Digital agriculture to enable adaptation

A supplement to the UNFCCC NAP Technical Guidelines

Working Paper No. 372

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security
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Abstract

This document is a supplement to the UNFCCC NAP technical guidelines. It aims to raise awareness amongst national policymakers on the potential importance of digital agriculture (DA) in National Adaptation Plans (NAPs), provide tangible information on how it can be incorporated into NAP formulation and propose ways forward to implementing DA at scale.

The research for this supplement included reviewing the existing literature on digital agriculture and its role in supporting climate adaptation, alongside consultations with experts from the research community and UNFCCC.

The influence of digital technology on the agricultural sector has grown rapidly over the last decade. So far, its greatest influence has been in the Global North, though it has the potential to greatly disrupt the agricultural sector in the Global South this decade.

NAPs offer an opportunity to boost the climate resilience of the agricultural sector through promoting policies, incentives and the public-private partnerships needed for digital agriculture to thrive. Although there can be high upfront costs, the return on investment in digital agriculture can be correspondingly high when designed well.

Spatial information can significantly inform future government priorities and decisions regarding crop suitability and adaptation in the agricultural sector. This information can be used to directly feed into the NAPs themselves, as well as to help integrate agriculture into NAP indicators and outputs.

Digital market access tools can strengthen farmers' resilience to climate shocks and resulting market fluctuations. Promoting the adoption of improved digital market access could therefore be a key option to review as part of NAP design.

Overall, when well designed, DA can 'leapfrog' the challenges associated with traditional delivery channels. By 2030 it is expected that 80% of the world's rural areas will be digitally connected. This presents enormous potential for DA to help build climate resilience in the agricultural sector.

Going forward the NAP process presents a unique opportunity to achieve consistency amongst countries and pool efforts towards implementing DA at scale. It can also provide an entry point for development partners and other actors seeking to expand their own digital agriculture support programs.

Keywords

Agriculture; climate change; food systems; food security; digital; adaptation.

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Contents

Acronyms

AAAP	Africa Adaptation Acceleration Program
ABDP	Agricultural Big Data Platform
AfDB	African Development Bank
AgTech	Agriculture technology
AI	Artificial Intelligence
AICCRA	Accelerating the Impact of CGIAR Climate Research for Africa
ALL IN	Advancing Local Leadership, Innovation and Networks
ARAF	Acumen Resilient Agriculture Fund
ATA	Ethiopia Agriculture Transformation Agency
CCAFS	Climate Change, Agriculture and Food Security
CIAT	International Center for Tropical Agriculture
CIF	Climate Investment Funds
CSIR	Council for Scientific and Industrial Research
CSO	Civil Society Organization
CTA	Technical Centre for Agricultural and Rural Cooperation ACP-EU
DA	Digital Agriculture
DAK-Hub	Digital Agriculture Knowledge Hub
DAP	Digital Agriculture Platform
DCAS	Digital Climate Advisory Services
eDIAL	Enhancing Digital and Innovations for Agrifood Systems and Livelihoods
EIAR	Ethiopian Institute of Agricultural Research
Embrapa	Brazilian Agricultural Research Corporation
ENACTS	Enhancing National Climate Services
FAO	Food and Agriculture Organization of the United Nations
GCA	Global Center on Adaptation
GCF	Green Climate Fund
GDP	Gross Domestic Product
GFCS	Global Framework for Climate Services
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GSMA	Global System for Mobile Communications
ICED	International Centre for Evaluation and Development
ICRISAT	The International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communications Technology
IDSS	Intelligent Decision Support System
IFAD	International Fund For Agricultural Development

IoT	Internet of Things
IRI	International Research Institute for Climate and Society
IVR	Interactive Voice Response
JICA	Japan International Cooperation Agency
KGS	Krishi Gyan Sagar
KOPIA	Korea Program on International Agriculture
LDC	Least Developed Countries
LEG	LDC Expert Group
MAFF	Cambodian Ministry of Agriculture, Forestry and Fisheries
MEA	Multilateral Environmental Agreements
MoFA	Ministry of Food and Agriculture, Republic of Ghana
MRR	Markets, Risk and Resilience
NAP	National Adaptation Plans
NGO	Non-Governmental Organization
PAD	Precision Agriculture for Development
PICSA	Participatory Integrated Climate Services for Agriculture
PPCR	Pilot Program for Climate Resilience
RAP	Robust Adaptation Planning
RDA	Korean Rural Development Administration
SIDA	Swedish International Development Cooperation Agency
UC	University of California
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WBCSD	World Business Council for Sustainable Development
WEF	World Economic Forum
WUR	Wageningen University & Research

PART 1: What is the case for digital agriculture in National Adaptation Plans?

In this section, we provide a brief overview of the current and potential future significance of digital agriculture in relation to National Adaptation Plans (NAPs). This is followed by a focus on the potential of spatial information, access to markets and leapfrogging pathways in digital agriculture. Where relevant, reference is made to the pathways identified in Part 2 of this document. A list of further recommended readings on each of these topics is provided in the Appendix.

1.1 The disruptive power of digital agriculture

The influence of digital technology on the agricultural sector has grown rapidly over the last decade. So far, its greatest influence has been in the Global North, though it has the potential to greatly disrupt the agricultural sector in the Global South this decade.

1.1.1 How is digital agriculture already disrupting the sector?

- In the last decade, the number of digital agriculture services in developing countries has grown 1220% from 53 to 700 active services, with the majority of these in sub-Saharan Africa (62%)[1]. The services are divided into five use cases: (1) digital advisory, (2) agri digital financial services (access to services), (3) agri e-commerce, (4) digital procurement (access to markets), and (5) smart farming (access to assets). However, the sector is still emerging, with a lot of the active services being small scale, dependent on donor financing and at a pilot stage (see examples Box 1).[2]

- In sub-Saharan Africa, there are almost 400 digital agriculture solutions with 33 million registered farmers.[3] However reliable data at scale on their active use and impact on farmer climate resilience is limited. Bundled digital agriculture models (e.g., digital advisory services and financial services together in one product) have been shown to

[1] Phatty-Jobe A. 2020. *Digital Agriculture Maps 2020 State of the Sector in Low and Middle-Income Countries.* London, UK. GSMA. https://www.gsma.com/r/wp-content/uploads/2020/09/GSMA-Agritech-Digital-Agriculture-Maps.pdf

[2] Ibid.

[3] Tsan M, Totapally S, Hailu M, Addom, Benjamin K. 2019. The Digitalisation of African Agriculture Report 2018–2019. Wageningen, The Netherlands: CTA/Dalberg Advisers. https://cgspace.cgiar.org/handle/10568/101498

increase smallholder farmer income by 57% and productivity by 168%[4], making a substantial contribution to their climate resilience and adaptive capacity.

- However, at a global scale there are still at least 150 million smallholder farmers in developing countries without access to digital services.[5] Mehrabi et al. (2020)[6] found in a global study that only 24–37% of farms under one hectare in size are served by third generation (3G) or 4G services (the backbone of digital service delivery), compared to 74–80% of farms over >200 hectares. Croplands with severe yield gaps, climate stressed locations and food-insecure populations have poor service coverage.

1.1.2 What does the future hold for digital agriculture and its influence in the Global South?

- Digitalization and smart automation are expected to contribute as much as 14% to global GDP gains by 2030, the equivalent of US$15 trillion in value[7], revolutionizing the industries they are applied in. The use of digital technology in agriculture can have a transformative and positive disruptive impact on the adaptive capacity of farmers and agribusinesses, revolutionizing farming practices and the management of agrifood value chains in the future. According to research by McKinsey, increasing connectivity in agriculture through digital technologies could add US$500 billion to global GDP by 2030.[8] However, the extent to which this will benefit low resource and smallholder farmers at scale remains to be seen.

- **Precision agriculture is set to grow in emerging economies but will take longer to expand across the Global South.** The agricultural technology market in the next decade in the Global North will be driven by precision agriculture technology such as drones, robotics, IoT, AI, and blockchain. These technologies are most common in North America and Europe and are being rapidly adopted in large emerging

[4] Ibid.

[5] Steiner A, Aguilar G, Bomba K, Bonilla JP, Campbell A, Echeverria R, Gandhi R, Hedegaard C, Holdorf D, Ishii N, Quinn K, Ruter B, Sunga I, Sukhdev P, Verghese S, Voegele J, Winters P, Campbell B, Dinesh D, Huyer S, Jarvis A, Loboguerrero Rodriguez AM, Millan A, Thornton P, Wollenberg L, Zebiak S. 2020. *Actions to transform food systems under climate change.* Wageningen, The Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). https://hdl.handle.net/10568/108489

[6] Mehrabi Z, McDowell MJ, Ricciardi V. *et al.* 2021. The global divide in data-driven farming. *Nat Sustain* 4, 154–160. https://doi.org/10.1038/s41893-020-00631-0

[7] Trendov NM, Varas S, Zeng M. 2019. *Digital technologies in agriculture and rural areas – Status report.* Rome. http://www.fao.org/3/ca4985en/ca4985en.pdf

[8] McKinsey & Company. 2020. Agriculture's connected future: How technology can yield new growth. https://www.mckinsey.com/industries/agriculture/our-insights/agricultures-connected-future-how-technology-can-yield-new-growth

economies including India, China and Brazil.[9] While it is still early in the adoption cycle, the global precision farming market is expected to reach US$12 billion by 2025, up from US$9.5 billion in 2019.[10] For agricultural economies in the Global South where these technologies can be too costly to adopt at scale, mobile applications are likely to remain the key digital agriculture tools this decade.[11]

- **The spread of mobile technologies is opening up new opportunities for digitally driven agricultural systems.** Despite the mobile network coverage challenges highlighted above, more than three quarters of people in developing countries own a mobile phone.[12] Access to smartphones in particular is expected to increase as their costs decline. By 2030, it is expected that 80% of the world's rural areas will be digitally connected.[13]

Box 1. How have digital agriculture solutions positively disrupted the agriculture sector in the Global South?

We provide examples below of how digital agriculture solutions have been taken up by the agricultural sector in a range of countries across the Global South.

- **Kenya** has more digital agriculture solutions and users than any other sub-Saharan country, with over 100 solutions on the market. This includes large solution providers such as WeFarm, iCow and Pula, which provide solutions to hundreds of thousands of farmers. Digital agriculture has grown rapidly in Kenya due to high levels of connectivity, mobile phone usage and data transparency.[14]

This range of digital solutions has been developed by the public, private, NGO and international donor sectors. One such initiative is the One Million Farmer Initiative, from the World Bank, the Kenyan Ministry of Agriculture, Livestock, Fisheries, and Irrigation and the Korea–World Bank

[9] Trendov NM, Varas S, Zeng M. 2019. *Digital technologies in agriculture and rural areas – Status report.* Rome. http://www.fao.org/3/ca4985en/ca4985en.pdf

[10] Market Study Report. 2020. Global Precision Agriculture Market? Analysis By Offering, Technology, Application, By Region, By Country (2020 Edition): Market Insights and Outlook Post Covid-19 Pandemic (2020-2025). https://www.marketstudyreport.com/reports/global-precision-agriculture-market-analysis-by-offering-technology-application-by-region-by-country-2020-edition-market-insights-and-outlook-post-covid-19-pandemic-2020-2025

[11] Trendov NM, Varas S, Zeng M. 2019. *Digital technologies in agriculture and rural areas – Status report.* Rome. http://www.fao.org/3/ca4985en/ca4985en.pdf

[12] Fabregas R, Kremer M, Schilbach F. 2019. Realizing the potential of digital development: The case of agricultural advice. *Science* 366: 6471. https://science.sciencemag.org/content/366/6471/eaay3038.full?ijkey=aPtdvYNBuaLN6&keytype=ref&siteid=sci

[13] McKinsey & Company. 2020. Agriculture's connected future: How technology can yield new growth. https://www.mckinsey.com/industries/agriculture/our-insights/agricultures-connected-future-how-technology-can-yield-new-growth

[14] Tsan M, Totapally S, Hailu M, Addom, Benjamin K. 2019. The Digitalisation of African Agriculture Report 2018–2019. Wageningen, The Netherlands: CTA/Dalberg Advisers. https://cgspace.cgiar.org/handle/10568/101498

Partnership Facility. The initiative aims to link one million Kenyan farmers across 14 different agricultural value chains and 45 counties in Kenya to a digitally enabled platform.[15]

- In **India,** the digital agriculture ecosystem is also developing rapidly, and precision agriculture, crop insurance, e-commerce and digital advisory platforms for agriculture are growing particularly quickly. It is estimated that these digital technologies will help bolster food security in India and add US$50 billion to US$65 billion of value to the economy by 2025.[16] An example of an existing public-led AgTech platform is the government's electronic National Agriculture Market (eNAM), which is available in 585 locations in 16 states and can help farmers improve the prices they receive for crops by 15%.

- **Brazil** has embraced digital agriculture, largely being driven by the government through the Brazilian Agricultural Research Corporation (Embrapa).[17] The technological infrastructure in the country has improved with increased connectivity, remote sensing and mobile network penetration. Between 2012 and 2017, smartphone penetration increased from 16% to over 70%.[18] As of 2018, there were 338 AgTech startups in the country, with the majority being located in the 'AgTech Valley', Piracicaba.[19] Precision agriculture has advanced rapidly in the country, with US$57.5 million of investments in precision agriculture technologies in 2019 (this is expected to reach US$330.8 million in the coming years).[20]

Given the reliance of digital agriculture solutions on national digital infrastructure and adequate supporting services, it is possible to conclude that they are less or even marginally relevant for countries in the **Least Developed Countries (LDC)** group. However, as outlined in Box 2 below, a number of the world's clearest examples of digital agriculture benefits for farmer resilience are within LDCs. The relevance of these solutions are arguably of equal importance in LDCs or in some cases even greater where there are opportunities to leapfrog infrastructure that hinders digital agriculture development in other countries. Efforts in LDCs may be more government led in their early years, transitioning to greater private sector engagement as the digital economy develops.

[15] Kim J, Shah P, Gaskell JC, Prasann A, Luthra A. 2020. *Scaling Up Disruptive Agricultural Technologies in Africa. International Development in Focus.* Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/33961

[16] McKinsey. 2019. Digital India. https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Digital%20India%20Technology%20to%20transform%20a%20connected%20nation/MGI-Digital-India-Exec-summary-April-2019.pdf

[17] OECD (2020). Going Digital in Brazil. https://www.oecd-ilibrary.org/sites/4f5ebe9d-en/index.html?itemId=/content/component/4f5ebe9d-en

[18] Ibid.

[19] AgFunder website. https://agfundernews.com/brazil-agtech-market-map-338-startups-innovating-in-agricultural-powerhouse.html

[20] Ibid.

Box 2. The emergence of digital agriculture solutions in LDCs

- **Ethiopia** has successfully implemented a government-led development model for digital agriculture. As of 2019, there are over 29 digital solutions active in the country, with 5 million total users.[21] The government is the sole distributor of farming inputs, and employs the largest network of agricultural extension agents in Africa. Ethiopia established the Agriculture Transformation Agency (ATA) to help grow and transform its digital agriculture sector. The ATA helps design and implement digital solutions in the country. For example, the ATA has developed a '8028 Farmer Hotline' service with the Ethiopian Institute of Agricultural Research (EIAR). This service provides agronomic advice via voice recordings and automated SMS messaging. Over 3.6 million farmers have registered to the hotline and have logged 30.3 million phone calls.[22] The ATA has collaborated with Mercy Corps to develop a data hub to provide data-driven solutions to help increase farmers yields, production and income.[23] The ATA and the Government of Ethiopia's Ministry of Agriculture have also partnered with Digital Green to provide agronomic advice via video, IVR, radio and mobile phones to over 440,000 farming households.[24]

- As part of Vision 2021, the Government of **Bangladesh** has established the 'Digital Bangladesh' strategy, which places digital technology at the center of the country's development plans and is looking to digitize systems and structures across rural administrative and local government units.[25] It aims to bring socioeconomic transformation through digital technology that can enable Bangladesh to eradicate poverty and transition to a middle-income country. The mobile industry has grown rapidly in the country, with 85 million unique subscribers to mobile networks (i.e. over half the population).[26] This increased connectivity and affordability of mobile phones and internet services that has been stimulated by Digital Bangladesh has increased the supply chain resilience of smallholder farmers, as shown during COVID-19.[27] Over 57 virtual call centers were set up in the country in eight high-poverty districts, to facilitate the purchase of agricultural inputs, services, and goods. Mobile money operators including bKash, Rocket and Nagad have helped facilitate paperless payments. As of February 2021, the virtual call centers have supported almost 60,000 smallholder farmers in Bangladesh, enabling the sale of thousands of tons of products, and providing agronomic information.[28]

[21] Tsan M, Totapally S, Hailu M, Addom, Benjamin K. 2019. The Digitalisation of African Agriculture Report 2018–2019. Wageningen, The Netherlands: CTA/Dalberg Advisers. https://cgspace.cgiar.org/handle/10568/101498

[22] ATA. 2018. 8028 Farmer Hotline. http://www.ata.gov.et/programs/highlighted-deliverables/8028-farmer-hotline/#:~:text=Smallholder%20farmers%20can%20access%20the,pulses%20and%20high%2Dvalue%20crops

[23] ATA. 2020. ATA and Mercy Corps sign a memorandum of understanding for the use of a digital platform to enable data-driven support to farmers. http://www.ata.gov.et/ata-mercy-corps-sign-memorandum-understanding-use-digital-platform-enable-data-driven-support-farmers/

[24] Digital Green website. https://www.digitalgreen.org/ethiopia/

[25] Bangladesh Government website. http://btri.portal.gov.bd/sites/default/files/files/btri.portal.gov.bd/page/a556434c_e9c9_4269_9f4e_df75d712604d/Digital%20Bangladesh%20Concept%20Note_Final.pdf

[26] GSMA. 2018. Country overview: Bangladesh Mobile industry driving growth and enabling digital inclusion. https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=30933394&file=Country%20overview%20Bangladesh.pdf

[27] Mostafa I. 2020. Digital technology ensures food supply in rural Bangladesh during COVID-19. https://blogs.worldbank.org/endpovertyinsouthasia/digital-technology-ensures-food-supply-rural-bangladesh-during-covid-19

[28] MMI Bangladesh A2F+ (n.d). Increasing access to finance for farmers' organizations in Bangladesh MMI Bangladesh A2F+ Project. https://datastudio.google.com/u/0/reporting/7d9695f2-51c9-49c3-aafc-e70773448675/page/qClLB

- The Government of **Cambodia** has included agriculture modernization as a key theme in its Agricultural Sector Master Plan 2030.[29] There has been rapid expansion of digital infrastructure in the country, with smartphone penetration increasing from 13% to 43% between 2013 and 2018.[30] The Cambodian Ministry of Agriculture, Forestry and Fisheries (MAFF) has partnered with IFAD to develop tools to ensure extension services are delivered to smallholder farmers through digital technology.[31] The partnership with IFAD is aiming to reach 200,000 rural households in the country. MAFF is also aiming to establish an Agricultural Big Data Platform (ABDP), which will provide traceability, agronomic advice and will help connect smallholders to financial services.[32] This enabling environment has attracted organizations in Cambodia to develop big data solutions, such as BlocRice, a platform using blockchain technology to connect players in the rice supply chain.[33]

1.1.3 How can digital agriculture enhance national adaptation actions and NAPs?

NAPs offer an opportunity to boost the agricultural sector's climate resilience through investing in the supporting services and public-private partnerships needed for digital agriculture to thrive. Although there can be high upfront costs, the return on investment in digital agriculture can be correspondingly high. Examples of the potential return on investment include cost-benefit ratios of 1:48 US$ for the Satellite-Assisted Pastoral Resource Management in Ethiopia; 1:10 US$ for the Precision Agriculture for Development program in India; and up to 1:70 in Kenya.[34] These potential returns on investment in digital agriculture should be kept in mind during Step B3 (Part 2) when appraising national adaptation options for the sector.

Some of the ways this investment can enhance national adaptation processes include:

- National digital advisory services can help increase productivity and efficiency across the entire agricultural sector, increasing its resilience and adaptive capacity to climate-related impacts. The wider reach of agronomic advice through digital platforms can help

[29] IFAD. 2019. Sustainable Assets for Agriculture Markets, Business and Trade (SAAMBAT) Project Design Report. https://webapps.ifad.org/members/eb/127/docs/EB-2019-127-R-24-Project-Design-Report.pdf

[30] GSMA. 2018. Joonaak: Helping small merchants navigate logistics challenges and benefit from e-commerce in Cambodia. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2018/08/Joonaak-Helping-small-merchants-navigate-logistics-challenges-and-benefit-from-e-commerce-in-Cambodia.pdf

[31] Kaushik Barua, Sakphouseth Meng. 2020. Never let a good crisis go to waste. https://www.ifad.org/en/web/latest/blog/asset/41974453

[32] Khmer Times. 2020. New high-tech move in farming. https://www.khmertimeskh.com/50757473/new-high-tech-move-in-farming/

[33] Oxfam (n.d.). BlockChain For Livelihoods From Organic Cambodian Rice (BlocRice) Project. https://cambodia.oxfam.org/BlocRice

[34] GCA (DRAFT). Investment Blueprint for Digital Climate Advisory Services to reach 300 million Smallholder Producers by 2030.

raise agricultural productivity, reduce negative environmental footprints, and increase resilience against shocks at a national scale. A meta-analysis of mobile technologies disseminating agricultural information in India and sub-Saharan Africa found that farmers were 22% more likely to adopt the recommended agrochemical inputs, yielding US$10 in benefits for every US$1 spent.[35]

The Intelligent Decision Support System (IDSS) in Bangladesh[36] has demonstrated efficiency gains for the 100,000 farmers that have been provided services, resulting in 30% reductions in seed volumes used, 20% less fertilizer and pesticides, and 15% less water usage for equal yields.[37]

However significant productivity and efficiency gains are not a given. There have been issues with substandard quality in the delivery of digital advisory services in particular and the enhanced use of sector-wide standards and guidelines are needed to help improve consistency in service delivery quality.[38]

- Digital agriculture can increase connectivity between farmers and enhance resilience across the agricultural value chain through digital networks, allowing for better access to high-quality, real-time data which can be utilized to adapt to climate impacts. For example, WeFarm has created a farmer-to-farmer digital network of over 2 million farmers using AI, machine learning and big data in Kenya, Tanzania and Uganda. Farmers received agronomic advice through SMS messaging. WeFarm also provides a platform for farmers to share knowledge, business ideas, questions and suggestions on access to quality products.[39]

Yet, digital penetration is not universal, and there are still barriers to access for certain farmer groups including a lack of access to electricity, digital illiteracy, and high costs to accessing broadband. Ensuring digital agriculture solutions are farmer-centered and provide equitable access across social groups is vital.

[35] Fabregas R, Kremer M, Schilbach F. 2019. *Realizing the potential of digital development: The case of agricultural advice.* https://science.sciencemag.org/content/366/6471/eaay3038?utm_campaign=toc_sci-mag_2019-12-12&et_rid=293396612&et_cid=3121433

[36] For more information: https://nso-g4aw.akvoapp.org/en/project/5305/#report

[37] GCA (DRAFT). Investment Blueprint for Digital Climate Advisory Services to reach 300 million Smallholder Producers by 2030.

[38] Personal communication. Steve Prager, January 29th 2021.

[39] GSMA. 2020. Digital Agriculture Maps 2020 State of the Sector in Low and Middle-Income Countries. https://www.gsma.com/r/wp-content/uploads/2020/09/GSMA-Agritech-Digital-Agriculture-Maps.pdf

- **Data from digital solutions can be used to respond to extreme climate events.** Accurate weather and climate forecasts combined with agronomic advisories can increase the ability of farmers to respond to high impact events and weather conditions influenced by climate variability and change. For example, in 2014, data from the national meteorological service was used by CIAT researchers to provide timely guidance on when to plant rice in Colombia, saving 170 rice farmers an estimated US$ 1.7 million in drought-induced losses.[40] The researchers used 10 years of historical data on yields and climate that was captured from mobile applications, which was then fed into a computer model that predicted the drought in the region.[41]

[40] CCAFS. 2014. Cracking patterns in big data saves Colombian rice farmers' huge losses. https://ccafs.cgiar.org/outcomes/cracking-patterns-big-data-saves-colombian-rice-farmers-huge-losses
[41] Ibid.

1.2 The power of spatial information: site-specific agriculture

The growing influence of spatial information and remote sensing

Significant progress has been made in remote sensing that can provide high spatial resolution images across the world on a daily basis.[42] Remote sensing satellite imagery can provide imagery from all parts of the globe, apart from areas under permanent cloud cover. This technology has evolved to provide very high-resolution images – with a possibility to go down to <1 meter, which makes it usable for precision agriculture solutions. Worldwide, two billion people are estimated to be users of remotely sensed data and geospatial datasets.[43] This shows the huge potential remote sensing has to inform and enhance the effectiveness of AgTech solutions and enhance their effectiveness as a tool for climate adaptation and operational management in agriculture. Some of the ways in which this can reduce uncertainty and improve decisions made by farmers include:

- **Remote-sensing data can be used to inform national-level adaptation plans**. A recent study by Michigan State University supported by the USDA National Institute of Food and Agriculture used remote-sensing data to identify areas with unstable crop yields to implement adaptation practices for crop production in Midwestern United States.[44] The study identifies 2.65 million hectares of water-stress prone cropland, which has lost US$536 million due to yield variation.[45] With access to the appropriate resources and expertise, this type of large-scale data analysis could directly feed into the agricultural components of adaptation plans for many other countries.

- Open data sharing by meteorological agencies with AgTech providers can be critical in helping farmers responding to fast-onset climatic events. Partnerships between meteorological agencies and organizations providing digital advisory services can use satellite data to provide rapid agronomic advice to farmers. For example, the Indian Government in collaboration with Handygo Technologies uses satellite data from the

[42] Digital Globe (n.d.). Remote Sensing Technology Trends and Agriculture. https://dg-cms-uploads-production.s3.amazonaws.com/uploads/document/file/31/DG-RemoteSensing-WP.pdf
[43] Ibid.
[44] Martinez-Feria RA, Basso B. 2020. Unstable crop yields reveal opportunities for site-specific adaptations to climate variability. *Sci Rep* 10, 2885. https://www.nature.com/articles/s41598-020-59494-2
[45] Ibid.

India Meteorological Department to deliver the mKisan digital advisory service[46], which currently reaches over 5 million farmers with weather-informed agronomic advice.[47] The NAP process can help to bring these stakeholders together to deliver collaborative programs that help farmers cope with climate variability.[48]

The World Bank Agriculture Observatory combines ground-based data with satellite-data and feeds this into machine learning applications to actively monitor the majority of the earth's agricultural land. This data comprises 7 billion data points generated every 6 hours from 1.5 million virtual weather centers.[49] The observatory can provide early warnings of potential food shocks months in advance of these occurring, and has been used by governments in Kenya, Ethiopia, Russia, Zambia and Zimbabwe.

- **Remote sensing data can be used to fill in temporal and spatial gaps in meteorological observations**, particularly in developing countries where the number of ground-based observations is very sparse and has been declining. An example would be the ENACTS (Enhancing National Climate Services) approach, which has been working with National Meteorological and Hydrological Services, mainly in Africa, to improve the availability of high-quality climate data through the combination of quality-controlled national meteorological observations with satellite-derived precipitation estimates.[50]

- **Remote sensing data can also improve local weather forecasts used in agronomic advisory services**. Remote sensing data can provide additional information, and offer more spatially consistent and localized information relative to traditional ground-based observations. Such information can be used (especially in combination with station-based data as referenced above) to develop and validate improved weather (and seasonal climate) forecasts. Such products have been developed by national meteorological agencies, but also by private providers (e.g. Ignitia). It is important that

[46] GSMA. 2016. Weather forecasting and monitoring: Mobile solutions for climate resilience. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2016/02/Weather-forecasting-and-monitoring-mobile-solutions-for-climate-resilience.pdf

[47] mKisan website: https://mkisan.gov.in/

[48] Dinesh D, Loboguerrero Rodriguez AM. 2019. Scaling Digital Agriculture to Leapfrog Development Pathways. https://ccafs.cgiar.org/news/scaling-digital-agriculture-leapfrog-adaptation-pathways

[49] World Bank Group. 2019. Future of Food - Harnessing Digital Technologies to Improve Food System Outcomes. https://openknowledge.worldbank.org/bitstream/handle/10986/31565/Future-of-Food-Harnessing-Digital-Technologies-to-Improve-Food-System-Outcomes.pdf?sequence=1&isAllowed=y

[50] Dinku T, Thomson MC, Cousin R, del Corral J, Ceccato P, Hansen J, Connor SJ. 2018. Enhancing National Climate Services (ENACTS) for Development in Africa. Climate and Development. https://doi.org/10.1080/17565529.2017.1405784

information producers both document and validate forecasts before incorporating them in operational advisory services.

- Spatial information can provide a powerful data set to inform future government priorities and decisions regarding crop suitability and adaptation in the agricultural sector. This information can be used to directly feed into the NAPs themselves, as well to help integrate agriculture into NAP indicators and outputs. Specifically, remote sensing can be used as a tool for monitoring process and outcome indicators such as productivity per unit of land, improved income stability and nutrition and/or improved adaptive capacity.[51] Digital tools can help to make the monitoring process simpler and more cost effective.[52]

Box 3. How climate finance is supporting spatial data-focused digital agriculture

The Green Climate Fund (GCF) is one the world's most prominent climate finance mechanisms. It has a number of projects in its portfolio that include the use of spatial information for agricultural resilience, with the majority focused on increasing the provision of climate and meteorological information systems and services. These include:

- Scaling Up of Modernized Climate Information and Early Warning Systems in Malawi;
- Africa Hydromet Program - Strengthening Climate Resilience in Sub-Saharan Africa: Mali Country Project;
- Africa Hydromet Program: Strengthening Climate Resilience in Sub-Saharan Africa: Burkina Faso country project;
- Scaling-up Multi-Hazard Early Warning System and the Use of Climate Information in Georgia;
- Climate services and diversification of climate sensitive livelihoods to empower food insecure and vulnerable communities in Kyrgyzstan;
- Supporting Climate Resilience and Transformational Change in the Agriculture Sector in Bhutan;
- Multi-Hazard Impact-Based Forecasting and Early Warning System for the Philippines;

[51] Dinesh D, Campbell B, Bonilla-Findji O, Richards M (eds). 2017. *10 best bet innovations for adaptation in agriculture: A supplement to the UNFCCC NAP Technical Guidelines.* CCAFS Working Paper no. 215. Wageningen, The Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). https://ccafs.cgiar.org/resources/publications/10-best-bet-innovations-adaptation-agriculture-supplement-unfccc-nap

[52] Dinesh D, Loboguerrero Rodriguez AM. 2019. Scaling Digital Agriculture to Leapfrog Development Pathways. https://ccafs.cgiar.org/news/scaling-digital-agriculture-leapfrog-adaptation-pathways

- Enhancing Climate Information Systems for Resilient Development in Liberia; and
- Enhancing Climate Information and Knowledge Services for resilience in 5 island countries of the Pacific Ocean.

The GCF has also invested in the Acumen Resilient Agriculture Fund (ARAF). ARAF seeks to support pioneering and early-growth stage innovative agribusinesses that enhance the climate resilience of smallholder farmers in East and West Africa. Specifically, the US$56 million fund invests in aggregators (companies that offer bundled climate solutions), digital information platforms and financial service providers.[53]

How can this support the pathways for the National Adaptation Plan process (see Part 2)?

- **Spatial information and remote sensing in digital agriculture is particularly useful for Element B of the NAP process** (analyzing current climate and future climate change scenarios). It can be a powerful tool to assess climate vulnerabilities in the agricultural sector and identify appropriate adaptation options.
- **It also has an important role in Element D (monitoring and reviewing the NAP process),** being used to help update NAPs based on the latest data and advances in remote sensing technology.

[53] Green Climate Fund. 2020. Acumen Resilient Agriculture Fund at a Glance. https://www.ctis.re.kr/en/downloadBbsFile.do?atchmnflNo=5071

1.3 Enabling access to markets

Digital agriculture is providing platforms for farmers to access new buyers and formal markets.

Digital procurement and e-commerce allow farmers to bypass intermediaries and gain access to new markets. Agri e-commerce services in developing countries have increased 1950% in 10 years and digital procurement services have increased 3600% in the same time period.[54] Market access is crucial for farmer development as it allows them to bypass intermediaries, to have better access to information, and to obtain fairer prices. Consequently, farmers are able to increase their income and resilience against climate change impacts. Some of the ways in which digital agriculture enables market access and supports national adaptation objectives include:

- Mobile technologies, particularly smartphones, can provide better access to markets and price information for smallholder farmers. This can help to reduce price market distortions caused by traditional intermediaries, thereby increasing the resilience of vulnerable farmers. A study of farmers in Bangladesh, China, India, and Vietnam found that 80% of farmers used mobile phones to connect with agents and traders to estimate market demand and the selling price.[55] NAPs could include actions to help expand the adoption and effective use of these services in countries where they aren't already in widespread use.[56]

- **Digitalization of market information can improve equitable access to information by disadvantaged and vulnerable groups.** Adaptation actions should focus on supporting vulnerable groups to engage in the agricultural marketplace more effectively. Female farmers may benefit to a disproportionate degree from digital agriculture market tools, as they are often more constrained in their access to technology, markets and

[54] GSMA. 2020. Digital Agriculture Maps 2020 State of the Sector in Low and Middle-Income Countries. https://www.gsma.com/r/wp-content/uploads/2020/09/GSMA-Agritech-Digital-Agriculture-Maps.pdf
[55] Reardon TA, Chen KZ, Minten B, Adriano L. 2012. The quiet revolution in staple food value chains. IFPRI. https://www.ifpri.org/publication/quiet-revolution-staple-food-value-chains
[56] GSMA. 2019. E-commerce in agriculture: new business models for smallholders' inclusion into the formal economy. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2019/05/E-commerce_-in_agriculture_new_business_models_for_smallholders_inclusion_into_the_formal_economy.pdf

information.[57] The NAP process is an opportunity to promote adaptation actions which address these gender and social inequities.

- **Digital technologies lower the barriers of entry into farming**, as technologies have become more affordable and accessible and they significantly lower costs linking buyers and sellers. Extension agents can use digital technologies including voice, text, videos, and the internet to communicate with more farmers. In India, Digital Green working with the Government of Andhra Pradesh has used this technology to reach 1.9 million smallholder farmers. Results indicate that this video-enabled extension has achieved 30% greater reach, 35% higher uptake of promoted practices, and a 22% increase in women accessing extension services.[58]

Box 4 below provides an example of how a digital solution in Ghana is improving market access to farmers.

Box 4. How a digital solution is improving market access for farmers in Ghana.

Esoko has established a digital platform model that has reached over 1 million farmers in 20 countries, providing market price information, weather forecasts, agronomic advice and access to a farmer helpline.[59] Esoko has established partnerships with governments, and curates open government data to help farmers improve their farming operations and achieve better prices.[60]

In Ghana, Esoko has developed partnerships with aWhere, Vodafone, the Ghana Meteorological Agency, the Council for Scientific and Industrial Research (CSIR), the Ministry of Food and Agriculture (MoFA) and farmers. This is strategically linked with the Government's 'Planting for Food and Jobs' initiative, which aims to improve food security and employment in the agricultural sector in Ghana. Over 300,000 farmers subscribed to Esoko in Ghana, and data from a pilot study indicated that access to and use of climate information resulted in increased crop yields and reduced crop failure by 70%.[61] This demonstrates that establishing PPPs can achieve impact at scale for farmers, helping to increase their climate resilience.

[57] Trendov NM, Varas S, Zeng M. 2019. *Digital technologies in agriculture and rural areas – Status report.* Rome. http://www.fao.org/3/ca4985en/ca4985en.pdf

[58] Digital Green website. https://www.digitalgreen.org/india/

[59] Esoko website. https://esoko.com/portfolio/improving-the-lives-of-farmers-with-vodafone/

[60] van Schalkwyk F, Young A, Verhulst S . 2017. Esoko – Leveling the Information Playing Field for Smallholder Farmers in Ghana. https://odimpact.org/files/case-esoko.pdf

[61] Partey S, Kotey Nikoi G. 2019. A CCAFS-Informed Public-Private Partnership Reaches 300,000 Farmers With Climate Information. https://ccafs.cgiar.org/news/ccafs-informed-public-private-partnership-reaches-300000-farmers-climate-information

How can this support the pathways for the National Adaptation Plan process (Part 2)?

- Promoting the adoption of improved market access technology for farmers could be a key option to review as part of B3, as a key tool to strengthen their resilience to climate shocks and resulting market fluctuations.

1.4 Leapfrogging development pathways

Digital agriculture can 'leapfrog' the challenges associated with traditional delivery channels.

By 2030, it is expected that 80% of the world's rural areas will be digitally connected.[62] This presents enormous potential for digital agriculture to help 'leapfrog' traditional delivery channels, which is already being demonstrated in a number of areas:

Farming households moving directly to digital rather than physical branch-based accounts. The number of bank account owners using digital financial services in the developing world rose from 57% to 70% of account owners between 2014 and 2017, showing their growth in popularity.[63] In 2019, there were 290 live mobile money services in 95 countries, serving over 372 million active customers.[64] This helps improve access to finance for farming households in remote rural areas. Globally, there are 200 million people in agricultural value chains who are paid in cash only – which suggest that there is a clear opportunity to reduce the number of unbanked individuals.[65] In South Asia, digitizing payments for agricultural products could reduce the number of unbanked adults by roughly 40 million.[66]

Having good access to financial services makes it easier for farmers to plan for the future, absorb climate-related shocks and manage risks. In Kenya, the introduction of M-PESA is estimated to have lifted 194,000 households, or 2% of Kenyan households, out of poverty.[67]

The digitalization of value chains can increase the accessibility and scale of delivering specialized inputs and machinery to smallholder farmers. Improved inputs such as climate-resilient crop seeds and fertilizers can help to increase yields and crop quality, resulting in increased sales and profits. Having the correct machinery can result in a 10% reduction in harvest costs, a 5% reduction in carbon emissions, and a 2% reduction in post-harvest

[62] McKinsey & Company. 2020. Agriculture's connected future: How technology can yield new growth. https://www.mckinsey.com/industries/agriculture/our-insights/agricultures-connected-future-how-technology-can-yield-new-growth

[63] World Bank. 2018. Financial Inclusion on the Rise, But Gaps Remain, Global Findex Database Shows. Press Release. https://www.worldbank.org/en/news/press-release/2018/04/19/financial-inclusion-on-the-rise-but-gaps-remain-global-findex-database-shows

[64] GSMA. 2020. State of the Industry Report on Mobile Money. https://www.gsma.com/sotir/wp-content/uploads/2020/03/GSMA-State-of-the-Industry-Report-on-Mobile-Money-2019-Full-Report.pdf

[65] World Bank. 2018. Financial Inclusion on the Rise, But Gaps Remain, Global Findex Database Shows. Press Release. https://www.worldbank.org/en/news/press-release/2018/04/19/financial-inclusion-on-the-rise-but-gaps-remain-global-findex-database-shows

[66] Ibid.

[67] Suri T, Jack W. 2016. The long-run poverty and gender impacts of mobile money. *Science* 354(6317). https://science.sciencemag.org/content/354/6317/1288

losses.[68] These assets are becoming increasingly accessible to smallholder farmers. Since their inception in 2013, there are now 20 asset-sharing platforms providing smallholder farmers access to a range of mechanized farm equipment in developing countries[69] (for an example of an asset-sharing platform see Tun Yat in Box 5 below).

Digital platforms link farmers to an expansive market, bypassing the reliance on traditional intermediaries and reducing the transaction costs for farmers. Enabling direct market access to farmers allows them to sell their products at better prices, increasing their income by 50–60%.[70] For example, Olam Direct provides a platform for smallholder farmers to directly sell their products. The platform has benefited over 70,000 farmers across 12 countries, allowing farmers to transparently view prices, sell products, accept offers and connect with buyers. In addition to enabling these services for farmers, the platform creates new employment opportunities through farmer micro-collector agents to collect the produce.[71]

Digital advisory can work in conjunction with traditional advisory services to provide solutions at scale. Traditionally, extension agents and agronomists are provided by the government to smallholder farmers, but this is expensive, and it is difficult to reach the scale required. For example, in Nigeria, there are only 3 extension agents for every 10,000 farmers.[72] To address this issue, in Zimbabwe, EcoFarmer (developed by the telecoms company Econet Wireless) provides the 'Dial-a-Muduemni (extension officer)' service delivered in partnership with the Ministry of Agriculture to over 700,000 registered farmers, to complement its digital services and help the Ministry expand its conventional extension coverage.[73] Video as a form of agricultural extension also helps in this process, reaching 24% more farmers when compared to other kinds of agricultural extension.[74]

[68] CGIAR. 2020. Uber for tractors: a digital tool to cut rice losses. https://bigdata.cgiar.org/blog-post/uber-for-tractors-a-digital-tool-to-cut-rice-losses/

[69] GSMA. 2020. Digital Agriculture Maps 2020 State of the Sector in Low and Middle-Income Countries. https://www.gsma.com/r/wp-content/uploads/2020/09/GSMA-Agritech-Digital-Agriculture-Maps.pdf

[70] Mercy Corps. 2018. Benchmarking E-commerce Models for Africa's Smallholders. https://www.findevgateway.org/sites/default/files/publications/files/afa_ecommerce_benchmark_slideshare_9.17_fnl.pdf

[71] Olam website. https://www.olamgroup.com/news/all-news/press-release/olam-wins-impact-award-for-digital-platform-that-empowers-smallholder-farmers-and-improves-incomes.html

[72] Cartmell-Thorp S. 2019. Digitalisation of agriculture will leapfrog challenges women farmers face. Wageningen, The Netherlands: CTA. https://spore.cta.int/en/spore-exclusive/article/digitalisation-of-agriculture-will-leapfrog-challenges-women-farmers-face-sid0f96ab376-7116-49c0-9307-542a1f74696d

[73] CTA. 2017. EcoFarmer: bundling information and financial services. Wageningen, The Netherlands: CTA. https://spore.cta.int/en/dossiers/article/ecofarmer-bundling-information-and-financial-services-sid0e5aee44f-bdc2-4ac1-9c2e-31737377f302

[74] CTA. 2019. Digitalising extension: Smart Advisory Services for Farmers. https://cgspace.cgiar.org/bitstream/handle/10568/103459/SP194_PDF_E.pdf

Box 5: How digital agriculture has helped Myanmar leapfrog traditional development pathways.

Myanmar is a good example of how access to an improved digital infrastructure has allowed for a transition away from low agricultural development and has encouraged a rise in agritech start-ups in the country.

The digital agriculture ecosystem in Myanmar has expanded in the last few years, predominantly through the use of smartphone apps.[75] In the 2012–2015 Framework for Economic and Social Reform, the Myanmar Government had indeed set a target of reaching 80% mobile phone penetration by 2015.[76] As of 2016, mobile phone penetration had reached 83%. As a result, Myanmar today has one of the highest smartphone penetration rates in the developing world, with smartphone ownership having increased up to 72% and mobile broadband connections having reached 44 million.[77] Building on this, and under the Myanmar Digital Economy Roadmap for 2018–2025, the government is focusing on enabling the use of digital technology amongst priority sectors, including agriculture.[78]

This has resulted in a rise in agritech start-ups utilizing this technology in the country, such as Tun Yat, which is an 'Uber' styled tractor/harvester rental business. They have managed to service 5,000+ farmers, saving them US$120 each harvest season by providing an affordable and reliable service.[79]

Other notable start-ups in the country include Green Way and Impact Terra. Green Way offers an online platform connecting farmers, traders and rural communities. They have connected over 96,000 farmers and helped provide agronomic advice on pest infestations, fertilizers, crop yields, and localized weather information.[80] The Myanmar Department of Agriculture will be partnering with Green Way to expand the project's reach and provide agronomic advice to farmers at scale.

Impact Terra has also developed the Golden Paddy app, which offers real-time advice and agronomic information to farmers, while providing loan origination services and credit scoring for MFIs and financiers. The app has over 50,000 farmers who benefit from weather forecasts, market prices of crops, water risk warnings, and crop simulation models.[81]

[75] GSMA. 2020. Digital credit scoring for farmers: Opportunities for agritech companies in Myanmar. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/02/Digital_credit_scoring_for_farmers_Opportunities_for_agritech_companies_in_Myanmar.pdf

[76] UNCTAD. 2020. Transition to the digital economy: technological capabilities as drivers of productivity. https://unctad.org/system/files/official-document/ldcr2020_ch4_en.pdf

[77] Ibid.

[78] Digital Economy Development Committee. 2019. Myanmar Digital Economy Roadmap. https://myanmar.gov.mm/documents/20143/9096339/2019-02-07+DEDC+RoadMap+for+Websites.pdf/

[79] Grow Asia Digital Directory. http://growasiadirectory.org/tun-yat/

[80] Grow Asia Digital Directory. https://directory.growasia.org/green-way-agri-livestock/

[81] Grow Asia Digital Directory. https://directory.growasia.org/golden-paddy-digital-platform/

How can this support the pathways for the National Adaptation Plan process (Part 2)?

- The potential for digital agriculture to 'leapfrog' traditional agricultural development pathways should be recognized during element B2 (assessing climate vulnerabilities and identifying adaptation options), whilst adaptation options for the agricultural sector are being considered.

- These leapfrogging options can also be considered during element C3 (enhancing capacity for planning and implementing adaptation), as the type of capacities to be developed may change if the leapfrogging pathway is pursued. Indeed, the capacities needed to navigate and understand the digital sector are very different to traditional agricultural expertise.

PART 2: Incorporating digital agriculture in NAP formulation

This text is the second part of the working paper, which **adds to the list of supplementary technical guidelines on the NAP process** with tangible information for policy makers when setting up and implementing **digital agriculture** (DA) as one part of their NAP.

"Digital agriculture is an application of the 'digital earth' concept proposed in the 1990s and is an expansion of the concept of 'precision farming' which emphasizes on agricultural production procedures." [82]

Building upon four building blocks in the NAP process which were determined by the COP through initial guidelines in decision 5/CP.17, this second part of the working paper provides an overview of 17 substeps. It also suggests how digital agriculture can be fed into the substeps as well help to proceed with the steps during the implementation of the NAP. More detailed information on each element can be found in the technical guidelines[83] by the LDC Expert Group (LEG). More in-depth information on how agriculture fits in the substeps is written in the supplementary technical guidelines[84] by the FAO.

Figure 1 below names all substeps included in the NAP process and shows how substeps of different elements feed into one another. A list of all substeps and guiding questions for each step can be found in the UNFCCC NAP Technical Guidelines by the LDC Expert Group[85]. Then, the tables in section 2.1 to 2.4

[82] Shen S, Basist A, Howard A. 2010. Structure of a digital agriculture system and agricultural risks due to climate changes. *Agriculture and Agricultural Science Procedia* (1). https://doi.org/10.1016/j.aaspro.2010.09.006.

[83] Least Developed Countries Expert Group. 2012. *National Adaptation Plans. Technical guidelines for the national adaptation plan process*. Bonn: UNFCCC secretariat. Bonn, Germany. December 2012. Available at https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf

[84] FAO. 2017. Addressing Agriculture, Forestry And Fisheries In National Adaptation Plans. Rome: Food and Agriculture Organization of the United Nations. http://www.fao.org/3/i6714e/i6714e.pdf

[85] Least Developed Countries Expert Group. 2012. *National Adaptation Plans. Technical guidelines for the national adaptation plan process*. Bonn: UNFCCC secretariat. Bonn, Germany. December 2012. Available at https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf

show how each substep of a NAP can be implemented with digital agriculture in mind – including concrete examples of activities as well as methods. Thereafter, Figure 2 graphically summarizes the substeps with a digital agriculture lens. Figure 3 concludes the section with a summary of suitable direct outputs for each substep when DA is merged into the NAP.

Pathway of the National Adaptation Plan process

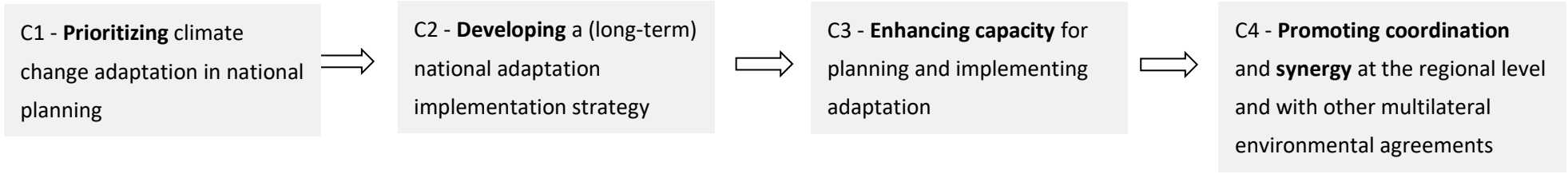
Element A

A1 - Initiating and **launching** the NAP process ⇒ A2 - **Stocktaking**: identifying available information on climate change impacts, vulnerability and adaptation and **assessing gaps and needs** of the enabling environment for the NAP process ⇒ A3 - Addressing **capacity gaps** and **weaknesses** in undertaking the NAP process ⇒ A4 - Comprehensively and iteratively assessing **development needs** and **climate vulnerabilities**

Element B

B1 - **Analyzing** current climate and future climate change **scenarios** ⇒ B2 - Assessing climate **vulnerabilities** and identifying **adaptation options** at sector, subnational, national and other appropriate levels ⇒ B3 - **Reviewing** and appraising adaptation options ⇒ B4 - **Compiling** and communicating national adaptation plans ⇒ B5 - **Integrating** climate change adaptation into national and subnational development and sectoral planning

Element C



Element D

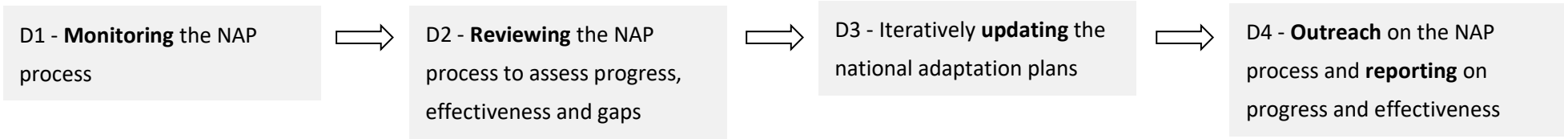


Figure 1: Synergies among NAP steps.

2.1 Element A: lay the groundwork and address gaps

How to take stock of existing digital agriculture initiatives and how to identify most suitable entry points for digital agriculture technologies?

"The main outputs of this element could include:

- a national mandate and strategic plan for the NAP process;
- the designation of a multi-stakeholder secretariat or coordinating committee to spearhead the process;
- results of a gap and needs analysis, and recommendations on how to address these;
- a synthesis of available data and knowledge; and
- a program to communicate and build capacity for the formulation and implementation of the NAP." [86]

[86] Least Developed Countries Expert Group. 2012. *National Adaptation Plans. Technical guidelines for the national adaptation plan process*. Bonn: UNFCCC secretariat. Bonn, Germany. December 2012. Available at https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf

Table 1: Pathway of the National Adaptation Plan process – Element A - Lay the groundwork and address gaps

Substep*		Integrating digital agriculture**	Examples, methods, resources
A1 - Initiating and **launching** the NAP process	Start the NAP process, create awareness among key actors in (sub)sectors on the process and set up institutional arrangements. Clarify expectations on outcomes and identify necessary financial, technical and reporting arrangements.	- Create awareness on DA among the NAP core team and the agriculture sector representative. - Explore available technical and financial support for DA within adaptation planning. - Create a vision on how DA will help the national adaptation planning and contribute to the SDGs. - Set up a roadmap for DA considering the country's specific conditions. - Possibility to include a flow chart clarifying responsibilities regarding DA integration among national climate	- Present documentation on impacts of DA in similar country contexts. - EIP-AGRI Seminar 'Multi-level strategies for digitizing agriculture and rural areas'.[87] - Apply Robust Adaptation Planning (RAP) framework to digital agriculture. The framework can reduce the complexity of adaptation responses implementation, and allows administrative actors from various levels to think collectively, identify key actors and allocate responsibility (also concerns A2).[88]

[87] EIP-AGRI Seminar on Multi-level strategies for digitising agriculture and rural areas: Final report. https://ec.europa.eu/eip/agriculture/sites/default/files/eip-agri_seminar_digital_strategies_final_report_2019_en.pdf

[88] Chaudhury AS, Thornton TF, Helfgott A. *et al.* 2017. Applying the robust adaptation planning (RAP) framework to Ghana's agricultural climate change adaptation regime.*Sustain* Sci 12, 657–676. https://doi.org/10.1007/s11625-017-0462-0

		change coordinating committee, technical committee, national climate change focal point, departments and ministries as well as the public, civil society and private sector.	
A2 - **Stocktaking**: identifying available information on climate change impacts, vulnerability and adaptation and **assessing gaps and needs** of the enabling environment for the NAP process	Take stock of available data and knowledge as well as existing methodology, policies, plans and investment frameworks. Assess possible gaps in capacity, data, information and resources. Identify potential barriers to designing and implementing adaptation.	- Compile past and ongoing projects, programs, policies and capacity development efforts on DA. - Identify relevant gender issues in DA. - Identify relevant data for DA and how to structure capturing and processing data. - Develop actionable recommendations on enhancing capacity on DA based on a capacity assessment.	- Apply the SNAP tool to assess current capacity and capacity gaps on digital agriculture.[89] - Draw insights from FAO analysis of existing gender barriers to women's access to, control and use of ICTs for agriculture and gender mainstreaming in ICT initiatives.[90] - A CCAFS study finds that women in agriculture without access to mobile phones are more vulnerable to climate change.[91]

[89] GIZ. 2016. SNAP: Stocktaking for National Adaptation Planning. Assessing Capacity for Implementing NDCs. https://www.adaptationcommunity.net/download/ms/mainstreaming-tools/giz_snap_EN_v161114.pdf

[90] FAO. 2018. Gender and ICTs: Mainstreaming gender in the use of information and communication technologies (ICTs) for agriculture and rural development, by Sophie Treinen and Alice Van der Elstraeten. Rome, Italy. http://www.fao.org/3/i8670en/I8670EN.pdf

[91] Partey ST, Dakorah AD, Zougmoré RB, Ouédraogo M, Nyasimi M, Nikoi GK, Huyer S. 2020. Gender and climate risk management: evidence of climate information use in Ghana. Climatic Change 158:61-75. https://hdl.handle.net/10568/96086

		- Identify barriers which could obstruct integrating DA in the NAP.	- Perform a participatory capacity assessment on digital agriculture across the individual and organizational level as well as the enabling environment.[92]
A3 - Addressing **capacity gaps** and **weaknesses** in undertaking the NAP process	Design and implement projects and programs to address capacity gaps and barriers identified in A2. Enhance awareness on the contribution of adaptation to development planning.	- Implement projects and programs addressing capacity gaps and barriers for DA based on A2. - Raise awareness on development benefits of DA among stakeholders in charge of policy planning in the agricultural sector. - Inform the public about DA benefits.	- Experiences from training on ENACTS Data Library and Maproom software (USAID, CCAFS, IRI, CIAT Rwanda Meteorology Agency).[93] - Address regional specificities of DA implementation, based on evidence from educational programs. [94, 95]

[92] FAO. 2018. Institutional capacity assessment approach for national adaptation planning in the agriculture sectors. Briefing note. http://www.fao.org/3/I8900EN/i8900en.pdf

[93] del Corral J, Rose A. 2018. Training on ENACTS Data Library and Maproom software in Kigali, Rwanda. CCAFS Workshop Report. Wageningen, Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). https://cgspace.cgiar.org/bitstream/handle/10568/92004/JDC%20January%20Workshop%20Report%20FINAL%20FOR%20UPLOAD.pdf?sequence=1&isAllowed=y

[94] Shockley J, Mark T, Dillon C. 2017. Educating producers on the profitability of precision agriculture technologies. Advances in Animal Biosciences, 8(2) 724-727. https://www.researchgate.net/publication/317286900_Educating_producers_on_the_profitability_of_precision_agriculture_technologies

[95] Dillon CR, Stombaugh T, Kayrouz B, Salim J, Koostra BK. 2007. An educational workshop on the use of precision agriculture as a risk management tool. Precision Agriculture 2007 - Papers Presented at the 6th European Conference on Precision Agriculture, ECPA 2007. 861-867. https://www.researchgate.net/publication/289640302_An_educational_workshop_on_the_use_of_precision_agriculture_as_a_risk_management_tool

A4 - Comprehensively and iteratively assessing **development needs** and **climate vulnerabilities**	Compile developmental policies, plans, programs and objectives. Identify key developmental goals sensitive to climate change and co-benefits of adaptation planning and development.	- Identify developmental goals, programs and policies which can co-benefit from integrating DA. - Identify and enhance links between the 2030 Agenda, the Paris Agreement and the Sendai Framework made possible through DA.	- DA can contribute to several of FAO's 20 interconnected actions to guide policy makers in transforming food and agriculture to achieve the SDGs.[96] - Example of activity: Global Forum for Food and Agriculture "aimed to increase awareness about the public policies that can guide structural changes of digital agriculture towards achieving national development strategies and the SDGs of the 2030 Agenda for Sustainable Development".[97]

* Content based on technical guidelines by the LDC Expert Group (LEG)[98].

** Content based on technical guidelines by the LEG[99] and supplementary technical guidelines by the FAO[100].

[96] FAO. 2018. Transforming food and agriculture to achieve the SDGs. 20 interconnected actions to guide decision-makers. http://www.fao.org/publications/transforming-food-agriculture-to-achieve-sdg/en/

[97] IISD. 2019. 11th Global Forum for Food and Agriculture (GFFA): Agriculture Goes Digital – Smart Solutions for Future Farming. https://sdg.iisd.org/commentary/guest-articles/11th-global-forum-for-food-and-agriculture-gffa-agriculture-goes-digital-smart-solutions-for-future-farming/

[98] Least Developed Countries Expert Group. 2012. *National Adaptation Plans. Technical guidelines for the national adaptation plan process*. Bonn: UNFCCC secretariat. Bonn, Germany. December 2012. Available at https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf

[99] Ibid

[100] FAO. 2017. Addressing Agriculture, Forestry And Fisheries In National Adaptation Plans. http://www.fao.org/3/i6714e/i6714e.pdf

2.2 Pathway of the National Adaptation Plan process - Element B: preparatory elements

How can digital agriculture get integrated in climate change scenarios as well as development and sectoral planning? [linked to 1.4]

"Typical outputs from these steps are prioritized lists of adaptation options by sector, by region and/or agro–ecological zone. On the other hand, concrete adaptation practices that will be implemented on the ground need to be location- and context-specific." [101]

Table 2: Element B: preparatory elements

Substep*		Integrating digital agriculture**	Examples, methods, resources
B1 - **Analyzing** current climate and future climate change **scenarios**	Determine current risk vulnerability to climate change based on variables and indices used in planning and decision making. This allows to identify deficits for adaptation. This includes identifying trends in local climate change and analyzing trends using climate and socioeconomic scenario analysis. Findings are publicly communicated.	- Mainly identify agricultural sectors, regions, ecosystems, communities and groups vulnerable to climate change and specifically how DA implementation must consider and adapt to current and future climatic changes. - Consider agro–meteorological indices of particular relevance to DA.	- Several modeling tools for agriculture are mentioned in FAO technical guidelines.[102] - Recommendations from EIP-AGRI Focus group regarding data capture and processing.[103]

[101] FAO. 2017. Addressing Agriculture, Forestry And Fisheries In National Adaptation Plans. http://www.fao.org/3/i6714e/i6714e.pdf
[102] Ibid
[103] EIP-AGRI Focus group. 2015. *Precision Farming. Final Report.* https://ec.europa.eu/eip/agriculture/sites/default/files/eip-agri_focus_group_on_precision_farming_final_report_2015.pdf

		- Building on A2, enhance generation of (localized) climate information if needed for DA implementation. - Identify points of improvement in scenarios to assess impact from and to DA.	
B2 - Assessing climate **vulnerabilities** and identifying **adaptation options** at sector, subnational, national and other appropriate levels	Based on analysis in B1, assess climate vulnerability on several levels (sector, national etc. as appropriate) and rank them to priority risks areas. This concerns current and future risks. Suggest points of action addressing major vulnerabilities at various levels.	- Reflect on how DA could be impacted by climate change, vulnerability and impacts. As necessary reflect on climate change, vulnerability and impacts as concepts. - Classify vulnerabilities and risks which can benefit from DA. - Identify existing programs/policies addressing vulnerability which incorporate DA and the potential to scale these up.	- Farmers in African, Caribbean and Pacific regions expect risk reduction through digitalization of agriculture; and DA contributed to sustainability readiness of farmer projects.[104] - Robotics process automation can help to proactively reduce risk by limiting human error.[105] - Draw inspiration from a chapter on the impacts of precision agriculture on food security in Africa.[106]

[104] CTA. 2019. *Managing the sustainability of digital agriculture projects.* CTA Technical Brief no. 18. https://cgspace.cgiar.org/bitstream/handle/10568/99345/2061_PDF.pdf?sequence=1&isAllowed=y

[105] Capgemini Consulting. 2017. *Digital Farming. Opportunities for a new way of agriculture.* https://www.capgemini.com/consulting-de/wp-content/uploads/sites/32/2017/11/digital-farming-booklet-capgemini-consulting.pdf

[106] Ncube B, Mupangwa W, French A. 2018. *Precision Agriculture and Food Security in Africa.* 10.1007/978-3-319-71486-8_9. https://www.researchgate.net/publication/324372637_Precision_Agriculture_and_Food_Security_in_Africa

		- Classify risks and DA reaction based on various timeframes (1–5, 5–10 and beyond 10 years).	- Food security monitoring and early warning system in Guatemala.[107] - Draw inspiration from 10 case studies by FAO and ITU on DA.[108] - Suitable tools: Intelligent agricultural Systems Advisory Tool (ISAT)[109]; and GeoFarmer[110]. - FAO guidelines include extensive list of risks and vulnerabilities to consider.[111] - Possible ways to cluster options.[112]

[107] Muller. 2018. *Guatemala implements a Food Security Monitoring and Early Warning System supported by Bioversity and CCAFS.* https://ccafs.cgiar.org/news/guatemala-implements-food-security-monitoring-and-early-warning-system-supported-bioversity-and

[108] FAO and ITU. 2017. *E-agriculture in action.* http://www.fao.org/3/i6972e/i6972e.pdf

[109] Rao KPC, Dakshina Murthy K, Dhulipala R, Bhagyashree SD, Gupta MD, Sreepada S, Whitbread AM. 2019. *Delivering climate risk information to farmers at scale: the intelligent agricultural Systems Advisory Tool* (ISAT). CCAFS Working Paper no. 243. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). https://hdl.handle.net/10568/99460

[110] Eitzinger A, Cock J, Atzmanstorfer K, Binder C, Laderach P, Bonilla-Findji O, Bartling M, Mwongera C, Zurita-Arthos L, Jarvis A. (2019). GeoFarmer: A monitoring and feedback system for agricultural development projects. *Computers and Electronics in Agriculture*. 158. 109-121. 10.1016/j.compag.2019.01.049. https://www.researchgate.net/publication/330994783_GeoFarmer_A_monitoring_and_feedback_system_for_agricultural_development_projects

[111] FAO. 2017. Addressing Agriculture, Forestry And Fisheries In National Adaptation Plans. http://www.fao.org/3/i6714e/i6714e.pdf

[112] Dinesh D, (Ed). 2016. *Adaptation Measures in Agricultural Systems: Messages to SBSTA 44 agriculture workshops*. CCAFS Working Paper no. 145. https://hdl.handle.net/10568/71049

B3 - **Reviewing** and appraising adaptation options	Analyze options suggested in B2 in depth including economic, ecosystem and social costs. Also discuss positive and negative potential impacts outside the scope of adaptation.	- Analyze and prioritize DA options developed before based on review and stakeholder consultation in B2. - Include economic, ecosystem and social costs of DA implementation. - Identify possible unintended economic, social or environmental effects of digital agriculture.	- Economic costs can be assessed through cost maps and lightbar adoption; these show how costs for technologies differ among regions and support farmers decision making.[113] - FAO guidelines include extensive list of decision criteria to consider.[114] - Discussion of unintended (especially social) effects in agriculture 4.0.[115]
B4 - **Compiling** and communicating national adaptation plans	Merge analysis of B1 to B3 into a national adaptation plan. Involve stakeholders in ranking options and allow review of NAP draft. Incorporate comments in the NAP and distribute final version widely among national stakeholders.	- Include how DA can contribute to top priorities of adaptation in agriculture. - Include how DA programs are/will include marginalized groups (based on A2).	- Assessment of stakeholder perspectives on precision farming in India, Coimbatore.[116] - Example stakeholder consultation by CCAFS on benefits of DA in Africa.[117]

[113] Kayrouz B. 2008. *Precision Agriculture: Realizing Increased Profit And Reduced Risk Through Cost Map And Lightbar Adoption.* https://www.semanticscholar.org/paper/PRECISION-AGRICULTURE%3A-REALIZING-INCREASED-PROFIT-Kayrouz/1fdc84f5ab59aa5afc84d3ad7c45f41464c3ddb7?p2df

[114] FAO. 2017. Addressing Agriculture, Forestry And Fisheries In National Adaptation Plans. http://www.fao.org/3/i6714e/i6714e.pdf

[115] Rose DC, Chilvers J. 2018. Agriculture 4.0: Broadening Responsible Innovation in an Era of Smart Farming. *Front. Sustain. Food Syst*. 2:87. doi: 10.3389/fsufs.2018.00087. https://www.frontiersin.org/articles/10.3389/fsufs.2018.00087/full

[116] Padma SR. 2013. Perspectives of Stakeholders on Precision Farming. Thesis Ph.D. TNAU, Coimbatore.

[117] Tita E, Solomon D. 2017. *Is Digital Agriculture The Key To Revolutionize Future Farming In Africa?* https://ccafs.cgiar.org/news/digital-agriculture-key-revolutionize-future-farming-africa#.XJOPB6RCfQw

		- Allow stakeholders to comment and review plans of DA implementation and incorporate stakeholder feedback.	- Review of decision support systems on precision agriculture strategies.[118] - FAO guidelines include example scoring chart for decision making which can also be useful for DA.[119]
B5 - **Integrating** climate change adaptation into national and subnational development and sectoral planning	Identify possibilities and constraints to integrate climate change in planning and facilitate its inclusion. Enhance capacity to include adaptation as needed.	- Find suitable entry points for DA in subnational planning processes (regions, provinces, districts). - Enhance organizational and institutional capacities within development authorities on DA. - Merge DA activities in development planning process considering development budgeting and planning cycles of development planning.	

[118] Lindblom, J., Lundström, C., Ljung, M. *et al.* Promoting sustainable intensification in precision agriculture: review of decision support systems development and strategies. *Precision Agric* **18,** 309–331 (2017). https://doi.org/10.1007/s11119-016-9491-4

[119] FAO. 2017. Addressing Agriculture, Forestry And Fisheries In National Adaptation Plans. http://www.fao.org/3/i6714e/i6714e.pdf

* Content based on technical guidelines by the LDC Expert Group (LEG). [120]

** Content based on technical guidelines by LEG[121] and supplementary technical guidelines by FAO[122].

[120] Least Developed Countries Expert Group. 2012. National Adaptation Plans. Technical guidelines for the national adaptation plan process. Bonn: UNFCCC secretariat. Bonn, Germany. December 2012. Available at https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf

[121] Ibid

[122] FAO. 2017. Addressing Agriculture, Forestry And Fisheries In National Adaptation Plans. http://www.fao.org/3/i6714e/i6714e.pdf

2.3 Element C: implementation strategies

How does digital agriculture fit into long-term sustainability planning and how can countries cooperate with each other? [linked to 3.1 and 3.2]

Main outputs include "a strategy for implementing the NAPs, concrete activities to implement priorities identified in the NAPs, and plans for ensuring and promoting synergy with other multilateral environmental agreements (MEAs) and programs at the regional and national level." [123]

Table 3: Pathway of the National Adaptation Plan process – Element C: implementation strategies

Substep*		Integrating digital agriculture**	Examples, methods, resources
C1 - **Prioritizing** climate change adaptation in national planning	Define criteria to prioritize implementation grounded in existing plans, developmental goals and climate vulnerability. Find ways to extend and build on existing activities.	- Review criteria to prioritize action within the NAP from a DA lens, identifying which criteria connect to DA, building on A4. - Draw up complementary criteria based on lessons learned from existing DA activities in similar contexts.	- Draw inspiration from 10 DA case studies by FAO.[124] - Review of decision support systems on precision agriculture strategies.[125] - Draw insights on criteria from sourcebook of indicators for monitoring and evaluation in rural agriculture by GDPRD, FAO and World Bank.[126]

[123] Least Developed Countries Expert Group. 2012. *National Adaptation Plans. Technical guidelines for the national adaptation plan process*. Bonn: UNFCCC secretariat. Bonn, Germany. December 2012. Available at https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf

[124] FAO and ITU. 2017. *E-agriculture in action.* http://www.fao.org/3/i6972e/i6972e.pdf

[125] Lindblom J, Lundström C, Ljung M. *et al.* Promoting sustainable intensification in precision agriculture: review of decision support systems development and strategies. *Precision Agric* 18, 309–331 (2017). https://doi.org/10.1007/s11119-016-9491-4

[126] GDPRD, FAO and World Bank. 2008. Tracking results in agriculture and rural development in less-than-ideal conditions. A sourcebook of indicators for monitoring and evaluation. http://www.fao.org/fileadmin/templates/ess/documents/Sourcebook-Web-Version.pdf

C2 - **Developing** a (long-term) national adaptation implementation strategy	Define a (long-term) strategy to implement adaptation building on existing activities. Assess costs involved and possibilities to cover these. Implement strategy through policies, projects and programs.	- Develop a long-term view on the contribution of DA to adaptation. - Include adaptation objectives met through DA in the proposed strategy. - Use remote sensing data and projections on the impacts of climate change and agriculture (see Section 1.2) to inform national-level adaptation plans. - Consider necessary technical and human resources. - Develop DA strategy closely linked to climate financing plans. - If possible, state concrete policies, projects and programs addressing DA planned or implemented.	- Build on the 'E-agriculture strategy guide' – a support document to set up or review e-agriculture strategy nationally (also relevant for C1).[127] - Example projects: 10 DA case studies by FAO.[128]

[127] FAO. 2017. *E-Agriculture Strategy Guide. A Summary.* http://www.fao.org/3/a-i6909e.pdf
[128] FAO and ITU. 2017. *E-agriculture in action.* http://www.fao.org/3/i6972e/i6972e.pdf

C3 - **Enhancing capacity** for planning and implementing adaptation	Enhance institutional and regulatory frameworks addressing adaptation and implement ongoing training on the NAP process at subnational and sectoral levels. Promote international cooperation and outreach.	- Based on A3 and B5 develop/update/strengthen regulatory frameworks incorporating DA and communicate changes publicly. - Implement ongoing training on technical and institutional capacities regarding DA in adaptation. - Look for possibilities to cooperate with (neighboring) countries regarding DA training and outreach options (e.g. South-South cooperation). - Ensure access for stakeholders to data used for DA.	- Support for smallholder farmers "Digital and Data-Driven Agriculture: Harnessing the Power of Data for Smallholders" (also useful for B1 and A2).[129] - A coalition of EU agrifood chain association sets up a code of conduct on agricultural data.[130]
C4 - **Promoting coordination** and **synergy** at the regional level and with other	Coordinate adaptation across sectors and identify possible synergies at regional level in assessing, planning and implementing adaptation. Identify	- Identify needs in the implementation of DA for the ministry of agriculture to collaborate with other ministries (finance, planning and others). - Following up on step A4, enhance synergies of DA activities with other international processes,	

[129] Maru Ajit et al. 2018. *Digital and data-driven agriculture: Harnessing the power of data for smallholders.* Rome: Global Forum on Agricultural Research and Innovation. https://hdl.handle.net/10568/92477

[130] Copa-Cogeca, CEMA, Fertilizers Europe, CEETTAR, CEJA, ECPA, EFFAB, FEFAC, ESA. 2018. *EU code of conduct on agricultural data sharing by contractual agreement.* https://cema-agri.org/images/publications/brochures/EU_Code_of_conduct_on_agricultural_data_sharing_by_contractual_agreement_2020_ENGLISH.pdf

multilateral environmental agreements	possible synergies with plans to implement other multilateral environmental agreements.	e.g. other multilateral agreements and conventions.	

* Content based on technical guidelines by the LDC Expert Group (LEG). [131]

** Content based on technical guidelines by the LEG[132] and supplementary technical guidelines by the FAO[133].

[131] Least Developed Countries Expert Group. 2012. *National Adaptation Plans. Technical guidelines for the national adaptation plan process*. Bonn: UNFCCC secretariat. Bonn, Germany. December 2012. Available at https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf

[132] Ibid

[133] FAO. 2017. Addressing Agriculture, Forestry And Fisheries In National Adaptation Plans. http://www.fao.org/3/i6714e/i6714e.pdf

2.4 Element D: Reporting, monitoring and review

How can digital agriculture support the reporting, monitoring and review of NAPs?

Main outputs include "a plan for monitoring and evaluation, with a plan for data collection and ongoing compilation and synthesis of new information on impacts and vulnerabilities to be used in updating the NAPs."[134]

Table 3: Pathway of the National Adaptation Plan process – Element D: Reporting, monitoring and review

Substep*		Integrating digital agriculture**	Examples, methods, resources
D1 - **Monitoring** the NAP process	Identify and define metrics for measures in the NAP evaluated to assess its effectiveness. Gather information on these metrics.	- Identify core needs for monitoring DA implementation. - Develop or identify different types of key indicators measuring DA effectiveness, keeping efforts bearable and measuring impact, output and outcome. - Merge these indicators into a framework including methods to store the evaluation data.	- FAO guidelines include useful list of possible focus areas in monitoring.[135] - Potential evaluation questions.[136] - Identify DA relevant indicators in FAO, World Bank, and Global Donor Platform for Rural Development's sourcebook of indicators for

[134] Least Developed Countries Expert Group. 2012. *National Adaptation Plans. Technical guidelines for the national adaptation plan process*. Bonn: UNFCCC secretariat. Bonn, Germany. December 2012. Available at https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf

[135] FAO. 2017. Addressing Agriculture, Forestry And Fisheries In National Adaptation Plans. http://www.fao.org/3/i6714e/i6714e.pdf

[136] FAO. 2017. Final Report of the Project "Strengthening Agricultural Market Information Systems Globally and in Selected Countries (Bangladesh, India and Nigeria) Using Innovative Methods and Digital Technology". http://www.fao.org/3/I8432EN/i8432en.pdf

		- Feed this framework into existing monitoring and evaluation of NAP/agricultural development. - Identify necessary roles among institutions in the monitoring process.	monitoring and evaluation in rural agriculture.[137] - Stakeholder engagement in developing indicators ensures greater relevance of indicators across various levels.
D2 - **Reviewing** the NAP process to assess progress, effectiveness and gaps	Compile information gathered through metrics and outcomes from activities initiated during the NAP process. Review activities regularly.	- Check if DA is effectively included in the draft NAP, i.e. if sufficient resources are/will be accessible, if necessary policy actions for DA implementation are included, and if the implementation pathway reflects gender specific issues. - If DA is not adequately included, identify alternative strategies before NAP is finalized.	- Base review on lessons learned in failed ICT4Ag projects by CTA.[138] - Build on 'E-agriculture strategy guide' – a support document to set up or review e-agriculture strategy nationally.[139]
D3 - Iteratively **updating** the national adaptation plans	Update NAP (framework, strategy) by repeating selected steps. If possible align NAPs updates with	- Identify successes and challenges in DA implementation, e.g. if DA programs and projects implemented contribute to resilience.	

[137] GDPRD, FAO and World Bank. 2008. Tracking results in agriculture and rural development in less-than-ideal conditions. A sourcebook of indicators for monitoring and evaluation. http://www.fao.org/fileadmin/templates/ess/documents/Sourcebook-Web-Version.pdf

[138] Shepherd A. 2016. *Lessons for sustainability – Failing to scale ICT4Ag-enabled services.* Wageningen: CTA. https://cgspace.cgiar.org/bitstream/handle/10568/97870/Failing_to_scale_en.pdf?sequence=1&isAllowed=y

[139] FAO. 2017. *E-Agriculture Strategy Guide.* A Summary. http://www.fao.org/3/a-i6909e.pdf

	national developmental plans.	- Review if implementation needs to be adjusted to state-of-the-art technology/practices. - Develop suggestions on adjustments in DA implementation based on the analysis. - Create a rhythm in this process through regular repetition.	
D4 - **Outreach** on the NAP process and **reporting** on progress and effectiveness	Distribute NAPS to the UNFCCC secretariat and stakeholders. Report nationally on progress and effectiveness of the NAPS.	- Define regular outreach activities including state-of-the-art technology/media to inform internal and external stakeholders on DA progress and experiences including through UNFCCC channels. - Investigate possibilities to share learning with countries in comparable context.	- For instance, develop joint lessons learned.[140]

* Content based on technical guidelines by the LDC Expert Group (LEG). [141]

** Content based on technical guidelines by the LEG[142] and supplementary technical guidelines by the FAO[143].

[140] Shepherd A. 2016. *Lessons for sustainability – Failing to scale ICT4Ag-enabled services.* Wageningen: CTA. https://cgspace.cgiar.org/bitstream/handle/10568/97870/Failing_to_scale_en.pdf?sequence=1&isAllowed=y

[141] Least Developed Countries Expert Group. 2012. *National Adaptation Plans. Technical guidelines for the national adaptation plan process*. Bonn: UNFCCC secretariat. Bonn, Germany. December 2012. Available at https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf

[142] Ibid

[143] FAO. 2017. Addressing Agriculture, Forestry And Fisheries In National Adaptation Plans. http://www.fao.org/3/i6714e/i6714e.pdf

2.5 Achieving synergies across different stages in the NAP process

Where can efforts among the four phases be connected and how can NAPs reflect digital agriculture as a whole? [Linked to Section 2.1 to 2.4]

The structure of the NAP process in element A to D and their substeps suggests a linear approach during implementation, i.e. to proceed from A1 to A2, etc. In practice, however, it is more likely that several steps will be addressed at the same time. It is therefore crucial to know which steps require input from preceding steps. There is path dependency, which must be taken into account during implementation. But there is also coherence and connection across elements; some common threads reoccur in several elements. This analysis also shows that there are steps which function rather independently while others either input to several other steps or receive input from several preceding steps. All these findings are visualized in Figure 3 and are discussed in detail below.

Firstly, steps B1, B4 as well as C3 require the completion of preceding steps before they can be started:

- In step B1, the generation of (localized) climate information should be enhanced. This requires that the current state of climate information is fully analyzed in step A2 so that step B1 can build on this knowledge.

- The draft NAP developed in step B4 must build on the stocktaking in step A2. Here, the analysis of the vulnerability of marginalized groups in step A2 is particularly important, and the (draft) NAP must take their needs into account.

- Similarly, during step C3, regulatory frameworks should be developed, updated and/or strengthened. For this to work properly under a changing climate, knowing the vulnerability of DA implementation among sectors, regions, ecosystems, and communities is key(step B1). To ensure these regulatory frameworks are coherent across regional, provincial, and district level, implementation strategies must address subnational planning

processes (step B5). Overall, regulatory frameworks supporting DA implementation need to address climate change vulnerability as well as various subnational planning processes. Therefore, step C3 must build on the outputs of step B1 as well as B5.

Secondly, it is apparent that element D, as it concerns monitoring and reporting, requires input from a variety of previous steps. Some important steps such as indicator development, outreach activities, and reporting rhythms can be set up before the NAP is implemented. However, review and update will mostly build on experiences during implementation and will therefore be less of a focus when the NAP is set up for the first time.

Thirdly, three common threads are apparent in several elements: capacity building, creating development synergies, as well as outreach and stakeholder engagement. When it comes to capacity building, the ongoing training implemented during step C3 needs to take into account all previous activities that entail capacity building (A2, A3 and B5). Also, capacity gaps in developmental authorities identified in step A3 will influence the capacity building plans in these authorities set up during step B5. As for developmental synergies, it is clear that benefits identified in step A4 should be leveraged in all following steps with this common thread (B5, C1 and C4). Finally, as outreach and stakeholder engagement activities are strongly tied to each substep, stakeholder feedback will generally only concern the specific call for feedback. However, all activities (B3, B4 and C3) must be included in the outreach and engagement plan developed during step C4.

Pathway of Digital Agriculture in the National Adaptation Plan process

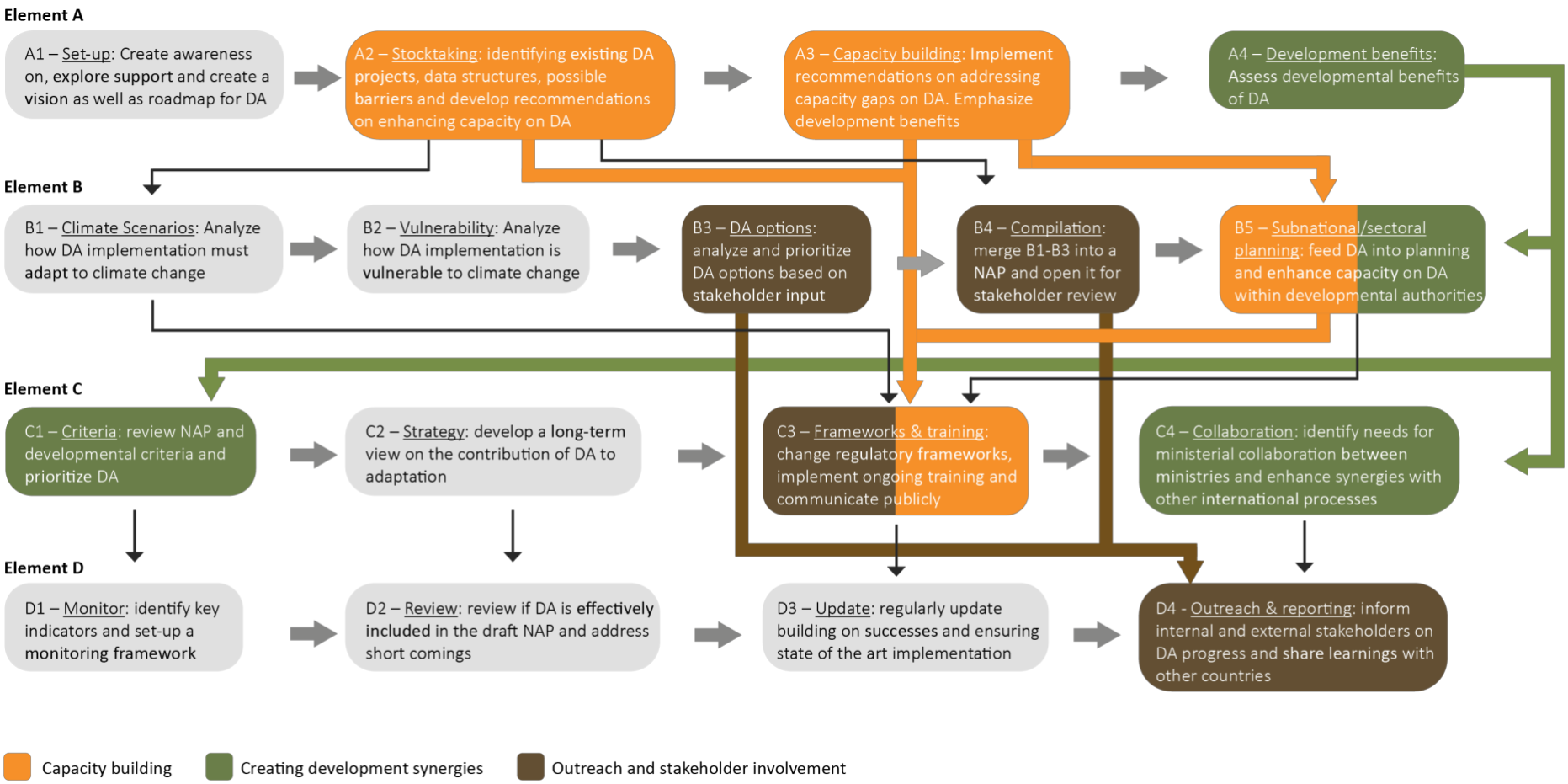


Figure 2: Synergies in DA implementation

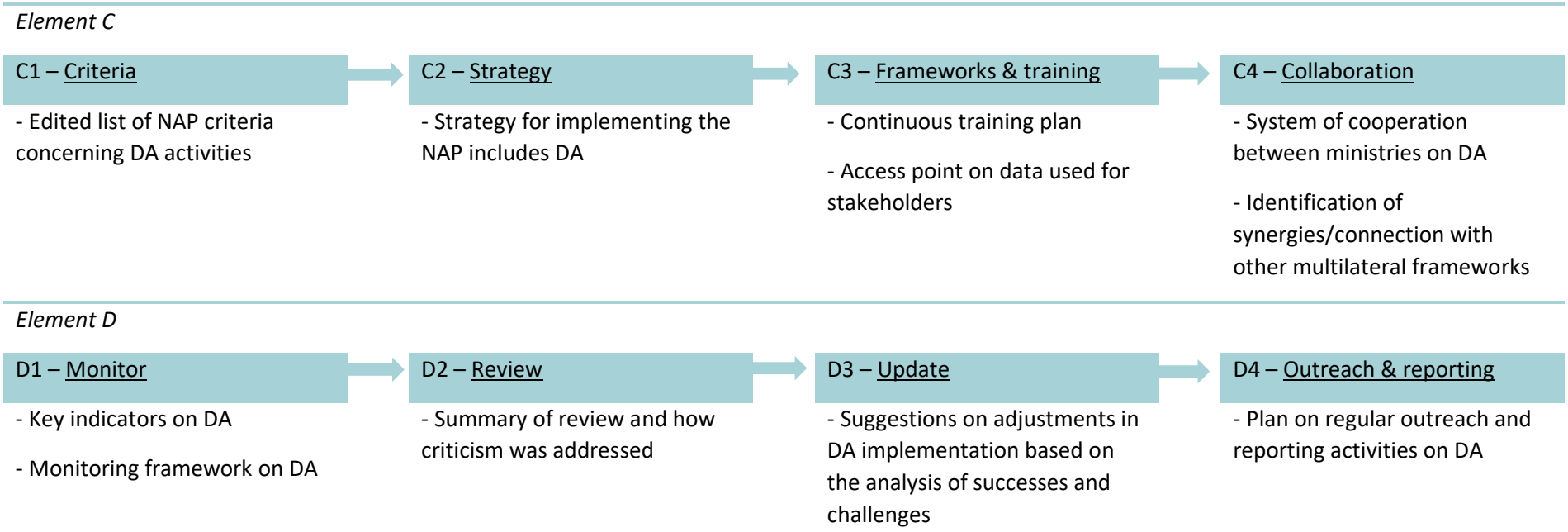
Direct outputs of the National Adaptation Plan process including Digital Agriculture*

Element A

A1 – Set-up	A2 - Stocktaking	A3 – Capacity building	A4 – Development benefits
- Strategic plan	- Synthesis of available data and knowledge - Compilation of projects, programs, policies and capacity development	- Gap and need analysis - Capacity building program - Communication/outreach program	- Compilation developmental goals, Sustainable Development Goals and Sendai Framework linked to DA

Element B

B1 – Climate Scenarios	B2 – Vulnerability	B3 – DA options	B4 – Compilation	B5 – Subnational/sectoral planning
- Identification of climate change impacts on DA connected sectors, ecosystems, regions, communities	- Reflection on DA climate change vulnerability and risks	- Prioritized lists of DA options by sector, region and/or agro–ecological zone **	- (Draft) NAP including DA - Summary of feedback and how it was addressed	- DA activities are included in development planning



* partly based on LEG, 2012[144] ** based on FAO, 2017[145]

Figure 3: Output of NAP process including DA

[144] Least Developed Countries Expert Group. 2012. *National Adaptation Plans. Technical guidelines for the national adaptation plan process*. Bonn: UNFCCC secretariat. Bonn, Germany. December 2012. Available at https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf

[145] FAO. 2017. Addressing Agriculture, Forestry And Fisheries In National Adaptation Plans. http://www.fao.org/3/i6714e/i6714e.pdf

PART 3: Towards implementation at scale

The NAP process presents a unique opportunity to achieve consistency amongst countries and pool efforts towards implementing DA at scale. It can also provide an entry point for development partners and other actors seeking to expand their own digital agriculture support programs. Below we highlight barriers countries may face in implementing DA at scale, resources and support systems available to help them overcome these barriers, and proposals for ways to take forward DA collectively within the NAP process.

Box 6 in section 3.2 also provides brief information on how non-government entities can support and engage with the NAP process to accelerate the implementation of digital agriculture.

3.1 Identifying and overcoming institutional, technological and financial barriers

Below we summarize some key barriers that countries may face in implementing DA initiatives as part of their NAPs, and offer some early thoughts on how they can be overcome.

- **The need to bring together 'hard infrastructure' with 'soft infrastructure'[146] –** the capacity to create better policies and plans using digital technologies depends not only on connectivity infrastructure (hard infrastructure), but also on the regulatory environment and institutional arrangements (soft infrastructure) which together govern access to and use of digital technologies and related data in the agriculture sector. These two elements together shape the creation of effective systems for digitalization in agriculture, or 'data infrastructure'.[147] The data infrastructure is the system enabling and governing the collection, access and transfer of data (which together are referred to as data governance), as well as storage, and analysis of farm data to produce knowledge and advice (actionable insights) and feedback loops to stakeholders in the agriculture sector, including farmers as well as policy makers.[148] Ministries of Agriculture or other agencies involved in DA implementation could seek advice and collaboration from parts of government more accustomed to implementing connectivity and data governance programs to help navigate this complexity (e.g. Media and Communications agencies).

- **Insufficient technical skills and human resources to effectively develop and implement DA initiatives –** there is relatively low awareness and technical experience in digital agriculture as a specific topic within governments, which can pose a challenge in further

[146] Text in this paragraph adapted from OECD (2019). *Digital Opportunities for Better Agricultural Policies.* https://www.oecd-ilibrary.org/agriculture-and-food/digital-opportunities-for-better-agricultural-policies_571a0812-en

[147] OECD. 2015. *Data-Driven Innovation: Big Data for Growth and Well-Being*. Paris: OECD Publishing. http://dx.doi.org/10.1787/9789264229358-en

[148] Antle J, Capalbo S, Houston L. 2014. *Towards a Knowledge Infrastructure for Science-Based Policy and Sustainable Management of Agricultural Landscapes.* http://www.foodandagpolicy.com

integrating it into policy making and program development.[149] Staff within Ministries of Agriculture tend not to be experienced in developing the consumer facing products digital agriculture often requires or conducting alpha/beta testing and managing user feedback in the same way private technology developers do.[150] This can be partly overcome by collaborating with private sector partners who are more skilled and experienced in this area, though this then leads to the next challenge below.

The type of partnerships that can be effectively developed depends on the 'digital readiness' of the country in question. Countries that are less digitally ready may require greater public and donor-led investments to scale up DA adoption. For countries that have a more active DA private sector, there could be more private-led partnerships working with government extension services to scale their coverage, such as EcoFarmer's extension services in partnership with the Zimbabwean Ministry of Agriculture.[151]

- **Lack of incentives for the private sector to invest time and resources engaging and partnering with governments –** this is partly due to the skills gap identified above, but also because of broader concerns around efficiency and often long timeframes associated with engagement. Governments can however incentivize private sector engagement through investing in data systems and certification, digital literacy, enabling policies, and subsidies for early innovators.

- **Challenges with equitable access for marginalized groups –** DA needs to be designed to allow equitable access and use of digital tools by all. More particularly, DA must be accessible and affordable to groups that have historically been excluded (e.g., women, youth, indigenous). For example, in sub-Saharan Africa, female farmers make up 52% of the population employed in agriculture,[152] but only 25% of subscribers of digital agriculture services are women.[153] The cost of access to digital technology can be prohibitive to these groups – for instance, the costs of a 1GB monthly data plan can make up over a quarter of annual income of the poorest 10% in African countries.[154] To combat these challenges related to access, DA should be provided at low or no cost services, and reach farmers and other users with low literacy, restricted access to technology, and limited decision-making power.[155]

- **Making a clear and realistic business case to farmers and rural communities on DA –** public engagement and support is vital in order to implement plans and policies related

[149] Fabregas R, Kremer M, Schilbach F. 2019. *Realizing the potential of digital development: The case of agricultural advice.* https://science.sciencemag.org/content/366/6471/eaay3038?utm_campaign=toc_sci-mag_2019-12-12&et_rid=293396612&et_cid=3121433

[150] Kremer M. Presentation during '*The Future of Development: A virtual seminar series*' organised by the Center for Global Development. https://www.cgdev.org/event/digital-agriculture

[151] GCA (DRAFT). A Blueprint for Digital Climate-informed Advisory Services: Building Resilience of 300 Million Smallholder Producers by 2030.

[152] World Bank. 2021. *Employment in agriculture, female (% of female employment) (modeled ILO estimate).* https://data.worldbank.org/indicator/SL.AGR.EMPL.FE.ZS

[153] Tsan M, Totapally S, Hailu M, Addom, Benjamin K. 2019. The Digitalisation of African Agriculture Report 2018–2019. Wageningen, The Netherlands: CTA/Dalberg Advisers. https://cgspace.cgiar.org/handle/10568/101498

[154] Mehrabi Z, McDowell MJ, Ricciardi V. *et al.* 2021. The global divide in data-driven farming. *Nat Sustain* 4, 154–160. https://doi.org/10.1038/s41893-020-00631-0

[155] Draft Investment Blueprint for Climate-informed Digital Advisory Services: Working Group 2 – Equity.

to DA effectively, but achieving this may face a number of challenges. One is a general mistrust around digital technology, and in some parts of the world a strong preference and familiarity for agricultural advisory services provided face to face (as opposed to via mobile phones). There are also countries where a prevalence of substandard digital advisory services has eroded trust and could make it difficult for the government to effectively promote digital agriculture further[156]. Recent research into digital extension services in East Africa showed that even though the cost benefit ratio of a recommended practice was 1:9[157], only 3–10% of farmers in the study adopted the practice[158].

DA should also be tailored to the different user needs and contexts of the various beneficiaries of the service. This could require providing other complementary digital services such as financing, input supply, market access and insurance. These services can often be bundled together into one, offering greater benefits to farmers. Therefore, governments should design communications campaigns with farmers and rural communities that present a balanced picture of the benefits of DA and put forward clear and well-evidenced reasons for adoption.

- **The need for public-private partnership expertise and coordination across multiple government agencies –** in many parts of the world the digital agriculture agenda is driven by the private sector, which means that designing and implementing plans for DA adoption requires the government to engage with and develop partnerships with business. However, developing effective public-private partnerships requires its own set of skills and experience that may be scarce outside of Ministries which regularly engage with the topic, such as Infrastructure, Transport and Energy. More broadly, there is a lack of coordination amongst ministries, government agencies, private sector companies and farmers, which can lead to a duplication of initiatives, redundant data collection and provision, services that fail to understand and meet farmers' needs, poor quality information, and gaps in policy.[159] Provided it receives requisite senior government support, the NAP process could serve as a mechanism to bring these actors together and improve coordination on DA.

[156] World Business Council for Sustainable Development. 2021. *Digital Climate Advisory Services (DCAS) for smallholder resilience*. https://www.wbcsd.org/download/file/11227

[157] The recommended practice was treating soil acidity with lime

[158] Fabregas R, Kremer M, Schilbach F. 2019. Realizing the potential of digital development: The case of agricultural advice. *Science* 366: 6471. https://science.sciencemag.org/content/366/6471/eaay3038.full?ijkey=aPtdvYNBuaLN6&keytype=ref&siteid=sci

[159] Draft Report of the GCA Working Group on Data and Governance (1). Data, Information, and Governance of Climate-Informed Digital Agricultural Advisory Services.

3.2 Resource and support systems

Below we provide a short overview of existing resources and support systems relevant to the topic of digital agriculture, which may be useful for Governments seeking to further integrate it into their NAPs. Initiatives listed below serve as illustrative examples only and are by no means intended to be comprehensive. In the Appendix to this document, we also include key reports and technical resources which may serve as useful references for governments as they consider options for integrating digital agriculture in NAPs.

- **Multilateral donors and funds**

Most global multilateral climate finance mechanisms have a track record of providing support for digital agriculture and climate resilience.

As identified in Box 3 (Part 1), ten projects have been supported by the Green Climate Fund in this area, with a combined budget of US$298m. The Adaptation Fund supports projects in agriculture, disaster risk reduction and food security, amongst other climate adaptation themes. As an example, the Fund has provided a US$7.4 million grant to enhance the adaptive capacity of National Meteorological and Hydrological Services to produce tailored climate services in Chile, Colombia and Peru.[160] IFAD also supports several projects in digital agriculture, including a partnership with Precision Agriculture for Development (PAD) to use digital technology to reach 1.7 million smallholder farmers in Kenya, Nigeria and Pakistan.[161] The Climate Investment Funds (CIF) – through their Pilot Program for Climate Resilience (PPCR) – have invested US$202 million into projects aimed at strengthening weather and climate services in developing countries.[162]

Another example includes the World Bank, which has provided a US$60 million grant supporting the Accelerating the Impact of CGIAR Climate Research for Africa (AICCRA) project. Through this project, the World Bank will support research and capacity-building activities carried out by CGIAR centers and partner organizations, with the goal of enhancing access to climate information services and validated climate-smart agriculture technologies in Africa.[163]

- **Bilateral development agency programs**

There are numerous examples of programs spearheaded by bilateral development agencies:

[160] Adaptation Fund. 2019. *ENANDES Full Proposal.* https://www.adaptation-fund.org/wp-content/uploads/2019/04/6532ENANDESRevisedproposal20190514NOtrackchanges.pdf

[161] Brett N, Salazar Canziani V. 2021. *Digital agriculture: key to helping small-scale producers overcome COVID-19 challenges.* https://www.ifad.org/en/web/latest/blog/asset/42279983

[162] CIFs. 2020. *Strengthening Weather and Climate Information Services: Highlights from PPCR-supported Project.* Knowledge for Resilience Series 2020. https://www.climateinvestmentfunds.org/sites/cif_enc/files/knowledge-documents/ppcr_resilience_series_weather_and_climate_information_services.pdf

[163] World Bank. 2020. Advancing Research on Climate Change: World Bank Grants $60 Million to Help Strengthen the Resilience of the Agricultural Sector in Africa. PRESS RELEASE NO: 2021/068/AFR. https://www.worldbank.org/en/news/press-release/2020/12/10/advancing-research-on-climate-change-world-bank-grants-60-million-to-help-strengthen-the-resilience-of-the-agricultural-sector-in-africa

- GIZ is working on a project focused on scaling digital agricultural innovation in Africa – which includes identifying and selecting startups, supporting them through capacity building, and connecting them with investors and partners to bring them to scale.[164] GIZ is also working with Mercy Corps AgriFin and Dalberg on a Digital Agriculture Platform (DAP) project.[165]
- USAID's Digital Development for Feed the Future program is attempting to scale up the use of digital technologies in agriculture through technical assistance to Feed the Future programs, capacity building for Feed the Future teams, and strengthening the knowledge base on best practices.[166]
- FCDO has developed the Enhancing Digital and Innovations for Agrifood Systems and Livelihoods (eDIAL) Program, which aims to increase productivity and incomes for farmers by harnessing digital innovation.[167]
- The Norwegian Ministry of Foreign Affairs also supports the Digital Public Goods Alliance, an initiative that facilitates the identification, development, use of, registration of and investment in digital public goods.[168]
- The Swedish International Development Cooperation Agency (SIDA) is supporting rural communities to help them have access to financial services through digital payment systems in Zambia, Mozambique, and Kenya.[169]
- The Japan International Cooperation Agency (JICA) has signed a loan agreement of US$56 million with Olam to use digital technology to provide support, stability and reliable market access to smallholder farmers[170].
- The Korean Rural Development Administration (RDA) has established the Korea Program on International Agriculture (KOPIA) which has set up agricultural centers in 12 countries and provides support for them to develop their own agricultural technologies.[171]

- **Regional development banks**

The African Development Bank (AfDB) launched the Digital Agriculture Flagship in 2019 to support African governments to put in place enablers for the growth of digital agriculture. The Digital Agriculture Flagship invests in hard and soft infrastructure, to help governments foster supportive environments for digital agriculture.[172] AfDB has also launched an Africa Adaptation Acceleration Program (AAAP), which is a US$25 billion fund that will focus on agriculture, infrastructure, youth and innovative finance. AfDB and the Global Center on Adaptation (GCA) will use this to leverage an additional US$12.5 billion through other key partners.[173]

[164] GIZ (n.d.). Promoting digital agricultural innovation in Africa. https://www.giz.de/en/worldwide/83909.html
[165] Mercy Corps website: https://www.mercycorpsagrifin.org/2021/01/28/introducing-the-digital-agriculture-platform-blueprint-series-with-giz-dalberg/
[166] USAID website: https://www.usaid.gov/digitalag
[167] FCDO website: https://devtracker.fcdo.gov.uk/projects/GB-GOV-1-300644/transactions
[168] Digital Public Goods website: https://digitalpublicgoods.net/about/
[169] SIDA website: https://www.sida.se/en/sidas-international-work/private-sector-development
[170] JICA website: https://www.jica.go.jp/english/news/press/2020/20200430_10_en.html
[171] RDA website: https://www.mafra.go.kr/english/1402/subview.do
[172] Afun-Ogidan K. 2020. The future of agriculture in Africa is in digital disruption. African Development Bank Group (AfDB). https://blogs.afdb.org/integrating-africa/future-agriculture-africa-digital-disruption-297
[173] AfDB. 2021. *New African Development Bank-GCA initiative will galvanize $25 billion to scale up African climate adaptation*. https://www.afdb.org/en/news-and-events/press-releases/new-african-development-bank-gca-initiative-will-galvanize-25-billion-scale-african-climate-adaptation-40567

The Asian Development Bank has also launched Digital Solutions to Improve Agricultural Value Chains to provide technical assistance to selected countries in Asia and set up a financially sustainable e-agriculture system.[174]

The Inter-American Development Bank has supported digital technology adoption in Latin America, through its collaboration with the FAO's Investment Center.[175]

- **South-South cooperation**

Initiatives such as the Alliance for Financial Inclusion, established in 2008 with nearly 100 participants from developing and emerging countries, is exploring financing opportunities to scale up measures proven to work to tackle the issues of climate change and food security. CCAFS has also facilitated South-South knowledge sharing and has highlighted the role of technology in strengthening agricultural resilience. The CGIAR Platform for Big Data in Agriculture, by bridging initiatives in the field of food systems – such as the Inspire Challenge competition, annual conventions, and data repositories (Gardian and Evidence Clearing House), has catalyzed partnerships between over 1000 CGIAR innovators and private sector start-ups, and awarded 28 digital innovators since its inception in 2017.[176]

- **Private foundations and philanthropies**

The topic of agricultural technology is a priority for some of the world's largest private foundations, most notably the Bill & Melinda Gates Foundation who have invested in over 115 digital agriculture projects[177] since 2009.[178] A range of other major private philanthropic organizations focus on this topic such as the Rockefeller Foundation, the Mastercard Foundation, the Grameen Foundation and the African Agricultural Technology Foundation amongst others. The World Bank's AgriFin initiative provides practical tools for agricultural finance practitioners as well as knowledge and examples of best practices for policy makers.

- **Non-Governmental Organizations**

Most major international development organizations working in agriculture include some degree of focus on digital technology and can play a valuable partnership role with the government in sharing information and scaling up models that have proven to be effective. To illustrate this with some examples:

Mercy Corps' AgriFin program provides market facilitation to drive collaboration and innovation between financial institutions, mobile networks, educators, climate information providers, tech start-ups & governments to develop and deliver DCAS and other digital solutions for smallholder farmers.[179] They conduct farmer-centric and farmer-driven market

[174] ADB (n.d.). *Regional: Digital Solutions to Improve Agricultural Value Chains.* Asian Development Bank (ADB). https://www.adb.org/projects/49054-001/main
[175] FAO website: http://www.fao.org/americas/noticias/ver/en/c/1197760/
[176] CGIAR. 2021. *Inspire Challenge website*. https://bigdata.cgiar.org/inspire/
[177] Gates Foundation website. https://www.gatesfoundation.org/How-We-Work/Quick-Links/Grants-Database#q/k=digital%20agriculture
[178] Ibid.
[179] Mercy Corps website: https://www.mercycorpsagrifin.org/how-agrifin-works/

research and needs assessments, identify core delivery partners, additional bundled service providers, and link service delivery to farmer education and digital literacy campaigns, acting as a trusted broker and intermediary to develop scalable solutions.

Precision Agriculture for Development (PAD), is an international NGO with deployments in eight countries across South Asia and East Africa. They partner with governments, donor organizations and in-country partners to provide digital advisory services to farmers.[180]

Solidaridad has been developing and integrating digital tools that facilitate detailed and contextualized information exchange with farmers about their farms and their crops. Solidaridad shares digital tools with partners and involves them in the co-creation of new digital technologies to ensure they respond to actual needs on the field.[181]

IDH Farmfit's digital transformation advisory is also providing tailored recommendations on how digital technology can add value to businesses and the farmers they serve, and match-make them with the relevant tech providers.[182] This advisory service could potentially be applied to government extension services and enterprises as well.

Digital Green has used its innovative digital platform for engagement with smallholder farmers and local governments to improve lives of rural communities across South Asia and sub-Saharan Africa (see more information in Section 1 for their engagement in Ethiopia and India).

TechnoServe has implemented and tested digital technologies in multiple programs, including working with Vodafone and other partners to test and deploy a mobile solution for payments and data for 500,000 smallholder farmers in Kenya, Tanzania and Mozambique, as part of the Connected Farmer Alliance.

One Acre Fund is a non-profit organization that supplies smallholder farms in East Africa with asset-based financing and agriculture training services to reduce hunger and poverty. The One Acre Fund has partnered with the Rwandan government to operate an agricultural training program through its nationwide extension network.

- **Private sector coalitions and associations**

A number of the world's leading business coalitions have active programs on digital agriculture, where they seek to work with governments and policymakers on scaling up its adoption. This includes the World Business Council for Sustainable Development (WBCSD) who, through its Farm of the Future workstream, has released a publication on the topic of Digital Climate Advisory Services (DCAS) for smallholder resilience.[183] This also includes the World Economic Forum's (WEF) who, through its New Vision for Agriculture initiative, has

[180] PAD website: https://precisionag.org/what-we-do/our-model/
[181] Solidaridad website: https://www.solidaridadnetwork.org/news/engaging-producers-with-digital-tools
[182] IDH FarmFit website: https://www.idhsustainabletrade.com/project/farmfit-digital-transformation-analysis-advice/
[183] World Business Council for Sustainable Development. 2021. Digital Climate Advisory Services (DCAS) for smallholder resilience. https://www.wbcsd.org/contentwbc/download/11227/165626/1

helped create public-private partnerships in 23 countries, benefiting millions of farmers.[184] Other examples include the creation of multi-stakeholder partnerships including Grow Asia and Grow Africa. The GSMA Innovation Fund for Digitization of Agricultural Value Chains aims to scale digital solutions for the last mile and improve smallholders' financial inclusion, livelihoods and climate resilience.

- **Knowledge platforms and research partnerships**

There are a range of academic institutions and partnerships engaged in action research on digital agriculture whose work may be useful for governments when integrating it into the NAP process. Examples that illustrate this include:

The University of Reading (UK)'s Participatory Integrated Climate Services for Agriculture (PICSA) initiative takes a participatory approach to climate services and agricultural extension, now in use in 20 countries.[185] PICSA combines historical climate data and forecasts with farmers' knowledge of what works in their own context, and then uses participatory planning methods to help them make informed decisions for their agricultural practice.

Wageningen University & Research (WUR) are continuing the work of the Technical Centre for Agricultural and Rural Cooperation (CTA), which ceased operations in 2020. Wageningen will continue to track the uptake of digital agricultural tools and services around the world. They will provide research and policy support for digital agriculture, including data science, modeling, data driven monitoring and evaluation, and on-the-ground activities to pilot innovations.[186] WUR has also partnered with GSMA, the Grameen Foundation and NpM to create a Digital Agriculture Knowledge Hub (DAK-Hub) to be launched in early 2021. The Digital Agri-Hub is meant to curate, synthesize and distribute content, data and evidence with the aim of clearly identifying digital solutions that achieve genuine impact for small-scale producers across the agrifood system, especially for women and other groups at risk of being left behind.[187]

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) also has several initiatives related to digital agriculture including Krishi Vani, a voice message based agro-advisory and Krishi Gyan Sagar (KGS), an ICT-enabled extension model in India.

The Digital Agriculture Convergence Lab is a French research initiative that brings together 400 researchers, teachers and entrepreneurs to help develop technology in a farmer-friendly way.

The University of California (UC) Davis, Feed the Future Innovation Lab for Markets, Risk and Resilience (MRR Innovation Lab) and the think tank International Centre for Evaluation and

[184] World Economic Forum. 2015. New Vision for Agriculture. https://www3.weforum.org/docs/WEF_CO_NVA_Overview.pdf
[185] University of Reading website: https://research.reading.ac.uk/picsa/
[186] Wageningen University & Research website: https://www.wur.nl/en/Research-Results/Research-Institutes/Environmental-Research/show-wenr/WUR-monitors-expansion-of-digital-tools-in-agriculture-worldwide.htm
[187] https://digitalagrihub.org/

Development (ICED) have developed the Advancing Local Leadership, Innovation and Networks (ALL IN) in Africa initiative. ALL IN will develop and test financial and market innovations that take the most promising agricultural tools for families in developing economies from the lab to the field.

The FAO e-Agriculture platform is a global community of practice that facilitates dialogue, information exchange and sharing of ideas related to the use of information and communication technologies (ICTs) for sustainable agriculture and rural development. They are also looking to establish a multi-stakeholder platform, the International Platform for Digital Food and Agriculture which will facilitate discussions on how to strengthen the potential of digital technology applications in food and agriculture and how to address related challenges.

The Global Framework for Climate Services (GFCS) by the World Meteorological Organization (WMO) is a global partnership of governments and organizations that produce and use climate information and services.

The International Center for Tropical Agriculture (CIAT) and the CGIAR Platform for Big Data in Agriculture have teamed up with the World Bank and FAO to create Digital Agriculture Country Profiles (DAPs). This is building on the success of the Climate-Smart Agriculture Country Profiles that are published by FAO, and so far, the initiative has created profiles for South Africa, Rwanda and Côte d'Ivoire.

Box 6: How can non-government actors engage with the NAP process for DA scale-up?

Multilateral and bilateral donors and funds: These entities may provide loans, grants, or guarantees to support governments in implementing DA components of NAPs. The NAP process can also provide an effective 'one stop shop' for multilateral donors and funds seeking to engage multiple countries at once to achieve economies of scale.

Regional development banks: Typically, these banks can provide loan finance and other forms of investment to support the scale up of DA adoption in their target countries or regions. This finance can also help to catalyze additional resources from the private sector. They can also provide policy advice and technical assistance to support governments in advancing the enabling environment for DA in their countries. The NAP process can provide a standardized framework to engage governments on this topic and to align with their own climate adaptation and agriculture-sector programming.

South-South cooperation: The NAP process could serve as an effective forum to support enhanced South-South coordination and learning between countries to support the scale up of DA adoption.

Private foundations and philanthropies: Private foundations can directly support and provide financing to public and private DA programs. The NAP process could provide an entry point for these actors to engage in public-led DA programs as part of a well-recognized international process.

Non-Governmental Organizations: NGOs can partner with government in information collection, information sharing, awareness raising and scaling up models that have proven to be effective. They can be the connection between policymakers and local communities and champion progressive DA policies. The NAP process can also help NGOs and civil society to further understand and align their activities to government priorities and potentially serve as a forum for NGO/CSO engagement with multiple governments simultaneously.

Private sector coalitions and associations: These organizations can lead and support the adoption of DA in countries and offer opportunities for public-private partnerships (see Section 3.1). The NAP process also offers them an opportunity to communicate what is needed from a private sector perspective to further invest in DA scale-up and engage with multiple governments in one setting.

Knowledge platforms and research partnerships: These initiatives can provide expertise with respect to data collection, analysis of DA, technical knowledge and collection of country-specific data. The NAP process can provide a centralized location for these platforms and organizations to collect and analyze data related to adaptation planning and DA.

3.3 A way forward for digital agriculture in NAPs

Below are a brief set of recommendations for how the subject of digital agriculture (DA) can be further explored and taken forward in the NAP process:

- **Integrating DA within the activities of different NAP support programs and bilateral donor support for NAP development** – this could begin with knowledge-sharing events on DA and how it can support and be integrated into NAPs, with follow-up exploration of more in-depth and tailored support to countries on the topic. There are a number of programs and initiatives that can support mainstreaming and integrating DA into the NAP process (e.g., The Integrating Agriculture in National Adaptation Plans (NAP-Ag) Program, the Global Water Partnership, and the Global Center on Adaptation).

- **Developing a DA community of practice** – as an informal collective effort to advance the integration of DA within the NAP process. This can help build and coordinate the programs and initiatives outlined above and provide a dedicated implementation vehicle for mainstreaming DA into the NAP process. The community of practice can provide a space for exchange of knowledge (see below), opportunities, and resources to scale up the implementation of DA.

- **Peer to peer knowledge sharing** – facilitating learning between countries that are at different stages of incorporating DA into NAPs. For example, this could be offered as a collaboration topic in the Open NAP process. A specific topic that could be explored is sharing knowledge from countries with more advanced private DA sectors on how the government has supported this through incentives, policies and regulation as well as through a broader enabling environment. The community of practice for example could host this peer-to-peer knowledge sharing process.

- **Identifying technical support and advice needs** – if these needs are identified collectively by the NAP DA community of practice, this could help prioritize potential asks from donors and support providers identified under Part 3.2.

- **Monitoring progress, evaluation and lessons learned** – this involves identifying resource and time efficient methods to track progress, and sharing ongoing lessons learned. For example, there could be annual or semi-annual virtual workshops on the topic, to help keep countries up to date with the latest advances in technology and new trends along

with countries sharing their own progress and lessons learned. Impact assessments and evaluations of country level programs or the work of global support programs can also be shared in the interests of continuous improvement.

References

Dinesh D, Campbell B, Bonilla-Findji O, Richards M (eds). 2017. *10 best bet innovations for adaptation in agriculture: A supplement to the UNFCCC NAP Technical Guidelines.* CCAFS Working Paper no. 215. Wageningen, The Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). https://ccafs.cgiar.org/resources/publications/10-best-bet-innovations-adaptation-agriculture-supplement-unfccc-nap

Fabregas R, Kremer M, Schilbach F. 2019. Realizing the potential of digital development: The case of agricultural advice. *Science* 366: 6471. https://science.sciencemag.org/content/366/6471/eaay3038.full?ijkey=aPtdvYNBuaLN6&keytype=ref&siteid=sci

Kim J, Shah P, Gaskell JC, Prasann A, Luthra A. 2020. *Scaling Up Disruptive Agricultural Technologies in Africa. International Development in Focus.* Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/33961

OECD. 2015. *Data-Driven Innovation: Big Data for Growth and Well-Being*. http://dx.doi.org/10.1787/9789264229358-en

Phatty-Jobe A. 2020. *Digital Agriculture. Maps 2020 State of the Sector in Low and Middle-Income Countries.* London, UK. GSMA. https://www.gsma.com/r/wp-content/uploads/2020/09/GSMA-Agritech-Digital-Agriculture-Maps.pdf

Steiner A, Aguilar G, Bomba K, Bonilla JP, Campbell A, Echeverria R, Gandhi R, Hedegaard C, Holdorf D, Ishii N, Quinn K, Ruter B, Sunga I, Sukhdev P, Verghese S, Voegele J, Winters P, Campbell B, Dinesh D, Huyer S, Jarvis A, Loboguerrero Rodriguez AM, Millan A, Thornton P, Wollenberg L, Zebiak S. 2020. *Actions to transform food systems under climate change.* Wageningen, The Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). https://hdl.handle.net/10568/108489

Trendov NM, Varas S, Zeng M. 2019. *Digital technologies in agriculture and rural areas – Status report.* Rome. http://www.fao.org/3/ca4985en/ca4985en.pdf

Tsan M, Totapally S, Hailu M, Addom, Benjamin K. 2019. The Digitalisation of African Agriculture Report 2018–2019. Wageningen, The Netherlands: CTA/Dalberg Advisers. https://cgspace.cgiar.org/handle/10568/101498

UNCTAD. 2020. Transition to the digital economy: technological capabilities as drivers of productivity. https://unctad.org/system/files/official-document/ldcr2020_ch4_en.pdf

World Bank Group. 2019. *Future of Food - Harnessing Digital Technologies to Improve Food System Outcomes*. Washington DC: World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/31565/Future-of-Food-Harnessing-Digital-Technologies-to-Improve-Food-System-Outcomes.pdf?sequence=1&isAllowed=y

World Business Council for Sustainable Development. 2021. *Digital Climate Advisory Services (DCAS) for smallholder resilience*. https://www.wbcsd.org/download/file/11227

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