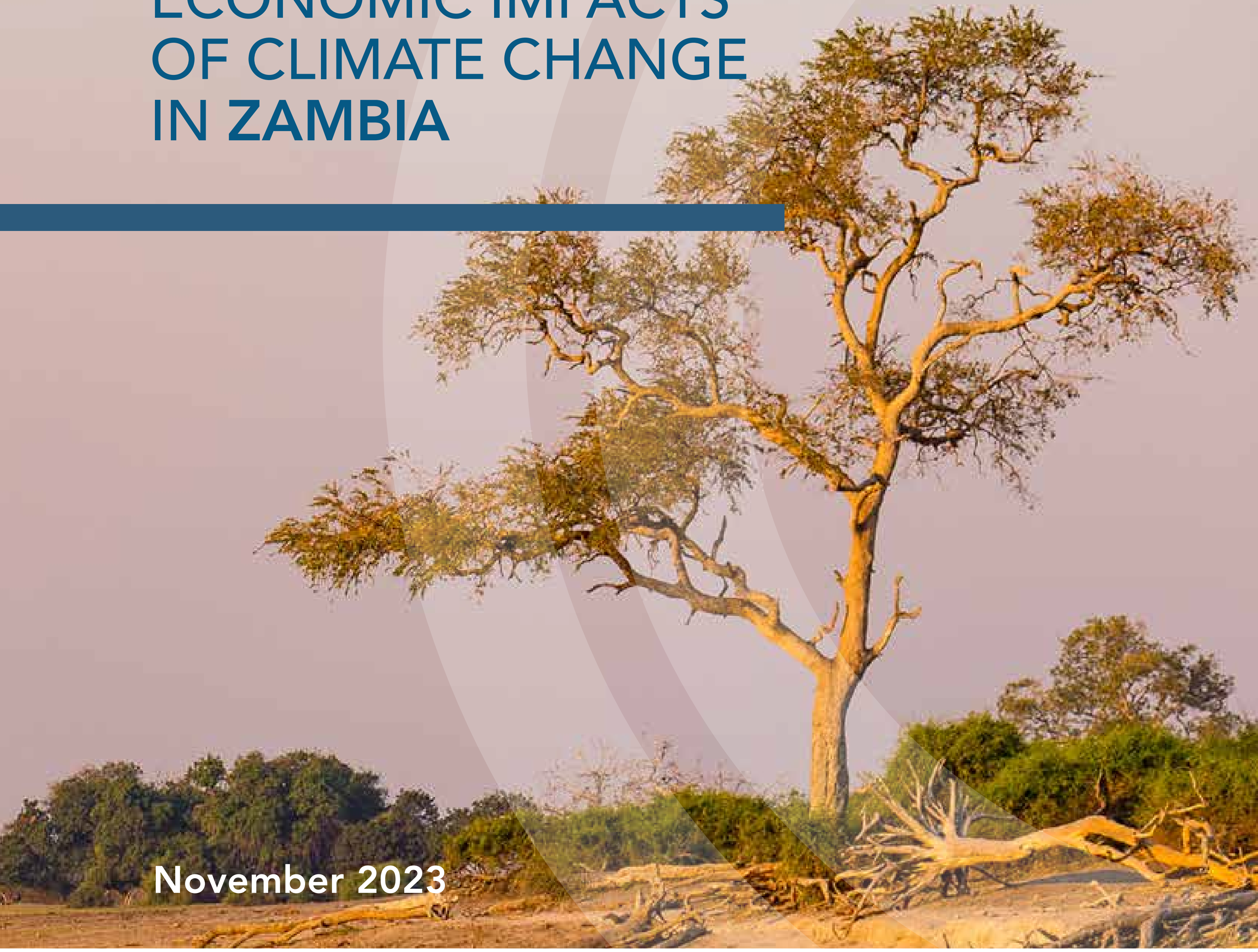
FROM CLIMATE RISK TO RESILIENCE: UNPACKING THE ECONOMIC IMPACTS OF CLIMATE CHANGE IN ZAMBIA



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PREFACE

This report, focused on Zambia, forms part of "From Climate Risk to Resilience," a series of country studies that analyze and explore the potential economic and social impacts of climate change on Kenya, Malawi, Mozambique, and Zambia, focusing on climate-vulnerable and critical economic sectors. The series is produced by the International Food Policy Research Institute (IFPRI), as commissioned by the African Climate Foundation (ACF), with additional support from the CGIAR Research Initiative on Foresight.

Each report summarizes an extensive literature review and internal views and recommendations in four main areas. Section 1 unpacks recent and projected changes to the country's climate profile and patterns, including updated climate scenario analysis modeling. Section 2 considers the potential implications of these projected climate changes for key economic sectors and for the economy as a whole. It also touches on the fiscal, trade, and other macroeconomic implications of climate change. Section 3 provides an overview of each government's existing and planned climate adaptation measures and priorities, as well as key challenges. Section 4 concludes with strategic considerations and suggestions, informed by the country's specific circumstances, and the subsequent steps that could support mobilization of funding for climate adaptation and resilience measures.

The purpose of these reports is twofold. First, they serve as a starting point for further national comprehensive climate change assessments, backed by evidence and climate scenario analysis. Such assessments would facilitate the quantification of climate change impacts, offer a nuanced understanding of potential costs and losses, consider trade-offs across various development indicators, and therefore help governments in identifying and prioritizing strategic public investments in a climate change context (building on existing efforts and strategies). It is intended that the "From Climate Risk to Resilience" reports will lay the foundation for further engagement with respective governments, development institutions, the private sector, and nonprofit organizations.

Second, "From Climate Risk to Resilience" forms part of the ACF foundational work on the development of country-led national Adaptation and Resilience Investment Platforms (ARIPs). ARIPs aim to provide in-country support to assist African governments in adopting a transformative approach to climate adaptation (one that enhances both climate and economic resilience). In particular, ARIPs would mobilize funding at scale and in a sustainable manner for prioritized climate adaptation and resilience measures (for example, by funding national comprehensive climate change assessments, linking them to a pipeline of adaptation projects under an investment plan, and providing support for the necessary institutional arrangements and investor engagement). "From Climate Risk to Resilience" informs ACF's work on ARIPs by: (i) providing an overview to potential investors, donors, and other stakeholders on the need for climate adaptation measures in the in-scope countries; (ii) outlining background research and preliminary considerations for the strategic identification of ARIPs' potential funding priorities (to be further informed by national comprehensive climate change assessments); and (iii) guiding development of a collaborative approach to address climate change risks, involving various stakeholders at different societal and governmental levels, as well as regional and international stakeholders.

EXECUTIVE SUMMARY

Climate change is projected to cause an increase in average temperatures in Zambia and a decline in rainfall, particularly in the southern and western regions. The country experiences high rainfall variability, which climate change is expected to exacerbate, resulting in likely higher frequency and intensity of already reoccurring extreme weather events, such as droughts and floods. The combined effect of the temperature and precipitation projections is anticipated to cause a decrease in water availability at national level and to adversely affect the Zambezi, Kafue, and Luangwa River Basins. Overall, these trends will exacerbate existing vulnerabilities in southwestern Zambia, as the region is already prone to droughts (as well as floods in some parts). On the other hand, the northern parts of the country are projected to experience a slight increase in rainfall and to be overall relatively positively affected by climate change.

The key sectors most likely to be significantly affected by climate change in Zambia include agriculture, road infrastructure, and energy. In agriculture, the key risk stemming from climate change is the projected lower maize yields, as this is the country's staple crop. Other crops are also expected to be adversely affected by higher temperatures, reduced rainfall, and increased occurrence of extreme events, particularly in southern and western Zambia. That said, changing climate conditions could create new agricultural opportunities in the north. Climate change is projected to negatively affect the livestock subsector, which will increase food security risks, particularly for subsistence farmers. In road infrastructure, the projected higher occurrence of flooding, especially in Lusaka Province, could have a knock-on effect for the rest of the economy, particularly if it damages key international corridors passing through this region and/or affects domestic supply chains. Zambia is significantly reliant on hydropower and is already experiencing severe power cuts due to drought. The risks in the sector are exacerbated by the location of key hydropower plants in the southern parts of the country and the projected drying up of main river basins. The electricity shortages have spillover effects on the rest of the economy, including the copper industry, Zambia's key export. This has international implications, as Zambia is a top copper producer worldwide, and demand for copper is expected to increase significantly due to its crucial role in various green technologies. Thus, absent adaptation measures, the adverse impact of climate change in Zambia could affect global mitigation efforts and strategies.

The Government of the Republic of Zambia (GRZ) demonstrates good awareness of these risks and has put effort into integrating climate change considerations in its national development planning. While some sectoral policies have already been developed, such as with regard to climate-smart agriculture (CSA) and renewable energy (to support diversification away from hydropower), Zambia is still in the process of developing its National Adaptation Plan (NAP). Key challenges to its response to climate change include mobilizing financing for adaptation measures, implementing efforts effectively (particularly due to capacity constraints), and establishing a successful governance framework for climate change that enables coordination at national and subnational level.

This report explores how an ARIP could support a strategic and integrated approach to climate adaptation in Zambia, with particular focus on the interactions between adaptation strategies in

different sectors. This will be particularly important to ensure effective water resource management, given the projected decrease in water availability in Zambia and the existing and planned water demands of various sectors, including under adaptation and mitigation measures (such as use of irrigation systems in agriculture and/or development of (small) hydropower. Similarly, a strategic approach to adaptation in road infrastructure could consider both (i) priority areas for increasing flood resilience and (ii) how future expansion of the network could support adaptation in other sectors (such as exploring opportunities for agricultural expansion in the north). The agriculture adaptation strategy could further explore regional-level impacts, both to prioritize measures supporting vulnerable communities in the south and west and to highlight investment opportunities under the future climatic conditions the country will face (and how to leverage them to reduce food security risks and projected increase of food imports).

More broadly, this adaptation approach will require effective cross-ministerial coordination, as well as more engagement with government bodies at subnational level. This will help to inform the national-level strategy, such as to include province-level adaptation pathways for key sectors, and to enable locally led implementation. An approach to mobilization of funding that follows a program rather than a project perspective could help achieve more scale and facilitate considerations of how to structure climate adaptation and resilience funding in a manner that supports Zambia's long-term development goals. Importantly, such an approach will require an investment portfolio view of Zambia's planned adaptation and resilience measures.

LIST OF ACRONYMS

8NDP	Eighth National Development Plan
AER	Agroecological region
ARIP	Adaptation and Resilience Investment Platform
CSA	Climate-smart agriculture
CSAIP	Climate-Smart Agriculture Investment Plan
GDP	Gross domestic product
GHG	Greenhouse gas
GRZ	Government of the Republic of Zambia
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NDC	Nationally Determined Contribution
NDP	National Development Plan
NPCC	National Policy on Climate Change

1. OVERVIEW OF CLIMATE CHANGE IMPACT ON ZAMBIA

Climate profile

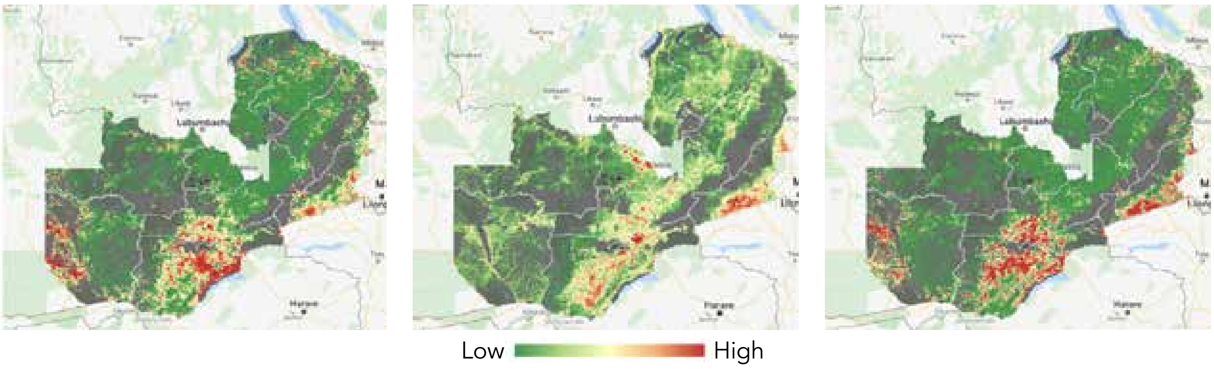
Zambia has a predominantly subtropical climate, but it is divided into three distinct agroclimatic zones. The country is landlocked, neighboring Democratic Republic of the Congo (DRC) and Tanzania to the north and northeast, Malawi and Mozambique to the east and southeast, Zimbabwe and Botswana to the south, and Namibia and Angola to the west. Most of the country (46 percent of land area) experiences a predominantly humid subtropical climate with rainfall above 1,200 millimeters (mm), particularly in the north and northwest. This region also has the longest growing season, between 130 and 160 days. The central and eastern areas have a warm semi-arid climate, with an annual rainfall of about 800–1,000 mm. Finally, the south and southwest are the most drought-prone regions, receiving less than 800 mm of precipitation annually (Zambia, Government of the Republic of Zambia 2020; USAID 2016). All climate regions in Zambia experience three distinct seasons: a hot dry season from mid-August to mid-November, a wet rainy season from mid-November to April, and a cool dry season from May to mid-August (World Bank n.d.-a).

Zambia experiences high rainfall variability. This is in part due to the movements of the Inter-Tropical Conversion Zone (ITCZ), which oscillates between the northern and southern tropics over the course of a year. The ITCZ brings rain between October and April of 150–300 mm per month, and can cause significant variation in the rainfall received from one year to another. In addition, rainfall in Zambia is influenced by the position of the El Niño Southern Oscillation (ENSO), which can contribute to significant interannual variability (World Bank n.d.-a).

The high rainfall variability means that Zambia is exposed to both floods and droughts. Most of the negative impacts of climate variability occur in the southern and central regions of the country, where food insecurity is most vulnerable to climate shocks (Hamududu and Ngoma 2019; Thurlow, Zhu, and Diao 2009). For example, Central, Eastern, Southern, and Lusaka Provinces experienced heavy flooding in 2023 (IWMI 2023b). The Zambia Disaster Management and Mitigation Unit reported the flooding as the most severe in 50 years, affecting 9 provinces, with Southern Province the most heavily hit (IFRC 2023). Some of the affected areas also experienced heavy flooding during the 2022 rainy season, leading to the displacement of households and significant damage to crop fields (GCA 2023). In between these flooding occurrences, drought in 2022 further significantly affected agricultural production (Stanbic Bank 2023). Drought in Zambia is a recurrent problem, affecting millions of people due to crop failure, livestock deaths, food and water shortages, and broader economic implications (IWMI 2023a). For example, Bowa-Mundia, Phiri, and Tembo (2019) estimate that the 2018/19 drought reduced Zambia's gross domestic product (GDP) growth to about 2 percent in 2019, significantly below the average growth rate of 4.6 percent during 2011–2018. Western and Southern Provinces are most vulnerable and at higher risk of drought (Figure 1) (SADRI 2021). Ngoma, Finn, and Kabisa (2023) similarly find that Zambia's Southern and Western Provinces are most exposed to climate shocks, and drought in particular.

Figure 1: Distribution of drought hazard, vulnerability, and risk in Zambia

a. Hazard b. Vulnerability c. Drought risk



Source: Maps generated by IWMI (International Water Management Institute).

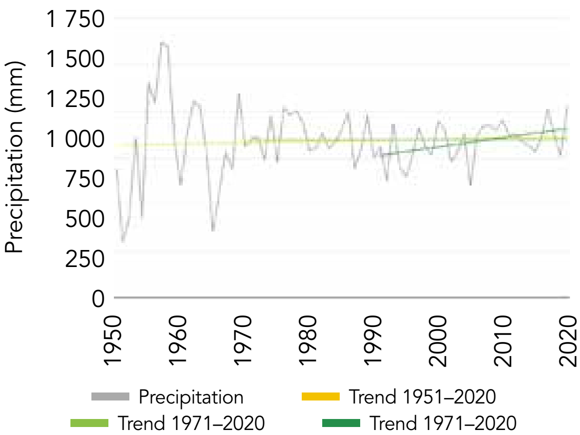
Note: Hazard is defined through meteorological and agricultural drought (that is, by the Integrated Drought Severity Index, IDSI). Exposure to vulnerability is expressed through population density, the Human Modification Index, water risk, and irrigated systems, while vulnerability is informed by agricultural practices. Drought risk is defined by characterizing hazard and exposure to vulnerability and the lack of adaptive capacity (SADRI 2021).

Recent trends

Zambia experienced increased annual rainfall variability over the past three decades, including an increase in the occurrence of consecutive dry days. Figure 2 illustrates that departures in annual rainfall from historical averages are frequently observed. This means that Zambia is becoming increasingly susceptible to both droughts and floods. Since 1991, the number of annual consecutive dry days has also increased noticeably (Figure 3) (Libanda and Ngonga 2018). Hamududu and Ngoma (2019) similarly observe a general trend of decreasing rainfall from the 1980s (though with some exceptions) and a higher frequency and severity of droughts and floods. Their study also highlights an increase in average temperatures, with the period between the 1900s and 1960s being colder than the period since the 1980s.

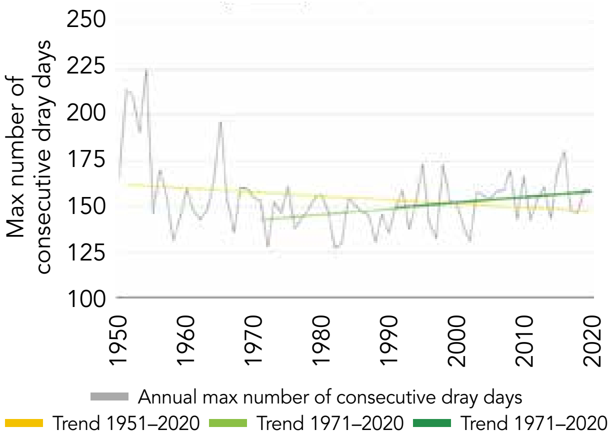
The changes in climatic conditions differ across Zambia's three agroecological regions (AERs), with the southern parts (AER I) projected to be most affected. AERs are usually defined based on the length of the crop-growing period and climatic attributes such as soils, rainfall, and landform.

Figure 2: Change in annual rainfall (mm)



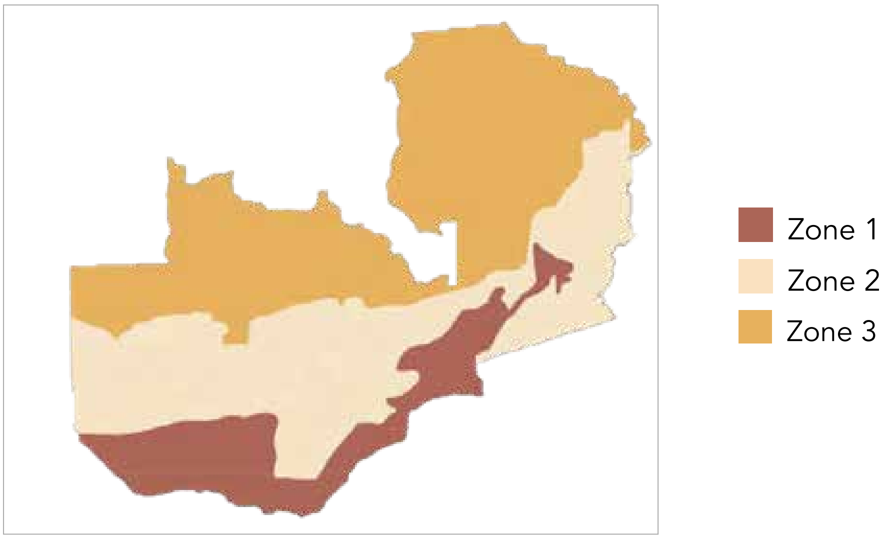
Source: The World Bank's Climate Change Knowledge Portal.

Figure 3: Number of consecutive dry days



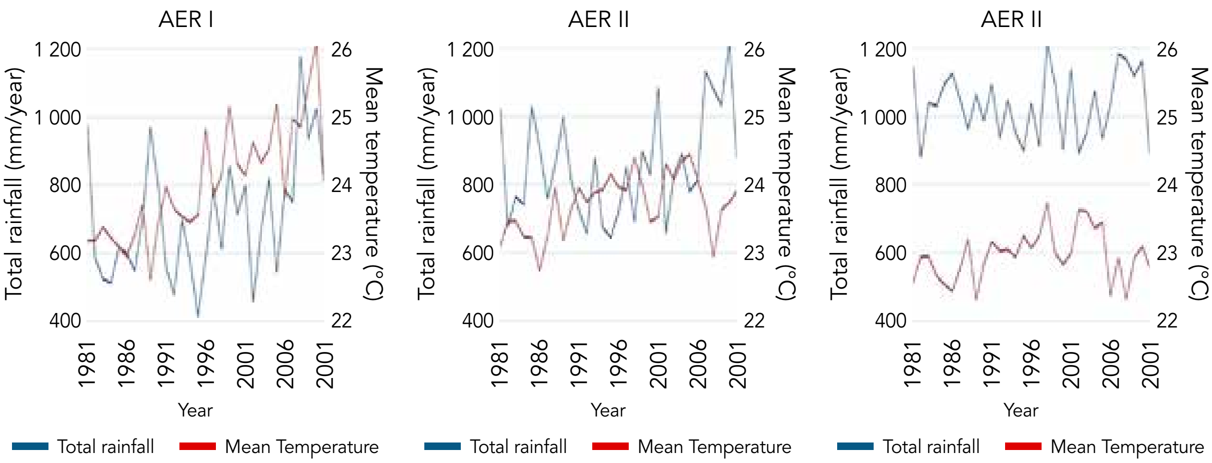
Source: The World Bank's Climate Change Knowledge Portal.

Figure 4: Map of Zambia's agroecological zones



Source: Mukosha and Siampale (2009).

Figure 5: Trend in annual temperature and rainfall in Zambia by agroecological zone, 1981–2011



Source: K. Mulungu, G. Tembo, H. Bett, and H. Ngoma. 2021. ***Climate Change and Crop Yields in Zambia: Historical Effects and Future Projections****, Environment, Development and Sustainability 23 (8): 11859–11880. Reprinted with permission.*

According to Mulungu et al. (2021), Zambia's three AERs are characterized based primarily on yearly rainfall and soil characteristics.[1] AER I represents the driest area, including major valleys in Zambia. AER II basically denotes the warm semi-arid climate zone, while AER III consists of the humid subtropical climate zone. Figure 4 shows how the three AERs are geographically distributed. Figure 5 shows the trend of annual rainfall and temperature by AER and highlights the heterogeneous variations in climatic conditions across the three regions. The average annual temperature in AER I, the driest region, has often been higher since 1991, whereas its yearly rainfall fluctuation is more significant compared with that of other AERs. However, regardless of the AER, the variation in annual rainfall over time is far from even.

1 The detailed characteristics of each AER in Zambia are presented in Mulungu et al. (2021).

Projected climate trends

Temperatures are projected to increase across Zambia. Hamududu and Ngoma (2019) expect temperatures to increase by 1.9°C (Celsius) and 2.3°C by 2050 and 2100, respectively, in a high emissions scenario. Similarly, Ngoma et al. (2021b) project temperatu res to be around 1.8°C higher on average by 2046–2050 if global greenhouse gas (GHG) emissions are not constrained, albeit the study notes that temperature increases in Zambia could even reach 3.6°C. The analysis finds that all regions in Zambia will likely experience temperature increases above the often-used 1.5°C threshold. USAID (2016) projects mean annual temperatures of 1.2–3.4°C by 2060 and flags that warming is likely to occur more rapidly in the south and west. The analysis estimates a substantial increase in the frequency of hot days and nights. The latter is corroborated by SADRI (2021), which projects hot days to increase by 15–29 percent by 2060, while hot nights increase by 26–54 percent in the same period.

Rainfall is expected to decline overall, particularly in the southern and western regions. Hamududu and Ngoma (2019) project rainfall to decrease by about 3 percent by mid-century and by about only 0.6 percent toward the end of the century countrywide. However, the study notes large geographic differences, with the southern, western, and eastern regions expected to be much more affected than the north. Ngoma et al. (2021b) similarly expect substantial reductions in rainfall in the southern and western regions, averaging between 3 and 4 percentage points (with an interquartile range—that is, spread of the data in the middle 50 percent of the dataset—of 8 percentage points). However, under worst-case scenarios, these regions could even experience a 20–30 percentage point decline in rainfall, rendering them particularly vulnerable to climate change. In contrast, the study projects rainfall to increase in the northern region by nearly 5 percentage points by 2050. USAID (2016) projects a decrease in the September–October rainfall but an increase in the December–February rainfall, particularly in the northeast. SADRI (2021) also reports this rainfall pattern projection, noting that the range of seasonal projections from different models is large. Zambia's National Policy on Climate Change (NPCC) (2016) assumes rainy seasons will be shorter and more intense. The annual number of consecutive dry days is projected to increase slightly for 2040–2059 (relative to 2020–2039), according to the World Bank Climate Change Knowledge Portal (World Bank n.d.-d).

Water availability at national level is expected to decrease. Hamududu and Ngoma (2019) focus on the impact of climate change on river basins in Zambia (Figure 6). They find that northern basins are likely to stay the same or experience slight decreases in water resources, while the Zambezi, Kafue, and Luangwa River Basins are likely to have less water resources available due to reduced rainfall and

Table 1: Water resources availability in Zambia (km³)

	Zambezi River, Victoria Falls	Zambezi Lower, Kariba	Kafue River, Road Bridge	Luangwa River, Road Bridge	Zambezi Lower, Chirundu	Luapula River, Chembe	Chambeshi River, Pontoon	Lufubu River
Current	32.3	6.6	22.3	15	3.5	16.5	5.5	0.4
2030	30.7	6	19.6	13.5	3	16.1	5.5	0.4
2050	29.4	5.8	19.2	12.7	3	15.8	5.4	0.4
2080	28.7	5.4	18.8	12.1	2.8	15.3	5.4	0.4

Source: Hamududu and Ngoma (2019).

higher temperatures (Table 1). Overall, the analysis estimates that the projected changes in rainfall and temperatures will reduce water availability in Zambia by about 13 percent from the current (observed) levels by 2100. Water availability is a regional issue and climate change impacts (as well as adaptation measures) can have knock-on effects on neighboring countries (Fant et al. 2015).

Extreme weather events, such as floods and droughts, are expected to increase in intensity and frequency (Tembo et al. 2020). The proportion of rain falling in heavy events is expected to increase annually (USAID 2016; World Bank n.d.-d), while SADRI (2021) projects the frequency of droughts (estimated at every four to five years) to also increase. And climate change is expected to increase the frequency and severity of El Niño events in Zambia (Alfani et al. 2019).

Figure 6: Main river basins in Zambia

Source: Hamududu and Ngoma (2019).

2. CLIMATE CHANGE IMPACT ON KEY ECONOMIC SECTORS

Zambia's economic performance correlates with climate variability. This is because of the country's exposure to climate-sensitive sectors, in particular agriculture and hydropower, as well as knock-on effects from climate-related damage to road infrastructure. The agriculture sector, which accounted for only 3.4 percent of GDP in 2021 (World Bank n.d.-b) but 23.6 percent[2] of total employment, is predominantly rainfed, which makes it very susceptible to climate change fluctuations (Hamududu and Ngoma 2019). Moreover, Zambia is heavily reliant on hydropower, with outages due to climate-related events such as droughts having ripple effects on the rest of the economy (Hamududu and Killingtveit 2016). The industrial sector, which accounted for 42.5 percent of GDP in 2021, is particularly dependent on electricity, as it includes the mining, construction, and manufacturing subsectors (Stanbic Bank 2023),[3] which employ 2.1 percent, 5.3 percent, and 10.5 percent, respectively, of Zambia's employed population (Zambia, Ministry of Labour and Social Security 2021). Energy deficits resulting from reduced rainfall decreased productivity in the manufacturing industry (which accounted for 7 percent of GDP on average in 2010–2017) by 60–70 percent (Tembo et al. 2020). The manufacturing sector is also susceptible to climate-related damages to agriculture, as growth is largely driven by the agro-processing of food and beverages, as well as textiles and leather (Stanbic Bank 2023). While the hydropower and agriculture sectors are likely to be the most affected by climate change, Tembo et al. (2020) find that damages to Zambia's road infrastructure introduce the most uncertainty to overall economic growth. In addition, the services sector, which represented almost 50 percent of 2021 GDP, is an important driver of the Zambian economy (Stanbic Bank 2023). It includes the tourism subsector (and adjunct line businesses), which could be negatively affected by climate change, with ripple effects for the transport and hospitality industries (Tembo et al. 2020).

The adverse impact on the Zambian economy is projected to increase progressively over time and adversely affect poverty and food security. In the absence of effective mitigation efforts globally (that is, the unconstrained emissions scenario), Tembo et al. (2020) estimate that climate change could reduce Zambia's GDP by about 6 percent by 2045–2050.[4] The impact is projected to grow progressively over the period (Ngoma et al. 2021b). Arndt et al. (2019) project Zambia's average GDP level over the period 2046–2050 to most likely be between -3 percent and -1 percent if global emissions are not constrained. UNDRR and CIMA (2019) estimate that the impact on GDP from droughts could more than double by 2050 in a high emissions scenario (with reference to the annual average potential affected GDP in 2016), with losses in hydropower production driving these results.

2 According to Zambia's Labour Force Survey Report (Zambia, Ministry of Labour and Social Security 2021). The World Bank data indicate that a larger proportion (59 percent) was employed by the sector in 2021, but this could be due to methodological differences. The World Bank data figure is included for comparability with the other IFPRI-ACF country-specific discussion papers (World Bank n.d.-c).

3 Major industries include copper mining and processing, construction, emerald mining, beverages, food, textiles, chemicals, fertilizers, and horticulture (Stanbic Bank 2023).

4 The analysis focuses on the projected outcomes for the period 2045–2050, using a dynamic computable general equilibrium model. In particular, it employs the Systematic Assessment of Climate REsilient Development (SACRED) framework.

Climate change is likely to reduce food security, create local production shortfalls, and lead to higher commodity prices, thus adversely affecting food systems (Verhage et al. 2018). Droughts are the most prevalent climate shock faced by rural smallholder farmers in Zambia, with 76 percent of smallholder farmers considered vulnerable. Southern and Western Provinces are the most affected (Ngoma, Finn, and Kabisa 2023). For example, Alfani et al. (2019) estimate that households affected by the drought due to the El Niño event in 2015/16 experienced around a 20 percent decrease in maize yield and up to a 37 percent reduction in income, all else being equal. Households' vulnerability is exacerbated by the high poverty levels and low diversification in food production in Zambia (CIAT and World Bank 2017). Currently, slightly over one-half of the population lives below the national poverty line, predominantly in rural areas (AfDB 2023). For example, approximately 80 percent of Southern Province communities rely on subsistence farming and animal rearing as a primary source of livelihood (IFRC 2023). Ngoma, Finn, and Kabisa (2023) note that the proportion of vulnerable households is larger than the national average in Eastern, Muchinga, Northern, and North-Western Provinces.[5] They find that adoption of climate-smart agriculture (CSA) practices significantly improves household resilience and highlight the need for adaptation measures and strategies to address both droughts and floods in smallholder agriculture.

Agriculture

As discussed above, the agriculture sector is very important to the Zambian economy, mainly because of the job opportunities it creates and for food security. The country's staple crop is maize. Other common food crops are cassava, millet, sorghum, and beans (CIAT and World Bank 2017). Zambia also cultivates cotton, soybeans, tobacco, groundnuts, paprika, sorghum, wheat, rice, and sunflower. The country is one of the biggest seed exporters in Africa (Stanbic Bank 2023). Subsistence farmers across the country grow 60 percent of Zambia's maize, 90 percent of sorghum, 85 percent of groundnuts, and virtually all cassava (Zambia, Government of the Republic of Zambia 2006). The livestock subsector produces derivative products from cattle, as well as chickens, eggs, pigs, hides, and skins (FANRPAN 2017). It contributes 3.2 percent to the national GDP and 42 percent to agricultural GDP (Zambia, Ministry of Fisheries and Zambian Statistics Agency 2022). Subsistence farmers hold a large share of the national livestock herds (Zambia, Government of the Republic of Zambia 2006). The fisheries subsector accounts for about 3.2 percent of GDP and 40 percent of protein intake in rural areas (PMRC 2018).

The agriculture sector's productivity and value added to GDP decreased over the past two decades, largely due to worsening and erratic climate conditions (Tembo et al. 2020). Most livelihoods depend on cassava (particularly in the north) and maize, whose yields rely on a timely rainy season and stable temperatures (Verhage et al. 2018; USAID 2016).[6] The sector is particularly vulnerable to drought, as more than 90 percent of smallholder production is rainfed (Ngoma et al. 2021b). For example, the agricultural growth rate dropped from +9.8 percent in the 2017/18 season to -21.2 percent in 2018/19 due to crop failure from prolonged dry spells (Kabisa, Chapoto, and Mulenga 2019). Zambia's CSA Investment Plan (CSAIP) (2019) estimates that climate change could lead to a decline in key crops' yields of 25 percent by 2050, depending on the AEZ. According to Verhage et al. (2018), parts of southern Zambia are projected to have a failed season one in every two or three years by 2050. Poor rural infrastructure is another key constraint to agricultural development in Zambia (Stanbic Bank 2023). Such challenges, particularly for smallholder farmers, include limited access to inputs, finance markets, and postharvest storage and management technologies (WFP 2020). Moreover, the climate change impact on other sectors could exacerbate

5 The analysis uses total household income to categorize vulnerable and resilient households.

6 These two crops provide over 50 percent of the population's intake of energy and protein intake (Verhage et al. 2018).

vulnerabilities in agricultural production. For example, Ngoma et al. (2021b) point out that adding in the other impact channels beyond agriculture, particularly roads and energy, could lead to a greater negative impact of climate change on various crops, especially maize and root crops.

That said, opportunities exist for further development and diversification within the agriculture sector, including from climate change. Zambia spans 75 million hectares, of which 58 percent is classified as medium to high potential for agricultural production. However, only 15 percent of its potential arable land is currently cultivated (Stanbic Bank 2023). CIAT and World Bank (2017) estimate that exports of cotton and groundnuts have the potential to increase over the period 2020–2050 under the conditions that climate change would create (relative to a scenario of no climate change). The analysis shows that rice yields may be 3.4 percentage points higher by 2050 under the climate change scenario. Furthermore, Zambia's CSAIP (2019) estimates CSA practices would not only help limit the adverse impacts of climate change; projections until 2050 indicate that CSA adoption may also help achieve or surpass sectoral development goals, such as increase crop and livestock production, improve food availability, reduce Zambia's trade deficit in certain commodities, and contribute to climate mitigation. Opportunities will differ by region, as further described below, with more potential for productivity gains and development in north and east Zambia.

Such expansion will need to be balanced with preservation of Zambia's important ecosystems. Approximately 38 percent of Zambia's land has protected status (Narain and Mubanga 2022). Agricultural expansion, alongside mining and logging, is a main driver of deforestation (Zambia, Ministry of Lands, Natural Resources and Environmental Protection 2014). Cropland expansion by smallholder farmers into forests represents about 60 percent of the estimated annual forest loss in Zambia (Ngoma et al. 2021a). Further deforestation would have negative implications for Zambia's mitigation targets, as land use, land use change and forestry, and the agriculture sector account for about 93 percent of the country's carbon footprint (World Bank Group and Zambia, Ministry of Green Economy and Environment 2019). Climate change—in particular, higher frequencies of droughts, high temperatures, and fire risk—is also affecting Zambia's wildlife, Miombo woodlands (a critical source of fuel, medicine, and fodder), southern Baikiaea woodlands (a key source of teak), and grasslands (USAID 2016).

Impacts of climate change on crop yields

Maize is highly vulnerable to climate change in Zambia. This is confirmed by the analysis shown in Table 2, as well as various other studies (Ngoma et al. 2021b; Verhage et al. 2018; Mulenga, Ngoma, and Tembo 2015). Ngoma et al. (2021b) project that climate change will reduce maize production much more than any other assessed crop by 2050 if global emissions levels are not constrained. The study estimates a yield reduction of up to 3–6 percentage points. More recent analysis shows that maize yields in Zambia will reduce by more than 9 percent in 2050 under a very high emissions scenario (SSP5-8.5)[7] (Table 2). This is likely to create food security challenges and adversely affect household incomes, as cereal crops (wheat and maize) are a staple food and provide over 60 percent of the energy requirements in Zambia (Mwanamwenge and Harris 2017).

Climate change is also expected to adversely affect other major crops in Zambia. Table 2 shows the estimated impact of climate change on six key crops in Zambia by 2050. The change in expected yields by 2050, relative to 2005, will strongly depend on the extent of CO_2 (carbon dioxide) fertilization.[8] Such impact is particularly pronounced for groundnut yields, the second most important

7 That is, the Shared Socioeconomic Pathway (SSP) 5-85.

Table 2: Yield impact of climate change on crops in 2050 under SSP5-8.5, relative to 2005 climate

	Without CO_2 fertilization Predicted yield change (%)			With CO_2 fertilization Predicted yield change (%)			
Crop	Minimum	Median	Maximum	Crop	Minimum	Median	Maximum
Groundnuts	-20.35	-14.30	-12.25	Groundnuts	-3.39	3.77	6.55
Maize	-21.76	-9.36	-4.79	Maize	-22.04	-9.84	-5.37
Rice	-4.40	-3.85	-1.98	Rice	4.51	5.93	7.86
Sorghum	-12.30	-4.94	-2.41	Sorghum	-11.36	-4.43	-2.09
Soybean	-25.47	-13.03	-6.77	Soybean	-7.29	7.24	13.70
Wheat	-15.69	-13.03	-6.77	Wheat	-6.28	0.17	5.10

Source: Authors' estimates.

Note: Figures represent a weighted average of the estimated yield change in rainfed and irrigated scenarios.

crop in Zambia (after maize). The projected yields of major crops in Zambia underscore the urgency of tackling the (adverse) consequences of climate change on agriculture.

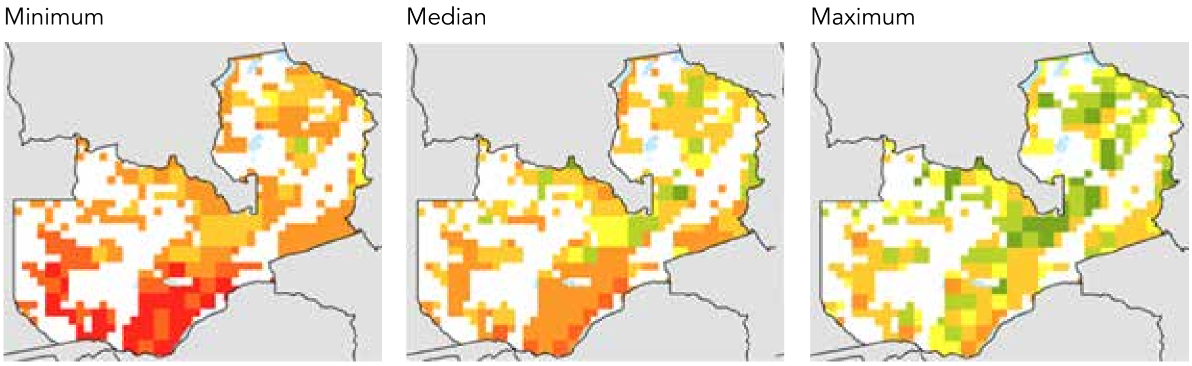
Significant regional differences arise with production in the southern and western regions, which are likely to be the most affected by climate change. For example, Figure 7 (Panel A) shows how projected yield changes for maize are likely to differ by region, taking into account where this crop is most typically cultivated. Ngoma et al. (2021b) predict the interquartile range for maize yields in these regions to be a 7.0 to 8.5 percentage point yield decrease by 2050 in a high emissions scenario. Maize production there is likely to be subject to more uncertainty relative to other parts of the country because of climate change, with yield variability ranging from 26–30 percentage points. The two regions accounted for 30 percent of national maize output during the 2017/18 farming season (IAPRI 2019). At the province level, Southern Province was the highest maize producer in that year, demonstrating its importance for food security and agricultural development in Zambia (Ngoma et al. 2021b). Mulungu et al. (2021) uncover that a higher volume of rainfall promotes maize yield in low-rainfall areas (AER I and II), whereas it negatively impacts maize yield in the high-rainfall AER III and has an insignificant effect on bean yields. Likewise, the impacts of temperature on agriculture vary by region and crop. Yet Mulungu et al. (2021) still project a noticeable decline in yields of the most important staple crop, maize, in Zambia. They conclude that maize yield is likely to be reduced by one-quarter by 2050 in AER II, where the projected yield of beans will also decline by 34 percent.

Climate change is projected to negatively affect production of other crops in these regions. For example, Figure 7 (Panels B and C) shows the projected impact on groundnut and soybean yields. Other crops likely to be adversely affected include root crops and tobacco, particularly in southern and western Zambia, albeit to a slightly lesser extent than for maize (Ngoma et al. 2021b). Ngoma et al. (2021b) find that cotton production is likely to be the least impacted at national level, but a decline in cotton yield is still likely in southern Zambia. Overall, the southern and western regions account for about 26 percent of agricultural value added. Household expenditure for rural households in these regions is also projected to decrease as a result of the adverse impact on agricultural productivity (Ngoma et al. 2021b).

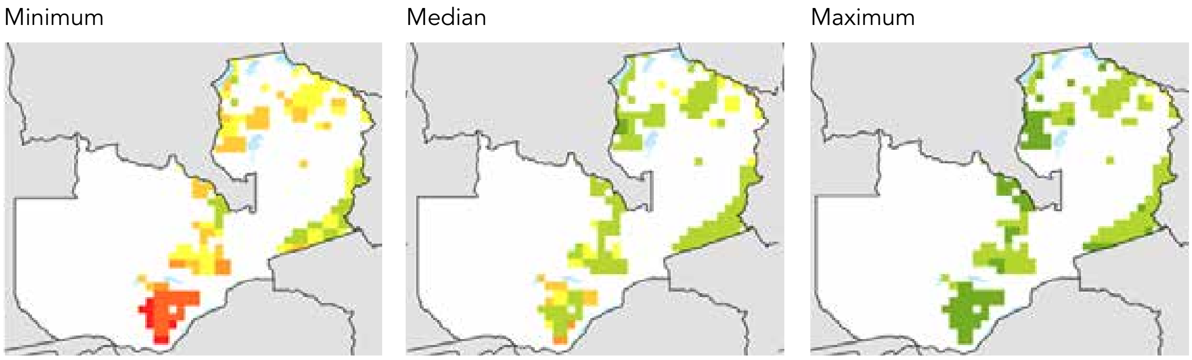
The climate change impact in the southern and western regions is likely to have broader implications for agricultural development in Zambia. Hamududu and Ngoma (2019) expect water availability to reduce the most in these regions (up to 9 percent by the end of the century) due to reduced rainfall and higher temperatures. In particular, the study projects Zambezi, Kafue, and Luangwa River Basins to have less water resources available. This risks undermining the use of irrigation to minimize the projected negative impact on the agriculture sector as: (i) less water would be available for irrigation in the southern and western regions to offset the negative impact of droughts on agricultural production; and (ii) the use of irrigation systems and other forms of

Figure 7: Visualization of projected yield changes

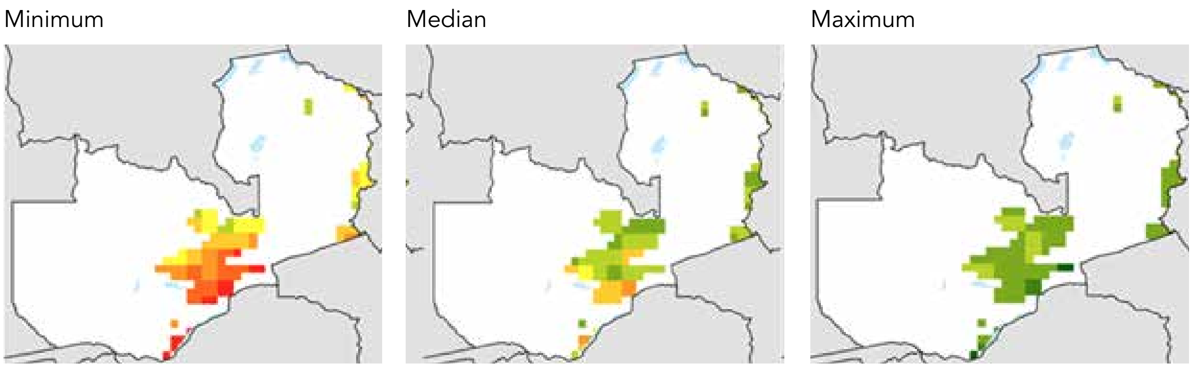
Panel A. Percent yield change, rainfed maize, 2005–2050, RCP8.5, with CO_2 fertilization, across 5 General Circulation Models (GCMs) in Inter-Sectoral Impact Model Intercomparison Project (ISIMIP), CMIP6 (sixth phase of the Coupled Model Intercomparison Project)



Panel B. Percent yield change, rainfed groundnuts, 2005–2050, RCP8.5, with CO_2 fertilization, across 5 ISIMIP GCMs, CMIP6



Panel C. Percent yield change, rainfed soybeans, 2005–2050, RCP8.5, with CO_2 fertilization, across 5 ISIMIP GCMs, CMIP6



Source: Authors' estimates

electricity-dependent agricultural processing and manufacturing elsewhere in the country could be affected because of power outages, as a significant portion of Zambia's electricity capacity stems from hydropower plants that depend on water from the Kafue and Zambezi Rivers. For example, Kabisa, Chapoto, and Mulenga (2019) find that the dry spells in 2018/19 led to electricity rationing that prevented commercial farmers from irrigating regularly.

Climate change is projected to affect other regions in Zambia to a lower extent, and some productivity gains may even be realized in the north and east. For example, maize productivity is likely to be less affected (below 2 percentage points) in the central, eastern, and northern regions of Zambia, which account for 50–60 percent of total maize production (Chikuba, Syacumpi, and Thurlow 2013; Ngoma et al. 2021b). The eastern region is more likely to experience a positive impact in agricultural value added from climate change, although negative impacts are also possible. Cotton production could experience a yield increase of 1 percentage point in the northern region of Zambia by 2050, while root crop yield may benefit by 0.5 percentage points, although the full range of outcomes is broad (Ngoma et al. 2021b). The tropical areas, which are typically planted with cassava, however, may be adversely affected by increased humidity and waterlogging (USAID 2016).

Impacts of climate change on livestock

The livestock subsector is likely to be adversely affected by projected increasing temperatures, especially due to its concentration in weather disaster-prone areas. This is in part because livestock production in Zambia relies heavily on rainfall (CIAT and World Bank 2017). Moreover, about one-third of the households engaged in livestock activities in Zambia are in Southern Province, where climate change is likely to exacerbate preexisting drought and flood risks (Zambia, Ministry of Fisheries and Zambian Statistics Agency 2022). Drought risk increases the risk to livestock from pests and diseases and reduced forage and feed (CIAT and World Bank 2017). UNDRR and CIMA (2019) estimate that the proportion of livestock affected by drought will rise from 21 percent (550,000 livestock units) currently to 34 percent under future climate conditions under a high emissions scenario. While livestock in southern Zambia are likely to be most affected, drought risk could increase across the whole country due to climate change (UNDRR and CIMA 2019). The projected higher temperatures and increased frequency of hot days are problematic for the subsector, as most livestock species perform poorly at higher temperatures because they reduce their feed intake at temperatures of about 30°C (Dinesh et al. 2015). Thus, climate change is likely to exacerbate the preexisting challenges in Zambia's livestock subsector, which include low productivity, low species diversification, low access to markets, disease prevalence, and management constraints (CIAT and World Bank 2017). Overall, these climate change projections are likely to pose a barrier to realizing Zambia's Eighth National Development Plan's (8NDP) goal of developing the subsector and increasing the livestock population. Adaptation measures will be important to ensure food security, given the large proportion of subsistence farmers engaged in livestock farming.

Road infrastructure

Zambia's road infrastructure is vulnerable to climate change. Zambia has a road network of approximately 67,671 kilometers (km), of which 40,454 km are core road network and only about 15 percent is paved (DLCA 2021). Chinowsky et al. (2015) consider how climate change—particularly projected changes to precipitation, temperatures, and flooding—could affect the road infrastructure of Zambia, as well as of Malawi and Mozambique, from 2010 to 2050. The study finds that Zambia will incur more than double the potential economic impacts from climate change compared to Malawi and Mozambique, given its significantly larger road network. And a large proportion of Zambia's network is unpaved, making it even more vulnerable to climate change. That said, this represents an opportunity for climate adaptation measures to bring significant annual maintenance savings, as detailed later in this report.

Risks from climate change to Zambia's road infrastructure are exacerbated by regional concentrations around Lusaka. Nearly all trunk highways go through Lusaka. Traveling from the north to the south of the country and vice versa requires passing through the capital due to the poor condition of alternative routes (DLCA 2021). However, Lusaka already experiences regular pluvial flooding and climate change is projected to increase such occurrences, as heavy rains increase in variability, frequency, and intensity (FCFA 2016; Nchito et al. 2018). For example, the severe flooding earlier in 2023 resulted in nearly 100 damaged roads and a number of damaged bridges across Lusaka Province (ERCC 2023). Jack (2022) asserts that even if current drainage plans are implemented, flooding will continue to be an ongoing issue, requiring a more holistic and long-term solution. This regional concentration of the road network could therefore exacerbate the damages of climate change to economic growth by affecting trade and supply chains. Moreover, Zambia has a road density of 9.1 km per 100 km^2, which is relatively lower than neighboring countries and is categorized as the minimal network for good connectivity under regional standards (World Bank 2017). This increases risks from climate change to rural populations, as a low road density implies that they may not have a transport alternative when a road is damaged due to weather events. Indeed, the World Bank (2017) notes the observed correlation between rural accessibility and rural poverty, as well as agricultural productivity. Thus, climate change is likely to exacerbate existing social vulnerabilities, as the poverty rate in rural areas is 77 percent, compared to 23 percent in urban areas (AfDB 2023).

Climate-related damage to road infrastructure is likely to have significant knock-on effects on Zambia's economic growth. This is because road damages have implications for the productivity of many other sectors of the economy (Chinowsky et al. 2013; Chinowosky et al. 2015). As a landlocked country (and because of the limited availability of railway routes), Zambia depends heavily on its road network for cargo transportation (RDA 2019). UNDRR and CIMA (2019) find damages to transport systems to be among the key drivers of direct economic losses due to flooding. Tembo et al. (2020) find that the impact of climate change on Zambia's GDP is most uncertain when the economywide effects from damages to roads due to climate variability (flooding and high temperatures) are taken into account. These include a reduction in value-added activities, particularly in the agriculture, mining, processed foods, and manufacturing sectors. The study finds mining and petroleum to be the most affected sectors. This has further economic implications: the mining sector is the largest foreign exchange earner (copper exports account for around 70 percent of Zambia's foreign exchange earnings), while the petroleum sector provides key inputs to all productive sectors of the economy. About 80 percent of people and goods are moved by road and this can impact the economy, with 70 percent of climate damages happening on unpaved networks that connect the rural agrarian hinterland (Colless 2020).

According to a vulnerability assessment of Zambia's road infrastructure and transport sector, the country will experience a number of indirect socioeconomic impacts from climate change-related damage. These are likely to include: (i) escalation of transport costs (as road links are damaged or inaccessible, transportation expenses will increase); (ii) disruption of economic activities (vital sectors such as agriculture, mining, industry, and tourism will be affected by interrupted or limited accessibility); and (iii) reduced access to social services (education and health services will suffer due to the damage to and hindered accessibility of road links). The northern region—including Copperbelt and Muchinga Provinces—is most vulnerable to climate-related damage to roads due to higher projected rainfalls. More than 80 percent of projected direct costs from climate-related damage on roads is expected to occur in the wetter northern part of the country (North-Western, Copperbelt, Luapula, Northern, Muchinga Provinces). Copperbelt Province (alongside Lusaka Province) carries the most traffic, as it is a center for the mining sector as well as for a significant portion of the manufacturing, construction, and service sectors. Climate change could also severely impact regional trade. This is because trunk roads, a critical part of the road network, are responsible for carrying primary exports—mining, construction, and retail goods—within and outside the country but are increasingly subject to climate-related damages, resulting in high direct and indirect costs. Such climate-related costs, in absolute terms, are especially high for trunk roads in the Muchinga Province (Colless 2020).

Important opportunity costs arise from the impact of climate change on Zambia's road infrastructure. As climate change increases the frequency and intensity of weather events that damage roads, it leads to higher costs for replacing or repairing damaged infrastructure, thus diverting funds from investment in other growth-enhancing activities (Tembo et al. 2020). In particular, Chinowsky et al. (2015) estimate that Zambia will face a potential opportunity cost of 11 percent in the median climate scenario if the GRZ does not take preemptive climate adaptation measures. This opportunity cost is equivalent to the lost potential of expanding the existing road network with new roads or upgrading existing unpaved roads by 8,760 km to paved roads.

Hydropower

Zambia's heavy reliance on hydropower for electricity renders it extremely vulnerable to climate change. Hydropower provides 85 percent of the country's installed capacity (ITA 2022). Other energy sources include coal, heavy fuel oil, diesel, and solar (ERB 2019). Moreover, current production is significantly below the existing optimal capacity due to the low water levels at different sources. For example, the reservoir behind the Kariba Dam has not been at full capacity since 2011 and is expected to fill up again only under rare circumstances (Centre on Global Policy Energy 2022). Meanwhile, demand for electricity is likely to increase, in part because of projected population growth, and in part due to future industrialization, as only 32.5 percent[8] of Zambian households are connected to electricity services, according to the GRZ's Renewable Energy Strategy and Action Plan (2022).[9] Various studies observe that climate change will add to the challenges of hydropower production in Zambia because of the increased risk of droughts (Tembo et al. 2020; Hamududu and Ngoma 2019; Spalding-Fecher, Joyce, and Winkler 2017), as well as lead to declines in runoff and increased irrigation activities in areas that are upstream to most hydropower plants (Tembo et al. 2020). UNDRR and CIMA (2019) project losses in hydropower generation due to drought to increase by almost 50 percent under projected climate conditions for 2051–2100 under a high emissions scenario (relative to the climate conditions for the 1979–2018

8 According to the World Bank (n.d.-a), 46.7 percent of the population had access to electricity in 2021.

9 About 70.6 percent and 8.1 percent of households electrified live in urban and rural areas, respectively.

period).[10] The study estimates that average hydropower losses over a five-year period will more than double under future climate conditions as a net result of increased losses in the south (Kariba Dam) and reduced losses in the other hydropower stations. In 2023, Zambia experienced power cuts of 12 hours per day due to a drastic reduction in available water in the Kariba Dam reservoir for electricity generation at Kariba North Bank Power Station, while Zimbabwe halted its electricity generation from the jointly owned dam in November 2022 (AfricaNews 2023).[11] Hamududu and Killingtveit (2016) project that the estimated decrease in water resources in Zambia because of climate change will lead to decreased hydropower production potential by 9 percent in the 2020s, 18 percent in the 2050s, and 28 percent in the 2080s, assuming a medium emissions scenario.

The concentration of hydropower infrastructure in Zambia adds to the sector's vulnerability to climate change. The majority of Zambia's nearly 3,500 MW (megawatt) installed hydropower capacity generation comes from the Kariba North Bank Power Station (1,080 MW), the Kafue Gorge Power Station (990 MW), and the Kafue Gorge Lower Hydro Plant (750 MW), all located in the country's south (ITA 2022; Kuhudzai 2023; Tena 2022; Trace 2019). Risks to this infrastructure stem not only from the projected higher frequency and intensity of droughts in the region but also from potential extreme weather events, such as flooding, that could damage the plants.

Declines in hydropower generation because of climate change could have significant implications for the domestic economy. Zambia's top exports—raw copper (47.3 percent of total exports in 2021) and refined copper (22.2 percent of total exports)—require energy-intensive production (OEC n.d.). Given Zambia's reliance on hydropower, climate change could lead to significant adverse impacts on Zambia's trade balance. In principle, Zambia could address potential shortages in domestic hydropower generation by importing electricity from the Southern Africa Power Pool regional market and therefore the direct economywide effects of climate change impact on the hydropower sector may be more limited. However, Zambia historically imports most of its electricity from Mozambique, South Africa, and Malawi, countries whose energy markets are also expected to be significantly affected by climate change. Mozambique and Malawi, in particular, are heavily hydropower-dependent and vulnerable to extreme weather event-related damage to infrastructure. Their regional proximity to Zambia introduces a wrong-way risk: for example, a regional poor rainy season resulted in power cuts of 8 to 14 hours per day in Zambia in 2015 (Jeffrey 2015). According to OEC (n.d.), 68.7 percent of Zambia's electricity imports that year came from the United Kingdom. While Zambia is usually a net electricity exporter, the 2015/16 drought led to a substantial electricity net deficit in 2017, with 81.7 percent of electricity imports coming from the United Arab Emirates to limit power outages. Thus, declines in hydropower generation are likely to have broader implications, including for Zambia's trade balance. In addition, the impact of climate change on hydropower generation could include higher commodity prices and inflation (Kabisa, Chapoto, and Mulenga 2019; Ngoma et al. 2021b).

Zambia's climate-related energy sector challenges could affect global mitigation efforts. Zambia is the world's top exporter of raw copper, accounting for 39.3 percent of global raw copper exports in 2021 (while its refined copper exports were 3.24 percent of global refined copper exports) (OEC n.d.). It is also among the top 10 copper producers in the world (when all types of copper are considered) (Garside 2023). Copper is a key component of energy transitions around the world, as many green technologies—such as electric vehicles, charging infrastructure, solar photovoltaics, and batteries—require much more copper than their conventional fossil-based counterparts. As a result,

10 For Mulungushi, Itezhi-Tezhi, Kafue Gorge, and Kariba Dams.

11 Zambia has had to deal with extensive power cuts since 2015 due to droughts linked to climate change in southern Africa, as well as long-term lack of investment in power generation capacity and increasing electricity demand, as per the Renewable Energy Strategy and Action Plan (2022). This has also led to increased use of charcoal, mainly by urban households.

Standard & Poor's projects global demand for copper to double by 2035, leading to a significant supply-demand gap and even risks to international security (Yergin et al. 2022). The expectation of price increases is corroborated by other studies, such as Elshkaki et al. (2018), who expect a doubling of copper demand until 2050; Klose and Pauliuk (2023) similarly estimate copper demand to increase from 24.3 metric tons (MT) in 2015 to 44.4 MT in 2050 if global warming is to be limited to 2°C (SSP2-RCP2.6 scenario), with copper demand for vehicles and transportation infrastructure likely to quadruple. While such demand would have a positive impact on the Zambian economy, the risks that climate change poses to the energy sector in Zambia could have significant implications for the copper industry domestically and internationally.

Climate change-related risks are likely to have implications for other alternatives to energy supply in Zambia. Forest biomass is an important energy source for the rural population but its availability is expected to decrease due to higher frequency of wildfires and drought (USAID 2016). Furthermore, lack of access to clean energy leads to increased consumption of firewood and charcoal. This exacerbates deforestation, which in turn reduces the river runoff needed for sustainable hydropower generation (Tembo et al. 2020). Overall, this section highlights the need for Zambia to diversify its energy mix, including the use of renewables, albeit the associated high technology costs represent a significant constraint.

Broader key macroeconomic impacts and vulnerabilities

Climate change could introduce more uncertainty to Zambia's economic growth because of the country's dependence on commodity prices. Zambia is sensitive to world commodity price fluctuations mainly because of its economic dependence on the mining sector and, more precisely, on copper exports (Tembo et al. 2020). Indeed, economic growth has in recent years in large part been due to the fall in the price of copper (Stanbic Bank 2023). In principle, copper prices are likely to be supported by strong demand due to their role in the transition to renewable technologies, as discussed above. Indeed, Zambia's GDP is projected to grow 4.0 percent in 2023 and 4.2 percent in 2024, supported by higher global copper prices, as well as continued recovery in mining, services, and manufacturing, alongside ongoing fiscal consolidation measures (AfDB 2023). That said, this dependence could still introduce significant climate-related volatility to the Zambian economy. Copper prices are commonly used by market participants as an indicator of global economic health and a barometer of economic cycles (Inspirante Trading Solutions 2022). This is because copper is a key ingredient in production in various sectors, such as building construction, electrical and electronic products, transportation, consumer products, and industrial equipment (CDA 2021). Several studies describe the relationship between copper prices and China's economic growth, including significant volatility cross-effects between international copper prices and real economic activity in China (Inspirante Trading Solutions 2022; Guo 2018). As climate change is projected to affect the global economy, including leading to GDP losses in China of 0.5–2.3 percent as early as 2030 (World Bank Group 2022), this could have knock-on effects on copper prices, and therefore on the Zambian economy. Furthermore, petroleum is one of the country's most important imports, contributing a crucial 9 percent of the nation's total energy requirements. Climate change is expected to lead to increased importation of electricity, which may expose the country to international oil price volatility (Tembo et al. 2020).

Surging international food prices could have a greater adverse impact on economic growth and food security in Zambia under a high emissions scenario. While Zambia's food imports are currently relatively low, CIAT and World Bank (2017) estimate[12] that Zambia may become more dependent

12 Using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT).

on imports of major agricultural commodities over the period 2020–2050. The analysis projects exports to be lower and imports higher for almost all crops considered in a scenario with climate change relative to a no climate change scenario. Most of Zambia's current food imports come from the regional market, in particular South Africa (OEC n.d.), which could expose the country to regional climate-related shocks and food price inflation. The regional drought caused by the 2015/16 El Niño event provides an example of the impact of climate shocks on regional trade and food security. The GRZ introduced an export ban on maize in response to the event to ensure food availability nationally. However, the policy led to a substantial decline in the price of maize, estimated to have impacted poor households much more than the El Niño event itself. This is because of the large share of poor households in Zambia that are net sellers of maize and whose incomes were reduced by the decline in maize prices. Moreover, the policy amplified food security risks in countries dependent on imports from Zambia, such as Malawi (Mamun et al. 2018).

Zambia's ability to address climate change risks is compromised by its fiscal position, as the country is currently in debt distress. The country's fiscal deficit stood at 8.9 percent of GDP in 2022 (up from 8.1 percent in 2021) and is projected to persist at 8.1 percent of GDP in 2023 and 7.3 percent in 2024 due to increased social spending. Zambia remains in high debt distress, with debt above 104 percent of GDP (AfDB 2023). It is classified as having "weak" debt-carrying capacity by the International Monetary Fund (IMF) and has been assigned a "default" credit rating, following the GRZ's failure to honor a Eurobond interest payment in October 2020 and subsequently suspending servicing of nearly all external debt (Fitch Ratings 2022, 2023). Fiscal consolidation measures are ongoing in Zambia and the country recently reached an agreement with the Official Creditor Committee (OCC) on restructuring US$6.3 billion in bilateral debt. Despite these developments, Zambia's fiscal position significantly undermines the GRZ's ability to take climate adaptation and resilience measures. For example, Kabisa, Chapoto, and Mulenga (2019) state that the annual budgetary allocation to the agriculture sector has steadily declined since 2017, mainly due to the high costs of servicing national debt. These costs were reported at about 34 percent of the national budget (prior to the suspension of debt servicing in 2020), which exceeded the combined budgetary allocations to agriculture, social protection, and health at the time. The agreed debt restructuring with the OCC may not free up much fiscal space for climate adaptation and resilience measures, as it includes a unique adjustment clause that will bring forward debt maturity dates and enable an increase in the interest rate of up to 4 percent from the negotiated 2.5 percent maximum if Zambia improves its debt-carrying capacity to "medium" (Fitch Ratings 2023). Climate change is likely to add fiscal pressure, including because it increases the likelihood of perennial drought (AfDB 2023).

3. ZAMBIA'S CLIMATE ADAPTATION AND RESILIENCE PLANNING AND PREPAREDNESS

The Government's climate change response

The current regulatory framework in the country is underpinned by a few key documents. Zambia launched its **National Policy on Climate Change (NPCC)** in 2017, which set out the governance framework for climate change and a number of overarching objectives (summarized in Annex A). The GRZ published a revised **Nationally Determined Contribution (NDC) in 2021** (updating its first NDC from 2016). The mitigation and adaptation programs elaborated in the NDC are integrated in the National Development Plan (NDP). As per the **Eighth National Development Plan (2022–2026)** (known as 8NDP), the GRZ plans to prioritize implementation of adaptation actions outlined in the NDCs. This includes several key programs: institutional framework strengthening; climate change mainstreaming; long-term adaptation planning; nature-based solutions; sustainable land, forest, and water management; sustainable agriculture; and climate-resilient infrastructure development. Legislation on climate change will be enacted to strengthen coordination and enhance coherence between adaptation and disaster risk reduction efforts, among other measures (8NDP 2022). Zambia has also developed a **Finance Strategy and Investment Plan for NDC**. Annex A provides details on the specific climate change-related programs in the NDC.

Zambia has not yet published a National Adaptation Plan (NAP), but the Ministry of Lands and Natural Resources initiated its development in March 2021, and is working toward finalizing the plan this year. Consistent with the objectives above, the ongoing **NAP development process (2021–2023)** focuses on:[13]

- **Improving institutional coordination and collaboration for adaptation planning in Zambia.** While the NPCC sets out national-level coordinating arrangements for climate change, gaps remain in terms of cross-sectoral linkages and processes related to national adaptation planning, as well as lack of clarity about how adaptation will be coordinated at subnational levels.

- **Establishing a system of integrating climate change adaptation in plans and budgets.** Currently, climate change adaptation is not mainstreamed into national and subnational development plans and budgeting in Zambia, in part due to the lack of guidelines and processes for this, especially at the subnational level.

13 As per the Global Water Partnership (GWP), which facilitates development of the NAP (GWP 2021).

- **Developing an overarching national plan that prioritizes medium-to-long-term, high-level adaptation actions for key economic sectors affected by climate change.** This would build on the National Adaptation Programme of Action (NAPA), which focused on short-term adaptation actions for immediate implementation.

- **Strengthening the capacity for implementing the NAP.** The GRZ has identified a need for support to carry out technical assessments, analysis, and project appraisals, including preparation of projects to access climate finance from international climate funders.

- **Developing a strategy for mobilizing financing for NAP implementation.** In this area, the 8NDP (2022) highlights the government's plans to promote engagement with the public and private sectors and other development and cooperating partners, as well as to use carbon markets, green bond issuance, and other innovative financial instruments.

The GRZ is putting in place measures to stimulate the climate finance market. At the end of 2022, the Ministry of Finance and National Planning announced that Zambia has put in place guidelines and listing rules for issuance of green bonds (Zambia, Ministry of Finance and National Planning 2022). The GRZ is also: developing a pipeline of potential developmental projects to be financed through green bonds; developing legislation to regulate the carbon market, including carbon trading; and more broadly working to improve the policy and regulatory environment and create market-based mechanisms to incentivize businesses (Chilufyua-Musonda and Mwamuliwa 2022; Reuters 2022). Annex B provides a short summary of Zambia's climate finance needs and landscape.

Climate adaptation preparedness in Zambia's agriculture sector

Zambia is actively engaged in climate change adaptation in the agriculture sector, recognizing the critical need to address the risks posed by changing climate patterns. Some of Zambia's adaptation measures include: promoting irrigation and efficient use of water resources; strengthening early warning systems and preparedness; and using GIS/remote sensing to map drought- and flood-prone areas (UNDP n.d.). GCA (2023) highlights that Zambia is a leading country in Africa in terms of crop area under conservation farming practices, but this is driven mostly by the large-scale commercial farming sector, and challenges hinder adoption of such techniques by smallholders, which is key for climate adaptation.

Under its CSA strategy framework, the GRZ is promoting the rollout of CSA practices to sustainably increase productivity, enhance resilience, and reduce or remove GHG emissions. In 2019, the GRZ, in collaboration with the World Bank Group, published a **Climate-Smart Agriculture Investment Plan** (CSAIP) aimed at informing the development of the National Agriculture Investment Plan (NAIP), the NDPs, and Zambia's NDC. The plan identifies the following CSA practices as most promising to achieve welfare and sectoral development goals: crop diversification into legumes, commercial horticulture, agroforestry, and strategies for reducing postharvest losses. It also includes recommendations for improving productivity, managing the pace of land use change to limit deforestation, and enhancing coordination and harmonization of policies across sectors, including livestock, forestry, water, and energy.

Zambia is developing a **Comprehensive Agriculture Transformation Support Programme (CATSP)** that will succeed its First NAIP (2014–2018). A draft version published in early 2023 recognizes climate change as a key constraint to agricultural development and identifies investment in CSA as a priority area, with focus on achieving synergies where possible between: (i) improvements in productivity and incomes; (ii) climate adaptation; and (iii) GHG emission reductions. That said, the precise measures set out in the draft document are more focused on mitigation than on adaptation (Zambia, Government of the Republic of Zambia 2023). Annex A provides details on climate-related initiatives and policy and strategy developments in Zambia's agriculture sector.

Climate adaptation preparedness in Zambia's energy sector

The GRZ recognizes the need to transform Zambia's energy sector, including diversification away from hydropower, to address climate change-related risks. It has outlined national priorities that emphasize the importance of expanding electricity generation and accessibility through both on- and off-grid renewable energy sources. Furthermore, Zambia's NDCs include specific actions aimed at transitioning from coal to biomass energy for industrial applications, promoting fuel switches as part of the mitigation strategy. Additionally, efforts to mitigate GHG emissions from energy use are closely aligned with the Sustainable Forest Management program, recognizing the significant contribution of biomass fuel usage and resulting land use changes to overall emissions.

Zambia's 8NDP (2022) aims to increase electricity generation capacity and promote alternative green and renewable energy sources, as well as scale up rural electrification. Additional investment in the sector will aim to increase electricity generation capacity to 4,457 MW by 2026, from 3,307.43 MW in 2021. The percent of renewable energy in the national installed electricity capacity, excluding large hydroelectricity generation, is projected to rise to 10 percent from 3 percent over the same period. This will in part be supported by 15 renewable energy off-grid projects that will be developed by 2026, in addition to the seven developed in 2021. The plan sets out reforms to enhance transmission and distribution of electricity in Zambia[14] through investments to upgrade electricity transmission infrastructure in an effort to reduce transmission losses and promote trade in electricity.

To support these efforts, the GRZ recently published a **Renewable Energy Strategy and Action Plan** (2022), among other policies and legal, regulatory, and institutional frameworks (outlined in the Action Plan). The GRZ aims to achieve 51 percent rural electricity access by 2030, which would help reduce deforestation. The plan also points to a recent analysis, which indicates that the least-cost option for reaching universal modern energy access for over 48 percent of the population by 2030 is through mini-grid or standalone systems based on solar photovoltaic (PV). The report highlights opportunities for growth in small hydropower,[15] alongside the potential and limitations for solar, wind, biomass, and geothermal energy. By 2030, Zambia aims to add about 2,015 MW of grid-connected renewable energy capacity, of which 68.6 percent would come from hydro, 24.8 percent solar, 6.5 percent wind, and 0.1 percent geothermal energy. In addition, it targets connecting 19.1 percent of the population by 2030 to mini-grids (predominantly solar PV mini-grids but also some small, hydro-based mini-grids) and 31.6 percent of the population to solar home systems. The plan includes targets for biofuels, biogas, and sustainable charcoal production and consumption. The GRZ has set a 2024–2030 window for implementation of the proposed initiatives (Zambia, Government of the Republic of Zambia 2022b).

Challenges to country preparedness

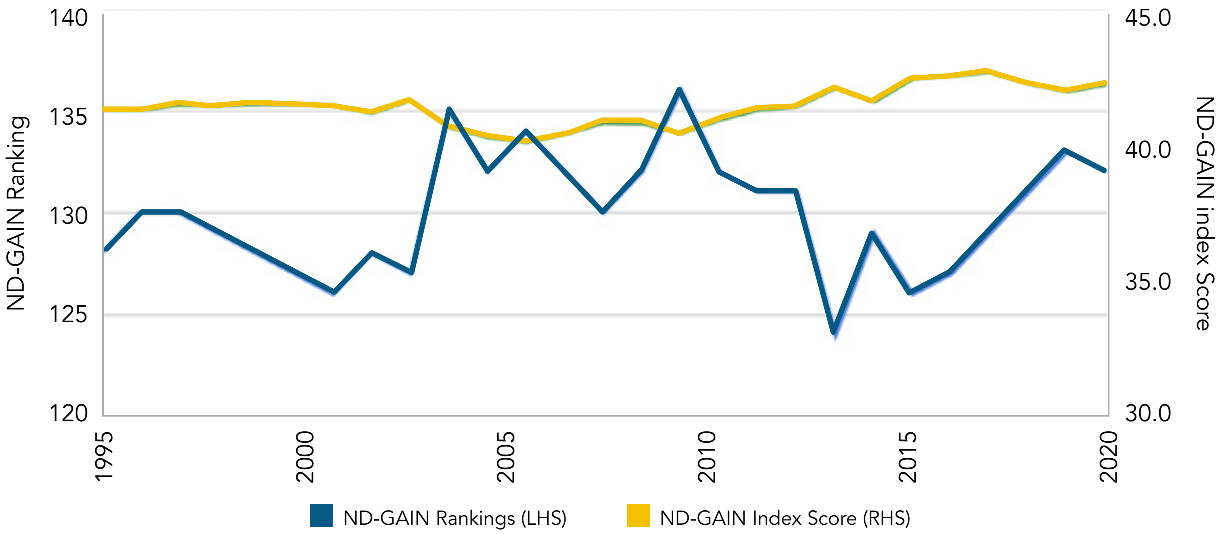
Overall, Zambia's resilience to climate change has improved since 2005, but some key vulnerabilities remain a challenge. Zambia ranks 132 out of 185 on the Notre Dame Global Adaptation Initiative (ND-GAIN) Index, as of 2021. In terms of key vulnerabilities, the index highlights: (i) projected change of cereal yields; (ii) agriculture capacity; and (iii) level of social readiness[16] (on which Zambia ranked

14 Some key projects to be implemented include the Zambia-Tanzania-Kenya (ZTK) and Zimbabwe-Zambia-Botswana-Namibia (ZIZABONA) interconnectors. The interconnector between Zambia and the DRC will be concluded by 2026.

15 Currently the total installed capacity of small hydro is about 40 MW, with about 20 MW under construction. However, the report estimates Zambia's small hydro potential at 1,106.95 MW.

16 The index defines social readiness as "Social conditions that help society to make efficient and equitable use of investment and yield more benefit from the investment." Indicators include: social inequality, information communication technology infrastructure, education, and innovation. Zambia scores particularly low on "education" and "innovation."

Figure 8: Zambia's ND-Gain Index, 1995–2021



Source: Notre Dame Global Adaptation Initiative (ND-GAIN) Index (GAIN 2021).

Note: Chen et al. (2015) provide details on the methodology for calculating the ND-GAIN Index, including how it reflects a country's readiness and vulnerability assessments.

second lowest of all assessed countries, just ahead of Zimbabwe). That said, Zambia's ranking is overall relatively better than a number of other countries, including Malawi (161), Mozambique (154), and Kenya (150), and has improved over the past decade (Figure 8).

The 8NDP outlines the following key constraints in relation to effective management of climate change-related risks: (i) **low levels of technical and technological capacities**; (ii) **funding limitations** for implementation of more ambitious climate change actions, including access to low-cost financing; (iii) **low integration of climate change in key sectors at national and subnational level**; and (iv) **insufficient hydrometeorological infrastructure and climate information services**, as well as early warning systems. More structurally, it highlights that **inadequate infrastructure** in economic sectors such as transport, energy, agriculture, and information and communication technologies constrain diversification and industrialization (which is necessary for climate-resilient development).

A study by Grobusch (2022) on enhancing flood resilience in Lusaka (noted above as important from both a social and an economic perspective) finds that the Lusaka City Council identifies climate resilience and adaptation as a priority—and has developed relevant plans and policies—but implementation is a key challenge, mainly because of financing constraints. The study reports that the council is able to implement only about 60–65 percent of relevant plans due to lack of capacity, and highlights the need for an appropriate financing mechanism for flood resilience.

The Finance Strategy and Investment Plan for NDC further highlights as key barriers: limited communication and access to information (such as data on NDC financing by the private sector, data on effectiveness of the use of climate finance, awareness of green investment opportunities); human and institutional capacities to access NDC finance; political, legal and institutional barriers (including coordination challenges); and slow uptake from the private sector.

The cross-sectoral impact of climate change, alongside the political environment and the extent of impact on key economic sectors, can exacerbate **governance and coordination challenges**. A study by Pardoe et al. (2020) of the political environment in Zambia identifies the challenges in establishing an institutional set-up for climate change; these have resulted in significant restructuring and changes at ministerial level to the responsibilities, ownership, and governance approach to the national response to climate change. Relatedly, FANRPAN (2017) notes the importance of ensuring that sector-specific policies, strategies, and plans regarding climate change risks are well coordinated and appropriately integrated into NDPs.

Challenges to effective climate change risk management exist at the sectoral level, too:

- In the energy sector, the Renewable Energy Strategy and Access Plan (2022) lists key constraints to renewable energy development as high investment requirements and high costs of capital, coupled with electricity tariffs that are not cost-reflective, and limited availability of financial instruments. These challenges are exacerbated by broader macroeconomic, institutional, and technical capacity constraints, as well as rural market and awareness barriers (Zambia, Government of the Republic of Zambia 2022b).

- In the agriculture sector, effective adoption of CSA practices, in particular among smallholder farmers, is a significant challenge. For example, Arslan et al. (2014) report that despite extensive efforts to promote such practices, as much as 95 percent of farmers have adopted and then abandoned one or more CSA practices in some locations. Zambia's CSAIP (2022) identifies as key obstacles to effective implementation and retention: (i) poor access to critical labor-saving equipment for smallholder farmers; (ii) limited knowledge and capacity; and (iii) high upfront and production costs (while there is usually a time lag for the benefits). More broadly, the CSAIP highlights that efforts on agricultural extension provision follow a project-based rather than a programmatic approach, which leads to fragmented and uncoordinated results.

- For the road and transport sector, Zambia's Road Development Agency (RDA 2017) outlines as key issues: (i) lack of adequate funds; (ii) road maintenance not seen as a priority by various stakeholders; and (iii) premature failures due to lack of consideration of climate change in the design of roads. That said, the 8NDP identified road maintenance as a strategic priority.

4. ADAPTATION STRATEGIES AND RECOMMENDATIONS

This report aims to support and inform the approach and design of Adaptation and Resilience Investment Platforms (ARIPs) that help mobilize funding for adaptation at scale. For Zambia, investment in climate adaptation and resilience would be particularly important with respect to agriculture, hydropower, and transport (road infrastructure), given their roles in the economy and with respect to household livelihoods, the interlinkages between these sectors, and the knock-on implications that they can have for the rest of the economy, food security, and various development goals. Overall, this report underscores the importance of a broad approach to climate adaptation that also helps achieve industrial diversification and structurally reduces Zambia's exposure to climate-sensitive sectors. The analysis also helps identify opportunities for growth and supports a climate adaptation approach that goes beyond disaster risk management and adaptation of current practices. An ARIP could support the GRZ in expanding its climate adaptation response by:

Mobilizing funding for adaptation at scale, from a program rather than a project perspective: Funding is a main constraint to climate adaptation and resilience across all these sectors. The GRZ has put effort into ensuring sectoral policies are consistent with overarching national development goals and that the latter include references to (sector-level) climate adaptation and resilience measures. However, funding is often accessed and disbursed on a project-by-project basis and does not achieve the necessary scale, creating issues for implementation, as discussed above. Thus, considering financing of climate adaptation and resilience measures as part of the strategy development and from a program perspective could help address the existing funding gap. Grobusch (2022) observes that the promise of additional funds, such as through mechanisms like the Green Climate Fund, provides a powerful incentive for ongoing interest in the climate change agenda. Thus, an ARIP in Zambia should aim to consider mobilization of funding for the national-level adaptation strategy (prioritizing key sectors), and secure upfront funding pledges that create an enabling environment for further strategy development and implementation.

Ensuring climate adaptation and resilience funding is structured in a manner that supports Zambia's long-term development goals. While Vision 2030 expresses a desire for the country to be free from donor dependence, Zambia's debt crisis is a significant constraint to its ability to mobilize funding. Therefore, a funding strategy for adaptation and resilience could explore in more detail appropriate mechanisms for mobilizing and disbursing funding from various sources, including considering the interplay between Zambia's ability to service debt and its ability to take key climate adaptation measures to avoid further climate change-related deterioration of its fiscal position and debt-servicing capacity, as well as of economic and social development. Such work could also explore opportunities for private sector investment in adaptation measures. Overall, the proposed work would support the 8NDP's objective on resource mobilization and would advance the NAP development process's intention of creating a strategy for mobilizing financing for NAP implementation. An investment portfolio view of Zambia's planned adaptation and resilience measures could help advance these strategic funding considerations.

Facilitating further development and implementation of Zambia's adaptation and resilience strategy. Several sources, including the NAP development process, highlight the technical capacity limitations for ensuring an effective response to climate change-related risks in the country (GWP 2021; Zambia, Ministry of National Development Planning 2016). Therefore, an ARIP should prioritize enabling access to relevant data and expertise, including to support the implementation and future reviews of Zambia's upcoming NAP. Such efforts could: (i) facilitate a holistic approach to the adaptation and resilience strategy to ensure coherence between proposed measures across different sectors, as well as their interaction with the broader industrial strategy (specific examples below); and (ii) showcase the investment opportunities in climate adaptation in Zambia, such as by helping link the strategy to a pipeline of projects and providing robust cost-benefit analysis to effectively prioritize various potential adaptation and resilience measures. This would require a regional approach to climate adaptation strategy development, given the heterogeneous impact of climate change on different parts of Zambia (as described below). This in turn would facilitate integration of climate change adaptation plans and budgets at subnational level. Importantly, this should build on, rather than duplicate, existing efforts, such as the various policies and studies explored in this report.

Promoting effective engagement and coordination in government ministries on climate change. Grobusch (2022) warns that in Zambia, institutional complexity, overlapping processes, and lack of clarity regarding the mandate for climate change result in a low implementation rate.[17] Greater cross-ministerial engagement on climate change could help deliver the recommendations in this report and ensure effective implementation of the national adaptation and resilience strategy. Therefore, an ARIP could aim to further facilitate the objective of the NAP development process of improving institutional coordination and collaboration on adaptation planning. Enabling engagement with local government could help support a locally led implementation approach.

An ARIP in Zambia could facilitate the following sector-specific actions:

Reviewing the national-level crop mix. Further analysis could help identify what crops the adaptation measures should prioritize in order to: (i) limit the adverse economic and social impacts of climate change; and (ii) leverage new opportunities that climate change may present. On the former, Verhage et al. (2018) undertake a prioritization process[18] that indicates Zambia should prioritize agricultural development interventions for maize, pulses (beans, cowpeas, etc.), and sorghum.[19] Given the role of maize in Zambia's economy and national diet, it is important to implement adaptation measures that support its cultivation under future climatic conditions. For example, improved germplasm could help adapt maize production to become more tolerant to drought and heat stress, and even lead to co-benefits for reduced deforestation (Cairns et al. 2013; Pelletier et al. 2020). This in turn may require consideration of how to accelerate varietal turnover and how to include improved germplasm in subsidy programs. That said, this should be alongside efforts to diversify the sector away from maize at national scale, particularly in regions that will become least suitable (Ngoma et al. 2021b), as already recognized by the GRZ. Alfani et al. (2019) recommend prioritizing livestock sector development, agroforestry adoption, and off-farm diversification to improve Zambia's drought resilience. In terms of opportunities, the findings of CIAT and World Bank (2017) on the potential for exports of cotton and groundnut, as well as productivity gains for rice, could be revisited and expanded, with focus on the geospatial impact of climate change and regional dynamics. ARIPs, particularly if established

17 Over 35 percent of survey respondents in Zambia shared that policy is rarely implemented. The study interviewed officials in ministries and government bodies, government staff in implementing ministries, multilateral and bilateral donors, civil society, private sector, and academics.

18 Based on: (i) the importance of the commodity to the economy of the country; (ii) the national yield gap compared with the regional average; (iii) the importance of the commodity in people's diet; and (iv) the projected impact of climate change on yield.

19 Sorghum could offer a potential for value chain development by involving small-scale farmers in contract farming arrangements with processors, such as feed manufacturers or breweries (Verhage et al. 2018). And as shown above, it is projected to be relatively less affected by climate change than other crops.

in various countries across Africa, could facilitate considerations of how to strategically improve coordination on ensuring food security during climate shocks, as well as trade integration and risk management strategies more broadly. This could help to: prevent the adverse consequences from policy responses like export restrictions, as highlighted above; improve regional economic resilience; and leverage new opportunities that changing climatic conditions may present.[20]

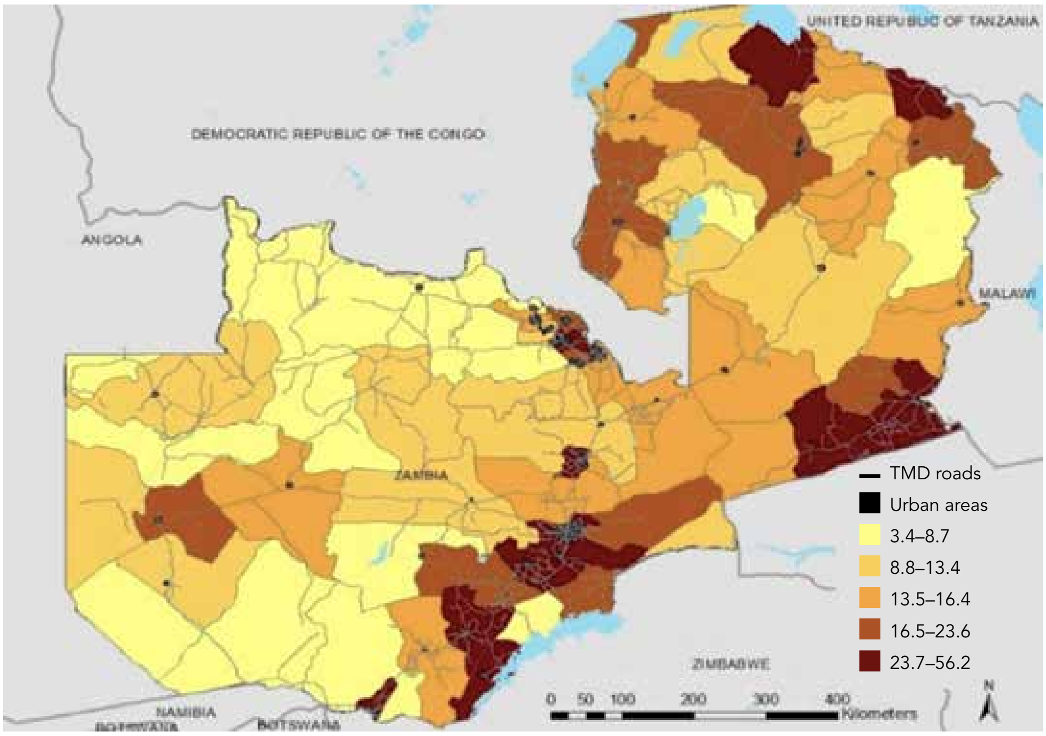
Making adaptation measures in agriculture region-specific. The impacts of climate change on agriculture are projected to vary by region. For example, several studies show that agricultural productivity may be relatively less affected in the north and east regions of Zambia, and gains may even arise for some crops, as noted earlier. Zambia's adaptation strategy could therefore be developed on an agroecological region-specific basis (Mulungu et al. 2021). This can include scaling up adoption of region-specific drought- and heat-tolerant crop varieties, use of alternative crops suitable for specific regions, and support to small-scale farmers through investment in efficient and cost-effective small-scale irrigation (Ngoma et al. 2021b). Robust cost-benefit analysis should underpin the prioritization of such measures for different areas and subsectors. Regional considerations should be more explicitly reflected in the development of investment plans for the agriculture sector to facilitate mapping to project pipelines.

Exploring cross-sectoral adaptation strategy integration. The analysis in this report suggests that further development of the agriculture sector in the north and east of Zambia could help reduce the negative impact of climate change on crop yields at national scale. However, such a shift will need to be accompanied by investment in appropriate transport infrastructure. Rural accessibility is significantly lower in northern Zambia, while a significant relationship exists between rural accessibility and agricultural productivity because farmers and agribusinesses need good access to markets (World Bank 2017) (Figure 9). Therefore, the climate adaptation and resilience strategy for Zambia's transport infrastructure could take into account the needs of the agriculture sector. Similarly, use of irrigation has been proposed as an adaptation measure to manage precipitation variability in Zambia, as it can reduce rainfall dependence in agriculture. Consideration of different irrigation systems could explore, among other factors, how water for irrigation would be sourced and any circumstances under which this may need to be balanced against the water resource needs of other sectors (for example, if development and adaptation measures in different sectors give rise to competition for the same water resources). The next section describes how an ARIP could facilitate effective water management.

Prioritizing the mobilization of funding for improvements to road infrastructure, particularly in areas prone to flooding and along international trade corridors. For example, Chinowsky et al. (2015) find that adaptation measures, such as changing dirt roads to gravel surfaces or increasing the base depth of gravel roads, can help reduce the impact of climate change on the economy. While this would require a significant upfront investment, the study finds that Zambia would experience a significant reduction in maintenance costs, with the positive impact increasing over time and becoming particularly apparent by 2050, when the adverse impact of climate change on Zambia's climate profile is projected to accelerate. The GRZ has already identified improving and maintaining the road infrastructure as a priority (8NDP 2022). Future efforts could focus on exploring innovative mechanisms for funding such measures, in light of limited resources and the benefits that such projects would have for various sectors.

20 For example, Mamun et al. (2018) recommend improving resilience to food security risks by considering options for strengthening grain market information systems, improving climate risk mitigation at the farm level, and designing innovative risk-financing strategies and adaptive social protection to protect the most vulnerable from severe climate shocks.

Figure 9: Rural Access Index for Zambia



Source: World Bank (2016).

Facilitating effective water resource management. Given the projections of lower rainfall, particularly in the south and west, as well as the expected decrease in water availability (Hamududu and Ngoma 2019; Ngoma et al. 2021b), it will be important to consider holistically the feasibility of economic activities and adaptation measures that require water. In the agriculture sector, reduced water availability could adversely affect the use of irrigation systems as adaptation measures. Cost-benefit analysis could help inform where such measures should be used,[21] where the costs of more water-efficient technologies and/or improvements to water harvesting and storage could be justified, and under what circumstances to explore options for bulky water transfer from low-demand, high-water areas in the north to high-demand, low-water areas in the south (Hamududu and Ngoma 2019). Such analysis should take into account the water demands of existing and planned large hydropower plants, as well as be co-developed alongside other considerations for expansion of small hydropower (particularly as the Renewable Energy Strategy and Action Plan (2022) envisages growth in both areas to meet national electricity access targets). Additional measures could include support for smallholder farmers[22] where adaptation costs are likely to increase due to water availability constraints, strengthened water resource management and regulation, and measures to ensure equitable access to water resources (Hamududu and Ngoma 2019). Given the projected adverse impact of climate change on the Zambezi River Basin, an ARIP should aim to facilitate effective regional cooperation, as well as consider the combined effect on water availability from the adaptation strategies of neighboring countries.

21 Such as overhead irrigation systems (for example, center pivots and drip irrigation) as opposed to the prevalent surface irrigation methods (Hamududu and Ngoma 2019).

22 Verhage et al. (2018) recommend improving climate and agricultural advisory services, agricultural risk insurance, and better access to credit to support farmers.

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ANNEX A:
CLIMATE CHANGE REGULATORY AND GOVERNANCE FRAMEWORK

Climate change policy response development

The GRZ has identified climate change as a key risk to Zambia's economic and social development since the mid-2000s. It published a National Adaptation Programme of Action (NAPA) in 2007 that focused on assessing climate vulnerabilities for agriculture and food security, energy and water, human health, and natural resources and wildlife, and proposed priority adaptation measures. Governance structures have undergone various restructurings since 2009 to reflect the need for policy action on climate change (Pardoe et al. 2020). The GRZ's initial response to these needs was set out in the National Climate Change Response Strategy (2010).

The GRZ has demonstrated increased commitment to addressing climate change concerns through its policies and strategies. Zambia has developed various climate change-focused policies, strategies, and projects, including: the NAPA (Zambia, Ministry of Tourism, Environment and Natural Resources 2007);

Table 3: Mainstreaming of climate change and CSA considerations within GRZ policies

Vision 2023 (2006)	Climate change	Adaptation	Mitigation	CSA
National Policy on Environment (2007)	✓			
National Adaptation Programme of Action on Climate Change (2007)	✓	✓		
National Climate Change Response Strategy (2010)	✓	✓	✓	
National Agriculture investment Plan (2013)	✓	✓	✓	✓
National Determined Constitutions on Climate Change (2015)	✓	✓	✓	✓
National Disaster Management policy (2015)	✓	✓		
Reduced Emissions from Deforestation and Forest Degradation (REDD+) (2015)	✓	✓	✓	✓
National Policy on Climate Change (2015)	✓	✓	✓	✓
Second National Agriculture Policy (2016)	✓	✓	✓	✓
Seventh National Development Plan (2017)	✓	✓	✓	✓
Climate-Smart Agriculture Strategy Framework (forthcoming)	✓	✓	✓	✓

Source: World Bank Group and Zambia, Ministry of Green Economy and Environment (2019).

the National Policy on Environment[23] (Zambia, Ministry of Tourism, Environment and Natural Resources 2009); the National Climate Change Response Strategy (Zambia, Ministry of Tourism, Environment and Natural Resources 2010); the National Strategy for Reducing Emissions from Deforestation and Forest Degradation (REDD+) (Matakala, Kokwe, and Statz 2015); and the National Policy on Climate Change (Zambia, Ministry of National Development Planning 2016). The GRZ has also taken actions to incorporate climate change adaptation and mitigation considerations into Zambia's major planning documents (Table 3).

The **2016 NPCC** includes nine overarching target climate change-related areas to promote/strengthen:

1. Implementation of adaptation and disaster risk reduction measures
2. Implementation of sustainable land use management practices
3. Mainstreaming of climate change into policies, plans, and strategies
4. Institutional and human resource (HR) capacity
5. Communication and dissemination of climate change information
6. Investments in climate-resilient and low-carbon development pathways
7. Research and development
8. Inclusion of gender equality and equity in the implementation of climate change programs
9. Appropriate technologies to build national capacity to benefit from climate change technological transfer.

23 The policy was revised from a previous version published in 2007.

Table 4: Climate change adaptation program descriptions, from Zambia's revised NDC (2021)

Program 1: Adaptation of strategic productive systems (agriculture, wildlife, water)
• Guarantee food security through diversification and promotion of Climate-Smart Agriculture (CSA) practices for crop, livestock, and fisheries production including conservation of germplasm for land races and their wild relatives. • Develop a National Wildlife Adaptation Strategy and ensure its implementation through supportive policies, local community, civil society, and private sector participation. • Protect and conserve water catchment areas and enhance investment in water capture, storage, and transfer (linked to agriculture, energy, ecological, industrial, and domestic use purposes) in selected watersheds.
Program 2: Adaptation of strategic infrastructure and health systems
• Institutionalize integrated land use planning compatible with sustainable management of natural resources and infrastructure development. • Mainstream climate change in the National Health Policy, Environmental Health (EH) Policy, and Water and Sanitation Policy. • Enhance decentralized climate information services for early warning and long-term projections on the effects of climate change to support sustainable management of the production systems, infrastructure development, and public health.
Program 3: Enhanced capacity building, research, technology transfer, and finance for adaptation
• Build capacity in Climate-Smart Agriculture (CSA), Sustainable Forest Management (SFM), Sustainable Fisheries and Aquaculture (SFA), Renewable Energy Technologies (RET), Early Warning Systems (EWS), and Change Management and Climate Change Planning. • Focus on water technologies for savings, recycling, irrigation, and sustainable management for household, agricultural, and industrial purposes. • Develop an insurance market against climate change-induced risks.

Source: Zambia, Government of the Republic of Zambia (2022a)

Notably, the objectives on "Investments in climate-resilient and low-carbon development pathways" prioritize climate mitigation rather than adaptation measures.

Under **Zambia's revised NDC (2021)**, adaptation measures comprise three goals/programs and 13 priority actions (which are also expected to result in mitigation co-benefits), as detailed in Table 4.

On adaptation, Zambia's NDC states that an in-depth countrywide Vulnerability Assessment was conducted in 2020 to provide an assessment and analysis of the effect of dry spells, floods, and pest infestation on different sectors. The report outlines recommendations for the following sectors: Agriculture and Food Security; Health; Nutrition; Water, Sanitation, and Hygiene; Education; and Development Project and Safety Net Programs being implemented in communities.

The **Eighth National Development Plan (8NDP) (2022–2026)** includes the following strategic priorities with regard to management of climate change-related risks (Table 5):

The GRZ plans to scale up engagement with communities to enhance climate change adaptation, particularly water harvesting, integrated water resources management including scaled-up irrigation development, and CSA.

The GRZ's **Comprehensive Agriculture Transformation Support Programme (CATSP)** is still under development. The draft version sets out five key sources of GHG emissions associated with crop production that will be targeted: (i) inefficient on-farm machinery and equipment; (ii) rice cultivation; (iii) overapplication of nitrogen; (iv) low use of low- and no-tillage practices; and (v) low application of organic fertilizers/manure. In the livestock and fisheries subsectors, targeted areas will be: (i) more efficient practices for production and processing of livestock feed; (ii) improved grassland management; and (iii) management of outputs of GHG emissions during digestion by cows and manure handling. The draft further details that the government's expenditures in this area would cover practices meeting the following criteria: (i) sustainable soil and land management practices; (ii) maintaining biodiversity in agriculture and environment practices; (iii) practices that preserve and enhance ecosystem services; (iv) practices to reduce pollution of land, water, and air; and (v) practices

Table 5: Climate change-related strategies and programs in Zambia's 8NDP

1. Strength climate change	a) Institutional framework strengthening b) Climate chance mainstreaming c) Long-term adaptation planning d) Nature-based solutions e) Sustainable land, forest and water management f) Sustainable agriculture g) Climate resilient infrastructure development
2. Strength climate change mitigation	a) Sustainable consumption and production b) Sustainable land management c) Pollution prevent control d) Greenhouse gas transparency framework e) Sustainable agriculture promotion f) Sustainable forest management g) Technology development and transfer h) Green and renewable energy
3. Enhance disaster risk reduction and response	a) Climate information service b) Early warning system c) Disaster preparedness and mitigation d) Disaster response and recovery

Zambia, Government of the Republic of Zambia (2022a) and technologies for efficient use of water. The program will include measures driven or funded by the GRZ to support the adaptation, development, and dissemination of CSA practices.

A number of initiatives also aim to promote adoption of CSA:

- Zambia was one of three initial pilot countries for the Africa Climate-Smart Agriculture Alliance (ACSAA), a platform that fosters collaboration between government, research, and international organizations and focuses on development of national CSA scaling-up plans (FANRPAN 2017).

- Vuna is a regional program focused on identifying and scaling up new and existing CSA technologies in the country through research on drought-tolerant crops, training of agricultural extension agents on locally appropriate CSA practices, and identification and development of financial services for smallholder investment in CSA (FANRPAN 2017). In Zambia, it included a program for integrating CSA into e-voucher farmer input subsidy (Genesis Analytics 2018).

- The Food and Agriculture Organization's project "Climate Smart Agriculture: Capturing the synergies among mitigation, adaptation and food security" aims to strengthen the technical, policy, and investment capacities of its three partner countries, including Zambia, at a national level (FANRPAN 2017).

Climate change governance framework

The National Policy on Climate Change (Zambia, Ministry of National Development Planning 2016) sets out the governance framework for climate change in Zambia, which is through an interministerial coordination structure.

The Council of Ministers is the supreme decision-making body in overseeing climate change interventions in the country and in providing policy guidance on climate change programming, mainstreaming, resource mobilization, monitoring, and evaluation. The Steering Committee of Permanent Secretaries is the advisory body to the Council of Ministers on policy and program coordination and implementation.

The Technical Committee on Climate Change provides technical advisory services to the Steering Committee of Permanent Secretaries. It comprises representatives from relevant ministries and a broad range of other stakeholders, including the private sector, civil society, and financial institutions, among others.

The Ministry of Green Economy and Environment is currently the National Designated Authority (NDA) for the Green Climate Fund (albeit this has changed a few times). The Development Bank of Zambia and Zambia National Commercial Bank PLC are both accredited as National Implementing Entities (NIEs) for Direct Access under the Green Climate Fund.[24]

Zambia is in the process of establishing a National Climate Change Fund (NCCF), according to its NDC (2021).

The Ministry of Green Economy and Environment recently launched Zambia's NDC Implementation Framework (NDC Partnership 2023).

24 GCF: https://www.greenclimate.fund/countries/zambia. Accessed on 26 July 2023.

ANNEX B:
ZAMBIA'S CLIMATE FINANCE NEEDS AND LANDSCAPE

Zambia has significant climate change adaptation funding needs. Zambia's overall need for climate finance is an estimated US$50 billion through 2030 (AfDB 2023). According to Zambia's Finance Strategy and Investment Plan for NDC, adaptation needs comprise USD 14.9 billion for 2023–2030. A study of the climate finance landscape in Zambia finds that GRZ significantly increased its national budget allocations for climate change-related activities from ZMW 133 million in 2016 to ZMW 931 million in 2018. However, the country is heavily dependent on donor funding: 95 percent of the climate-related development expenditure in 2016–2018 was funding from international partners channeled into the national budget and 5 percent was from domestic public resources. The report also highlights that 87 percent of funds from the private sector were dedicated to mitigation, as the business case for investment in adaptation is not well understood (Commonwealth Secretariat 2021).

Closing Zambia's climate finance gap will require mobilization of funding from various resources. AfDB expects Zambia to mobilize funding for climate change-related measures through a combination of sources, such as the Global Climate Fund, and other climate-related bilateral, multilateral, and domestic financing, including the private sector. Examples of the latter include the US$53 million Green Outcomes Fund (recently established by Zambia National Commercial Bank, Kukula Capital, and the World Wide Fund for Nature–Zambia). Carbon-market financing mechanisms remain underexploited but could be explored in the future. Weather-indexed insurance instruments are already being used, as well as infant-stage green bond initiatives (AfDB 2023).

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