Capita, PPP."

7 The World Bank Group, "Agriculture, Forestry, and Fishing, Value Added (% of GDP) | Viet Nam."

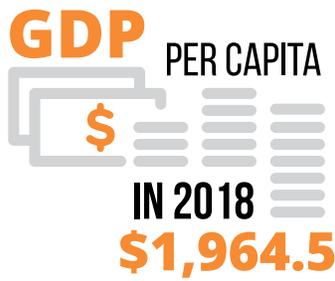
8 World Bank Group, "Transforming Vietnamese Agriculture: Gaining More from Less."

9 World Trade Organization, "Viet Nam."

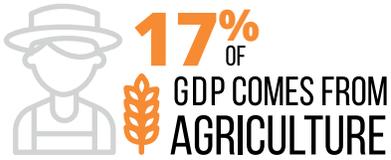
10 Socialist Republic of Viet Nam, "Ministry of Agriculture and Rural Development."

11 World Bank Group, "Transforming Viet Nameese Agriculture: Gaining More from Less."

GDP
PER CAPITA
IN 2018
\$1,964.5



17%
OF
GDP COMES FROM
AGRICULTURE



Rising labor costs in particular are resulting in a shrinking, aging agricultural population, and are beginning to inhibit the agricultural sector's ability to compete on the global stage as a low-cost producer of undifferentiated bulk commodities. Agriculture's share of national GDP currently stands at 17%, whereas up to 2013, GDP contributions had been over 19%.¹²

Agricultural production systems

Viet Nam has a diverse landscape of mountains, valleys, fertile deltas, and dense forests—each with unique soil characteristics and microclimatic conditions. The eclectic range of habitats supports an equally wide array of production systems and agro-ecological zones. Agriculture accounts for 10.2 million hectares, or 35% of the country's total land area.¹³ The Ministry of Agriculture and Rural Development prioritizes 11 key production systems in Viet Nam based on total yield, nutritional quality, and export value: rice, maize, coffee, shrimp, rubber, cassava, cashew, tea, pepper, oranges, and pork.

Smallholder farms currently produce 71% of the food consumed in Viet Nam.¹⁴ Rice is the most important agricultural commodity, supports the highest level of employment, and has been paramount to ensuring national food security. At more than 5.5 tonnes per hectare, average yield exceeds that of the region by over a tonne.¹⁵ Rice production accounts for approximately 7.8 million hectares, or 77% of total agricultural land. Maize and cassava account for 11% and 5% of productive land, respectively.¹⁶ Higher value cash crops—coffee,

rubber, cashew and fruits—make up the remaining 15%. Vietnamese producers apply over 10 million tonnes of fertilizer each year. Rice constitutes nearly 2/3 of this total.¹⁷ On average, farmers apply 142 kg of nitrogen, 67 kg phosphorous, and 49 kg potash per hectare.¹⁸

People, livelihoods and agriculture

The last three decades have been marked by steady advances in alleviating poverty and improving the quality of life. Viet Nam is home to 95.5 million people, 65% of whom reside in rural areas.¹⁹ Urbanization is slowly redefining the demographics of the country and outlining several emerging trends. As of 2016, only 2.3% of the total population was living below the international poverty line (US\$1.90 per day).²⁰ However, the national poverty lines of US\$31/month for rural areas and US\$40/month for urban areas is more revealing. A total of 7.5% of rural residents live in poverty, compared to just 2% of urban residents. Ethnic minorities in the mountainous northern region and central highlands make up an outsized portion of the rural poor.²¹ Household income is also divided, with non-farm and urban laborers earning higher average incomes than agricultural producers.²²

Over 99% of Vietnamese have access to electricity in both rural and urban areas, and over 97% of the country's youth are literate.²³ While water resources are abundant, access to quality and well-managed water remains an issue, particularly in rural areas.²⁴ According to the Human Development Index, Viet Nam ranked 116 out of 189 in 2017 with a composite value of 0.69, placing it in the middle of the developmental index.²⁵ Significant accomplishments have been achieved since 1990, most notably in terms of life expectancy, which increased by 6 years, expected years in school, which increased by 4, and the Gender Development Index value per capita, which increased over 324%.²⁶

¹⁷ World Bank Group, "Transforming Vietnamese Agriculture: Gaining More from Less."

¹⁸ Food and Agriculture Organization of the United Nations, "FAOSTAT," 2019.

¹⁹ Food and Agriculture Organization of the United Nations, "Viet Nam Part 1: Macroeconomy."

²⁰ The World Bank, "Poverty Headcount Ratio at US\$1.90 a Day | Viet Nam."

²¹ Government of Viet Nam, "General Statistics Office."

²² World Bank Group, "Transforming Vietnamese Agriculture: Gaining More from Less."

²³ The World Bank, "Literacy Rate, Youth Male (% of Males Ages 15-24)"; The World Bank, "Access to Electricity (% of Population) | Viet Nam"; The World Bank, "World Development Indicators."

²⁴ World Health Organization, "Safely Managed Drinking Water."

²⁵ United Nations Development Programme, "Human Development Indices and Indicators."

²⁶ United Nations Development Programme, "Viet Nam | Human Development Indicators"; United Nations Development Programme, "Human Development Indices and Indicators."

¹² World Bank Group.

¹³ Government of Viet Nam, "General Statistics Office."W

¹⁴ Ylipaa, Gabrielsson, and Jerneck, "Climate Change Adaptation and Gender Inequality."

¹⁵ Food and Agriculture Organization of the United Nations, "Crops."

¹⁶ Food and Agriculture Organization of the United Nations, "Land Use."



VIET NAM IS HOME TO
95.5 MILLION PEOPLE
(65%)
LIVE IN RURAL AREAS



THE INDICES FOR HUMAN DEVELOPMENT
IN VIET NAM ARE HIGH-PERFORMING,
WITH **2.3%** OF THE TOTAL POPULATION
LIVING BELOW THE INTERNATIONAL
POVERTY LINE: **US\$1.90**



ACCORDING TO
THE NATIONAL POVERTY LINES OF
US\$31/MONTH
AND **US\$40/MONTH**



A TOTAL OF
7.5% RURAL
OF RESIDENTS
LIVE IN POVERTY, COMPARED
TO JUST **2%** URBAN
OF RESIDENTS



99%
HAVE
ELECTRICITY



YOUTH
LITERACY
RATES IN VIET NAM
ARE ESTIMATED
AT **97%**



VIETNAM RANKS
116 IN THE WORLD ON
THE HUMAN DEVELOPMENT INDEX,
AND **118** ON THE GENDER
INEQUALITY INDEX



Contributions from agriculture have also helped to ensure social and financial stability. The sector currently employs 40% of Viet Nam's workforce. Labor trends show a declining number of male workers involved in primary agricultural production and a growing number of females.²⁷ Currently, women account for roughly 51% of the sector's workforce.²⁸ The role of women in agriculture is crucial yet often overlooked. The departure from collective farming towards private markets is increasing women's workload,²⁹ further disabling their full potential to participate in other forms of employment, education, leisure activities, and social or civic engagement. Gender-biased social norms imply that women have relatively limited access to rural advisory services, training, and technology transfer. This results in lower education levels, more limited mobility, and greater time constraints, among other limitations.

Agricultural landholdings have traditionally been controlled by men, as women did not have rights to assets and therefore collateral for securing credit.³⁰ The Land Law of 2003 allowed women to be named on land tenure certificates, thus supporting equity for joint farm and household decision-making and reflecting the actual makeup of the sector's workforce more accurately. The Gender Development Index, which measures gender gaps in terms of health, knowledge, and living standards, rates Viet Nam higher than its neighbors at 1.00. In contrast, the Gender Inequality Index, which highlights the human development costs of inequality via measures of women's reproductive health, empowerment, and economic status, ranks Viet Nam lower than its neighbors at 0.30.³¹

Challenges in the agricultural sector

The biggest challenge across all agricultural subsectors is value chain fragmentation. Each value chain (with the possible exception of the fisheries subsector) is littered with myriad intermediaries, each operating with different technologies, capabilities, and ethics. This fragmentation has resulted in a lack of information and knowledge flow across value chains, which consequently instigates inefficient, unsustainable farming practices and a lack of actionable decision-support tools. Stakeholders across hubs are thus burdened with additional transaction

27 International Labour Organization, "Summary Report."

28 Food and Agriculture Organization of the United Nations, "FAOSTAT," 2019.

29 Ylipaa, Gabrielsson, and Jerneck, "Climate Change Adaptation and Gender Inequality."

30 "How to Tackle Inequality in Viet Nam."

31 United Nations Development Programme, "Human Development Indices and Indicators."

time and cost from initial production through final sale. Producers are particularly vulnerable to knowledge gaps and the resulting resource mismanagement and unnecessary expenditures. For downstream stakeholders, the value chain fragmentation decreases transparency and compliance with regulations on sustainability and good agricultural practices. Consumers are unaware of production conditions despite their growing demand for higher quality products and increasing pressure on distributors to ensure food standards.

While agriculture is a key driver of the economy, high-productivity manufacturing and service-oriented industries have fueled much of the recent economic growth. Agriculture has, to some extent, kept pace through intensification and high input use. As a result, the agricultural sector is now the second largest emitter of greenhouse gases in the country, and is responsible for significant environmental degradation, deforestation, soil erosion, and biodiversity loss.

Current landscape of digital tools and policies

Digital infrastructure, availability and access

Telecommunication has played an essential role in the *Doi Moi* economic reforms. Competition in telecommunication markets began in 1995 with mobile services. Initially providers were strictly operated by state-owned firms and overseen by the Vietnamese Department General of Posts and Telecommunications and the Viet Nam Post and Telecommunications Corporation. In 2001, the government opened the market to international and private sector Internet service providers. Business Cooperation Contracts limited most ventures to infrastructure and financing, and ensured continued oversight of services by state operators. The government telecommunication sector has since become more permissive of foreign and private sector competition; Viet Nam joined the World Trade Organization (WTO) in 2007, and implemented WTO regulatory principles in 2009 via the Law of Telecommunication.³² In doing so, Viet Nam was able to pave the way for 3G and 4G services and become a fertile market for telecom providers. Currently, the country is preparing for the launch of 5G services in 2020, which will enable machine-machine and machine-human connections.

Viet Nam shows significant promise in terms of capability to adopt digital technologies. From 2015 to 2016,

³² Lee, "Telecommunications in Viet Nam."

Viet Nam advanced 5 places in the Networked Readiness Index, which measures enabling environments for technological use and development, including ICT³³ infrastructure, affordability and skills; technology adoption; and socioeconomic impact.³⁴ Out of 139 countries, Viet Nam ranked 79, ahead of Laos, Cambodia and Myanmar. Its predominant strength is the excellent affordability of ICT services; Viet Nam ranks 3rd in the world in terms of affordability. Thanks to healthy market competition, the average rate for fixed-line broadband has remained at US\$2.93 per month; in many countries average prices for minimum speeds exceed US\$580.³⁵ In 2016, the Ministry of Information and Communication reported that 74 operators provided fixed telecommunication services in Viet Nam.³⁶ Viet Nam ranked lower in terms of infrastructure (121), economic impact (92), business and innovation (91), and individual usage (85).³⁷

The International Telecommunications Union ranks Viet Nam 88 in the world (17 in Asia) for the E-Government Development Index, which measures online governmental services, extent of telecommunication connectivity and infrastructure, and level of human capacity for using these technologies. The country scores above both the global and regional averages. Viet Nam ranks 72 in the world and 19 in Asia for overall E-Participation, indicating high usage of digital services to share information, engage other stakeholders, and support decision-making processes.³⁸

There is a wide range of digital literacy levels across geographies and generations. The Information Communication Technology Development Index shows the accessibility, usage and skills related to information and communication technologies in Viet Nam have been stagnant since 2016. Telecommunication infrastructure in Viet Nam also shows room for improvement. According to the 2018 Telecommunication Infrastructure Index, the country scored below both world and regional averages due to the relatively low number of fixed broadband and fixed telephone line subscribers, accounting for only 9.6% and 5.9% of Vietnamese inhabitants respectively.³⁹ In the same year, the International Telecommunications Union found that 23% of all households owned computers and

³³ Information Communication Technology

³⁴ Baller et al., "The Networked Readiness Index 2016."

³⁵ World Bank Group, "Digital Dividends."

³⁶ Ministry of Information and Communications, "White Book of Viet Nam Information and Communication Technology."

³⁷ Baller et al., "The Networked Readiness Index 2016."

³⁸ United Nations, "EGOVKB | Viet Nam."

³⁹ For the 2018 Telecommunication Infrastructure Index, all indicator scores (with the exception of internet use) were determined from a sampled group of 100 inhabitants.

 **THE NETWORKED READINESS INDEX**
RANKS VIETNAM: **79/139**

VIETNAM RANKS 3RD
IN THE WORLD 
IN TERMS OF AFFORDABILITY

THANKS TO HEALTHY MARKET COMPETITION
THE AVERAGE RATE FOR FIXED-LINE BROADBAND
HAS REMAINED AT **US\$2.93 PER MONTH**

IN MANY COUNTRIES
AVERAGE PRICES FOR MINIMUM SPEEDS EXCEED
US\$580 

THE INTERNATIONAL TELECOMMUNICATIONS UNION
RANKS VIETNAM 88 **IN THE WORLD**
17 **IN ASIA FOR THE**
E-GOVERNMENT
DEVELOPMENT INDEX

 **AND RANKS**
72 **IN THE WORLD AND**
19 **IN ASIA**
FOR OVERALL
E-PARTICIPATION

IN TERMS OF USAGE,
ONLY 46% OF
INDIVIDUALS USED BROADBAND INTERNET
WHILE ANOTHER 46% HAD
DATA SUBSCRIPTIONS
FOR MOBILE DEVICES



25% had access to the Internet.⁴⁰ In terms of usage, only 46% of individuals used broadband Internet while another 46% had data subscriptions for mobile devices.⁴¹

The three largest telecommunication providers in the country are Viettel, MobiFone and Vinaphone, together accounting for 93% of total mobile connections.⁴² The Ministry of Information and Communication reported that the number of 3G subscribers in 2016 was 38 million, up 30.5% from the previous year. Within two years of deploying 4G, the number of subscribers had exceeded 13 million.⁴³ This spike in connectivity has been driven largely by the country's growing middle class, affordable mobile phones, and low-cost subscription packages. Over the last 3 years, the number of mobile connections in Viet Nam has grown by 1.67% according to the Global System for Mobile Communications Association (GSMA) and has exceeded 143 million connections as of 2018.⁴⁴ The vast majority (89%) are made with prepaid SIM cards. For those using mobile devices, 42% had 3G or 4G mobile broadband subscriptions, a 36% increase since 2015. The number of smartphones has grown rapidly as a result of higher household incomes and the government's decision to remove import tariffs on mobile devices in 2016; the most recent agriculture census found only 4% of households had fixed telephone lines, while 10% had computers with Internet access and 90% owned a mobile phone. While mobile coverage is good overall, the northern and mountainous regions have lower connectivity and less 4G coverage.⁴⁵ Additionally, the demand for digital applications on mobile devices is slightly below the global average. The Global Connectivity Index found that only 2 new mobile applications per capita are downloaded on average.⁴⁶

Viet Nam is also expanding its earth observation capacity using remote sensing satellites, but the ability to store and process such data is still in its infancy. The VNREDSat1 was Viet Nam's first earth observation satellite, launched in 2013. The Viet Nam Data Cube project will provide easy access to forest, rice, and water quality monitoring using Landsat, Sentinel, ALOS-2 and LOTUSat satellites.

⁴⁰ BSA Software Alliance, "Country: Viet Nam."

⁴¹ United Nations Department for Economic and Social Affairs, "E-Government Survey."

⁴² Oxford Business Group, "Operators in Viet Nam Bolster Infrastructure and Introduce New Products and Services in Telecoms Sector."

⁴³ Viet Nam Net, "Viet Nam Has More than 13 Million 4G Subscribers."

⁴⁴ GSMA Intelligence, "Data."

⁴⁵ Center for International Agricultural Research, Viet Nam digital agriculture stakeholder workshop.

⁴⁶ Huawei, "Country Profile for Viet Nam."

3G SUBSCRIBERS IN 2016
WAS **38** MILLION,
UP 30.5%
FROM PREVIOUS YEAR



WITHIN TWO YEARS OF DEPLOYING **4G**
THE NUMBER OF SUBSCRIBERS
HAD EXCEEDED **13** million

THE NUMBER OF MOBILE CONNECTIONS
HAS EXCEEDED **143** million
CONNECTIONS
AS OF 2018



THE VAST MAJORITY
(**89%**)
ARE MADE
WITH PREPAID SIM CARDS



THE MOST RECENT AGRICULTURE
CENSUS FOUND ONLY **4%**
OF HOUSEHOLDS HAD
FIXED TELEPHONE LINES,



WHILE **10%** HAD COMPUTERS WITH
INTERNET ACCESS AND **90%**
OWNED A MOBILE PHONE



Regional infrastructure investments, such as China Telecom's Information Superhighway optical fiber transmission system,⁴⁷ have significantly improved the potential for digital agriculture solutions, allowing prominent international organizations to deliver improved extension services to the region at much lower costs than traditional in-person approaches.⁴⁸

End-user diversity and demand

Digital agriculture end users may be generally grouped into four hubs. Each hub has unique resources and needs in terms of digital agriculture, and each hub faces unique challenges for which digital agriculture could offer solutions. The hubs are not mutually exclusive; any given individual may function within multiple end-user hubs.

The **Input hub** includes all actors providing agricultural inputs, such as seeds, feeds, agrochemicals, machinery, and finance. Private local distributors from mountainous regions and large input distributors in the Mekong Delta region make up the two main groups of input providers in Viet Nam. Input providers in the Mekong Delta have high access to mobile and smartphones, and moderate levels of connectivity in terms of SMS,⁴⁹ fixed broadband, 3G mobile networks, and weather and market forecasts. Providers in mountainous regions have relatively low levels of connectivity and limited market and weather forecasting access. The Mekong Delta and mountainous regions also differ drastically in terms of topography, thereby resulting in significant differences in terms of accessibility of basic services. Compared to other stakeholders, input providers have the least access to information on yield potential, demand, crop prices, and supply chain logistics. Commercial input services are outnumbered by producer organizations and distributors.

The **Production hub** fundamentally consists of farmers and livestock keepers. Producers in Viet Nam are disaggregated into small- and large-scale farms. Small-scale farms (<0.5 ha), make up nearly 70% of agricultural landholdings in Viet Nam and have the lowest levels of access to digital infrastructure and digital agricultural solutions.⁵⁰ The few large-scale producers have the highest levels of digital solutions, including weather stations, soil sensors, and decision-support tools providing information on for example markets, weather, pests, and diseases.

47 Warnest and Bell, "Country Focus Viet Nam. In Information and Communications Technology Utilization in Land Administration in the East Asia Region."

48 Deichmann, Goyal, and Mishra, "Will Digital Technologies Transform Agriculture in Developing Countries?"

49 Short Message Service

50 General Statistics Office of Viet Nam, "Results of the 2011 Rural, Agricultural, and Fishery Census."

The **Distribution hub** consists of all actors in the value chain between farmers and consumers; this includes traders, transporters, and processors, among others. The main distributors in Viet Nam are traditional open-air markets and larger supermarkets. Both subgroups have similar rates of connectivity (i.e., SMS,³⁹ fixed broadband, mobile networks), but traditional distributors have significantly less access to the same via technologies such as smartphones. Both traditional and supermarket distributors are also constrained by the lack of information sharing and communication with other value chain stakeholders.

Supermarkets are a recent phenomenon, but their presence has grown noticeably and is evidence of the country's increasing household incomes, urbanization rate, and consumer preference for high-quality products. Supermarket sales climbed from US\$2.8 billion in 2005 to US\$6 billion in 2013, and now comprise 15% of total food sales in the country.⁵¹ One of the externalities of supermarket success has been a shift in product sourcing to support higher quality products and food safety; this has resulted in higher food costs. Although supermarkets are increasingly common, the Distribution Hub remains largely comprised of fragmented and unorganized traditional, open-air markets.

The **Consumer hub** consists of consumers of both raw and processed agricultural—in effect, the entire population. Consumers are subdivided by income. Both low- and high-income consumers have similar rates of connectivity, but the latter have much higher access to smartphones, allowing them to make better informed decisions and utilize traceability technologies when buying agricultural goods. While consumers in larger cities frequent supermarkets more than rural consumers, the majority of Vietnamese buy agricultural products in open-air markets. Consistent with other middle-income countries, consumption trends in Viet Nam show that consumers buying less subsistence food, such as rice, and more animal products. Vegetable and fruit consumption has remained stable.⁵²

Institutions and policies for Digital Agriculture

As the concept of digital agriculture is relatively new and evolving, there are no policies in place for it explicitly. Nevertheless, the transformation to innovative digital agriculture services enjoys significant commitment from relevant government agencies and stakeholders in terms

of creating effective policies and incentives. Over the past two decades, Viet Nam has introduced broader regulatory frameworks that support digital agriculture, albeit through fragmented policies and agencies. Government ministries, especially the Ministry of Agriculture and Rural Development and the Ministry of Natural Resources and Environment, have played vital roles in creating enabling policies for the adoption and implementation of digital technologies. The Institute of Policy and Strategy for Agriculture and Rural Development was established in 2006 to serve as a consultant to state agencies on research and policy effectiveness. The Plant Protection Department and National Agriculture Extension Center have also been key to agricultural policy developments in Viet Nam, as well as the Prime Minister, who has been proactive in attracting financial support to the sector with the Ministry of Planning and Investment.

The Strategy for Information Technology Application and Development for Natural Resources and Environment provided a vision for reforming Viet Nam's land information system. In 2008, the Viet Nam Land Administration Project began integrating digital solutions, including land information systems, into the country's reform agenda in order to improve administrative service efficiency and transparency.⁵³ By 2011, Bac Ninh, Viet Nam's smallest and most densely populated province, had over 21 local networks established and one of the most developed e-government initiatives in the country.⁵⁴ In the same year, 86% of manufacturers and service industries were using the Internet within their business operations. Nevertheless, only 2.2% utilized the technology to conduct online sales.⁵⁵ The Management Information System for the Forestry Sector was another early initiative to defragment information services and integrate remote-sensing and mobile data capture into development projects.⁵⁶

In 2010 the Gender Strategy for Agriculture and Rural Development set a national objective to integrate public services with new technologies to improve sustainability and agricultural extension services, as well as facilitate women's participation in agricultural research, production and training.⁵⁷ As part of the Agriculture 4.0 model, Viet Nam has also renewed its commitment to integrating

53 Warnest and Bell, "Country Focus Viet Nam. In Information and Communications Technology Utilization in Land Administration in the East Asia Region."

54 The World Bank, "ICT in Agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions."

55 World Bank Group, "Digital Dividends."

56 The World Bank, "ICT in Agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions."

57 Ministry of Agriculture and Rural Development, "Gender Strategy for Agriculture and Rural Development."

51 World Bank Group, "Transforming Vietnamese Agriculture: Gaining More from Less."

52 World Bank Group.

new technologies into the agricultural sector to support economies of scale, input efficiency, commodity value, and environmentally friendly products. Formed on the basis of “more is less”, the 2014 Agricultural Restructuring Plan sets strategic sectoral goals to ensure agricultural development is financially, socially, and environmentally sustainable. This initiative is underlain by an emphasis on strengthening cooperation between value chain stakeholders in order to facilitate robust agricultural growth and competitiveness by improving productivity, efficiency, value-addition, and understanding of consumer preferences. Decision No. 879/QĐ-TTg, signed by Prime Minister Nguyen Tan Dung in 2014, approved the Industrial Development Strategy Through 2025 and Vision Toward 2035 to prioritize advanced technologies and communication in agriculture, concentrating on digital services, telephones, and software development.⁵⁸ Reiterating the national focus on technology development, the Overall Strategy for International Integration through 2020 specifies a focus on digital, cloud-based technology, e-commerce, and strengthening digital literacy.⁵⁹ The Strategy also focuses on attracting foreign and domestic investments by simplifying procedures for business establishment, and utilizing information technology in local governments for increased transparency. The 2016-2020 Five Year Socio-Economic Development Plan calls for better value chain management to accelerate processes involved in agriculture and food production and improve linkages between producers and consumer markets.⁶⁰

Viet Nam has recently taken steps to creating a more enabling environment for digital agriculture through infrastructure development and financial support. In early 2016, the Prime Minister approved the national Broadband plan, which aims to have 95% of residential areas covered by 3G/4G networks by 2020, provide 25 Mbps service to 60% of Internet users, and offer Broadband services at all public access points. This plan will improve communication capabilities and enable more efficient cooperation among value chains stakeholders.⁶¹ In preparation for 5G services, Viet Nam has passed the Law on Information Security, the first step towards a comprehensive piece of legislation for protecting users’ personal information and supporting cloud-based and data-driven technologies.

58 Socialist Republic of Viet Nam, “Prime Minister Nguyen Tan Dung on June 9, 2014 Signed Decision No. 879/QĐ-TTg to Approve the Industrial Development Strategy through 2025, Vision toward 2035.”

59 Socialist Republic of Viet Nam, “Overall Strategy for International Integration Through 2020, Vision to 2030.”

60 The National Assembly, “Resolution on Five-Year Socio-Economic Development Plan from 2016 - 2020.”

61 BSA Software Alliance, “Country: Viet Nam.”

Decision No. 575/QĐ-TTg aims to increase agricultural production value 500% by enhancing large-scale farm automation, establishing high-tech agriculture zones, and creating 500 digital agricultural cooperatives by 2020.⁶² As part of this effort to increase the quality of agricultural products and reduce costs, the Prime Minister has committed to improve investments in businesses developing digital agriculture solutions, and to host at least two hundred such businesses within its borders. Such full-fledged support from the government will enable producers to afford digital agriculture solutions, and will promote development of innovative and smart solutions, such as alternative credit scoring systems. The government has also acknowledged the tremendous potential of digital solutions in aquaculture. To help address communication gaps and information fragmentation within the sector’s value chain, the government’s national action plan for the development of the shrimp industry (Decision No. 79/QĐ-TTg) calls for the utilization of digital communication technologies. The Ministry of Agriculture has also promoted digital solutions for improving information access and multidirectional communication, and has recognized (Directive 6524/CT-BNN-KHCN) the limitations of the current legal framework in terms of a digital transformation toward 4.0 technologies in agriculture.

The government has also taken steps to strengthen its advisory and extension services, to champion multi-directional flows of information between providers and end users, and to support agribusinesses developing services for better market access and competition. The Ministry of Agriculture and Rural Development is currently building on the success of other programs, including the Viet Nam-Sustainable Agriculture Transformation Project, to develop a digital database to improve coffee seed traceability and resource management.⁶³ In 2019, the Department of Plant Protection also introduced a mobile app called Thuoc BTV to increase the efficiency of pesticide use and provide information on non-chemical alternatives.⁶⁴ As part of the government’s incentive package for financing digital agriculture, Decree No. 57/2018/ND-CP provides financial support for rural development programs to advance agricultural research and technology transfer. In early 2019 the Ministry of Agriculture and Rural Development, together with Viet Nam’s Youth Union, launched the One Commune One Product Initiative to provide US\$645 million

62 Shira and Das, “The Need for High-Tech Farming in Viet Nam.”

63 VNA, “Viet Nam to Manage Coffee Quality through New Database.”

64 IDH, “New App to Help Farmers in Viet Nam Improve Pesticide Use.”

in financial support to stimulate rural economies and start-ups.⁶⁵

The primary digital agriculture zones – Bac Ninh, Lam Dong, Ho Chi Minh City, Ninh Phuc, Thai Nguyen and the Mekong Delta – house the majority of the country's digital agriculture firms and cooperatives.⁶⁶ Universities and research institutes working in digital agricultural solutions include the Viet Nam Academy of Agricultural Sciences and their Agriculture Genetics Institute, Can Tho University, and the Viet Nam National University. The Viet Nam Farmers' Union has also been essential to the promotion of agricultural development and technology transfer. These entities work closely with nongovernmental organizations such as the United Nations Development Programme, Food and Agriculture Organization of the United Nations, German Society for International Cooperation, CARE, GrowAsia, the International Center for Tropical Agricultural, the International Agroforestry Center, and Market and Agricultural Linkages for Cities in Asia, as well as government agencies, to localize technology use on the ground with farmers. In some cases, farmers themselves have acted as co-producers in technology development. Cau Dat Farm, near Da Lat, was one of the first producers in Viet Nam to integrate IoT⁶⁷ technologies using a Demeter system called Connected Edge to control irrigation systems, weather stations, drones and sensor systems and produce cloud-based data and data analysis.⁶⁸

Digital agricultural services and applications available

A range of digital solutions are emerging in Viet Nam. In general, complex and pseudo-complex solutions are still in pilot phases, while those employing relatively simple digital technologies and services are being used at scale. More traditional services, such as broadcast programs, also provide basic information that is broadly accessible but simple in content, such as the televised 'Friends of Farmers' and the 'Voice of Viet Nam' radio program. Web-based initiatives offered by national ministries include Linking Extension and Research Needs through Information Technology (LEARN-IT), Vietnamese Rice Knowledge Bank, and Viet Nam Maize Knowledge Bank.⁶⁹

Private enterprises have been and continue to be the main solution developers in Viet Nam's digital agriculture. Some of the most prominent enterprises include VinEco, Hachi, TH True Milk, Vinamilk, Agrimedia, GreenCoffee, MimosasTEK, BacTom, RTAnalytics, Fsoft, TraceVerify and the Digital Agriculture Association of Viet Nam. The digital agriculture epicenters of Bac Ninh, Lam Dong, Ho Chi Minh City, Ninh Phuc, Thai Nguyen and the Mekong Delta are also home to the majority of these digital agriculture firms.⁷⁰ While these companies' cutting-edge technologies have yet to reach smallholders, and are not affordable for the vast majority of Viet Nam's farmers, their success has drawn national attention to optimizing agricultural processes and investing in digital solutions. The government has begun pushing for digital interventions to enhance resource management and productivity for smallholders and non-export crops.

For example, companies like VinEco, TH True Milk, and Vinamilk, with governmental support, have helped progress complex technologies such as automation, precision farming, genetic engineering,⁷¹ and IoT⁷² for applications in e.g., fully automated greenhouses⁶² for export crops. GREENcoffee offers market information, tailored crop calendars, and good agricultural practice information via push SMS⁷³ to coffee producers.⁷⁴

Public-private partnerships have helped to facilitate digital agricultural innovation. The remote sensing-based Information and Insurance for Crops in Emerging Economies (RIICE) is a collaborative project between the International Rice Research Institute, SwissRe, Sarmap, the German Society for International Cooperation, and the Swiss Agency for Development and Cooperation, to deliver advanced technologies to low-income farmers who would otherwise be unable to access them. Using remote-sensing technologies, RIICE provides producers and government officials with advanced information to make better decisions and manage risks.⁷⁵ In 2017, Google, in collaboration with the Viet Nam Farmers' Union (VNFU), began an initiative to enhance farmers' digital skills by recruiting 40 trainers and 500 support staff to provide training to at least 30,000 farmers in nine provinces by 2020.⁷⁶ The off- and online training program teaches

65 Nhan Dan Online, "One Commune One Product Start-up Programme Launched in Ho Chi Minh City."

66 Dung and Hiep, *Industrial Revolution 4.0: Opportunities and Challenges to Viet Nam's Economic Development*.

67 Internet of Things

68 Dung and Hiep.

69 Sylvester, "Information and Communication Technologies for Sustainable Agriculture: Indicators from Asia and the Pacific."

70 Dung and Hiep, *Industrial Revolution 4.0: Opportunities and Challenges to Viet Nam's Economic Development*.

71 Vy, "Hi-tech Farming Means Better Vietnamese Agriculture."

72 Internet of Things

73 Short Message Service

74 ICCO International, "Launch of GREENCoffee App for Coffee Farmers in Viet Nam."

75 Remote Sensing Based Information and Insurance for Crops in Emerging Economies, "About."

76 VNS, "Google to Help 30,000 Farmers Use Internet."

farmers how to use the Internet to find information, and how to use agricultural apps to boost productivity. The trainings also address the generational divide in digital literacy by including younger family members. The project is ongoing, and farmers have reported excellent outcomes, including using their new digital skills to compare crop and equipment prices and identify and treat animal health problems without traveling to reach a veterinarian.⁷⁷

Challenges for digital agriculture

The physical infrastructure required for technologies represents one dimension in the transformation to digital agriculture; another is the ability to interconnect these technologies with policies and financial mechanisms to enable their scale and success. In terms of enabling digital agriculture in Viet Nam, physical infrastructure is not the bottleneck, but rather the mechanism necessary to capture, store, and analyze data from various sources to develop value-added services.

Access to financial services and instruments is essential for producers to invest in improving efficiency of their production systems. However, there are very few financial institutions in the country that provide services for smallholders. Those that do provide loans and credit lines offer them at unaffordable interest rates. Several digital innovations, including alternative credit scoring approaches, employ data collected via mobile apps and app usage behavior as a proxy to assess risk of non-payment. In the neighboring countries of Cambodia and Myanmar, the concept of digital financial services, including alternative credit scoring for smallholders, has gained momentum and enabled the development of farmers' digital financial profiles. Given the lack of digital services consistently used by Vietnamese farmers, such metrics are nonexistent.

Consequently, similar services have not yet been achieved in Viet Nam, possibly because of a lack of available data on smallholders.

This creates a key problem for smallholders: financial services tend to be exclusively available to large-scale farms and producers of exportable commodities. Without sufficient financial services, small-scale producers are limited in their means to innovate. Digital innovations, mechanization, and automation, for example, have the potential to increase profitability, but adoption among producers is minimal due to poor access to loan and credit services. Even the preferential low-interest loans

used to incentivize digital agriculture investments have been limited to producers with the bandwidth to tackle onerous procedural requirements. For example, despite the aforementioned intensive agricultural research and development in recent years, only 30 agriculture businesses were certified as being high tech from 2010 to 2018.⁷⁸

Perceived quality, relative price point, and affordability have been shown to be particularly important prerequisites to the scaling of digital services in Viet Nam.⁷⁹ Approximately 60% of Vietnamese farmers are willing to pay for forecast information and advisory services. Farmers become less willing to pay if they consider the service to be a governmental responsibility, or if the content is comparable to free online information. Older farmers and women farmers as a whole are less willing to pay for weather services, probably because these groups tend to be less digitally literate and have lower household incomes.

Currently available technologies can be roughly divided into those accessible on feature phones and those accessible on smartphones.⁸⁰ For feature phones generally rely on IVR/SMS -based systems, such as the weather advisory service provided by Agrimedia. Smartphones offer more flexibility, ranging from IVR/SMS⁸¹-based services to automated irrigation control systems, such as those provided by MimosasTEK. Services that gather information and/or provide predictive decision-support tools remain very limited. Many simple processes, like certifications, are still being processed with pen and paper. In general, digital solutions are still in their infancy, with only large entities adopting advanced digital agriculture. Small-scale operations remain disorganized, but have an undeniable potential for digital transformation.

Perhaps the greatest barrier preventing stakeholders from effectively implementing digital solutions is low digital literacy. Among all four hubs, digital skills were highlighted as a key constraint. Although the majority of stakeholders have access to feature phones or smartphones, the actual usage of innovative features beyond SMS⁸² is relatively low. Digital literacy is distinguishable in each hub. For example, among producers it is marked by a generational gap favoring younger farmers, whereas for consumers, it is more prevalent in higher income individuals who have better access to smartphones. Producers require

78 VNS, "Agriculture Firms Struggle to Get Loans."

79 Trinh, Simelton, and Le, "Farmer Demand for Climate Services: Survey Results from Ha Tinh Province, Viet Nam."

80 Smartphones are distinguished from feature phones by the presence or absence of a touch screen.

81 Interactive Voice Response / Short Message Service

82 Short Message Service

77 Gajria, "Bringing Digital Skills Training to 30,000 Farmers in Viet Nam."

more and more sophisticated levels of knowledge and information to make informed decisions and identify deviations from traditional environmental conditions, but in order to access this information they need adequate digital skills. This highlights why digital literacy is perhaps the first step to be made in the digital transformation, as it renders or prevents the effective implementation and success of most digital interventions.

Enabling Digital Agriculture

An important first step in leveraging digital agriculture to solve real-world problems is identifying the most promising technologies across multiple end-user barriers.⁸³ This enables investors and implementers to focus their efforts on the areas of highest impact. Once enabling factors are identified and understood, the mainstreaming of digital agriculture in Viet Nam can begin in earnest.

Technologies with greatest potential and their impact⁸⁴

The major **cross-cutting** challenge for Viet Nam's agricultural sector is fragmentation in terms of intermediaries, stakeholders, and the flow of information and knowledge. The sector has become exceedingly business-oriented even while remaining small scale. This has led to various superfluous transactional costs and activities. The means of direct interactions and exchanges between producers, input providers, distributors, and consumers are drastically underdeveloped. The lack of information sharing and communication applies to each hub, and disproportionately impacts producers and distributors, who require ample information on market prices, weather, and yields to make critical decisions. The opportunities to address fragmentation are also cross-

83 In this analysis, we focus on identifying, for each of the end-user hubs, the main challenges confronting the agricultural sector. We then identify, using participatory methods, a set of technologies and associated functions and outcomes. Table 1 shows the results of the technology prioritization across hubs. Next, each technology was assessed across six dimensions: Progress (the current degree of development, use, maturity, scaling, uptake, and profitability of the technology), Policy and enabling environment (the degree to which policy, programs, and investments enable further development, adoption, and impact of the technology), Potential impact (the expected uptake and return on investments of the technology over the next decade), Efficiency (the extent to which the technology enhances food systems efficiency in terms of labor, inputs, yield, transport, and transaction cost reduction), Equity (the degree to which the technology breaks down barriers to equity, particularly in terms of youth and gender inclusivity), and Environment (the extent to which the technology supports environmental sustainability through waste reduction, greenhouse gas intensity reduction, and improved natural resource use efficiency). Each of these is assessed using a number of indicators. The results of the technology identification and assessment are described below, followed by a discussion of the policies, the role of the public and private sector, and the financing options available to support the promotion of the most promising technologies.

84 Disclaimer: These results are based on a combination of desk-research and stakeholder consultation. The latter includes 3 key interviews with the government and the private sector companies, as well as a one day workshop with 28 key experts in the fields of agriculture, policy and/or information communication technologies.

cutting: Viet Nam as a whole excels in digital infrastructure relative to neighboring countries. This creates a unique enabling environment in which the adoption of a single digital technology can easily benefit multiple hubs. For example, the creation of services that connect stakeholders and subgroups can improve decision making and efficiency across the value chain. **Smartphones** and **QR codes** show very high short-term potential and some degree of progress in addressing this issue. As a multi-hub platform, smartphone services will strengthen connections across hubs to help improve transparency, encourage knowledge sharing, and eliminate unnecessary intermediary costs. Using QR code, stakeholders will be able to trace product origins, production conditions, and pricing, thus improving marketing by meeting customer preferences and augmenting food safety by supporting good agricultural practices.

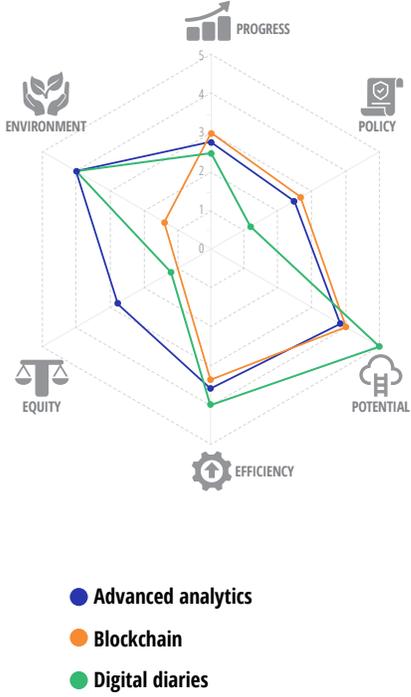
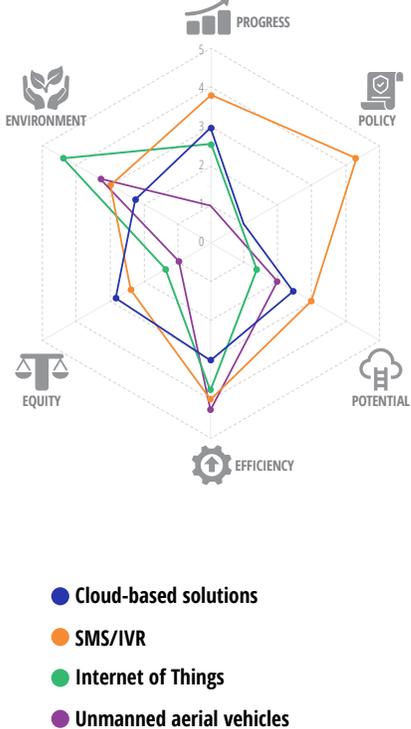
The **Input hub** struggles with an absence of accessible market information and digital farmer profiles. **Smartphone digital diaries** offer the greatest promise for establishing farmer profiles in the short to medium term. Digital diaries collect data to establish farmer profiles, promote experiential learning, and enable improved decision-making by monitoring the time and money allocated to individual farm activities. This results in increased input efficiency and environmental sustainability. The technology has huge potential in Viet Nam pending sufficient policy support. **Big data and analytics** show high potential for integrating Viet Nam's currently fragmented market and value chain information and improving accessibility to the same in the short term. Big data and analytics can also increase environmental sustainability, and have recently been supported by enabling policies that address Viet Nam's data security issues. This technology will provide both input suppliers, as well as other hubs, with consolidated market information to strengthen negotiation leverage.

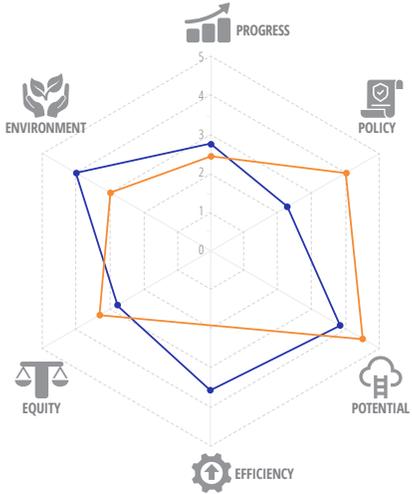
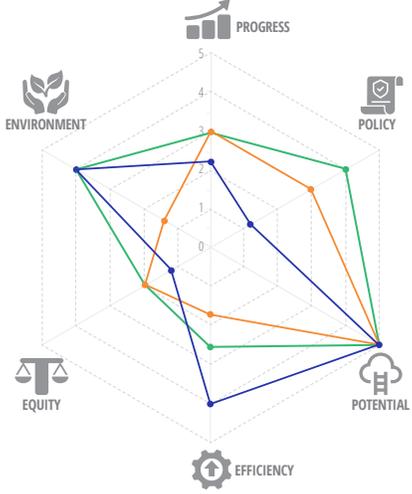
The **Production hub** faces the largest range of barriers, rooted in a lack of decision-support tools and monitoring systems. Addressing these issues would pave the way to resource use efficiency, streamlined communication, coordination with other stakeholders, and traceability, all of which are needed in order to achieve economies of scale and reduce greenhouse gas emissions⁸⁵

Digital technologies have already had important impacts in linking farmers to markets and key stages of the value chain in Viet Nam. Some degree of information access

85 World Bank Group, "Transforming Viet Nameese Agriculture: Gaining More from Less."

Table 1: Prioritized technologies

	Challenge	Technology	Outcome	Analysis
INPUT AND PRODUCER HUB	Lack of financial and decision support	 Advanced analytics for calculating accurate market information	Consolidates current market information to give farmers negotiation leverage	
		 Blockchain for Traceability	Allows E-Contracts and E-Finance to reduce processing times and improve input traceability	
	Lack of financial and decision support	 Digital Diaries for financial decision support	Improves input efficiency and provides weather advisories and information for better decision making	
PRODUCER HUB	Lack of effective and efficient farming systems based on quantitative information	 Cloud-Based Solutions for improved data sharing solutions	Improved on-farm decision support tools	
		 SMS/IVR systems for decision support	Producers have access to knowledge sharing	
		 Internet of Things for decision support	Improved on-farm decision support tools	
	Lack of information on farming systems	 Unmanned aerial vehicles for monitoring of farming systems and landscapes	Producers have access to knowledge sharing	

	Challenge	Technology	Outcome	Analysis
PRODUCTION & DISTRIBUTION HUB	Lack of decision support	 Advanced analytics for customized solutions	Customized solutions and improved decision making for end users using individual needs-based analytics	 <p>● Advanced analytics ● Cloud-based solutions</p>
		 Cloud-Based Solutions for improved information access	Improves stakeholder access to information and data, facilitates sharing and better decision making	
CROSS-CUTTING HUB	Accessible market information and multidirectional communication	 Mobile applications for integrated solutions	Saves time and money for farm activities, promotes experiential learning and improves decision making	 <p>● Applications ● Online platforms ● QR</p>
		 Online platforms for Price Info/Online Market	Improved decision making and competition on inputs, crop sales, processing, storage etc. based on market information and strengthen connections between farmers and retailers with guaranteed prices	
		 QR Code for Traceability	Tracking and tracing enables all parties in the value chain to trace back in case of problems or for marketing	

and extension services for producers are in place in the country, and the impact of connecting farmers to the Internet has brought well-documented improvements at the farm level in terms of productivity, profitability and sustainability. Phones give farmers better access to market prices, weather information, and knowledge about soil, seeds and fertilizer. Farmers are able to expand their networks and establish contacts directly with other buyers. This means that the prevailing market price more clearly signals the aggregated demand and value on any given day, and is more likely to fluctuate with demand and value over time. A recent study found that about 80% of farmers used a mobile phone to connect with agents and traders to estimate market demand and the selling price,⁸⁶ and more than half of these farmers would then make sale arrangements over the phone. Phones may also be enabling a sharing economy to take hold, whereby farmers who can't afford to buy mechanical equipment can rent it by the hour from other farmers by accessing online sharing sites. The growing sophistication and knowledge of value chains means that farmers can work directly with larger intermediaries, thus capturing more of the product's value.

Nevertheless, there remains several gaps in pest and disease forecasting and in peer-to-peer information sharing that are inhibiting producers from optimizing farm efficiency. Smartphone services are available that send out good agriculture practice information. However, most of these solutions are "pseudo-complex" in that they do not fully leverage the potential of smartphones to, for example, capture information from farmers via multidirectional communication. There is also very limited use of modern data analytics (machine learning and predictive analytics) in making advisory systems smarter, which may be due to the lack of data. For example, MimosasTEK's irrigation control systems, are automated, but still do not provide predictions to help farmers make better informed decisions.

The expansion of **mobile networks** and **cloud-based solutions** in the short term, and the **Internet of Things** in the long term, will enable farmer access to quantitatively-based decision-support tools. This will be particularly important in the isolated northern and mountainous regions. Cutting-edge network coverage increases the overall efficiency of advisory services and allows for cloud-based solutions and IoT⁸⁷ integration. These technologies, in turn, can generate new data sources to improve advisory services and decision making. Cloud-

⁸⁶ Reardon and Timmer, "The Economics of the Food System Revolution."

⁸⁷ Internet of Things

based technologies also promote data sharing, and IoT improves environmental sustainability through enhanced biophysical connectivity. Moreover, IoT can increase production efficiency by removing unnecessary manual labor, which may be especially important for women farmers. Thanks to government support in agricultural restructuring, the application of IoT in agriculture has already had preliminary successes. For example, IQShrimp is a digital software developed by Cargill. The software captures data about shrimp size, water quality, feeding patterns, health, and weather conditions from mobile devices, sensors, and automated feeders in shrimp ponds. IQShrimp uses this data to provide insights and recommendations on e.g. feeding management strategies and optimal harvest dates. Similarly, Smart Agri by Global CyberSoft collects remote real-time data, and enables farmers to monitor production status, adjust growing environments, and control production devices.

Unmanned aerial vehicles, data analytics, and cloud-based solutions offer the greatest short- to medium-term promise for establishing on-farm monitoring systems. Unmanned aerial vehicles (drones) are able to provide additional data and high resolution imagery to enhance landscape monitoring. Data analytics can create customized solutions for end users on a needs-basis, ensuring better decision making for on- and off-farm activities. Drones and analytics both generate large amounts of data; cloud-based systems are therefore key for providing easy data access to farm monitoring and decision-support tools. All three technologies show tremendous promise for increasing efficiency and environmental sustainability. However, their current state of progress, policy support and equity in Viet Nam is remarkably low. These technologies require significant capital investments, and sensor-equipped drones are not currently legal.

The **Distribution hub** faces the growing challenge of meeting consumer demands for higher quality products, requiring traceability technologies and improved monitoring systems. **Blockchain technologies** offer the most sustainable long term solution to these issues. Poor traceability extends to global markets, and the Ministry of Agriculture and Rural Development has acknowledged that the lack of proper labeling and inconsistency of standards threatens the success of Viet Nam's exported agricultural commodities.⁸⁸ Monitoring agricultural exports is essential for ensuring food safety and meeting import regulations. This is especially pertinent within the European Union, where Viet Nam has already accrued several violations

⁸⁸ VOV.VN, "Viet Nam's Hi-Tech Path towards Top Quality Agriculture."

and faces temporary bans. The absence of traceability technologies prevents proper monitoring of not only agricultural products and inputs, but also pest and disease control. There is already a demand for product traceability, but few technologies or services currently exist. Blockchain has matured to a moderate degree in Viet Nam with some policy support, but shows remarkable potential to enhance the overall efficiency of agricultural value chains. The scaling of blockchain technology will foster more e-contracts and e-finance to reduce processing times and improve traceability on both ends of the value chain.

Finally, the **Consumer hub** grapples with a lack of decision-support mechanisms. Consumers are demanding decision-support tools to inform their purchases, but generally remain unable to access relevant information or trace agricultural products to satisfy personal preferences. This represents an important opportunity for the producers of higher quality and local products to market them as such. **Smartphones** and **QR codes** are the most promising technologies in this regard. Traceability is a larger barrier for low income consumers whose purchases come from traditional distributors; supermarkets already require higher standards of food safety and certification.

Potential avenues for the public sector

Viet Nam has recently acknowledged the increased need for greater public financial support of enabling conditions to effectively stimulate digital innovation throughout the agricultural value chain, rather than just among large-scale stakeholders.⁸⁹ Public funding for agricultural research, which is administered through the Ministry of Agriculture and Rural Development and the Ministry of Science and Technology, has increased dramatically in recent years, from US\$10 million to US\$40 million between 2000 and 2012. Nevertheless, the total amount relative to Viet Nam's neighboring countries and the sector's GDP share remains small. Meanwhile, national investments in digital infrastructure, including servers, storage, peripherals, devices, network equipment, software, services, and network operations, are on par with the global averages relative to national GDP,⁹⁰ and investment levels in Internet infrastructure have been relatively stable since the early 2000s. Several digital innovations, such as database analytics, drones, and cloud-based systems, require substantial capital investment. Public financial support is needed in order for these technologies to reach their full potential. Specifically, financial support packages

should be allocated to smaller tech providers offering comprehensive services that consolidate farm and market data and offer multi-directional communication.

While the country is working to build international confidence in its digital economy, Viet Nam continues to censor Internet content and has not formulated comprehensive policies for protecting data or improving cybersecurity. Open data movements at the government level promote digital agriculture innovations,⁹¹ but current state-level data management still does not allow flow between ministries. There are also no mitigation mechanisms or safety nets for producers if government service algorithm predictions were to fail.

Some changes to existing policy and infrastructure would help establish an important enabling environment for technology providers, investors, and foreign companies. Viet Nam has already made much progress expanding 3G and 4G networks and is paving the way for 5G; continued investment in this regard will be essential to supporting communication and service delivery. Existing intellectual property laws are overseen by three separate ministries with little inter-sectoral communication. The Director of the Intellectual Property Department at the Ministry of Science and Technology has recommended an overhaul of the current system, with new policies and laws, better enforcement, increased awareness, and capacity building of government workers on intellectual property issues.⁹² Implementing such changes with an eye toward the emerging fields of digital transformation could significantly increase uptake of new technologies.

Additionally, cross-border data transfer and cloud systems are restricted by fragmented de facto requirements. The Law on Cybersecurity, which went into effect in 2019, has caused some concern for the nationalization of cloud-based systems.⁹³ Organizations that carry data and companies providing Internet-enabled services are now required to have at least one server system in the country, which in some cases may decelerate or prevent a move to the cloud. Cloud-based service providers are also not entirely exempt from tariffs or trade barriers, given that Viet Nam's licensing regulations for technology transfer may be applied to cloud services in some instances.⁹⁴ In addition, the Decree on Civil Cryptography (58/2016/ND-CP) allows the government

89 World Bank Group, "Transforming Vietnamese Agriculture: Gaining More from Less."

90 Huawei, "Country Profile for Viet Nam."

91 Department of Agriculture, Cooperation & Farmers Welfare, "Soil Health Card."

92 Tap chi Cong San, "Improving the Effectiveness of Intellectual Property Practices in Viet Nam to Meet the Requirements of Development and International Integration."

93 Das, "Viet Nam Approves New Law on Cybersecurity."

94 BSA Software Alliance, "Country: Viet Nam."

to access encrypted information. According to the BSA⁹⁵ Global Cloud Computing Scorecard, legal protection for intellectual property and requirements for data localization have kept Viet Nam in last place for every year since the scorecard index began.

Drones have also been subject to less favorable legislation despite having invaluable advantages in the context of agriculture. Current laws allow for drones to be flown, but ban any type of sensor use, which virtually eliminates their utility in the context of agriculture. Nevertheless, the Viet Nam National University of Agriculture has developed an ultra-light drone that is capable of applying fertilizer and pesticide inputs, monitoring diseases, and surveying landscapes. This recent success may be a helpful catalyst for additional innovation and policy revisions in this regard. At scale, this technology would reduce manual labor and labor costs, mitigate soil and water pollution, and save farmers up to 40% on chemical expenditures.⁹⁶

There is a need for public policy to stimulate the generation, dissemination, and use of agricultural data, with the ultimate goals of reconstructing the relevant agencies and programs to focus on the demands and priorities of producers, closing the digital literacy divide, and expanding farm-level knowledge of digital solutions. For example, digital diaries have huge potential in Viet Nam. To date, however, the technology has demonstrated only moderate growth as a result of a lack of sufficient policy support. Specifically, the public sector could expand existing extension services to offer centralized information resources on the entire value chain, including weather conditions, market prices, and pest and disease warnings. Local farmers' unions and NGO interventions could incorporate digital literacy and skills into their agricultural services.⁹⁷ Piloting, demonstration plots, and public awareness campaigns would help ensure that all stakeholder hubs and entrepreneurs are familiar with the digital innovations, solutions, and opportunities available to them. The generation and dissemination of such data resources would incentivize the private sector to leverage the data in developing practical and impactful solutions within the current context of the sector. Public data, in combination with digital agriculture providers' databases, could fill many data gaps in Vietnamese farming systems, thus facilitating additional needs-based research and services.

It is likewise up to the public sector to find ways to use private data in a manner that is beneficial to both

95 Software.org

96 Quy and Lam, "Ultra-Light Drone Used in Agriculture."

97 Gajria, "Bringing Digital Skills Training to 30,000 Farmers in Viet Nam."

public and private sector services while still respecting individuals' data privacy. An important aspect of this is building stakeholder trust through adequate vetting and regulation of digital agriculture services in terms of quality and potential risks around product validity, saliency, data privacy, and similar factors. Care must also be taken to avoid data inutility. As databases are developed, service providers eventually become data companies. When multiple data-driven companies exist in an environment that lacks interoperability, the problem then becomes excessive data that cannot be used .

Potential avenues for the private sector

One of the largest areas for growth in Viet Nam is within agribusinesses. In 2016, agricultural enterprises accounted for only 0.3% (1,740) of total businesses in the country.⁹⁸ Most (95%) of these were micro- or small-scale operations with fewer than 200 employees and less than US\$866,000 in capital. The few agricultural start-ups and solution developers that have been active in the country, however, have shown remarkable success. Encouraging more organizations to leverage the now-simplified procedures for high-tech agriculture producer certification will enable more farmers to qualify for loans from the preferential US\$4 billion credit package reserve.⁹⁹ The Agriculture and Rural Development Bank has also promised to reserve US\$2.3 billion in credit to support individuals, collectives, and enterprises engaged in higher standards of food production.¹⁰⁰ Continued engagement of public-private partnerships and co-financing will also be crucial in scaling digital interventions in Viet Nam.

Outlook / synthesis of recommendations

Viet Nam has laid a strong foundation for digital agricultural solutions, and the digital agriculture ecosystem is growing rapidly. Connectivity and subscription rates are high thanks to affordability, accessibility, and good governmental support. A number of digital solutions in agriculture have been met with significant success. This suggests important opportunities for digital solutions to the major challenges facing Vietnamese agriculture, most particularly information and communication gaps, inefficient systems, and a lack of decision support.

By integrating digital solutions into Viet Nam's agricultural

98 Dung and Hiep, Industrial Revolution 4.0: Opportunities and Challenges to Viet Nam's Economic Development.

99 VNS, "Agriculture Firms Struggle to Get Loans."

100 VNS, "Government to Promote High-Tech Agriculture."

value chain, stakeholders will be able to make better informed decisions to address the core challenges in food production. Through the utilization of communication, monitoring, and traceability technologies, the agricultural sector as a whole will transform from resource heavy to knowledge heavy, thus achieving a higher level of environmental sustainability, equity, efficiency, and prosperity.

Our research suggests that stakeholders who focus their efforts on developing solutions to provide information facilitating production, distribution, and purchase; actionable advisory systems; monitoring of farming systems and landscapes; and information exchange between input suppliers and producers are most likely to bring high-impact solutions to Viet Nam's agricultural sector. Specifically, QR codes and smartphones are the most promising technologies for creating production, distribution, and purchase information channels. Mobile networks, cloud technology, and Internet of things show the highest potential for creating actionable advisory networks. Unmanned aerial vehicles, data analytics, and cloud-based systems are best positioned for monitoring farming systems and landscapes. And digital diaries, big data, and blockchain show great promise for facilitating information exchange between input suppliers and producers. In all cases, piloting, demonstration plots, and public awareness campaigns will help ensure that farmers remain abreast of the digital innovations, solutions, and opportunities available to them.

Supportive national policy; public-sector investment; private-sector engagement in innovation and monetization; research and development contributions from organizations such as the World Bank, CGIAR and FAO; and other international donor support will all be crucial to ensuring the success of such solutions.

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