Digital Adaptation in Agriculture Profile for Zambia

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Acronyms

AAAP	Africa Adaptation Acceleration Program
ABMs	Agent-Based Models
AfDB	Asia Development Bank
AI	Artificial Intelligence
APPSA	Agriculture Productivity Program for Southern Africa
CRIDF	Climate Resilient Infrastructure Development Facility
COMESA	Common Market For Eastern And Southern Africa
COVID-19	Corona Virus of 2019
DCAS	Digital climate-informed advisory services
EbA	Ecosystem-based Adaptation
FAO	Food Agricultural Organization
FDI	Foreign Direct Investments
FISP	Farmer Input Support Programme
GCA	Global Center on Adaptation
GDP	Gross Domestic Product
GM-UNCCD	Global Mechanism of the United Nations Convention to Combat Desertification
GRZ	Government of the Republic of Zambia
ICT	Information And Communication Technology
IoT	Internet of Things
IPCC	The Intergovernmental Panel On Climate Change
ML	Machine Leaning
NAPA	National Adaptation Programmme of Action
NCCRS	National Climate Change Response Strategy
NGOs	Non-governmental organizations
PIDACC-ZM	Programme for Integrated Development and Adaptation to Climate Change
SADC	Southern African Development Community
SCRALA	Strengthening Climate Resilience Of Agricultural Livelihoods In Agro-Ecological Regions I And II
SDGs	Sustainable Development Goals
SIM	Subscriber Identity Module
SMEs	Small and Medium Enterprises
UNDP	United Nations Development Programme
USSD	Unstructured Supplementary Service Data
WARMA	Water Resource Management Authority
WFP	World Food Programme
ZAMCOM	Zambezi Watercourse Commission

1. Introduction

The Zambezi River Basin is the largest basin in the Southern African Development Community, and the fourth largest basin in Africa, with a total area of 1.37 million km^2 (World Bank, 2010). It is shared by eight countries including Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe. The Zambezi River Basin has high transboundary importance in terms of water management. This is not only because of the different contributions of these sub-basins to the overall runoff of the Zambezi River but also because of the very high variability of climate in space and time, the valuable natural resources and major differences in sub-basin characteristics Approximately 41 percent of the basin's 1.37 million square kilometres spread is in Zambia. (World Bank, 2010).

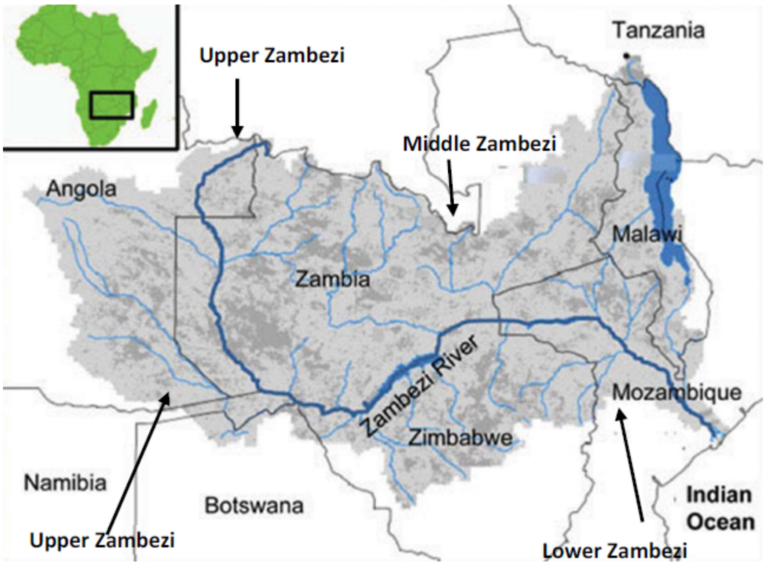

Figure 1: Picture of the ZRB position in Southern Africa, the eight riparian countries (Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe) and the three (upper, middle and lower ZRB)
Source: Senzanje & Dirwai., (2020)

The Basin lies within the tropics with the upper and middle course of the river placed on an upland plateau. Although there are slight differences between different latitudes, rainfall varies between 500 mm to 1400 mm per year. The temperature ranges between 18° and 30° C in the Southern part of the catchment and the northern Zambian and Angolan regions respectively *(Beyer et al.*, 2016). During the period May to July, the winter months, temperature averages 20° C and may reach 40 ° C between August and October before the onset of the rainy season in November. The rainy season runs from November to April. Since the Zambezi basin lies within the unimodal zone, there is not much difference in rainfall patterns except in amounts from North to south. The southernmost areas, in particular the Namibian, Botswanan and southern Zambian regions, display the least favourable preconditions for rain-fed farming while the northern part of the Basin receives more total rainfall over the wet period, and experience longer rainy seasons, and more productive rainfall events. Rainfall averages 1100 mm to 1300 mm per year near the Zambezi source but may be as low as 500 mm per year in the low southern areas (Killingtveit & Hamududu, 2016).

The Zambezi River Basin supports the needs of more than 30 million. It also supplies 20 percent (and likely to rise to 40 percent) of its total water runoff for major economic activities including hydropower generation, irrigation and both urban and rural consumption. Hydropower generation is the biggest water user through reservoir evaporation, followed by agricultural irrigation and lastly domestic water consumption.

Figure 2, Sanchez, 2018). However, with respect to renewable water resources, agriculture is the largest user in all the river basin countries with countries such as Malawi, Mozambique, Tanzania, Zambia and Zimbabwe having more than 75% of renewable water resources being consumed by agriculture (Senzanje & Dirwai., 2020). Changes in water demand overtime in the river basin will likely put pressure on water allocation among the eight countries and more so with the effects of climate change such as increased temperature, droughts and dry spells.

	KM^3	%
Available Runoff	$103.2*10^0$	100.00
Hydropower (Evaporation)	$17.0*10^0$	16.46
Agriculture	$3.2*10^0$	3.13
Urban Domestic Consumption	$1.8*10^{-1}$	0.17
Rural Domestic Consumption	$2.4*10^{-2}$	0.02
Industrial Consumption	$2.5*10^{-2}$	0.02
Mining	$1.2*10^{-1}$	0.12
Environmental Releases	$1.2*10^0$	1.16
Livestock	$1.1*10^{-1}$	0.11
Total Water Demand	$21.9*10^0$	21.19

Figure 2: Sources of runoff demand in the Zambezi River Basin
Source: Sanchez, 2018

As part of the Zambezi River Basin and in reference to the area of the basin, Zambia is a key country in Programme for Integrated Development and Adaptation to Climate Change (PIDACC-ZM)[1], an initiative established to to build strong communities that are resilient to climatic and economic shocks in the Zambezi Basin.

1.1 A brief overview of Zambia

Although landlocked, Zambia is a resource-rich country with sparsely populated land in the center of Southern Africa. It has a population density of 25 per km² (Statista 2020) and covers approximately 75 million ha of land of which only about 15 percent is under cultivation. However, 42 million ha, representing 58 percent, is classified as having medium to high potential for agriculture production. Zambia has eight neighbouring countries including Angola, Botswana, Democratic Republic of Congo, Malawi, Mozambique, Namibia, Tanzania, and Zimbabwe, who provide an expanded market for its goods. The country is divided into ten administrative provinces namely Central, Copperbelt, Eastern, Luapula, Lusaka, Muchinga, North-Western, Northern, Southern and Western provinces. Lusaka province being the capital city[2].

Zambia has s one of the world's youngest population by median age (16.8 years). Its population is estimated at above 17.9 million, much of it urban (44%), with an annual growth rate of about 2.8 percent (World Bank, 2021). The rapid population growth is linked to high fertility levels at 4.5 births per woman, resulting in the population doubling close to every 25 years (World Bank, 2021).. As the large youth population enters reproductive age, this trend is expected to continue, which will put even more pressure on the demand for jobs, health care and other social services.

[11] PIDACC is discussed in section 1.2
[2] https://www.citypopulation.de/en/zambia/admin/

Due to the Corona Virus of 2019 (COVID-19), the Zambian economy fell into a deep recession. Real Gross Domestic Product (GDP) contracted by an estimated 4.9 percent in 2020, after growing by 4 percent in 2018 and 1.9 percent in 2019 (AfDB, 2020). During this period, all key sectors of the economy deteriorated; manufacturing output fell sharply as supply chains were disrupted, while the service and tourism sectors were hurt as private consumption and investment weakened due to measures taken to contain the spread of COVID–19. GDP was estimated to be US$[3] 19.32 billion in 2020 from US$ 20.27 billion in 2010 (World Bank 2020).

It is however, worth noting that even before the pandemic, the economy was already experiencing serious macroeconomic challenges such as high inflation, widening fiscal deficits, unsustainable debt levels, low international reserves, and tight liquidity conditions(AfDB, 2020; MacroTrends, 2020). Between the period 2010 and 2020 the Government of the Republic of Zambia (GRZ) borrowed approximately US$20 billion in debt (US$ 14 billion external debt and US$5 billion domestic debt). The borrowed funds did not result in economic growth.

Agriculture remains the main economic activity in rural Zambia and forms an integral part of the economy's poverty reduction strategies for rural households (Middelberg *et al.*, 2020). Agriculture is key to Zambia's economy with 7% total GDP share (Matchaya *et al.,* 2022). Despite the agriculture and agribusiness sectors high contribution of 20 percent to the GDP, Zambia was ranked as the 15th hungriest country in the Global Hunger Index in 2018. Poverty rates remains high at 64 percent of its population living below 2 US$ a day, out of which 40 percent are considered to live below US$ 1.25, a state of extreme poverty. In spite of the levels of poverty, especially in rural areas, Zambia is food secure in terms of maize production, which is a staple food for the country. Although maize production fluctuated substantially in recent years, it showed an increase through the 1971 - 2020 period. In 2020, yield was estimated at 3,387 thousand tonnes (Knoema, 2020).

Nonetheless, Zambia's agricultural production is vulnerable to weather shocks. Over the years, Zambia has been challenged by climate change impacts such as inconsistent rainfall patterns associated with floods, droughts and dry spells. This variability in rainfall patterns has been a challenge for transforming the agriculture sector since most farmers depend on the rain-fed crop production system (Ngoma *et al.*, 2021). Evidence further shows that rainfall is expected to reduce by 0.87 percent by 2050, with Southern and Western provinces of Zambia being the worst affected (Mulenga, 2021; Ngoma *et al.*, 2021). In addition,

1.2 Climate Change Adaptation Efforts

In the face of climate change, there has been an increasing effort among nations to build resilience. Globally, there are a number of organization working on key adaptation opportunities including the Africa Adaptation Acceleration Program (AAAP) and the Zambezi Watercourse Commission (ZAMCOM). The AAAP was developed jointly by the Global Center on Adaptation (GCA) and the African Development Bank (AfDB) to prioritise adaptation in Africa. This African Union-backed program targets to mobilize US$ 25 billion to drive adaptation on the African continent as a pathway towards the reduction of malnutrition for at least 10 million people, support one million youth with entrepreneurship skills and job creation, and integrate climate resilience into about US$ 7 billion worth of infrastructure investments, among other results. Partnerships with Multilateral Development Banks and other leading implementation organizations, stakeholders, and political and technical bodies will be important to deliver these results (AfDB, 2021).

[3] US$ referrers to United States Dollars

The AAAP focuses on four action areas (pillars) that collectively address Africa's adaptation priorities. The action areas are shaped to fit identified niches that provide key opportunities to drive adaptation through transformative and innovative action (AfDB, 2021). The four pillars are;

1. Climate-smart digital technologies for agriculture and food security
2. Africa infrastructure resilience accelerator
3. Empowering youth for entrepreneurship and job creation in climate adaptation and resilience
4. Innovative finance initiatives

Another effort to manage or address future imbalances between water supply and demand in the Zambezi River Basin in the face of uncertain climate risks projections is ZAMCOM. ZAMCOM was established "to promote the equitable and reasonable utilization of the water resources of the Zambezi Watercourse as well as the efficient management and sustainable development thereof". It is a major river basin inter-governmental organization bringing together the eight (8) Riparian states that share the Zambezi River Basin, as stipulated in the 2004 ZAMCOM Agreement[4] and in accordance with the revised SADC Protocol on Shared Watercourses of 2000[5]. Other coordination among the 8 Riparian countries include the Zambezi River Authority (ZRA) and the Integrated Water Resources Management Strategy (ZAMSTRAT)[6].

The key influencing factors behind the ZAMCOM Agreement include the recognition and consciousness by the Riparian States of the following:

- The scarcity and the value of water resources in the southern African region and the need to provide the people in the region with access to sufficient and safe water supplies;
- The significance of the Zambezi Watercourse as a major water source in the region, as well as the need to conserve, protect and sustainably utilize its resources;
- The commitment to the realization of the principles of equitable and reasonable utilization as well as the efficient management and sustainable development and management of the basin's water resources;
- The desire to extend and consolidate existing relations of good neighbourliness and cooperation amongst the Zambezi Riparian States on the basis of existing international water instruments.

ZAMCOM has established a strategic partnership with the Global Mechanism of the United Nations Convention to Combat Desertification (GM-UNCCD), the Climate Resilient Infrastructure Development Facility (CRIDF) and the African Development Bank (AfDB). This partnership established the PIDACC-ZM initiative. The overarching objective of PIDACC Zambezi is to build strong communities that are resilient to climatic and economic shocks in the Zambezi Basin through promoting inclusive transformative investments, job creation and ecosystem-based solutions. This Country Profile seeks to contribute to the PIDACC objective through developing a document with empirical information on climate adaptation in Zambia.

1.3 Objectives of the profile

Digital technologies are important in the Zambezi River Basin as a climate adaptation strategy due to climate risks. With these variations in climate, the digital technologies required are not one size fits all technologies. The climatic conditions will determine the type of digital technology required in that area. The use of digital technology in agriculture can revolutionize farming practices and the management of agri-food value chains

[4] https://zambezicommission.org/sites/default/files/clusters_pdfs/ZAMCOM agreement.pdf
[5]https://zambezicommission.org/sites/default/files/publication_downloads/Revised_Protocol_on_Shared_Watercourses_-_2000_-_English.pdf
[6] https://zambezicommission.org/sites/default/files/publication_downloads/factsheet_zamcom.pdf

in the future. It has the potential for a transformative and positive disruptive impact on the adaptive capacity of farmers and agribusinesses. Digital technologies can help improve production efficiency and effectiveness for smallholder farmers and also provide governments with a wealth of data for policy formulation (or adaption) and planning for climate adaptation. McKinsey (2020) estimates that increasing connectivity in agriculture through digital technologies could add US$ 500 billion to global GDP by 2030.

Digital technologies also play a vital role in addressing five of the seventeen Sustainable Development Goals (SDGs), namely: No Poverty, Zero Hunger, Good Health and Well-Being, Responsible Consumption and Production, and Climate Action (Crawford, 2017).

In line with the first pillar which is climate-smart digital technologies for agriculture and food security and to feed into the implementation of the PIDACC, GCA and the Bank are embarking on a project concerning climate-smart digital technologies around the Zambezi river basin with a deep dive on the Zimbabwe and Zambia side. One key output during the feasibility stage is the development of a country profile on Zambia.

The objectives of the profile are as follows:

i. Conduct a stocktaking and needs assessment to identify digital innovation infrastructure, institutional capacity, policies and programs, ongoing activities, key partners, gaps and opportunities, including the identification of low-hanging fruits for necessary analytical work and adaptation investment prioritization.
ii. Summarize key information related to the state of digitization and the extent to which digital innovations are mainstreamed into adaptation, especially in the context of agriculture.
iii. Understand the enabling environment that governs adaptation as well as the extent to which adaptation uses digital innovation.
iv. Understand digital innovations challenges, the extent of penetration, their general cost structures, and the prevalent adaptation techniques among smallholder farmers.
v. Summarize the key institutional, policy and human capital challenges to digitization.
vi. Make recommendations on key actions and opportunities to be undertaken/pursued in order to mainstream adaptation to climate change.

The country profile will be useful in arriving at country specific recommendations for upscaling the uptake of digital innovations in climate adaptation, in support of small and medium enterprises (SMEs), smallholder farmers and their enabling environment.

The report is structured as follows: It first presents the Conceptual framework for digital technology adoption and upscaling and afterward the study approach. It then highlights the most important climate hazards in Zambia and the uptake of digital technology. The country context including the economic relevance of Agriculture, water and energy follows after. The profile then delves into Zambia's climatic risks, vulnerability and resilience; challenges and opportunities for digital adaptation; digital adaptation to climate change; digital adaptation readiness; and a summary of the profile. Key annexes present case studies on the use of digital platforms and the list of key regional stakeholders in digital technology adaptation.

1.4 Conceptual framework for digital technology adoption and upscaling

Technology adoption has a number of constraints that fall in the realm of finance, behaviour influence and policy. However, within the constraints, there lies opportunities for improvement and investment.

A number of models have been developed that discusses technology adoption and use. Key among the many are the: (i) Unified Theory of Acceptance and Use of Technology, (ii) Technology Acceptance Model,

(iii) Enhanced Technology Acceptance Model, and (iv) Innovation Diffusion Theory (Kim & Crowston, 2012). This country profile will however, discuss the conceptual framework for empirically grounded Agent-Based Models (ABMs) of adoption and diffusion of digital farming technologies as presented in Figure 1 (Shang *et al.*, 2021).

The framework for empirically grounded ABMs of adoption and diffusion of digital farming technologies is a holistic approach that connects the dots between the wealth of empirical research on technology adoption. It is based on synthesized literature of empirical farm-level adoption studies and agent-based models simulating systemic diffusion mechanisms. The framework is a model-driven investigation of innovation diffusion in agent-based studies focusing on digital farming technologies. Furthermore, the framework may serve as a reference study on the adoption and diffusion of such technologies beyond the farm scale. It can also be the basis for contextual applications to inform policy-makers trying to foster the diffusion of suitable digital technologies through interventions since it highlights where policy can impact important aspects of adoption (Shang *et al.*, 2021).

The conceptual framework has five stages of innovation decision. These are the (i) knowledge stage, (ii) the persuasion stage, (ii) the decision stage, (iv) the implementation phase and (v) the confirmation stage. During the knowledge stage the technology recipients, usually farmers, become aware of the existence of the technology and get interested in it (Shang *et al.*, 2021; Rogers, 2003). The awareness is based on interaction with the technology and obtaining information about where it comes from and learning from agents and other sources. This stage can be modelled using information sharing through social networks.

The persuasive stage involves the farmer thinking through the potential value of adopting the technology. This is determined by attitudes, subjective norms and perceived behavioural control. The recipient's attitude refers to positive or negative evaluation of adoption. The farmer in this stage can be influenced by assumptions about the relative advantage which includes profitability dependent on cost and benefit of technology, farm characteristics and input and output markets. The compatibility of the technology to the existing farm equipment is also a key assumption that can influence adoption. Compatibility is based on the innovation's technical adaptability of the existing equipment and practices in the farming system. The disapproval or approval of adoption by 'important others' also greatly influences adoption i.e. the subjective norm. This subjective norm can be influenced by policies from institutions and social norms in respected farmers and consultants. Perceived behavioural control is the farmers' believed ability to implement adoption. This is the farmers' financial ability (income, and access to credit and subsidies), complexity (operator characteristics particularly knowledge and capacity) and trialability of the technology.

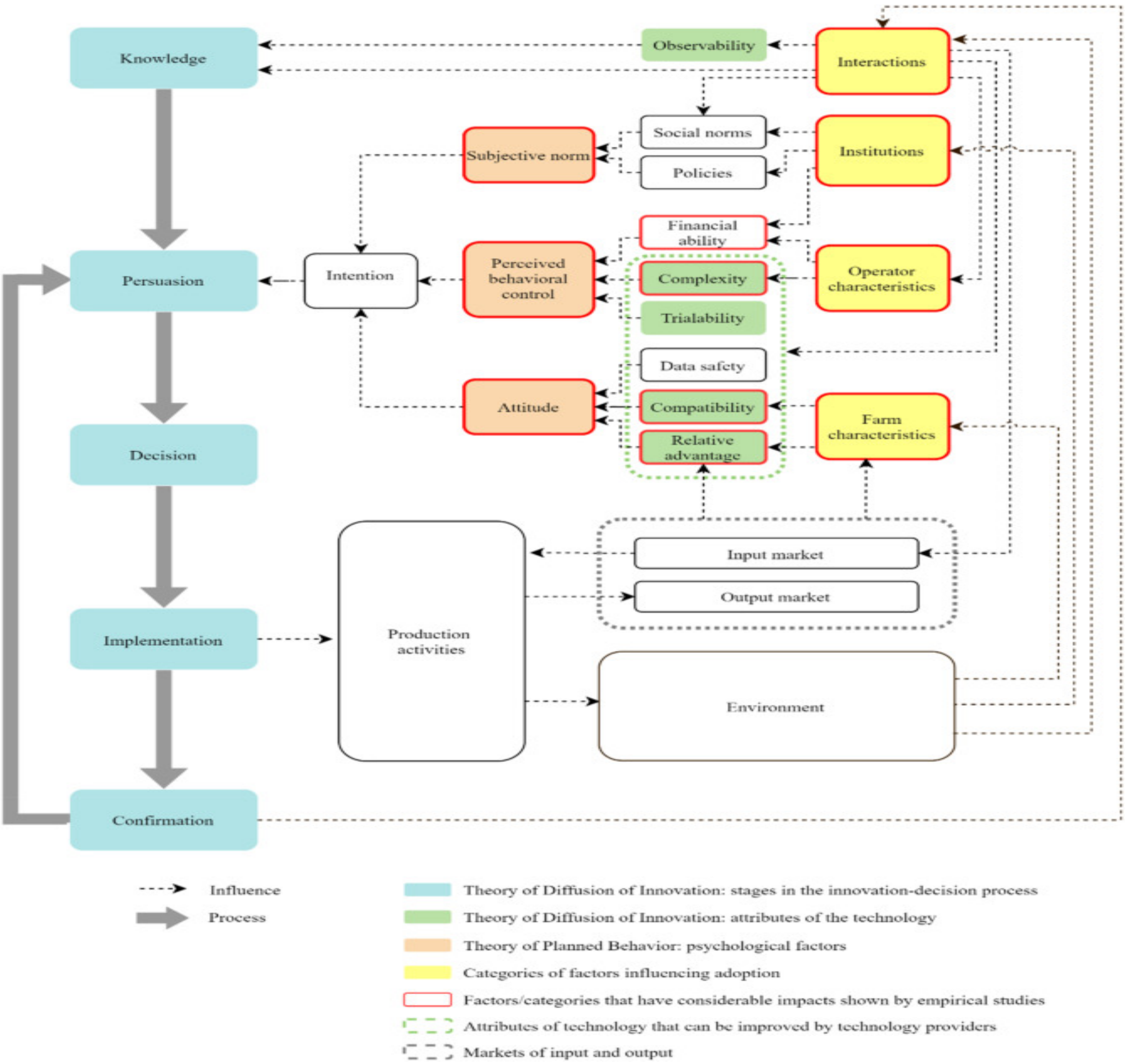

Figure 3: Conceptual framework for empirically grounded ABMs of adoption and diffusion of digital farming
Source: Shang et al., 2021

After intention is formed under the persuasion stage, comes the decision stage where technology is either adopted or rejected. This can be constructed along observed adoption rates in farm populations and modelled through setting a threshold for the intention of adoption using deterministic or probabilistic decision models. The framework considers the implementation stage as the period during which the farmer's adoption decision influences production activities carried out. These maybe productive activities with the intention to maximise profit subject to the farm's capability using the adopted technology. Activities may also largely depend on how the farm activities contribute to input and output markets. Changes in the market greatly influence farm characteristics and lead to structural change in the long run (Appel *et al.*, 2016). Changes in the environment also affect farmers' cultivation options with environmental pressure likely to induce policy makers to adjust regulations and influence the behaviour of agents and thereby adoption of technology.

In the confirmation stage, the farmer conducts an evaluation based on whether the criteria initially set up for adoption or rejection has been met. The farmer decides whether they will consider the technology according to the performance of the technology and the investment cost. This means there is still potential in this stage for dis-adoption and mal-adoption. The opportunity here is that this process of evaluations can act as input for technology providers to improve some attributes of their technology.

1.5 Benefits of technology in agriculture

Technology adoption in agriculture involves using a wide range of technologies, channels and analytical capabilities to make farming more precise, productive and profitable (Dinesh & Rodriquez, 2019). Digital adaption in agriculture also involves services such as (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) (Stephenson *et.al*, 2021),.

Stephenson et al. (2021), reports that sub-Saharan Africa has almost 400 digital agriculture solutions with 33 million registered farmers. There is however, no data at scale on their active use, and impact on farmer climate resilience is limited. The authors also state that agricultural technology in the Global North in the next decade will be driven by precision agriculture technology such as drones, robotics, Internet of Things (IoT), Artificial Intelligence (AI), and blockchain. Inversely, 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. Early warning systems may also need further strengthening.

Specific examples of digital technology applications in agriculture include new packaging[7] material, digital and wireless technologies for data measurement, weather monitoring, animal monitoring, geospatial monitoring and precision application of water and chemicals. Satellite imagery in cropping is also another digital technology. This tracks and produces data on variable seed rates, seed depth and soil moisture. Digital infra-red light and heat sensors, when used with geographical system technology in drones can be used to measure paddock crop health, and inform the decision on irrigation, pest management, fertilizer application and harvesting.

Technology such as AI, machine learning (ML) analytics, and connected sensors could foster increase in yields, improve the efficiency of water and other inputs, and build sustainability and resilience across crop cultivation and animal husbandry. It can also eliminate information asymmetry by increasing access to data to all stakeholders, lower operational and transaction costs by reducing manual and paper processing or data entry errors, improve access to markets by connecting farmers directly to consumers (thereby eliminating the middlemen and resulting in better pricing for their products and savings to consumers), enable access to finance by using alternative data to evaluate the creditworthiness of farmers and increase the ability to perform sustainable farming techniques that ultimately help the environment (Goh, 2022).

However, there is still a lot of work that needs to be done if the benefits of digital technologies are to be extended to low resource and smallholder farmers more so in the global south.

1.6 Study approach

The country's digital adaption profile is a detailed assessment of Zambia's digital sector and how it can be utilized to help the country adapt against the effects of climate change. It conducts a needs assessment to identify digital innovation infrastructure, institutional capacity, policies and programs and identifies low-hanging fruits for necessary analytical work and adaptation investment prioritization. The profile will

[7] Digital technology in packaging include QR code and image recognition. Image Recognition uses augmented reality where brand owners uses real world object https://www.adecesg.com/resources/blog/the-role-of-technology-in-the-un-sdgs,-part-one/s to create experiences for their consumers and thereby loyalty (Parker, 2020).

highlight key information related to Zambia's state of digitization and the extent to which digital innovations are mainstreamed into the agricultural sector ecosystem-based adaptation (EbA).

Further, the country profile will clarify the potential and challenges associated with investments intended to support digital solutions supporting ecosystem-based adaptation to climate change, by smallholder farmers and Small and Medium Enterprises (SMEs) in Zambia. It will also elaborate on adaptation needs at the country level and suggest targeted digitally enabled adaptation solutions.

To complete the country profile, a desk-based assessment was conducted using available literature and data. Literature reviewed included those specific to climate risks, adaptation strategies, and available digital tools for climate adaptation and the opportunities and challenges for scaling up those technologies in Zambia. Literature on the preparedness of the country for digital adaptation investments were also reviewed. To support the desk-based assessment, a consultative workshop was also held on March 11, 2022. The stakeholder consultation also sought to understand climate risks, adaptation strategies, available digital tools for climate adaptation, the opportunities and challenges for scaling up those technologies and the preparedness of the country for Digital Adaptation investments

To fill in information gaps from the desktop review and the stakeholder consultation and prioritize digital interventions, several key informant interviews were conducted. To review and finalize the profile, a validation workshop will be held with key stakeholders.

Table 1: Summary for analytical methods used for each objective

Research Question	Research Objective	Data collection method
What are the climate hazards and impacts experienced in the Zambezi basin part of Zambia?	To understand climate change vulnerability based on the climate hazards experienced by households in the Zambezi basin communities	Literature review, Key Informant interviews/Consultations
What is the contribution of digital tools to climate change adaptation in the Zambezi basin area?	To develop and understand digital tools that enhance high adaptive capacity to climate change and improve resilience the Zambezi basin communities	Literature review, Key Informant interviews/Consultations
What are strategies that can be used to scale adaptations through digitalisation in the Zambezi basin	To evaluate opportunities and barriers for scaling digitalization as a climate change adaptation solution in the Zambezi basin.	Literature review, Key Informant interviews/Consultations

2. Highlights

The United Nations Development Programme (UNDP)[8] reports that Zambia has been experiencing adverse climate change impacts which have also increased in frequency and severity. These include seasonal droughts, occasional dry spells, increased temperature in valleys, flash floods and changes in the growing season. These impacts are likely to exacerbate pre-existing socio-economic development challenges and increase vulnerability in food security, water resources, human health and in key eco-systems such as forests, grasslands and wildlife[9].

In view of the challenges that climate change is likely to predispose Zambia to, it is important that technology is enhanced and adopted to counteract and plan for future impacts. In so doing, it is important to overcome barriers that could hinder the use and uptake of digital adaptation solutions to climate. These barriers include the unintegrated and outdated policy environment, limited agriculture financing, and lack of infrastructure among others. For example, although telecommunications infrastructure, subscriber identity module (SIM) penetration, and internet usage vary greatly from country to country, Zambia still lags behind leading countries in -Southern Africa. SIM penetration stood at 17.2 million active subscribers while only 9.1 million had mobile broadband SIM Cards. This included multiple SIM card ownership by individuals. In comparison to Botswana, South Africa, Tanzania and Uganda active SIMs for Zambia stood at 78.61 per 100 inhabitants compared to 102.41 per 100 inhabitants for the mentioned countries. Likewise, mobile broadband connection per 100 inhabitants was 41.94 compared to 69.37 comparison average while international bandwidth per user was 3.92 kilo bytes per second (kbps) compared to 50 kbps for to Botswana, South Africa, Tanzania and Uganda. Mobile specific taxes were also higher in comparison at 17.5% compared to 8.3 percent (World Bank, 2020; FAO and ITU, 2022).

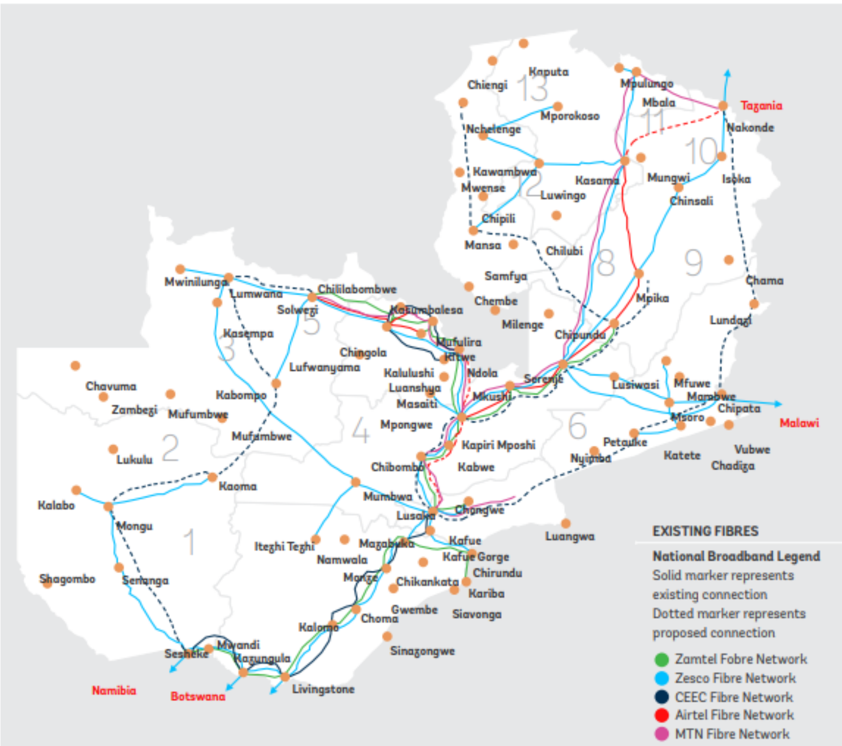

Figure 4: Zambia's Fiber Map
Source: World Bank (2020)

[8] https://www.adaptation-undp.org/explore/africa/zambia#
[9] ttps://www.climatelinks.org/sites/default/files/asset/document/zambia_adaptation_fact_sheet_feb2012.pdf

In 2018, over 50 percent of the population had a mobile phone and of these 62.5 percent were in urban areas and 33 percent in rural areas. Internet use was only 28 percent in urban areas and 5 percent in rural areas. Out of 116 districts, only 30 had fiber from either FibreCom or Liquid Telecom Limited[10] which is still relatively unreliable due to fiber cuts, electricity grid failure and lack of maintenance. Fibre as depicted in Figure 4*: Zambia's Fiber Map* is mainly along the line of rail and connects organizations. The number of 4G only sites stood at 202 in 2019 and increased by 5 percent between 2016 and 2019. There were 5,081 2G sites and 2,906 3G sites and 2,316 sites that simultaneously offered the three. Compared to South Africa, Botswana, Namibia, Uganda and Tanzania, Zambia has the lowest 3G coverage. Regarding 4G coverage, Zambia lags behind South Africa, Botswana, and Namibia. For internet protocol–based interactions, such as e-government or e-health, 2.5G or better coverage is required and in Zambia, these are mainly in urban and peri-urban areas. Where only 2G coverage is available, interactions are limited to voice, interactive voice response, SMS, and unstructured supplementary service data (World Bank, 2020; FAO and ITU. 2022).

Despite the lag in technology, Zambia is already hosting promising initiatives for digital adaptation. Some of these include the Zambia National Data Centre, e-platforms hosted by SMART Zambia (FAO and ITU, 2022) such as the e-Extension and the Zambia Integrated Agricultural Management Information System (ZIAMIS), and others such as e-Msika, and AgriPay. Proposals are also in development for e-bikes to make access to markets especially for perishable goods efficient (Project Consultative Workshop-Zambia, 2022). Despite these opportunities, financing which can leverage adoption and integration into such systems is still a challenge for small and medium farms with less than 5 percent of institutional credit going to small and medium scale farms. This hinders the ability of small and medium farms from growing and adopting digital technologies that have a cost implication. However, with the gains in non-traditional banking financial access points such as mobile money, there is an opportunity for growth in the small and medium scale farming sector. In addition, the Agriculture Productivity Program for Southern Africa (APPSA) of the World Bank promoted 22 new technologies to farmers in Zambia one of which is the Agripay App identified during the consultations. The Zambia Open University also partnered with the Southern Africa Telecentre Network and Zambia's Library and Information Association to establish a digital platform for the adoption of ICT in rural areas and across agriculture sector. FAO and ITU (2022) note that despite the increase in digital innovations and initiatives in the agriculture sector, Zambia has is yet to develop a National Digital Agriculture Policy ~ another opportunity for the PIDACC-ZM to offer capacity building. Limited investment into Research and Development (R&D) and Digital technologies is also a key constraint for skills training provision. Agriculture research spending is only 0.51 percent of agriculture GDP and only 2.9 percent are ICT good imports, a fact also highlighted as a key constraint for digital adoption in Zambia during the consultations. This shows that much still needs to be done for Zambia to improve on digital agro-innovation.

[10] Does not include fiber owned by ZAMTEL, MTN, AIRTEL and others

3. Country Context

Zambian is an agrarian country with a larger population's livelihood centred around agriculture (comprised also of forestry and fishing) *(Ngoma et al.*, 2021, Matchaya *al.*, 2022). Agriculture employs more than 50 percent of the population and nearly 26% when the definition of labour force aligned is to the International Conference of Labour Statisticians of 2013 (Matchaya *al.*, 2022). Agriculture employs nearly 60 percent of the labor force and around three-quarters of the country's population is employed in the agriculture sector. Around 67% of farmers are smallholders, cultivating less than two hectares of land. Maize is the major crop grown in Zambia- the staple crop of the country. Other crops grown include; soya bean, groundnuts, mixed beans, wheat, sorghum, cassava and many others. As mentioned above, the country is faced with several climate challenges including floods, droughts and dry spells and inconsistent rainfall patterns affecting crop production and food security (Ngoma et al., 2021).

Over the past decade, Zambia's agricultural sector's contribution to GDP has been declining, with the lowest contribution seen in 2018 at 2.86 percent from 9.42 percent in 2010 (Statista, 2020). Agriculture Contribution to total GDP share was estimated at 7 percent in 2022 (Matchaya *al.*, 2022). High rainfall variability experienced over the years has impacted the largely rain-fed production systems typical of smallholder farmers and ultimately led to the fluctuations in the contribution of agriculture to GDP. In 2015 and 2018, long dry spells (El Nino) resulted in crop failure and thus a serious decline in the sector's contribution to GDP (Mulenga, 2020). In this vein, the importance of digital technologies cannot be overemphasized, especially along the Zambezi river basin.

3.1 Available Digital technologies

Globally, there are several digital technologies available for use in the Agricultural sector. For African smallholder farmers and pastoralists, inclusive digital-enabled agricultural transformation could help achieve meaningful livelihood improvements (CGIAR, 2019). For women and youth, it could drive greater engagement in agriculture and create employment opportunities along the value chain (CGIAR, 2019).

There are several digital technologies available for the agricultural sector. The most notable ones include Digital climate-informed advisory services (DCAS), which are tools, platforms or activities that can help to disseminate climate information and assist individuals and/or organizations to make climate-resilient decisions and adapt to climate variability and change (Ferdinand et al., 2021). The services under DCAS include mobile apps, radio, and online platforms, as well as digitally enabled services (e.g., bulletins, extension services) for agricultural producers who may not be digitally literate or lack access to digital technologies. Instead of replacing person-to-person communication channels and strong agricultural extension services, DCAS tools support person-to-person communication channels (Ferdinand et al., 2021).

3.2 Potential for digital technologies in Zambia

There is potential for digital technology in Zambia since 80 percent of smallholders in Zambia have access to a mobile phone and accept mobile payments (Zambia Agribusiness Society, 2021). The GRZ however, needs to create a favourable environment through the right policies for digital technologies to work efficiently. This will not only benefit the smallholders who constitute 70% of rural farmers and produce 80% of the food but also urban farmers. Digital technologies in the agriculture sector could help smallholder farmers bypass a number of challenges such as financial access, timely decision making, resource conservation and at the same time complement human and physical infrastructure to ensure balanced growth and sustainability (Zambia Agribusiness Society, 2021). Particular attention will need to be given to both smallholder and medium (emergent) farmers as they need the most support in terms of access to productive resources. Commercial farmers usually have access to long term loans which increases their ability to invest in digital technology such as center pivot irrigation, weather based index insurance, mobile technology, quicker access to information and use of drone technology. Emergent farmers (farming 5 to 20 hectares) also have the biggest potential for quicker uptake since they have more investment fund at farm level than smallholder farmers who produce mainly for consumption. Emergent farmers can thus be a pilot study and may be the route used to increase emergent farmers in Zambia since smallholder farmers may increase their production area as well as productivity.

Zambian farmers are already adopting some digital technologies. Some of the digital technologies is the use of sensors that gather data about climate from satellites and the Internet; which is helping to improve the way farmers communicate with each other and with other services (Digital Journal, 2017). Further, a completely different technology being adopted in some areas is the use of solar-powered drip irrigation kits that pump water from any source, efficient use of water resources, strengthening early warning systems and preparedness, and using geographic information system (GIS)/remote sensing in the mapping of drought and flood-prone areas. In addition, some smallholder farmers using mobile phones have organized themselves into social networks with the aim of having fair market pricing information when marketing their products (Digital Journal, 2017).

3.3 The role of agriculture, forestry and fishing in the Zambia economy

Agriculture remains the key priority sector in the growth and poverty reduction agenda of Zambia and so does the forestry and energy sub-sectors. To fully exploit agriculture, Zambia has developed well-articulated agricultural policies and strategies towards the attainment of food security, maximizing farmers' incomes, promoting sustainable agriculture, and enhancing private sector roles in input and output markets (Trevor and Kwenye, 2018). Forests play a crucial role in enhancing human well-being and in sustaining the economy of Zambia. It contributes to economic growth, employment, wealth, export revenues, a stable supply of clean water, recreation and tourism opportunities, as well as essential building materials and energy for a wide range of economic sectors (UNEP, 2015).

Strategic utilization and development of Zambia's energy sources have the potential to increase industry competitiveness, improve rural service delivery and reduce rural poverty. The energy sector is also important to drive the industrialization of the agriculture sector towards intensive production and value addition. This can in turn lead to economic development. However, 85 percent of power generated in Zambia is hydro based. Since 2013, generation had fluctuated, largely due to the impact of droughts on the water availability at large dams.[11] Weather risks such as the El Niño experienced during the 2015/16 and 2018/19 thus pose a risk to the potential of industrializing the agriculture sector. The government in response is opening up new bring online additional megawatts of solar and thermal power through 2030 (World Bank Data, 2018).

3.4 Key economic drivers in Zambia

The growth in real GDP is important for any economy because it brings with it improvements in living standards. The Zambian economy is a dual economy characterized by both capital- and labour-intensive industries, particularly in the two major economic areas of mining and agriculture (Chirwa and Odhiambo, 2017). The labour-intensive industries use traditional methods while the capital-intensive industry uses mostly modern technology. The key macroeconomic drivers of economic growth in Zambia include human capital development, international trade, accumulation of capital stock, inflation and exchange rate (Chirwa and Odhiambo, 2015). The major policy reforms that Zambian authorities have instituted, especially

[11] https://www.opml.co.uk/blog/the-impact-of-climate-change-on-hydropower-in-africa

moving from a command economy driven by nationalist ideologies to a market-oriented economy have influenced the performance of these macroeconomic drivers.

Accumulation of physical stocks such as infrastructure development and industrialization has a great contribution to the economic growth of the country through growth in GDP. Human capital also has a great impact on economic development as it has a major influence on a country's capacity to absorb technology from developed countries. International trade is beneficial to economic growth. In light of this, GRZ, has entered into agreements such as the Southern African Development Community (SADC), Common Market for Eastern and Southern Africa (COMESA), and Tripartite Free trade area agreements to help drive economic growth. The country has embarked on deliberate trade policies that reduce trade restrictions to increase foreign direct investments (FDI) (Chirwa and Odhiambo, 2015).

The future economic growth prospects for Zambia may be challenged by its dependence on mineral growth, the deteriorating balance-of-payments position during lean periods, and low human capital development (Chirwa and Odhiambo, 2015). Other factors that shape economic growth in Zambia may include external influences, domestic economic policies and reforms, and political circumstances. Summary statistics on agriculture and the economy are provided in Table 2.

Table 2: Agriculture and the economy in Zambia

INDICATOR	2007	2009	2011	2013	2015	2017	2019	2021
GDP per capita (2015 US$)[1]	1,124	1,160	1,673	1,878	1,338	1,535	1,305	1260
Contribution of agriculture to national GDP (%)[1]	12.1%	11.6%	9.6%	8.2%	5.0%	4.0%	2.7%	-
Value of total agricultural exports (Millions $)[2] [4]	380	250	647	539	810	638	415	-
Value of total agricultural imports (Millions $) [2]	198	228	277	304	386	370	439	-
Agricultural area (1000 ha)[1] [2]	22984	23586	23636	23736	23836	23836	23836	-
Agricultural area as a percentage of total land area (%) [2]	30.8	31.7	31.5	32.1	32.1	32.1	32.1	-
Total population in the country (million) [1]	12.50	13.21	14.02	14.92	15.88	16.85	1786	18,92
Rural population in the country (%)[1] [3]	62.1	61.1	60.1	59.1	58.0	57.0	55.9	-
People actively employed in primary production agriculture (%)[1]			60.4	54.5	52.3	50.7	49.6	-
Women actively employed in primary production agriculture, as a percentage of female employment (%)[1]			68.1	61.3	58.5	56.3	54.7	-
Population living on less than US$ 1.90/day (%)[1]					58.7			
Rural population with access to electricity (%)[1]	-	-	5.2	5.1	4.7	14	13.9	-
Adult male literacy rate (%) [1]	64.1	-	-	-	-	-	90.6 (2018)-	-
Adult female literacy rate (%) [1]	51.8	-	-	-	-	-	83.1 (2018)-	-
Youth literacy rate (%)[1]	64.1	-	-	-	-	-	92.1 (2018)-	
Gender Inequality Index [5][6]				0.5 (2014)				0.73 (2020)
Prevalence of people undernourished (%)[4]	53.5	51.50	48.80	46.20	44.80	46.70		
Prevalence of children underweight (%)[4]	12.412.4	12.2	12	11.8	11.6	-	-	-
Prevalence of children wasting (%)[4]	5.6	-	-	6.2	-	-	4.2 (2018)-	-

Table Notes: Except where otherwise noted, the source of the data presented in Table 2 is [1] World Bank (2020), [2] Statista 2020, [3] Trading Economics (2020) and [4] the Food and Agricultural Organization FAOSTATS**12**, [5] Knoema (2020).

[12] https://www.fao.org/faostat/en/#search/ZAMBIA

As can be seen in Table 2 and according to the World Bank (2020), there are limited statistics on some of the indicators due to the inconsistence of data collection and data aggregation. These statistics are indicative of challenges associated with agriculture development in the country over time, as well as the potential set of opportunities for agriculture to contribute to economic development. Specifically, they set the stage for both the adaptation challenges presented by climate change and the potential for digital solutions to help farmers, and the country as a whole, respond to these dynamics.

In Zambia, the agriculture sector plays a key role in providing livelihoods to the country's population as it continues to be the biggest employer in the informal sector and provides the highest proportion of formal employment opportunities across all economic sectors in the country (Mulenga, 2020).

However, climate change has negatively affected Zambia's economy, especially in the agricultural sector the domain of smallholder farmers who depend on rain-fed agriculture (IAPRI., 2019). The Southern and Western regions of Zambia are projected to experience more negative impacts of climate change on crop yield and production and will become progressively more vulnerable over the coming years (Mulenga, 2020). Climate change and variability have led to crop losses, increased instances of food shortages leading to increased food insecurity, reduction in agriculture's contribution to GDP, including livelihood losses due to malnutrition, especially in children below the age of 5 (Ngoma et al., 2021).

Climate change also led to phases of electricity rationing which at certain periods in 2020 had gone up to 15 hours per day. This was largely due to the lagging effects of the 2015/16 and 2017/18 El Niño periods Zambia experienced which saw a significant reduction in rainfall activity and therefore water stored for hydropower generation. Southern province where the Kariba North Hydroelectric Station is located, was hardest hit and thus affected power supply nationwide (Siderius et al., 2018). However, Zambia continues to invest into the energy sector and power rationing has been drastically reduced to very low levels. For example, the construction of the additional 750 megawatts Kafue Lower Gorge Power Station is nearing completion, with four of the five generators already commissioned and the fifth expected to be commissioned at the end of 2022 (People's Daily Online, 2022). Thera are also plans to build smaller hydro power station around the country to reduce dependence on the Kafue Gorge Hydroelectric Power Station, the largest power station in Zambia, with an installed capacity of 900 MW.

There was also high volatility in maize grain and maize meal prices due to limited irrigation as well as supply shortfalls in some years (Ngoma et al., 2021). As noted, smallholder production in Zambia is predominantly rain-fed and the proportion of land irrigated to total arable land stands at under 7 percent (Matchaya et al., 2022).

Matchaya et al., (2022) report that the overall reduction in production due to erratic rainfall is 25 percent for Maize, and can be as large as 83 percent for Groundnut. The authors suppose the negative effects of erratic rainfall is likely due to the direct effect from limited water availability, and perhaps owing to the fact that frequent dry spells may discourage farmers from investing other complimentary inputs in production. Maize in this case is a crop of interest as it is Zambia's staple. Results from the 2019 Rural Livelihoods Survey show (Chapoto et al., 2019) that maize and groundnuts are the crops most grown by rural households in Zambia at 89 percent and 55 percent respectively.

4. Climatic Risks, vulnerability and resilience

4.1 Key messages

Climate change risks are one of the toughest challenges that Zambia grapples with currently. Climate change is predominant throughout all the provinces but provinces located within agro-ecological regions I and II are most vulnerable (Figure 5). Climate change has already been seen to negatively affect yields at the production stage of the various value chains that the farmers engage in. This is due to droughts, dry spells and/or erratic rains, floods and increased temperatures that result in the increased incidences of pests and diseases that attack crops, animals as well as humans (Low, 2005; (Project Consultative Workshop-Zambia, 2022). This ultimately results in reduced output which has a direct impact on the incomes and welfare of smallholder producers. Predictions by Hambulo *et al.* (2021) suggest that climate warming will occur at a faster rate and the majority of people are most likely to be affected by this challenge. Furthermore, it has been noted that productions systems such as maize which are so much dependent on water are most likely to be affected because of reduced rains and increased incidences of droughts throughout the country, especially in regions I and II.

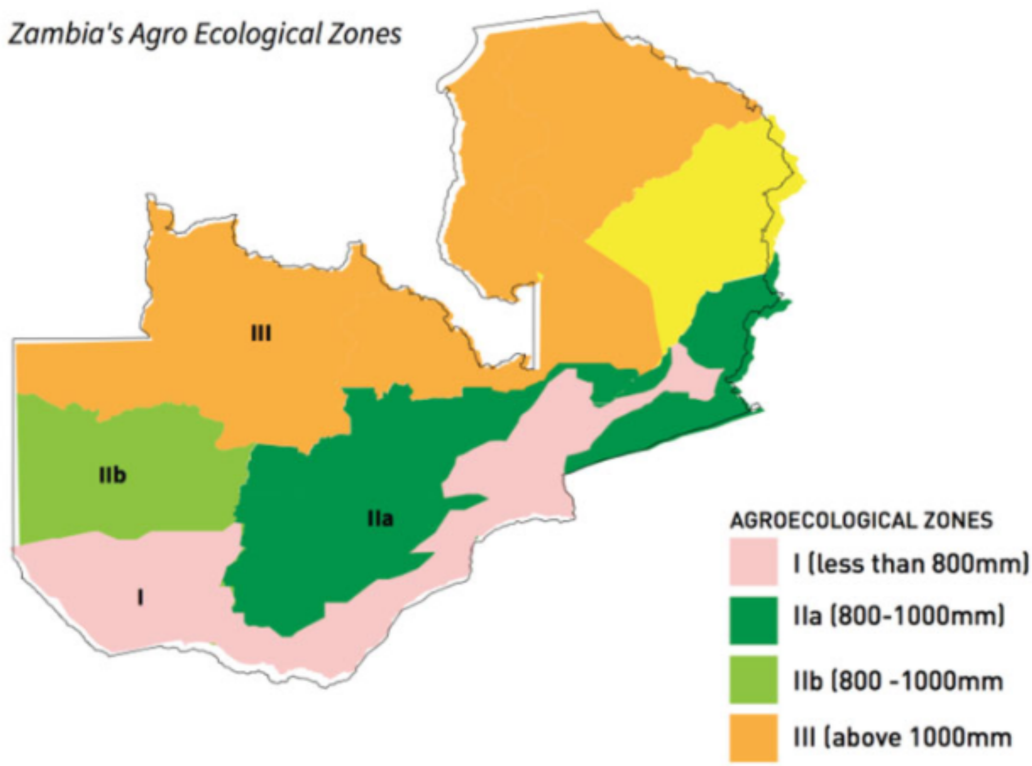

Figure 5: Zambia Agro Ecological Zones
Source: PMRC, 2020

The extent to which rural households can effectively manage climate shocks is constrained due to low adaptive and coping capacities especially during reduced rainfall activity. One key shock coping strategy particularly for the dependence on rain-fed agriculture is irrigation. However, in Zambia as noted in sections above, uptake is still low. Irrigation can rise resilience to rain-fed farming systems risks and rural households to climate change and variability while raising crop productivity is built. It would compensate for lost output from rain-fed agriculture at the very least because it enables all year round production, increases productivity and household incomes, builds adaptive capacity and reduces climate-induced production risk. Ngoma et al., (2019) and Matchaya et al., (2022).

4.2 Vulnerability

The Intergovernmental Panel on Climate Change (IPCC, 2001) defines vulnerability as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. This system may include human beings, their livelihoods, and assets among others. They further note that vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. In addition, country climate readiness is defined as the ability of the country to leverage on investments and convert them into effective adaptation actions (Sarkodie & Strezov, 2019).

The section of the report that follows examines the various climate hazards and vulnerabilities in Zambia based on various themes. Specific climate vulnerability and resilience themes include agriculture, environment, technology, and the socio-economy.

4.3 Adaptation to natural hazards and climate variability in the Zambezi River Basin

Zambia is part of the Zambezi sub-basin and strongly affected by short term climate related natural hazards and climate variability Floods, droughts and short growing seasons are commonplace, for, example, the Southern and Western parts of Zambia have been facing varied climate with increased incidences of floods and droughts which have negatively affected various livelihood activities. This has had a negative effect especially on rain-fed agricultural systems as well as on small businesses that are dependent on agricultural output to function fully (Project Consultative Workshop-Zambia, 2022). Further, changes resulting from climate drive incidences of diseases and poverty as well as shifting seasons. Moreover, there are underlying factors that increase the sensitivity and exposure of farmers to climate-related risks while at the same time undermining their adaptive capacity. These factors include social, economic, educational, institutional, policy-related, market-related, and infrastructural issues. The most exposed farming households show relatively low adaptive capacity and vulnerability to climate change and variability (Tessema and Simane, 2019). A country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience is measured by the ND-GAIN index, which evaluates a country's overall vulnerability by considering its main sectors including food, water, health, ecosystem services, human habitat, and infrastructure. Zambia's ND-GAIN indices are presented in Table 3).

Table 3: ND-GAIN country indices for Zambia over time.

Country	ND-GAIN index country rank*	ND-GAIN index	Vulnerability score	Readiness score
2021				
2020				
2019	137	40.5	0.52	0.33
2018	134	40.9	0.52	0.34
2017	135	40.8	0.52	0.34
2016	134	40.6	0.53	0.34
2015	137	39.8	0.53	0.32
2014	135	40.3	0.53	0.33

Source: https://gain.nd.edu/our-work/country-index/rankings/

The ND-GAIN index essentially distils a complex set of interacting factors into a simple metric that allows us to measure a country's vulnerability to climate change and readiness to respond. Generally, Zambia is the 41st most vulnerable country to climate change and 53rd least ready to respond to climate change effects. The larger population, especially those low-income groups located in rural areas are the most vulnerable due to high levels of poverty as well as the fact that they mostly depend on agriculture; the most vulnerable sector to climate change. This will further be compounded by low soil fertility due to a number of climate change effects. In addition, temperatures are expected to reach 1.9 °C and 2.3 °C by 2050 and 2100 respectively. Further, in Zambia, rainfall has been projected to decrease by 3 percent by mid-century and only marginally (0.3 percent) at the end of the 2100 (Hamududu and Ngoma, 2019; McSweeney et al., 2010). Predictions on temperature and rainfall for the Zambezi river basin are depicted in Figure 6. Temperature increases likely to exceed 1.5°C by 2050.

In Zambia, the most vulnerable areas are the Southern and Western regions which experience prolonged droughts as well as floods while the Central and Eastern parts of the country experience mild climate change effects and mostly droughts and increased pests as well as disease attacks. The Southern and Western regions will have the most substantial reductions in rainfall averaging between 3 to 4 percent (20 -30 percent more reduced rainfall over time worst-case scenario). The least affected regions are in the North, which have been predicted to continue receiving normal to above normal rains over the next decade; nearly 5 percent more rainfall by 2050 (Ngoma *et al.* 2021; Hamududu and Ngoma, 2019).

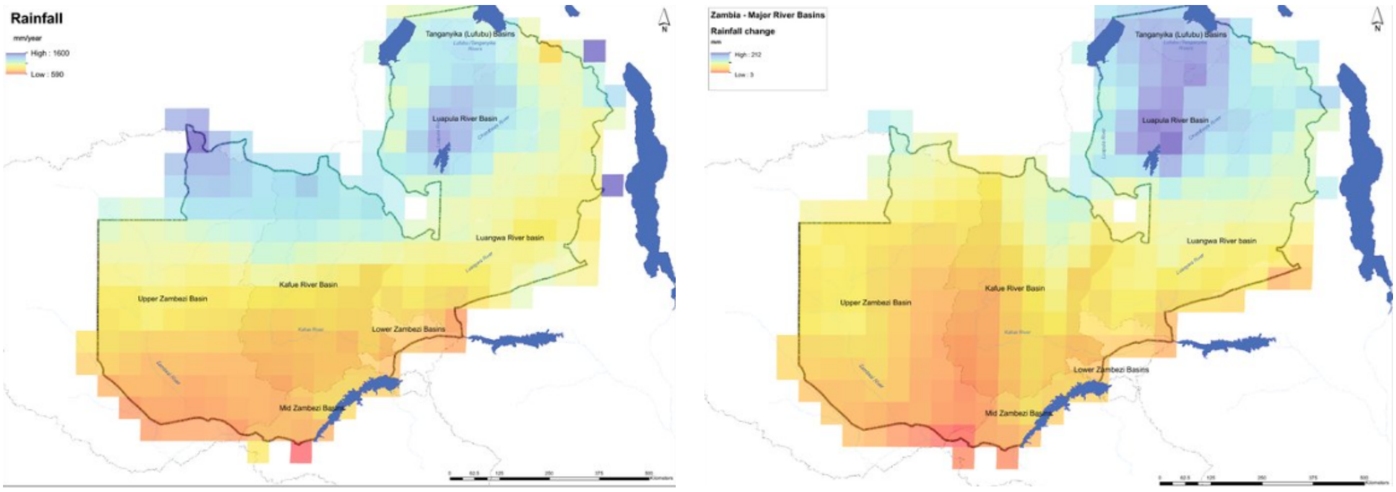

Figure 6: *Historical and Future Maximum Temperature and Rainfall* projections *in the Zamb*ia to 2100.
Source: Hamududu and Ngoma, 2019

4.4 Summary

Climate related hazards vary across time and province in Zambia. However, the most notable hazards occur during the growing season, i.e. November – March of every agricultural year. Floods, droughts, high temperatures, disease and pests are the most common, and affect the different parts of the country in varied ways. The provinces that face the most risk of these hazards are Southern and Western Provinces while Lusaka, Central and Eastern Provinces face mild risks. Further, the provinces located in the northern belt of the country are the least affected (Table 4) Irrigation can offer a real potential for climate risk resilience to rain-fed agriculture by providing a means through which rural households can have all year production to cushion output losses in periods of erratic rainfall or drought.

Table 4: Table of Common Hazards per province in Zambia

Province	Level of Hazard		
	Highest	Medium	Lowest
Lusaka		Drought	Floods
Eastern		Drought	Floods
Copper Belt		Floods	
Central		Droughts	
Luapula			Droughts
Muchinga			Droughts
North Western			Droughts
Northern			Droughts
Western	Droughts	Floods	
Southern	Droughts	Floods	

Source: Tessema and Simane, 2019; Project Consultative Workshop-Zambia, 2022

4.5 Climate change projections to 2050 in Zambia

Climate change has continued to affect various sectors in Zambia including agriculture. These effects are expected to continue beyond the next thirty years. Hambulo et al. (2021) conducted a study to predict the effects of climate change within the agricultural sector looking at different parameters such as temperature, rainfall and yields among others. In the aforesaid study, it was found that all regions within the country would experience temperature increases exceeding 1.5°C by 2050, especially during the growing seasons. In addition, Hambulo *et al.* also looked at the rainfall trends up to 2050 and noted that at the regional level, the Southern and Western regions would have the most substantial reductions in rainfall averaging between 3 and 4 percent. This suggests that the Southern and Western regions of Zambia are the most vulnerable to climate change and will likely experience more reduced rainfall over time and in the worst-case scenario, rainfall may reduce by 20–30 percent in these regions. On the contrary, the Northern region was projected to receive nearly 5 percent more rainfall by 2050.

Occurrences of droughts are also expected to increase over the same period and will be more predominant in the southern and western regions of the country. In instances where rains occur, floods are also expected to occur more in the southern, western, and eastern regions as well. These predicted changes are expected to affect various production systems including yields. On average, climate change is likely to reduce the yields for maize, other cereals, root crops, and tobacco with appreciable differences in the impacts of climate change on these crops by 2050. In addition, maize is projected to be the worst affected crop, with estimated yield reductions of up to 3–6 percentage points in the worst affected Southern and Western regions. In the aforesaid regions, yield variability is high, ranging from 26 to 30 percent. However, maize productivity is likely to be less affected (< 2 percent) by climate change in the Central, Eastern, and Northern regions of Zambia, which account for 50–60 percent of total maize production (Chikuba et al. 2013; CSO/MAL/IAPRI 2019). Further, cotton and root crops are projected to be less adversely affected by climate change. Cotton yields will increase by 1 percent in the Northern regions of Zambia by 2050, while root crop yields rise by 0.50 percent. These effects on yield are further going to impact other downstream players within the various value chains such as small businesses and Small and Medium Enterprises (SMEs) who may not be able to purchase the optimum amounts of outputs for processing and/or onward trading.

5. Digital Adaptation to Climate Change

5.1 Key messages

Zambia is working to develop sustainable and appropriate programmes for crops, livestock and water resources in the face of climate change. Some of Zambia's adaptation measures include the promotion of irrigation and efficient use of water resources, strengthening early warning systems and preparedness, and using GIS/remote sensing in mapping of drought and flood-prone areas (UNDP, 2022a). The following are some of the climate adaptation programmes implemented at different levels by governments, multi-lateral programs, and individual farmers:

The United Nations Development Programme's (UNDP) "Strengthening climate resilience of agricultural livelihoods in Agro-Ecological Regions I and II in Zambia" (SCRALA) project supports the GRZ to strengthen the capacity of farmers to plan for climate risks that threaten to derail development gains, promote climate resilient agricultural production and diversification practices to improve food security and income generation, improve access to markets, and foster the commercialization of climate-resilient agricultural commodities. The project is financed by the Green Climate Fund and implemented by the Zambian Ministry of Agriculture and will support the GRZ in building climate-resilient food security and poverty reduction measures for approximately 940,000 people (UNDP, 2022a).

The UNDP had also implemented a project called "Strengthening Climate Information and Early Warning Systems in Zambia to support climate resilient development", which responds to priorities and actions identified in the National Adaptation Programme of Action (NAPA) of Zambia. The NAPA articulates the need for securing, transferring and installing critical technologies, as well as developing the necessary systems for climate change-related information to permeate into decision-making processes. The technologies required to achieve these aims will increase the capacity of the national early warning network to forewarn and rapidly respond to extreme climate events (UNDP, 2022b).

The World Food Programme (WFP) is providing technical assistance to the GRZ to improve the design and management of the insurance provided under the Farmer Input Support Programme (FISP). The technical assistance aims to increase uptake of weather index insurance. Working with Smart Zambia Institute, WFP seeks to see how the digital payment platform for facilitating insurance payouts can be enhanced for the Farmer Input Support Programme (FISP). WFP is also working with private agricultural insurance providers (Pula Advisors, ZEP-RE, MTN, Mayfair Insurance) to improve the design and management of private insurance schemes, including the development of a phone app to allow farmers to voluntarily pay their insurance premiums and receive pay-outs. WFP has also developed training manuals and radio messages on weather index insurance in seven local languages to sensitize and encourage farmers to insure against climate risks (United Nations Zambia, 2021).

Although many parts of Zambia have underdeveloped water resources, there are many agricultural water management initiatives through dam constructions in some of the districts of Zambia. Iirrigation development is a priority government agenda for improving the resilience of rural households to climate change as well as for agricultural development as highlighted in national policies. These include the Second National Agricultural Policy (SNAP), the National Investment Plan (NAIP) and the Seventh National Development Plan (7NDP), among others (GRZ 2004, 2013, 2016, 2017). Key implementation model include the government-led farm block development programme aimed at agriculture commercialization. This intends to increase area under irrigation in the country. PIDACC-ZM has an opportunity here to provide technical assistance for the incorporation of digital technology during irrigation plan implementation in the farm blocks (Ngoma et al., 2019).

5.2 Data-driven digital services

Data-driven digital services are important for farmers' decision-making in the following ways:

i. Planning – Data-driven digital services can help farmer to plan what to produce, when to produce, where to produce, whom to produce, and what operations to do when and where on the farm. Weather data, market data, crop and animal growth models, soil data can be used to achieve these.
ii. Monitoring and assessment – To monitor the growth of crops and the status of the natural agricultural resources using data from sensors.
iii. Event management and intervention – Soil data from sensors can help farmers to decide which action to take and when. Soil data collected may include soil nutrition, temperature, moisture and carbon dioxide which can guide soil nutrition and water needs. This data mainly requires localized farm data but can benefit from external data such as weather forecasts, growth models or advisories (extension), and market information.
iv. Autonomous actions – Switching on water pumps to irrigate fields when soil humidity falls below at he pre-determined levels and auto feeding animals at the scheduled times of the day.
v. Optimization – Market data, consumption statistics, land and water use data can help a farmer decide what the economic, environmental or social effect on the investment or action will be.
vi. Livestock and crop forecasting – How much will be the crop or animal yield?
vii. Tracking and tracing – where is the product, item, resource or material?
viii. Negotiation and market access – Where are the customers?, What do they want?, Who else is selling the same product?, Which service providers can I best work with? Which all help the farmer to negotiate better prices, price discounts etc.(Maru et al., 2018).

5.3 Support for digital adaptation

Digital adaptation can be supported by investments into basic infrastructures such as communication towers, digital weather forecast equipment, human capacity at the weather forecast station, investment in farmers' education, collaboration between the government and the private sectors (credit providers, banks, insurance providers, network providers) and a conducive policy environment that prioritises climate adaptation. As noted in the framework for empirically grounded ABMs, a recipient's attitude to technology i.e. positive or negative evaluation of adoption is a key first stage for adoption. If there is no positive evaluation in terms of how well digital technologies can be implemented in Zambia through both investment and policy environment, adoption may be low. Zambia does not have the adequate supportive infrastructure for digital adaptation, which limits its penetration, especially among smallholder farmers. There are many challenges that hinder the global digital adaptation in Zambia, and these are listed below (Maru et al., 2018):

i. Immature technologies – Much of the suitable technologies, applications, software systems and platforms for data-driven agriculture and precision farming are just emerging. Most of these technologies such as AI are not smallholder ready and the farmers are not data-savvy. The knowledge stage of technology adoption as presented in the ABM framework will thus be vital. Awareness will need to be build through interaction to ensure rural households and stakeholders are aware of existing climate adaptaion technologies. With the slow smallholder farmer uptake of digital technology, any plans to promote adaptation needs to take into condideration the fast obscelenceof fast technology such as web-based technology. However, the key to such challenges in technology is through creating an enabling environment for private sector digital companies to flourish. These include increase in mobile network service providers who will in turn invest in the nucg needed cellphone towers. The World bank (2020), reports that for Zambia "progress is particularly evident in digital infrastructure, digital financial services, and digital platforms, while more significant gaps remain in digital skills and digital entrepreneurship". This means that there is need to build existing startups in zambia for them to bridge between investments in infrstructure and skill and/or entrepreneureship. While the government continues to invest in infrastructure, the private sector should take the opportunity to invest in the human resource to ensure they have country level efforts to create affordable updated technology in keeping.

ii. At legistlature level, the World bank (2020) suggests that the digital transformation strategy should include reducing government transaction costs and reducing the cost of doing business through digitally optimized government systems, improving the adoption of innovative digital solutions by enabling entrepreneurship, and leveraging data and digital systems to improve sector-specific outcomes in secondary towns and rural areas, all strategies that the government is trying to achieve within the next 4-5 years. If the momentum of such political will persists and these efforts are realised, there is a bright future for digital adaption in Zambia. The legislative environ ment is key to adoption as stated by the ABM theory. For example, the government through the Citizens Economic Empoerment Commisison has included and a loan empowerment ptoduct on ICT innovations and creative arts. This is envision to create 15, 000 jobs. The government has also incentivised servers, laptops and routers for SMEs for instituting 0% customs duty as a way to grow SMEs (Zambia Revenue Authority, 2022). In addition, the government has reduce the threshold to US $50, 000 for a Zambian citizen to qualify for incentives provided under the Zambia Development Agency Act No. 11 of 2006 from US $500, 000.

iii. Capacity challenges – Capacity of smallholder farmers to generate and process data and effectively use information is weak. This is because of high levels of digital illiteracy, especially among smallholder farmers.

iv. Exclusion challenges – Most farmers are excluded from the financial system (banks, credit providers) due to a lack of data on their situation, making it impossible to convince lenders that they are a good investment.

v. A lack of partnerships between different stakeholders and ensuring coordination, accurate and advanced climate modelling and forecasting capacities.

vi. Data availability (quality and quantity) – There is limited data at the local (district) level. National level data is used which often times than not is out of date or limited. There is also limited capacity to obtain climate data at the local level.

vii. High levels of climate illiteracy is also another challenge for digital adaptation. Many farmers are unable to use digital technologies as they are seen to be complicated (Sarku et al., 2020).

Much of the adaptation process and corresponding initiative is taken on by the individuals most affected by the climate-related issues. As stated in the ABM framework of technology adoption, this is because the farmers have to assess the relative advantage and profitability of adopt a particular response. Farmers thus play a key role in adaptation to climate variability and change. Several adaptation programmes have been launched in Zambia by many development partners such as the UNDP, Conservation Farming Unit (CFU)[13] etc., and data shows that farmers can adapt to climate change, however, programme success is often variable. This is so because some farmers are only actively practicing in climate-smart agriculture for instance if they can receive input support and discontinue the practice once the project ends; again, here persuasion is key as stated in the ABM framework. If farmers find adoption is not compatible with their

[13] CFU works to provide small and medium scale farmers with the supporting environment, knowledge and practical experience to help them successfully adopt conservation farming and conservation agriculture practices.

existing equipment, practices and investment costs, adoption may be reconsidered. The major adaptation programmes launched and adopted by farmers in Zambia include climate-smart agriculture practices such as crop rotation, crop diversification, the abandoning of crop residue burning to crop residue retention, adoption of early maturing crop varieties, adoption of drought tolerant seed varieties, and abandoning long term cultivation (Haggblade and Tembo, 2003).

There are several ongoing and completed climate adaptation programmes in multiple areas in Zambia. These programmes are donor funded but implemented in collaboration with the Government of Zambia through the respective ministries and departments. Table 5 below highlights some completed and ongoing climate change adaptation programmes in Zambia.

Table 5: Completed and ongoing climate change adaptation programmes in Zambia

Title	Lead organization	Funding sourcesource
Adaptation to the effects of drought and climate change in Agro-ecological Zones I and II in Zambia (2009-2013)	The United Nations Development Programme (UNDP)/ministry of Agriculture and Cooperatives	GRZ/UNDP/Global Environment Facility (GEF): Least Developed Country Fund
Strengthening climate resilience of agricultural livelihoods in Agro-Ecological Regions I and II in Zambia (2018-2015)	UNDP, Food and Agriculture Organization of the United Nations (FAO), World Food Programme (WFP), Ministry of Agriculture, Meteorological Department of Zambia	Green Climate Fund
Community Markets for Conservation Phase II Scaling up across the Luangwa Valley (increasing farmers resilience to climate change) (2008-2010)	Wildlife Conservation Society of Zambia	Government of Norway

Source: Haggblade and Tembo, 2003

5.4 Digital technologies and climate adaptation initiatives in Zambia

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. Yet, digital penetration is not universal in Zambia, and there are still barriers to access for smallholder farmers 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.

The introduction of weather index insurance onto the FISP as a platform for climate adaptation by GRZ is one main adaptation technology. Pula advisors have been instrumental in weather index insurance, where they use satellite imagery to capture the extent of damage to crops and pay out the affected farmers. Pula is another digital innovation that addresses crop and livestock digital insurance. Through Pula, a digital innovation, the insurance risks are removed through improved data and monitoring (https://www.pula-advisors.com/). Lima Links is developing an initiative to increase access to finance, market, climate information and advisory by uploading farmer information onto the Unstructured Supplementary Service Data (USSD) platform. The Water Resource Management Authority (WARMA) has produced digital geological maps which work to see areas of high rainfall and areas with sufficient groundwater or other alternative sources of water. However, access to digital geological maps is at a fee.

There are also a few private digital innovation and technology hubs in Zambia such as BongoHive Consul, a consulting firm that builds technology platforms, products, and processes. It also offers custom tailored skills training to organizations. Jakaranda Hub is an organization that aims at developing young people in ICT and entrepreneurship through innovation hubs. Anakazi Centre is an innovation hub used to mentor women in business development and equal participation of women and men in development issues (Digital innovation in Zambia, 2022). The Zambia-German Agricultural Knowledge and Training Centre (AKTC) has also promotes technology adoption in its knowledge dissemination and training. AKTC's target groups are emergent farmers, farm managers, technical stuff, students and lectures of agricultural learning institutions, as well as field extension officers (from both government and private institutions) who in turn operate as multipliers in knowledge and skills dissemination[14]. Key training are on Global Positioning System (GPS) use in Agriculture and irrigation and water management. Both the government and private network providers (Airtel, MTN and Zamtel) have also been key with the use of mobile money technology as well as the use of the ussd codes for farmers to access information on agriculture.

Lima Links and eMsika also use ussd technology to make it easy for farmers to access information for both extension and marketting. eMsika also uses web-based technoly as well as call centres for the much needed human interaction that the ussd service does not provide. This helps create a platform where farmers ae able to reach out to staff and discuss issues or information they may need in more depth.

However, there are only a few digital applications in Zambia that are currently in use for climate adaptation in agriculture. The main ones include: PLANt is a risk prediction tool that allows farmers to determine the level of risk in planting a given variety on a given date (crop failure risk). It can also be used to plan planting operations with a service provider. Using a smartphone, the user can select a location and PLANt calculates in real time when it is best to plant. PLANt uses real time soil moisture and evapotranspiration data, past climate (temperature and rainfall) and weather forecast data (FAO, 2022). The other application is called Nexus Environmental Assessment Tool (NEAT+), which is an innovative tool for environmental data gathering and risk assessment (UNEP, 2019). In agriculture, plots vulnerable to deforestation and flood damage for instance, can undergo modification to prevent further deforestation and to reduce flood risks.

5.5 Government ministries spearheading digital adaptation

The following ministries are relevant for digital adaptation to climate change; the Ministry of Green Economy and Environment, Ministry of Agriculture, Ministry of Lands and Natural Resources, Ministry of Water Development and Sanitation, Ministry of Energy, Ministry of Fisheries and Livestock and the Ministry of Technology and Science.

5.6 Score card of technologies that can be considered for mainstreaming into adaptation

The review of the top 5 digital technologies from the three group stakeholders from the consultaive workshop held in Lusaka on 11 March, 2022 at the New Government complex on the Role of Digital and endorsed during the 26 April, 2022 validation workshop. During the validation meeting, it was recommended that the technologies be split inot soft and hard technologies. Hard technologies are tangible components that can be purchased and assembled into assistive-technology systems while soft technologies reffers to technological knowledge, non-tangible material, administrative or organizational use.

[14] http://aktczambia.com/

Technology in Agriculture in the Zambezi River Basin showed that the key intersecting technologies recommended by all were:

i. Soft TechnologiesMobile Telephony: Platforms such as the USSD platform open a wide range of possibilities including access to weather information or markets and commodity prices.
ii. E- extension and E-market platforms for timely and widespread access of information. The E-extension seats with SMART Zambia and can be linked to the ZIAMIS for integrated information provision.
iii. E- market information platforms will enable market players to get the information required for improved trading.
iv. Index-Based Weather Insurance and Agro-meteorological Bulletin: This was a top pick due to the fact that it gives farmers a means of resilience in case of crop failure due to dry spells, drought or floods. Premiums paid out can ensure farmers are cushioned in case they do not have funds to repurchase agricultural inputs.Access to weather information packaged for agricultural production also enables farmers make production choices as well as decide whether to subscribe foe insurance.

Hard Technologies

v. Mobile Telephony: Smart gadgets (phones, tablets, computers)open a wide range of possibilities including access to weather information such as Zambia Meteorological Department's(ZMD) Agro-meteorological Bulletin and digital applications such as Aquacrop and AgriPay.
vi. Digital hydrological/geological Maps: These maps help assess ground-water quality, land management and land-use planning, and water resources management in the face of climate risks such as dry spells and drought.
vii. Solar-powered radio and TVs for information dissemination on climate risks and adaptation strategies. Community centres can house sloar powered devices and conduct the group meetings during broadcasts that would provide opportunity to have a feedback system for farmers. Radios are also widespread in rural communities.

Guided by the ABM framework of technology adoption, it will be imperative smallholder farmers are not only made awrae of the existing technology but that the potential value to climate change resilience is communicated. This will enable them to make informed decision on adoption. To persuade adoption of technology will need to be compatible or adaptable to the existing equipment and practices in their farming systems. Already, all technologies above in the exception of hydrological/geological Maps are technologies that are known by farmers. Expansion of adoption in the the contect of climate resilience is what will be required. Training on use will also be needed to ensure farmers do not find the technologies too complex to use andunderstand. In this regard, the use of local langage for awareness and information packaging will be key. In addition, government environment and stakeholder involvement will play role in influencing behavior on adoption. The cost of access and the connection to production ouput and market access will ensure that farmers consider the technologies.

5.7 Adaptation practices

The Zambia National Climate Change Response Strategy (NCCRS) identifies agriculture, food security, fisheries, water, forestry, wildlife, health, mining, tourism, human settlements, and physical infrastructure as priority sectors for adaptation based on their economic vulnerability and national development priorities. The main adaptation practices in Zambia include early warning system via weather forecast to facilitate timely dissemination of weather information to enhance preparedness, diversifying crops and livestock to improve nutrition and food security and having alternative sources of livelihood to reduce vulnerability to climate change. Other adaptation measures include enhancing water management to withstand erratic rains through water harvesting, water conservation, and small-scale irrigation, timely planting, crop residue retention, and using drought tolerant seed varieties among others (USAID, 2012).

5.8 Enhancing adaptation through digital innovation

The availability of better and relevant information that is both generated and accessed via digital means is of critical importance to the climate adaptation process in Zambia. For example, climate models predict changing rainfall patterns. Without well-informed, locally suitable adaptation strategies that take most likely conditions into account, these changes may disrupt existing production systems. Digital adaptation could contribute to greater climate resilience by, among others, supporting farmers' access to short-range weather forecasts, seasonal climate forecasts, locally specific recommendations about climate-smart agricultural practices, and weather index-based insurance.

Some types of adaptation practices can more easily be supported by digital adaptation than others in the following ways: (i) better-informed decision-making by farmers on agronomy and planting dates, e.g., by providing agronomic advice, weather and climate forecasts, or drought warnings, (ii) better-informed decision-making by extension services and policymakers, e.g., by providing climate forecasts and early disaster warnings, and (iii) economic risk mitigation, e.g., through index-based insurance schemes, and (iv) access to improved financial information and services, e.g., market information and credit. These services aim at enhancing key activities related to agricultural productivity, post-harvest handling, market access, finance, and supply chain management to increase household incomes for smallholder farmers, expand the economic inclusion of vulnerable persons, such as youths and women, and improve food security and nutrition so that smallholder farmers can purchase and consume nutritious foods and build their climate resilience.

5.9 Digital advisory and adaptation

Digital advisory services can help facilitate response to adaptation challenges faced by farmers in Zambia by informing flexible and data-driven responses to climate variability, other related hazards, and other relevant information such as pest and disease outbreaks and more. They offer crucial opportunities regarding access to services such as financing, input supply, market access and insurance. Digital advisory services are delivered using the following technologies: interactive voice response, SMS, mobile applications, radio, television, bulletins, self-help groups and extension agents. However, digital advisory services will be successful if the following principles are followed (Ferdinand et al., 2021).

i. Data quality and assurance

There are existing relevant standards and governance principles that ensure data quality which must be used and accepted. Poor quality data decreases the ability of digital advisory services to support farmers, which erodes farmers' trust and use of advisory services. Poor quality information may impact farmers' decision making and destroy their only livelihood.

ii. Promote equity

In digital advisory services, equity means that women, youth, the under-resourced, disabled, and socially marginalized groups are equally served by advisories according to their intersectional needs (e.g., those relating to their identity, experiences, and environment). This includes those who may not have access to digital tools. When services fail to address the differences in the needs of men, women, youths, disables, the literate vs illiterate and those in the urban or rural areas, they might exacerbate existing gender biases.

iii. Co-create with stakeholders

In this case, co-creation of climate services means bringing together producers of weather and climate data with farmers, often with intermediaries to connect these actors, to find a solution to weather and climate data. Co-creation is intended to be used to create capacity and empower stakeholders rather than to an end (i.e., the product). The degree to which an information service is used and valued is directly linked to users who may influence its design and have a sense of ownership. Farmers' capacities to use services and communicate changing demand are strengthened through co-creation processes, which increase legitimacy, salience, and sustainability.

Other important aspects of digital advisory services include accountability and transparency, financial sustainability, the capacity to scale the climate services to other areas, availability, usability and ease of understanding (Vogelsang et al., 2018).

5.10 Required investments to maximize potential

There are several challenges to digital adaptation in Zambia. The major barriers include the lack of internet connectivity, especially in rural areas. A large proportion of the population does not have access to smartphones or internet connectivity. Where smartphones or internet connectivity exists, it is frequently unreliable with slow internet speed. Another barrier to digital adaptation is the lack of or unreliable electricity especially in rural areas. Other challenges with digital adaptation are the low literacy levels among the rural population, a lack of capacity to pay for digital technologies or digital technology related services and tightened cyber security. Nonetheless, these challenges can be overcome by employing strategies that include investment in solar power for phone charging, rural electrification (a strategy already being implemented by the GRZ), and increasing network towers, especially in rural areas to deliver internet and mobile signals. Digital technology also requires specific technology needs assessments and quantitative market analysis in climate-relevant sectors and sustainability-relevant sectors. Additionally, digital technologies should be adapted to the local circumstance. Investment in local innovation environments that can build the needed indigenous digital technologies is thus needed (Asian Development Bank, 2021; World Bank, 2020).

Digital climate services such as weather forecast reports are an entry point for digital adaptation strategies. According to Below and Nalwimba (2021), Zambia has 41 manual and 107 digital weather forecast stations. Once this climate information is churned, it is disseminated to the people using the following digital technologies; television, radio stations, short message service (SMS) and social media – mainly Facebook. Generating climate information products and making them available online may not necessarily lead to their uptake. Users need to be engaged in the value and application of such information products. Users need to be aware of the existence of these products and be trained to understand and use the products. Users should also contribute to the development of relevant information products because these digital technologies are not without constraints (Dinku, 2018). Some constraints include the inability by service providers to use local languages in the SMS, low literacy rate which limits some users to understand and effectively use the climate information received, and poor network reception in some areas (Asian Development Bank, 2021)

Another challenge is the weak policy implementation. Supportive policy frameworks that enable adaptation are relatively well established in Zambia. For example, National Climate Change Policy of 2017 details a broad approach to strengthen the implementation of adaptation measures to reduce vulnerability to climate change. The policy also supports and builds on the objectives outlined in the 7th National Development Plan. However, these policies are generally not effectively applied or fully implemented due to several related barriers, such as the breadth of technical capacity, conflicting discourse on development objectives, lack of financing opportunities, and weak institutional arrangements. This is particularly true in rural areas, where institutional arrangements and related enforcement mechanisms are relatively weak and government institutions are poorly capacitated; yet people in these areas are the most vulnerable to the impacts of climate change (Rawlins and Kalaba, 2021).

6. Digital adaptation readiness

There is not enough information on the state of digitalization in the different provinces of Zambia, however, the provincial level information found through the review of literature is presented in the proceeding tables. According to ZICTA (2018b), most individuals that had used the internet before or were active users of the internet were mainly from Lusaka province, Southern province and Copperbelt province. On the other hand, the smallest proportion of individuals that had used or were active users of the internet were based in Northern Province, North-western province and Western province. From the foregoing report, we can easily see the need for enhanced investment and promotion of digital technologies such as the internet by installing more network towers to enhance digital adaptation, especially in the three provinces with very low internet use. However, the provision of digital tools alone is not enough; people must be educated about the need for digital adaptation and how to use these digital technologies.

The percentage of Television (TV) ownership is low at the national level with only 37 percent of the population having ownership as at 2018. The Majority of owners at 63 percent were in urban areas and at the district level, Lusaka and Copperbelt had the most population with TVs. The trend of ownership was similar for radio and cellular mobile ownership (Table 6, Table 7 and Table 8).

Table 6: Percent of TV Ownership

TV Ownership (%)	2013	2015	2018
TV Ownership National level	35.5	33.0	37.0
Urban	62.0	61.2	63.0
Rural	16.0	14.3	15.5
Lusaka	-	-	38
Muchinga	-	-	4
Northern	-	-	4
North Western	-	-	3
Southern	-	-	11
Western	-	-	2
Central	-	-	8
Copperbelt	-	-	21
Eastern	-	-	5
Luapula	-	-	4

Source: ZICTA (2018b),

Table 7: Percent of Radio Ownership

Radio Ownership	2013	2015	2018
National	52.7	45	40
Urban	59	48.3	46.8
Rural	48	42.5	34.3
Lusaka	-	-	24
Muchinga	-	-	5.2
Northern	-	-	7.3
North Western	-	-	3.5
Southern	-	-	11
Western	-	-	4.3
Central	-	-	10.5
Copperbelt	-	-	18.9
Eastern	-	-	9.2
Luapula	-	-	5.6

Source: ZICTA (2018b),

Table 8: percent Cellular Mobile Telephones Ownership

Cellular Mobile telephones	2013	2015	2018
National	-	64.5	73.6
Urban	-	84.8	88.1
Rural	-	50.4	61.6
Lusaka	-	-	25.5
Muchinga	-	-	4.8
Northern	-	-	6.4
North Western	-	-	4.2
Southern	-	-	12.7
Western	-	-	4.9
Central	-	-	9.8
Copperbelt	-	-	16.8
Eastern	-	-	9.8
Luapula	-	-	5.1

Source: ZICTA (2018b),

Household access to computers at the national level stood at 8.1 percent (Table 9), and explains the low Knowledge on how to use a computer (basic Information and Communication Technology ((ICT) knowledge) at 6.8 percent (Table 10). Network coverage, however, was high at the national level (86.9 percent) and it stood at greater than 74 percent in all provinces.

Table 9: Household Access to Computers

Access and Usage of Computers by Households	2013	2015	2018
National	4.9	7.1	8.1
Urban	9.2	14.1	14.7
Rural	1.7	2.3	2.7
Lusaka	-	-	39.6
Muchinga	-	-	3.8
Northern	-	-	1.7
North Western	-	-	3.7
Southern	-	-	13.5
Western	-	-	3.3
Central	-	-	6.2
Copperbelt	-	-	19.0
Eastern	-	-	3.8
Luapula	-	-	5.3

Source: ZICTA (2018b); FAO and ITU (2022)

Table 10: Mobile network availability and ICT knowledge

Parameter	Availability of mobile network coverage at a place of residence by province (2018)	Knowledge on how to use a computer (basic ICT knowledge) by province (2018)
National	86.9	6.8
Urban	97.8	11.8
Rural	79.9	2.8
Lusaka	96.0	12.1
Muchinga	74.7	6.1
Northern	74.9	2.3
North Western	80.2	4.4
Southern	89.5	11.1
Western	76.3	2.6

Parameter	Availability of mobile network coverage at a place of residence by province (2018)	Knowledge on how to use a computer (basic ICT knowledge) by province (2018)
Central	84.8	5.3
Copperbelt	91.8	5.7
Eastern	88.1	2.3
Luapula	89.9	8.6

Source: ZICTA (2018b)

Table 11 below explores the adoption of technology for smart water management. Smart water management uses ICT and real-time data and responses as an integral part of the solution for water management challenges. It can provide a more resilient and efficient water supply system, reducing costs and improving sustainability.

Table 11: Technology for Smart Water Management

Components	Purpose	Example Applications	A success?
1. Digital output instruments (meters and sensors)	To collect and transmit information in real time	- Rain gauges, flow meters, water quality monitoring and other environmental data - Acoustic devices for real-time leakage detection - Video camera for asset management - Smart water meters for measuring consumption - Pressure monitoring for leakage detection and pump optimization	At the adoption stage. E.g. Nkana Water and Sanitation Company acquired smart water meters (NWSC) [1][2]
2. Supervisory control and data acquisition (SCADA) systems	To process information and remotely operate and optimize systems and processes.	- Pressure management - Pump station optimization - Water treatment plant control - Sewage treatment plant control - Environmental controls, reservoirs, flows, etc.	Being implemented. Water supply and sewerage monitoring [2].
3. Geographic information system (GIS)	To store, manage, manipulate, and analyze spatial information.	- Asset mapping and asset management - Fully integrated network models - Environmental data analysis and management	Network monitoring system [2]
4. Software	To store, use, and report data. For modeling infrastructure and environmental systems to improve design, decision making, and risk management.	- Usually integrated with GIS and/or SCADA systems to manage water networks, control pressure, monitor leakage, etc. Improved decision making and risk management Customer data bases - Smart metering, billing and collections - Hydraulic design and optimization	Smart metering, network control, customer database and billing software in place [2].

Components	Purpose	Example Applications	A success?
		- Water resources and hydrological modelling for water security - Cloud-based data management and hosting options	

Table Note: Unless otherwise stated, information in Table 10 is from [1] (Smart Energy International, (2021), [2[Ministry of Water Development 2018)

Digital use and adoption in Zambia still lags behind its neighbours. Although mobile cellular subscriptions have risen to 94 per 100 inhabitants (Table 12), 2G is more prevalent than other broadband networks. Internet use still remains low despite the number of population covered by mobile networks.

Table 12: Digital access, use, and affordability in Zambia over time

INDICATOR	2007	2009	2011	2013	2015	2017	2019	2021
Population covered by a mobile-cellular network (%) [23]	-	-	-	-	-	86.9 in 2018	-	-
Mobile-cellular suscriptions (per 100 inhabitants)[24][27]	21.107	33.346	58.222	69.046	72.789	79.737	82.20	103.918 in 2020
Active mobile-broadband subscriptions (per 100 inhabitants)	-	-	0.2	0.7	13.5	45.8	51.1	-
Individuals owning a mobile phone (%)	-	-	-	-	83.8	83.4 in 2018	-	-
Male mobile phone ownership as a percentage of total male population (%) [24]	-	-	-	-	-	86.5 in 2018	-	-
Female mobile phone ownership as a percentage of total female population (%)[24]						80.8 in 2018		-
Individuals using the Internet, total (%) [25]	-	4.9	6.3	11.5	-	14.3 in 2018	19.0	-
Female internet users as a percentage of the total female population (%) [23]						12.0 in 2018		-
Male Internet users as a percentage of total male population (%)[25]						17.3 in 2018		-
Households with Internet access at home (%) [23]						49.7 in 2018		

INDICATOR	2007	2009	2011	2013	2015	2017	2019	2021
Households with a computer at home (%) [23] [25]				2.43	5.89	8.1 in 2018		
Individuals with basic ICT skills (%)[25]						6.8 in 2018		
Affordability, out of 100 (Data from Alliance for Affordable Internet)				33.2	37.8	44.95	44.94	42.39
Price per GB ($)[25]					14.5	9.3	3.9	2.82
Mobile cellular basket as a percentage of GNI per capita (%)	-	17.1	16.3	12.45	5.7	7.04	5.62	
Mobile broadband basket (prepaid handset-based 500MB) as a percentage of GNI per capita (%)(Alliance for Affordable Internet)	-	-	13.74	6.62	9.99	-	-	-
E-Government Development Index * rank out of 193 countries (United Nations)	180 in 2005	158 in 2008	143 in 2010	154 in 2012	163 in 2014	132 in 2016	133 in 2018	148 in 2020
E-Participation Index *rank out of 193 countries (United Nations)	151 in 2005	170 in 2008	180 in 2010	134 in 2012	143 in 2014	118 in 2016	132 in 2018	158 in 2020
Network Readiness Index *rank out of 134 countries[26]	-	-	109 in 2012	115	114	-	-	

Table Notes: Unless otherwise mentioned, the data in this Table is from [23] ZICTA (2018a) and [24] ZICTA (2018b), [25] World Bank, (2022b), [26] Zambia global standing, (2016), and [27] FAO and ITU. 2022

Zambia has made significant progress in digital infrastructure, access to digital financial services and digital platforms in the recent past. This can be seen by an increase in digital infrastructure and access to digital technologies over the years. These improvements show that Zambia is on the right path to digital transformation, which will enhance digital climate adaptation. However, the development of a digital transformation strategy to help the country meet its national development targets and improve the fiscal space is recommended (World Bank, 2020). Regarding access to digital technologies by gender, there are consistent gender disparities in ownership and access to digital infrastructure. For example, 73.6 percent of the Zambian population own mobile cellular telephones. From this population of mobile cellular telephone owners, 76.7 percent are male headed households, while 64.9 percent are female headed households. Access to internet in Zambia is very low at 14.3 percent. For women, it is even lower at 12 percent, while for men it is 17 percent. Mobile use, as well as mobile and smartphone ownership among women, is also lower than for men. There is a need to better understand why women have consistently lower access to digital infrastructure than men, and to identify appropriate measures to bridge the gender gap. Zambia has a universal service and access fund that potentially could be used for this purpose.

As can be seen in Table 10, Zambia's is among the lowest ranked countries worldwide in e-governance and e-participation rates. However, Zambia's digital challenges are heterogeneous throughout the country over time due to different levels of basic infrastructure development, levels of education, population dynamics, income etc., which drive the capacity to develop digital infrastructure solutions in different ways. For instance, ownership of mobile cellular telephones in Lusaka is at 25.5 percent of the national total, while the percent ownership of mobile telephones in North Western province stands at 4.2 percent (ZICTA, 2018b). Table 13 presents data on Digital access, use, and affordability in Zambia.

Table 13: Digital access, use, and affordability in Zambia over time

Digital Technology/service	2007	2009	2011	2013	2015	2017	2019	2021
Weather index insurance[1]								1 million per year
Hydro-modelling	-	-	-	-	-	-	-	-
Smartphones (%)[2]				38.8	13.5	29.6 in 2018		
Early warning systems [3]	Agro bulletins SCRALA districts					Strengthening climate resilience of agricultural livelihoods in Agro-Ecological Regions I and II in Zambia (SCRALA) in 16 districts.	Access: agricultural bulletins and community radio programmes. The programme has free access	However, only in the 16 districts were SCRALA operates[15].
Sensors for irrigation	-	-	-	-	-	-	-	-
Artificial Intelligence [4]							Use of digital maps design and management of critical infrastructure services, land use planning, transport planning, land tenure, ownership and administration together with the integration of future **census data**	
Machine learning	-	-	-	-	-	-	-	-
Short Message Service SMS capable phones [2]						86.9 % in 2018		
Remote sensing data abilities	-	-	-	-	-	-	-	-
Interactive voice response (IVR),								Available, used but not common
Fixed telephones (subscriptions)[5]			85, 727	115, 762	116, 165	)		

[15] Predominant in Strengthening climate resilience of agricultural livelihoods in Agro-Ecological Regions I and II (SCRALA) i.e. in Mambwe, Nyimba, Chongwe, Luangwa, Chirundu, Rufunsa, Chama, Mafinga, Kazungula, Siavonga, Gwembe, Namwala, Shangombo, Senanga, Sesheke and Mulobezi

Digital Technology/service	2007	2009	2011	2013	2015	2017	2019	2021
Radios and TVs[6]	-	-	-	-	-	-	(IBA, 2022)	147 Radio stations 52 TV stations
telemetry system	-	-	-	-	-	-	-	Satellite telemetry in South Luangwa National Park for tracking wildlife
hydraulic modelling	-	-	-	-	-	-	-	-
- ultrasonic smart meters,	-	-	-	-	-	-	-	ZESCO smart meters for electricity billing
electronic billing and payment system						-	-	Widely used: large businesses
Online portals for feedback						-	-	Widely used. RTSA, Banks, Companies
Irrigation	-	-	-	-	-	-	-	Used mostly by large commercial farms. Government to facilitate irrigation in the farm block development programme
Digital financed (Active)[6]						2,300,000	6,522,399	
Digital apps database	-	-	-	-	-	-	-	-

Table Note: Unless otherwise stated, information in Table 10 is from [1] (Index Insurance Forum, 2021), [2] ZICTA (2018b), [3] Project feasibility consultative workshop(2022), [4](African Review, 2021), (ZICTA, 2015), IBA (2022), [7] (UNCDF, 2019)

6.1 Weather forecast stations

The Zambia meteorology department is responsibility for weather forecasting in Zambia. And has onlys 41 manual and 107 digital weather forecast stations throughout the country, to cater for 117 districts (UNDP, 2020; Below and Nalwimba, 2021). Weather forecast information is mainly broadcast through extension officers, radio, television and social media (Facebook). The main challenges in weather forecasting and distribution include inadequate weather forecast stations/equipment for location specific weather forecast, a lack of interpretation of weather information into local languages for access to rural farmers and a limited number of trained broadcasters of weather information espacially at radio stations to interpret the weather forecast information (Below and Nalwimba, 2021). The impacts of inadequate weather stations is that the communities, especially smallholder farmer communities who depend on rain-fed agriculture in Zambia, are not sufficiently served. Farmers depend on weather forecasts from a wider coverage (such as a district), and as such are ill-advised on when to plant and what to plant. Therfore, Inadequate trained broadcasters of weather forecast information, leads to misinformation for farmers and inability to plan for the farming season. Improving timely access of small-scale farmers to accurate, intelligible and useable climate information and early warning systems across Zambia has the potential to significantly improve lives, build resiliency and support global efforts to achieve the Sustainable Development Goals (UNDP, 2020). It is therefore, recommended that investments in digital weather forecast equipment should be fast-tracked to serve the communities across the country. Training of more information broadcasters at radio stations is also recommended to ensure that accurate information is delivered to the intended people.

6.2 Zambia's disaster risk management programme

In view of the common hazards and vulnerabilities in the country such as floods, droughts, epidemics, environmental degradation, human/animal conflicts, food insecurity, animal and plant diseases and pests, and road and water accidents in Zambia, the Government has been making efforts to create a permanent response mechanism to deal with these threats. The Disaster Management and Mitigation Unit (DMMU) within the office of the Vice President is tasked to manage disasters. The disaster risk management programme entails building capacity for disaster preparedness, response, prevention, disaster mitigation, rehabilitation, recovery and restoration, coordination, disaster risk management information and communication, monitoring and evaluation, research and assessment, administration, logistical and management support services, and for resilience to climate change.

6.3 Challenges

Systems in Zambia are open to excessive political interference, which tends to undermine the credibility of programmes and in some instances smooth implementation of well-meant programmes. The Disaster management coordination system is weak, and hence the risk of costly operations and duplication of efforts among key players. One of the major reasons for poor coordination is lack of adequate information flow and resources among active players. There are also observed risks of deliberate distortions, especially by interest groups bent on swinging disaster relief resources to areas of personal or political advantage. This is also common among Non-governmental organizations (NGOs) involved in disaster relief, as there is a tendency to exaggerate the relief needs to boost the NGOs operations (Simwanda).

6.4 Successes

The disaster risk management programme in Zambia has also scored some major successes, especially in terms of responding to the effect of climate change such as the provision of food and shelter (tents) for the flood victims in recent years. Another area of success involves providing relief food to the victims of severe droughts (Reliefweb, 2021). Other successes include the drilling of boreholes to provide clean drinking water.

6.5 Examples of ICT use for agriculture and climate change Adaptation

The commonly used ICTs in agriculture, and as noted during the consultations, include mobile and smartphones, television, community radio, text-based messaging, mobile weather applications for smartphones, websites, social media, geographic information system (GIS) and satellite imagery (Sarku et al., 2020; Project feasibility consulations, 2022). These digital tools for adaptation are not without challenges as discussed below.

i. Social media

Social media requires advanced ICTs such as applications and smartphones, not accessible to all farmers. The unavailability of the internet and other infrastructures can be challenging, farmers' inability to navigate several ICTSs and read messages. There is also little local content and guide on the application of information. It will also be important to ensure that farmers are protected from fake information through ensuring that they get their information from sites and pages recommended by existing institutions in their communities which should be official sites or monitored for information. This can be done by extension staff as well as the MoA. In addition, in 2021, Zambia signed into law the the Cyber Security and Cyber Crimes Act, 2021(GRZ, 2021). This makes persons sharing wrong information laible to prosecution and thus will greaty contribute towards deterring the propgataion of fake information. Lobbying will be needed to ensure that wrong information provided to smallholder farmers becomes of key interest to the Zambia Computer Incidence Response Team. Extension support under the ICT suport system can also be integrated to provide oversight over information security for the agricultural sector. IFPRI/FAO/IICA (2011) reports that as at 2011, Zambia had less than 30 MOA ICT extension staff. More human resource in this category will be needed if promotion and adoption of technology is to be achieved in agriculture.

ii. Mobile weather applications for smartphones

The challenges include low levels of smartphone ownership, especially in the rural areas, mobile data is expensive, unavailability of the internet in some areas, the inability to use a smartphone, complexity attached to navigating applications and many farmers are smartphone phobia due to language and literacy barrier.

iii. Smartphones

Challenges include the difficulty in swiping sensitive screens, switching data and renewal of internet data, high cost of internet bundles, inaccessible internet in most rural areas, and the technology is not coded in local language.

iv. Websites

Websites offer limited opportunities for interactions. Limited internet access affects its use in many rural areas, and farmers find it difficult to read and interpret information by themselves because of limited literacy levels.

v. Short messaging services (SMS)

SMS have many challenges including the deductions debited from call credit, SMS nuisance due to numerous messages from telecommunication networks. Information is mostly delivered in English, making it difficult for some farmers to understand. Additionally, the lack of graphic communication and smaller short messages sometimesleadto inadequate comprehension of information. Lack of interactions and a lack of outlook forecast for the day are other challenges.

vi. Mobile phone

Access to messages is at a fee which may deter farmers from accessing them. Also, illiterate farmers cannot read and understand messages delivered in the English language while novice users cannot trace or navigate through the phone to trace missed calls. Loss of phone may result in permanent loss of messages and implies a cost for the purchase of a new phone.

vii. Television

The main challenges with television include the lack of interaction with viewers. Information access is affected by the unavailability of electricity, weak network signals and poor reception in some areas and unfamiliarity with symbols depicting weather conditions such as rainfall and sunshine.

viii. GIS

Some of the major challenges with GIS include the cost of acquiring the software as it may be expensive. Another challenge has to do with the inability to use the application, especially that many smallholder farmers are illiterate. Using GIS entails having another ICT such as a computer, which increases the cost of using the application. This as noted during the consultations will need to be limited to technical personnnel who will also need capacity building in climate modelling systems.

6.6 Access to electricity

The GRZ set a goal for universal electricity access for all Zambians by 2030. Energy has been identified as an important driving force behind economic development in Zambia, and the government has declared its commitment to developing and maintaining energy infrastructure and services.ZESCO Limited, a state-owned company is the largest power company producing about 80 percent of the electricity consumed in Zambia. The main sources of electricity in Zambia include hydro, coal, thermal and solar. Climate risks such as erratic rainfall and drought have severely impacted on the production of hydropower and thus climate change adaptation strategies will also need to ensure resilience is built for energy production in Zambia. Regarding access, Zambia's access to electricity stands at 43 percent of the entire population as of 2019. In urban areas, access to electricity stood at 79.9 percent, while it was only 13.9 percent in rural areas (World Bank, 2022a; The global economy, 2019). It is hoped that through the rural electrification programme, access to electricity in rural areas will improve and in turn have a positive effect on the adoption of and access to digital adaptation to climate change.

6.7 Access to other digital infrastructure and services

Table 14 summarises Zambia's access to 2G or 3G sites, the number of network towers, the number of active mobile subscribers, number of broadband users and fibre connections.

Zambia has had an increase in terms of 2G/3G sites from 2,141 in 2017 to 2,906 in 2019 and currently at 3,663 in 2021. This shows positive strides towards access to the mobile cellular network, especially in rural areas. The number of communication towers has also been increasing from 2,426 in 2017 to 3,235 in 2019 and 3,413 in 2021. The increase in digital infrastructure has resulted in corresponding increase in the number of active mobile subscribers from 13 million in 2017 to 17 million in 2019 and standing at 20 million in 2021 (ZICTA, 2021). From the available data, the number of Fiber-to-home/building internet subscriptions has also been increasing from a meager 175 in 2011 to 1,308 in 2015 (ZICTA, 2015). Despite all these developments in digital infrastructure and access, Zambia's digital technological uptake is still low and efforts to enhance uptake and expansion are indeed encouraged.

Table 14: Access to digital technologies (2021)

Access to digital tool/Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Number of 2G/3G Sites	-	-	-	-	-	2,354	2,141	2,727	2,906	3,472	3,663
Number of Towers	-	-	-	-	-	-	2,426	2,496	3,235	3,225	3,413
Number of active subscribers (Millios)	8.16,	10.52	10.39	1011	11.55	12.,01	13.43	15.47	17.,22	19.10	20.24
Mobile broadband users (Millions)	0.38	2,.31	2.,22	3.74	6.09	5.17	7.72	9.82	9.14	10.22	10.35
Fibre-to-home/building internet subscriptions	175	170	340	435	1,308	-	-	-	-	-	-

Source: ZICTA (2021), ZICTA (2015)

6.8 Digital platforms in Zambia

A digital platform is **a** place for exchanges of information, goods, or services that occur between service providers, producers, consumers as well as the community that interacts with the said platform. The commonly used digital platforms in Zambia include social media platforms like Facebook and media sharing platforms such as YouTube. As of 2020, Zambia's use of social media stood at 13 percent of the population (Data reportal, 2022), with Facebook getting the biggest share (Statcounter, 2022).

6.9 Financial payment platforms

Zambia has had a boom in financial payment platforms which include Real Pay, Airtel Mobile Money, MTN Mobile Money, Bayport, Touch4Pay, Zamtel Kwacha, Broadpay Zambia, Zoona, Xapit (Zanaco), Shoprite Money Transfer, Swiftcash, Kazang (Spargis), FNB e-wallet, Cash send (Absa), Payment card (e-voucher), Speed pay, Stanbic IM Voucher among others (ZICTA, 2018b). According to Siliminaa (2020), the number of mobile money service users grew to over 8.6 million in 2020, compared to 4.85 million in 2019.

6.10 Digital technologies and gender

Access barriers, affordability, a lack of education, low participation in social media and mobile phone use, as well as inherent biases and socio-cultural norms limit women's capacity to benefit from digital technologies (OECD, 2018; FAO and ITU, 2022, (Project Consultative Workshop-Zambia, 2022).). Furthermore, women's lower educational enrolment in disciplines that would enable them to perform well in a digital world (e.g., science, technology, engineering, and mathematics [STEM] and information and communication technologies [ICTs]), combined with women's limited use of digital tools and the relatively scarcer presence or activity on platforms – e.g., for business purposes – suggest a potential scenario of widening gaps and greater inequality. Policy, particularly in the form of coordinated and complementary efforts, has the potential to reverse these trends and set the stage for a more inclusive path based on closing digital and gender disparities. Raising awareness and combating gender stereotypes are required to close the digital gender gap, as well as providing improved, safer, and affordable access to digital tools and fostering strong collaboration among stakeholders to remove barriers to women's full participation in the digital world (Organisation for Economic Co-operation Development, 2018).

Digital technologies such as the internet, mobile phones and digital financial services offer opportunities for women to earn extra income, increase employment opportunities and access knowledge and information. As such, platforms such as online or video-based upskilling and tutorials may help women make better use of the digital tools and extract more value from them. Compulsory ICT training in schools would help to eliminate the digital gender divide. Raising awareness about education opportunities is key for women. For instance, some online courses can be accessed for free and cover a range of topics. Removing obstacles to adult education is also key because it provides more opportunities for adults to upgrade their skills (OECD, 2018).

6.11 Summary

Zambia still has many opportunities to expand its use of digital adaptation solutions. With political will on climate change adaptions, there is room for investments in agricultural digital technology. Telecommunications infrastructure investments are needed beyond Lusaka and the Copperbelt provinces. Improvement in network range to catch up with technological advancements around the world and within the region is also key.

7. Challenges and opportunities for digital adaptation in Zambia

7.1 Key messages

The ultimate end users of various digital services are diverse and occur at different points of the value chains including at the input and production stage, processing, distribution, retail and consumption. This implies that end users have varied needs and thus developers of different digital technologies have to consider this. Further, the different end users of these technologies face various challenges as a result of climate change. Some of these challenges include low quality of inputs, low production due to droughts, floods, pests and diseases among others. The major digital adaptation tools include messages through radio, television and phones (Project Consultative Workshop-Zambia, 2022).

The GRZ has provided a sufficient legal framework under which companies in the business of developing digital technologies ought to operate. In addition, the institutional framework is also sufficient for the operations of various digital companies. The Zambia Information and Communications Technology Authority (ZICTA) is a quasi-government institution formed to regulate ICT and postal services in the country. It further supervises/regulates operators within the digital space in Zambia. In addition, a number of laws exist which include the Postal Services Act No. 22 of 2009, Electronic Communications and Transactions Act No. 21 and the Information and Communications Technologies (ICT) Act No. 15 of 2009 to regulate ICTs, postal and courier services in Zambia.

The consultations revealed that a number of digital services and applications do exist and are currently in use by smallholder farmers across the country. Mostly, the focus is on access to market information as well as extension services related to potential pest and diseases attacks and control measures. Examples of digital service providers in Zambia include the private led Lima Links and eMsika, as well as government led SMART Zambia and MoA among others.

It is important to note that there is a need to further open up the Zambian ICT space so that more companies are able to operate and provide various services. This can be achieved by the government providing a conducive and enabling regulatory environment. Further, there is a need to improve access to electricity, broadband network coverage, SIM registry procedures, and adult literacy, especially in rural areas. This will enable the country to tap the full potential of digital adaptation for smallholder farmers. Such improvements will likely lead to increased mobile phone uptake and greater demand for digital adaptation solutions among farmers. In addition, both the public and private sectors need to invest in digital infrastructure support as well as awareness among farmers. This can be coupled with women inclusion and this will enhance the quest for enhanced climate change adaptation (Project Consultative Workshop-Zambia, 2022; FAO and ITU, 2022.).

It has also been observed that majority of information on various agricultural related technologies reaches smallholder farmers via public as well as private extension service providers, especially in remote and rural parts of the country. Thus, in order for digital services to be effective in climate change adaptation, there is need to enhance the capacity of extension providers, especially those in the public sector through refresher training courses with emphasis on digital service provision methods. In addition, there is need to assist government extension services with modern digital equipment that would enable them transfer adaption messages over a wider coverage. The delivery of extension services through digital means would further enhance the efficiency and effectiveness of extension service delivery to smallholder farmers and enhance climate change adaptation within communities. Furthermore, the relationship between smallholder farmers and extension service providers would be expected to improve as digital adaptation would allow smallholder farmers to communicate more with extension service providers and obtain feedback on pressing matters such as pest attacks at a faster rate.

The following section presents key insights into the strengths, weaknesses, opportunities, and threats that are relevant to digital adaptation. These analyses highlight promising intervention and investment opportunities in infrastructure, policy, capacity building, and digital agriculture services. These are framed from the literature review as well as the consultative workshop.

7.2 Strengths

When conducting a Strength, Weaknesses, Opportunities and Threats (SWOT) analysis, the identified strengths are critical as they help an organization to select key areas where investments could be consolidated for enhanced outcomes and returns. One of the strengths identified is the ease of doing business in Zambia with regular engagements and collaborations between the private and public sectors. The government also works closely with development organizations with the aim of enhancing climate change resilience among farmers. In addition, the relatively stable economic and political environment experienced in Zambia compared to other regional countries like the DRC offers reduced risk for private sector investments. A growing population that is 36.7 percent youth, further provides an opportunity for easy uptake and adoption of various digital technologies. In addition, a host of companies are already providing mobile financial services and this could provide a platform for the roll-out and acceleration of digital climate change adaptation strategies.

7.3 Weaknesses

A number of weaknesses have been identified and include the following:

i. <u>Poor mobile network in rural areas</u> -A higher percentage of the rural population do not have access to mobile networks and this is potentially one of the key weaknesses for digital adaptation against climate change especially among the rural population.
ii. <u>Poor electricity coverage</u> - The majority of Zambia's rural areas have no access to electricity and this has the potential to negatively affect efforts aimed at digital adaptation.
iii. <u>Poor road network in rural areas</u> - Infrastructure such as roads are vital for investment in various sectors including the digital subsector. However, in Zambia, especially in rural areas, roads are in a very poor state and this negatively affects both private and public sector provision of various services essential for the development of the agriculture sector.
iv. <u>Fewer mobile service providers -</u> In Zambia, there are only 3 main mobile service providers which is quite low compared to other regional countries such as South Africa which has five mobile services providers. The low number of mobile service providers implies less competition among themselves which results in poor service delivery at the detriment of the end-users.
v. <u>Linguistic fractionalization -</u> Despite having seven official vernacular languages, Zambia has at least 72 dialects and this creates a challenge for digital service providers to create products that accommodate all the dialects. Ultimately, this impacts negatively on digital climate change adaptation.
vi. <u>Fragmented extension services -</u> Extension services are key in the development of the agriculture sector. In Zambia, both the public and private sectors provide the service but it is highly fragmented due to low coordination between the private and public sectors. This has the potential to negatively affect digital adaptation against climate change.
vii. <u>Gender gap in literacy -</u> Illiteracy levels among the rural population in Zambia is high and more so among women. This implies that it is difficult for the majority of the population to interpret digital

information that maybe the key to adaptation. This is one of the key impediments in digital climate change adaptation.

7.4 Opportunities

Despite the weaknesses listed above, Zambia has great opportunities for digital adaption and they explained below:

i. Huge rural population - The majority (at least 55%) of people in Zambia live in rural areas, engage in agriculture and are the most affected by the effects of climate change. Thus, the huge rural population creates a great opportunity for climate change adaptation impact at scale.
ii. High youth population: At least 50% of the population in Zambia is dominated by the youth and they are more technologically savvy and this presents a good opportunity for increased uptake of climate change digital adaptation technologies in the country.
iii. Droughts - Over the past decade, the country has been experiencing droughts throughout the production season and this has contributed to low production levels that have been observed. However, this creates a great opportunity for the introduction of advanced irrigation approaches such as precision irrigation and this could potentially help them adapt against the consistent droughts.
iv. Use of remote sensing data and real time data for decision making - Zambia has continued to invest in equipment in various ministries that could be used for generating remote sensing data and in decision making for enhanced effectiveness and impact.
v. Gender-inclusiveness - Design of gender inclusive digital adaptation services can help to address the existing gender gap in mobile phone and internet usage by creating solutions that specifically target women farmers.
vi. The strong penetration of mobile banking and mobile networks could enable better access to modern farm inputs through digital "crowdfunding" solutions, whereby farmers who do not know each other pool investments to bulk input purchases.
vii. Macroeconomic stability observed over the past years presents an opportunity to attract more investments within the digital space which enhances the chances of utilizing the investments for climate change digital adaptation.
viii. Existing Infrastructure in the country such as weather stations, IT communication towers can be used as platforms for enhancing digital adaptation among communities especially in rural areas.
ix. Existing efforts by the government for climate change adaption and water management such as SMART Zambia extension platform, ZIAMIS, Weather based Index Insurance and the incorporation of irrigations plans in the farm block development plan as well as dam building.

7.5 Threats

A number of threats to digital adaptation exist. Firstly, it has been observed that there is limited government emphasis on investing in infrastructure support in agriculture and this potentially raises concerns about the long-term private sustainability of investments and interventions. FAO and ITU, (2022) for example report that spending in the research and development in agriculture is only 0.51 percent of the agricultural GDP and the Capacity for innovation is at 3.83. (index ranking 1–7: not at all/to a great extent). ICT imports are 2.99 percent of total imports. In addition, the country has experienced a boom in the cybercrime industry in rural as well as urban areas and this has the potential to undermine trust in digital solutions aimed at climate change adaptation. Further, the heavy reliance of the agriculture budget on input and output subsidies puts infrastructure investments and the sustainability of government-led digital agriculture initiatives at risk. The frequent occurrence of climate hazards which have potential to damage ICT infrastructure further poses a threat to digital climate change adaptation in the country.

7.6 Opportunities space

An important first step in leveraging digital technologies to enhance climate adaptation is identifying the most promising technologies across multiple end-user barriers. This enables investors and implementers to focus their efforts on areas of the highest impact. Identifying and understanding these enabling factors will lay the foundation for effective mainstreaming of digital adaptation to climate change. Communication through radio as well as mobile phones have the greatest potential to reach a wider group of players within the country, especially in rural areas. This could lead to a higher impact on overall welfare among the people.

The public sector through the government can easily reach out to the populous by providing key messages related to access to inputs, production as well as marketing. In addition, the government can easily relay information aimed at helping communities combat the effects of climate change such as droughts, diseases and pests among others. In the same vain, the private sector can reach out to a larger clientele and possibly earn more profit through demand generation for their various products used by smallholder farmers throughout the country. This can also be coupled by the creation of regional Information technology (IT) hubs across the country to create a platform for learning and promotion of youth entrepreneurship. However, in order for this to work effectively, the government needs to learn from other technologically advanced countries, support infrastructure, services as well as create an enabling regulatory environment. Table 15 below summarizes the SWOT analysis which has been conducted above:

Table 15: SWOT Analysis Summary

Strengths	Weaknesses	Opportunities	Threats
• Stable political and economic environment • Regular collaboration between public and private sectors • Growing population with 36.7% youth • Existing private sector systems that can be used as platform for launch of digital adaptation services • Availability of climate change adaptation polices • Good rates of adult literacy • Zambezi basin has diverse ecosystem which attracts **tourism investments**	• Poor mobile network in rural areas • Poor electricity coverage, especially in rural areas • Poor rural road network • Few mobile service providers • Linguistic fractionalization • High cost of mobile devices • Fragmented extension service provision by both the public and private sectors • Low literacy levels especially among women	• High rural population (over 55%) • Frequent droughts presents an opportunity for adoption of new CSA technologies such as precision irrigation • Existing basic IT infrastructure • General interest in use of Its such as remote sensing in decision making by both government and private sector • Strong mobile service penetration even in rural parts of the country • General macroeconomic stability in the short and long runs • General interest in Digital technologies • Population growth with high youth share (over 50%)	• Low investments in agriculture infrastructure by government • Vandalism of ICT infrastructure • Booming cybercrime industry that has the potential to undermine trust in digital solutions • Agriculture budget heavily skewed towards subsidies and this leaves little resources for investments in other key sub-sectors such as digital adaptation technologies • Damage to ICT infrastructure due to climate hazards

Source: Authors' Own compilation

7.6 Summary recommendations and Conclusions

Digital adaptation in Zambia faces a number of challenges which include availability, affordability, and access to mobile phone subscriptions and to the internet. In addition, there are low levels of investment in infrastructure that support a host of digital services as well as a difficulty for farmers to use the technologies due to the fact that they are mostly illiterate and not technologically savvy. Lack of data and limited cross-country learning requires further investment in expanding national and regional innovation hubs and data centres for coordination and knowledge sharing. Further, the costs of data are relatively high with poor internet connectivity in most parts of the country, especially in rural areas. It has also been observed that the lack of best practices for guiding the use of digital technologies in adaptation in Zambia has negatively affected efforts aimed at digital adaptation.

In order for these barriers to be addressed, additional capacity is required as is an enabling policy environment fostering data sharing, privacy considerations, interoperability standards, and improved soft and technical infrastructure. In addition, there is a need for government to increase electricity access across the country as well as enhance the coverage and quality of mobile network services in Zambia. Further, the government needs to invest more in rural infrastructures such as roads and telecommunications towers for improved access. It is further recommended that there is more coordination and collaboration among public and private sectors in the provision of digital extension services as well as bridging the gap in gender literacy.

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In order to further mainstream digital technologies into climate change adaption and enhance resilience, various stakeholders engaged during the stakeholder consultative meeting (11 March, 2022) and validation meeting (26 April, 2022) proposed the following:

- Adoption and promotion of user friendly software and technologies. Special consideration for digital technology appropriate for youths, women and the differently abled should be made, for example, voice synthesis especially for the blind and people that are not able to read and write.
- Farmers need to be educated and exposed to key digital technology. A means of reaching out to uneducated small-scale farmers need to be planned if digital information is to be easily accessed and understood by farmers. Information and awareness tools should be package into local languages for easy absorption.
- Making announcements in communities and targeted broadcast messages concerning the current climatic changes and the way forward can increase access to information on climate change and adaptation.
- To ensure the agricultural sector becomes more resilient to climate change shocks, there is need to facilitate access to market information. Digital technology should be used to link producers to markets and consumers.
- Farmers and other key players need to know all the adaptation strategies to climate change available and should be taught how to implement them. The information must be crop specific and must efficiently inform the farmers on the required adaptation processes. This will allow for efficient and effective use of targeted information shared with farmers and market players.
- Increase financial inclusion and access to affordable finance among small scale farmers.
- Public Private Partnerships (PPPs) are key in climate adaptation and these have worked well in Kenya, Ethiopia, and Nigeria. PPPs should be used in raising awareness, visioning, planning plan for the future, and looking for implementation opportunities.
- Tax exemptions (waivers) should be used as an incentive for upscaling digital technologies and digital awareness for the private sector.

- Create farmer information centers with solar radios or televisions were farmers can meet on agreed days to engage with climate adaptation promoters. Alternatively, lead farmer should have a smart phones so that they can share information with fellow farmers with information free to access on the internet. In areas without internet access, the USSD code can be developed with required information.
- Zambia has at least 2.7m smallholder famers and they need access to smart technologies. Financial Sector Deepening Zambia (FSDZ) bought and gave smart phones to group members. With 2.7 million farmers in Zambia, more smart phones need to be made available for farmers.
- Prompt payment of weather index insurance claims to ensure farmers are resilient. Insurance needs to pay farmer association in order for them to give the affected farmers to receive their benefits.
- Meteorological stations should be properly equipped.
- Climate messages should be sent simultaneously to remove time lag in action.
- There is need to look at the relevance of digital technologies in each area. e.g., according to agro-ecological or cultural conditions
- There is need to distinguish hard and soft technologies as both are important for climate change adaptation. It was important that both side of technology is enhanced.
- In areas identified to have little to no network coverage, it is proposed that the focus is on the utilization of existing public and private extension services for the delivery of adaptation messages to smallholder farmers. Zambia has a well networked extension service system as well as civil services in ward committees who respond to different challenges that rural households encounter. The starting point for digital adaptation should thus be through the intermediary service providers who can then work with farmer groups. For example, for early warning services, information may reach farmers faster if this is shared through such mediums. These are also trusted within the communities. If well trained and with the adequate resources, they can be a force for change and an ambassador for digital technology adaptation.
- The PIDACC would need to ensure that it adopts technology in the three forms:
    - Data collection technologies – digital weather stations, sensors, drones for example
    - Data analysis technologies – models, and
    - End-user information dissemination technologies – extension and market e-platforms.

Table 16 presents a summary matrix of digital technology, their constraints and recommendations to increase uptake from the project stakeholder consultative workshop held on 11 March 2022 and validation workshop on 26 April, 2022.

Table 16: Digital Tools for Adaptation

S/N	Government Stakeholders	NGOs/Development Partners	Private Sector stakeholders
1	Index Based Weather Insurance was listed as key for resilience in smallholder production	Smart gadgets (phones, tablets, and computers) were a key tool listed. The group found it desirable for smallholder farmers to have a smart phone with creation of a time range for free internet	Smartphones to check the weather forecast. The weather applications, social media such as WhatsApp used to share the weather updates that inform when to plant
2	Radio and TV programmes for information dissemination of climate risks and adaptation strategies. Radios are widespread in rural communities.	Scale up the use of solar TVs in farmer centers would allow farmers receive information in real time for implementation	Community radio stations are key to targeted and area specific information dissemination
3	SMART Zambia is working on the e-extension platform which will be linked to the ZIAMIS platform which holds information on all farmers in the FISP. In this regard, E-extension Officers need to be trained in information translation and disseminations for proper uptake by smallholder farmers	Encourage use of mobile application for easy and frequent access of required information	E-voucher system for crop diversification. This system can be leveraged on as it already has a strong stakeholder base through the ZIAMIS
4	Sensitization through SMSs for feature phones and use of USSD to access information	Drones although expansive, were viewed as a key technology for agriculture digitalization. Modalities of procurement could be changed to ensure cost saving measures. For example, drone technologies can be procured at district or even community level.	USSD platform has the potential to open up access to finance, markets, climate information and advisory messages.
5	E- extension platforms for timely and widespread access of information	Animal tracking device (e-tagging) - gives animal history and health record, which is good to break into the European market. Animal tracking could revolutionize the livestock sector as farmers may be able to compete in the international market because potential markets would have access to animal health information.	The use of digital geological/hydrological maps can help plan adequately for the future through assessing ground-water quality and contamination risks; waste repository siting; land management and land-use planning
6	E- market information platforms	Remote sensing was also another technology stakeholders felt needed to be adopted. This would help with temperature and precipitation monitoring for farmers and at a wider angle flood and drought monitoring.	Weather Index Insurance using satellite images to capture the extent of the damage

S/N	Government Stakeholders	NGOs/Development Partners	Private Sector stakeholders
7	Climate projection models to ensure preparedness measure are made in time		Insurance package for smallholder farmers on FISP also need scaling up to increase uptake
8	The Agro-metrological Bulletin has been instrumental in informing farmers on production. Reach however has been limited		Agri-Pay for digital loans can help respond to issues of financial inclusion for smallholder farmers
9	Mapping of water resources in the country to keep stock of water needs for farmers and plan for eventualities		

Source: Project Consultative Workshop-Zambia, (2022)

Table 17 presents the top 5 Digital technologies in Zambia while Table 18 provides information related to key constraints as well as overall score. The scores are based on, stakeholder comments on the report and the consultation and validation workshop held on 11 March and 26 April, 2022, respectively.

Table 17: Digital apps score card

Digital technology	Constraints	Score
Mobile Telephony (Smart gadgets, access to internet and USSD platforms)	Limited infrastructure and cost of smart devices and data	1
Digital hydrological/geological Maps	Cost of access to maps and Poor support infrastructure	2
E-market and extension information systems	Poor support infrastructure through mobile telephony, poor investment in R&D investments, low ICT goods imports	3
Index based weather Insurance and Agro Meteorological Bulletin	Limited awareness on importance of insurance as well as limited reach and time lag of information dissemination for agro-bulletins. Information packaged in English	4
Solar-powered radio and TV	High cost	5

Source: Project Consultative and validation Workshop-Zambia, (2022)

This scorecard summarizes the constraints of adoption of these technologies.

Table 18: Top 5 recommended technologies

Focus of Technology	Technology	Where to invest in	Target beneficiaries
General information access	Mobile Telephony (Smart gadgets, access to internet and USSD platforms)	Purchase of gadgets/capacity building among lead farmers, investment in middleware infrastructure, capacity building of start-ups using USSD platforms Awareness raising and technical assistance	Small holder farmers and all value chain actors
Assessing ground-water quality, land management and land-use planning, water resources management	Digital hydrological/geological Maps	Investment in remote sensing to make access more widespread and affordable for rural households and technical staff working on weather modelling	Small holder farmers, staff working on weather modelling, and all value chain actors
E-market and E-extension information systems	E-market and E extension information systems	Regional ICT hubs/Capacity building among MoA staff and start-ups	Small holder farmers and all value chain actors, ministries of agriculture, start-ups
General information access	Index based weather Insurance and Agro Meteorological Bulletin	Technical Assistance to further digitalize index insurance implementation and access. Expansion of Agro Meteorological Bulletin reach beyond the 16 SCRALA districts and translation of information	Government/Ministry of Agriculture, Ministry of information, Department of Weather services, Smallholder farmers, other agro-processors,
General information access	Solar-powered radio and TV	Purchase of radios/TVs, farmer centre and capacity building among lead farmers	Small holder farmers and all value chain actors Lead farmers

Source: Project Consultative and validation Workshop-Zambia, (2022)

Table 19: Proposed interventions at the Country Level- Zambia

Interventions areas	Knowledge & Analytics	Investment in middleware infrastructure	Capacity building
Development of Digital Climate Services	• Strengthen National Adaptation plans by mainstreaming Digital Technology . The draft policy should be finalized and operationalized	• Develop national integrated database management system for climate data collection and analysis for dissemination to avoid confusion in messaging. • ZMD needs investments to properly equip it with automated weather stations-currently these are few	• Provide training/capacity building to national early warning systems to improve coordination and knowledge sharing on disaster preparedness and implement other management practices • Provide training to the Zambia Meteorological Department to enable it to provide precise climate, weather predictions for Zambia.
Facilitating access to advisory services and markets through digitalization	• Develop climate science communication mechanism in Zambia that use all local languages and integrate these in mobile applications for climate information dissemination. Currently some languages not covered	• Create farmer information centres with solar TV/Radios in all districts – to ease information access • Target rural women farmers with subsidized smart mobile phones; Promote business models that target rural women farmers with low cost smart mobile phones, and innovative financing , through cooperatives • Develop more user friendly geological maps that summarize crop, soil, and rainfall information in each location • Expand telecommunications infrastructure, eg mobile towers	• Train media personnel and farmers on the interpretation of climate/weather information from weather stations
Promotion of Climate-smart innovations and technologies	• Undertake a feasibility studies on uses, policy and regulatory issues of digital agriculture with a focus on climate adaptation and resilience for food and nutrition security for the region. • Possible study on AI on people's wellbeing	• Increase the number of functional Automatic Weather Stations in Zambia	• Train staff in the national meteorology departments on reporting and aggregation of weather and climate data and predictions. • National training of trainers on a/some specific climate-smart solutions/technologie(s) using AAAP adaptation toolkit.
Promote Natural resources management	• Promote awareness among farmers on the importance of technology use in farming and climate adaptation- For example, sensors in irrigation	• Equip Universities with remote sensing and AI software to be used in teaching • Introduce chameleon sensors in irrigation management	• Provide training on the use of remote sensing data to monitor production, deforestation and water availability.

Table 20: Climate Adaptation Technology in Zambia

S/N	Technology/Delivery medium	About	Target Beneficiaries
1	Weather based index insurance(WBII) (Technology)	FISP hosts +1 million farmers	Famers, government
2	E-extension platforms (delivery medium)	SMART Zambia spearheading initiative under GRZs/ZIAMIS Platform	Farmers, extension workers and other value chain actors
3	E-market information platforms (Technology)	Lima Links offering USSD based platform	Farmers, other value chain actors
4	Mobile telephony (delivery medium)	Text messages utilized for Met information, Extension staff receive information to disburse -Use of mobile applications - Agri-Pay, Field Area Measure App, AquaCrop,	All value chain actors (farmers, retailers, transporters, processors)
5	Radio and TVs (delivery medium)	Disbursement of climate information	Farmers, all other value chain actors
6	Rain stations (Automated and Manual) (Technology)	Offered by ZMD	ZMD, farmers, all value chain actors
7	Climate projection models(Technology)	ZMD and UNZA, UNZA	ZMD and UNZA, UNZA, farmers
8	Digital geological maps (Technology)	Offered by WARMA to view water resources	Farmers, all value chain actors
9	Agro-metrological Bulletin (delivery medium)	ZMD and MoA offer farmers ag information	Farmers, All value chain actors

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Annex 1 - Case studies from Zambia

This section gives an overview of cases studies on the use of digital platforms in Zambia

A1- The XAG (Xaircraft) - Sunagri Investment Zambia

Sunagri Investment Zambia Limited is a Chinese owned company operating in Zambia. It uses drone technology for services that include precise spraying of crops, high efficiency and multi-spectral scanning of crops, and unmanned aerial vehicle operations. Before being incorporated in Zambia in 2017, the company had already noted challenges in fighting fall armyworms and was testing its technology that would revolutionize the fight against the devastating pest.

Photo: © Sunagri Investment Zambia

The XAG (Xaircraft) drone used by Sunagri is effective in combating armyworms due to the fact that it bypasses labour-intensive manual spraying of maize fields in favour of intelligent automatic spraying. Manual spraying, as a traditional method of fighting armyworms during the day, is not only labour intensive, less effective and costly but also a waste of chemicals since worms only come out at night to feed on the crops. The drone technology is effective as it can be used at night to combat armyworms. Each XAG (Xaircraft) drone can cover 45 hectares per day and the drone can effectively destroy even the bigger worms that usually hide inside the maize stalk.The use of drone technology among farmers resulted in a rise of wheat, soybean and sugarcane yield by about 6%, 9% and 15% respectively. The drone technology can help farmers save 30% in chemicals and 90% in water when applying pesticides. However, it is not affordable for all farmers as it costs between two thousand to three thousand US dollars.

Source: (Silimina, 2020; Opali, 2021)

A2 - Field Area Measure App - Agricultural Knowledge and Training Centre (AKTC Zambia-Germany) Zambia Germany

AKTC introduced the “Field Area Measure App” among its farmers in 2019 which measures distance and field areas. AKTC teaches farmers how to measure distances, field areas and how to get the coordinates of a particular point by using the Fields Area Measure App. The app is available in both ISO and Android app stores and uses GPS technology that usually comes with each mobile device.


Photo: © AKTC

Using this app, farmers can measure their fields using a smartphone instead of manually measuring distances and areas which is time-consuming and tiring. With the use of the App, accurate quantities of inputs like agrochemicals and fertilizer can be applied, guaranteeing optimum input usage through applying the right quantities per area. During training, AKTC also teaches farmers how to use their smartphones to access information on weather updates, market prices and agronomic advice from the relevant internet sites and apps. It also teaches farmers how to use social media platforms such as Twitter and Facebook to access information from other farmers worldwide.

The centre also introduced tractor service providers and emergent farmers to GPS based technology.

Source: AKTC Zambia- Germany, (2021)

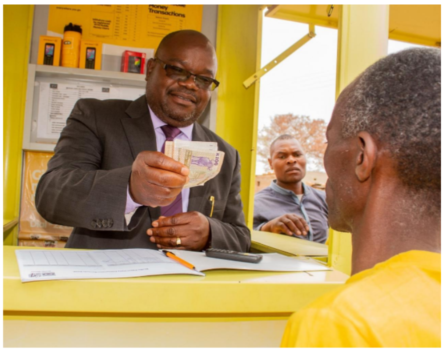
A3 - Weather-based index insurance

The Weather Based Index Insurance (WBII) is an innovative approach to managing climate-related risks using a pre-defined index, such as rainfall, to determine pay-outs. The smallholder farmers are helped to recover their investment losses resulting from weather-related events through the financial pay-outs

The Technical Centre for Agricultural and Rural Cooperation (CTA) was at the forefront in implementing the weather-based index insurance. The partnership alongside CTA comprised of Zambia Open University (ZAOU), The Professional Insurance Company of Zambia (PICZ), Ministry of Agriculture and Musika Development Initiatives (Musika). As at 2022, smallholder farmers under the FISP) are covered through Mayfair Insurance.

The weather-based index insurance was initially designed to target 60,000 farmers in 12 districts within three years with yield-based index insurance. The policy shift by the government in 2018 however, led to a positive impact on targeting. The government of Zambia announced that it was making the purchase of weather-based insurance compulsory for all farmers benefiting from the farmer input support programme (FISP). With this move, More than a million farmers, including many of the 60,000 targeted by the CTA project subscribed to weather-based insurance. In addition to the index insurance, PICZ created an ICT platform to improve communication with FISP farmers by incorporating information about pay-outs as well as e-extension services. This was done through the use of digital platforms to profile and register farmers for access to ICT and mobile-enabled weather information services.

Further, WFP has been supporting farmers by helping them to take up the index insurance by contributing 75% of the premium. Following the drought in the 2018/19 agricultural season, each eligible smallholder farmer received an average pay-out of ZMW 620, facilitated digitally through MTN mobile money wallets. To improve the design and management of the insurance provided under the Farmers Input Support Programme (FISP), WFP is providing technical assistance to the government by working with private agricultural companies (Pula Advisors, ZEP-RE, MTN and Mayfair Insurance). In addition, WFP is working with Smart Zambia Institute to see how the digital payment platform for facilitating insurance pay-outs can be enhanced for the FISP programme with the hope to see weather index insurance services extended to the one million smallholder farmers on FISP across the country. WFP further developed training manuals and radio messages on weather index insurance in seven local languages to sensitize and encourage farmers to insure against climate risks.



Caption: Pemba District Commissioner performing payout at the Pemba Weather Index Insurance payout in Kasiya, Pemba, Zambia.

Photo: © WFP Zambia/Paul Mboshya Jr

Source: CTA, (2019); UN, (2021)

A4 - Lima Links Platform

Lima Links is a Zambian social enterprise that was set up in August 2016 to connect farmers to the wider agricultural marketplace via technology platforms. Its focus is on building ICT tools to drive agri-business growth. Lima links has built an ICT platform accessible on the most basic phone on USSD, targeting the smallholder farmers. Through this platform, farmers can access live buying prices across the full range of Agri sectors, including fresh vegetables, field crops, and livestock from different market actors. In addition, farmers can view agricultural products, agricultural equipment and access messages on important disease alerts as well as events and opportunities relevant to them. By dialling *789# farmers anywhere in the country can access the platform on any basic phone and a registered SIM card with Airtel. Through Lima links' platform, farmers now have access to various live market prices for various products, which now help them know where to sell, and translate all their efforts into profits.

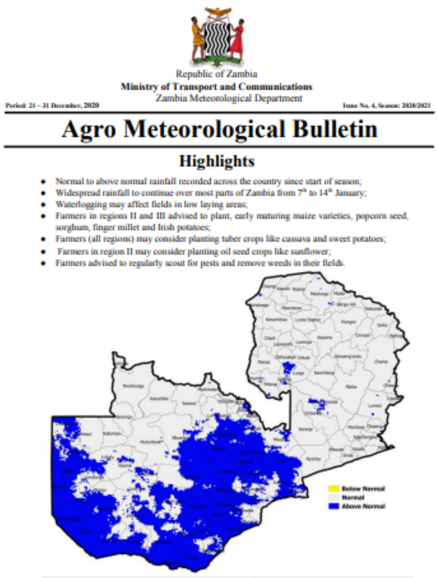
Photo: © Masida Temwani Gondwei

Lima links believe that its platform will construe significant improvements in the country's Gross Domestic Product (GDP), contribute to employment generation, and reduce the levels of poverty in the country.

Source: Lima Links, (2019)

A5 - Agro Meteorological Bulletin - Zambia Meteorological department

The Zambia meteorological department prepares the Agro Meteorological bulletin. The contents of the bulletin expected rainfall, agrometeorological conditions, cumulative rainfall, water requirements satisfaction index for maize and soil water index for maize. It also gives a summary table of the 10-day rainfall and makes a comparison to the normal situation based on weather forecast models.


Republic of Zambia
Ministry of Transport and Communications
Zambia Meteorological Department

Period: 21 – 31 December, 2020 **Issue No. 4, Season: 2020/2021**

Agro Meteorological Bulletin

Highlights

- Normal to above normal rainfall recorded across the country since start of season;
- Widespread rainfall to continue over most parts of Zambia from 7th to 14th January;
- Waterlogging may affect fields in low laying areas;
- Farmers in regions II and III advised to plant, early maturing maize varieties, popcorn seed, sorghum, finger millet and Irish potatoes;
- Farmers (all regions) may consider planting tuber crops like cassava and sweet potatoes;
- Farmers in region II may consider planting oil seed crops like sunflower;
- Farmers advised to regularly scout for pests and remove weeds in their fields.

An Agro Meteorological Bulletin assists farmers, agricultural business managers, and, government officials in their decision-making processes by providing relevant information in user-friendly terms in time for analysis of the situation. It targets farmers countrywide and advises which crops and crop varieties to grow per region depending on the prevailing weather conditions. Through the agro bulletin, farmers are advised to regularly scout for pests and remove weeds in their fields. The seasonal rainfall forecast is done at the national level in September, transmitted to provinces and then to the district level where a translated version is made available to farmers. The information is transmitted through newspapers, television, emails, radio, internet and telephones.

Zambia meteorological department at the district level provides climatic information to the following;

i. The ministry of agriculture; uses the information when making yield estimations before crop harvests (mainly maize which is the staple crop). Further, climate information is also used to determine outbreaks of crop and animal diseases.
ii. The ministry of health uses the information in the prevention of cholera, malaria, and other water-borne diseases.
iii. The ministry of water development and sanitation uses the information from the bulletin for monitoring water levels in dams, rivers, lakes and boreholes.
iv. The disaster management and mitigation unit under the office of the vice president use the information for the vulnerability assessment in areas where disasters occur.
v. The ministry of finance and ZamStats uses the information to advise on general socioeconomic activities affecting the economy.

Source: World Agrometeological Information Service; Khumalo, (2019)

Annex 2: Key Regional Stakeholders

Name	Role/Focus
Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL)	Research and Capacity
United Nations Development Programme (UNDP)	Financing
International Water Management Institute (IWMI)	Research and Financing
International Institute of Tropical Agriculture (IITA)	Research and Financing
African Development Bank (AfDB)	Financing
Global Center on Adaptation (GCA)	Research and financing
Zambezi Watercourse Commission (ZAMCOM)	Research
USAID	Financing
Center for Agriculture and Food Policy (CAFP)	Research

Annex 3: Stakeholders consulted

Name	Sector
Lima Links	Non-governmental Organization
United Nations Development Programme (UNDP)	Development Partner
Zambia Meteorological Department (ZMD)	Government
Disaster Management and Mitigation Unit	Government
Zambia Environmental Management Authority (ZEMA)	Quasi Government
Water Resources Management Unit (WARMA)	Quasi Government
Zambezi River Authority (ZRA)	Quasi Government
Conservation Farming Unit (CFU)	Non-governmental Organization
KRI Zambia	Research-Private
National Association for Small Scale Farmers (NASFA)	Private
Ministry of Agriculture	Government
Ministry of Finance and National Planning	Government
NATSAVE	Private
Ministry of Green Economy and Environment (MGEE/GEZ)	Government
ZANACO	Government
SMART Zambia	Government
Petauke District Farmers Association	Private

Annex 4: Technology Ranking from Validation Meeting

Technology	Rank Count from number 1 to 11											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Mobile Telephony	11	3	2	1	7	3	0	2	0	0	1	30
E- extension platforms	6	1	8	1	6	1	1	1	2	1	2	30
Index-Based Weather Insurance	2	5	2	5	4	1	0	7	2	1	1	30
Digital geological maps	1	6	0	0	2	4	3	3	2	6	3	30
Radio and TVs	6	2	3	3	2	5	5	2	0	2	0	30
Drones	3	1	2	3	1	1	3	4	1	3	4	26
Agro-metrological Bulletin	1	3	1	5	3	1	6	3	3	2	2	30
Climate projection models	0	2	2	4	2	4	3	3	4	4	2	30
Animal Tracking Device (e-tagging)	0	0	3	1	0	3	4	1	6	3	5	26
Rain stations (Automated and Manual)	0	5	6	4	1	3	0	3	1	2	5	30
E-market information platforms	1	3	2	5	2	2	4	2	6	1	2	30