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

November 2023

THE AFRICAN CLIMATE FOUNDATION

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

CGIAR
INITIATIVE ON Foresight

This country report is a joint publication of the African Climate Foundation (ACF) and the International Food Policy Research Institute (IFPRI), with support from the CGIAR Research Initiative on Foresight. It was prepared under the overall guidance of Iva Detelinova (Senior Advisor - Climate Adaptation and Resilience, ACF) and a team consisting of Timothy S. Thomas (Senior Research Fellow in IFPRI's Foresight and Policy Modeling Unit), Junyan Tian (Research Analyst in IFPRI's Foresight and Policy Modeling), and Wole Hammond (Research Assistant - Climate Adaptation and Resilience, ACF), with oversight from Channing Arndt (Senior Director for Transformation Strategies, IFPRI).

The team would like to express its appreciation for the provided insightful comments and support to Sam Jones (Research Fellow, UNU-WIDER, Mozambique), Laurence Harris (Professor of Economics at School of Finance and Management, SOAS, University of London), Adam Kennedy (Programme Head of IFPRI's Development Strategies and Governance Unit), and Alan Wallis (Strategic Advisor, ACF).



**Image credits**

Cover: AdobeStock; pvi: Thiébaud Faix/Unsplash; p7: Zeke Tucker/Unsplash; p23: Benjamin DeYoung/Unsplash; p33: Edvin Johansson/Unsplash; p35: Przemyslaw Stroinski/Unsplash

Designed and typeset by COMPRESS.dsl | 800834 | www.compressdsl.com

# TABLE OF CONTENTS

# PREFACE

**This report, focused on Mozambique, 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 modelling. 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 the ACF 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

**Mozambique is already vulnerable to extreme weather events and climate change is projected to exacerbate their frequency and intensity**. The occurrence of cyclones and flooding has increased in recent years and the trend is expected to continue. The country's coast—where 60 percent of the population, the three biggest cities, and critical infrastructure are situated—is most exposed to climate change-related risks, including damage from cyclones and projected sea level rise. Densely populated and low-lying regions, such as Zambezia, Nampula, Sofala, and Maputo Provinces, are particularly exposed to risks from flooding. More broadly, climate change is projected to increase average temperatures across the country and to result in higher variability in precipitation, especially in the south.

**The most critical economic sectors vulnerable to climate change in Mozambique are agriculture, transport, and potentially energy.** In agriculture, maize is likely to be the most affected key crop. This can pose risks to food security (alongside expected higher food inflation because of climate change), given maize's widespread cultivation and role in nutrition. The impact on other crops is likely to be more limited, and to a large extent driven by damages from increased frequency of extreme weather events. This could exacerbate challenges in the sector, which is already constrained by low productivity and limited arable areas. That said, climate change could create some opportunities; for example, rice yields are projected to improve. Most studies project agricultural production in the central region to be most adversely affected by climate change, albeit the impact varies by crop and within regions. Mozambique's transport infrastructure is highly vulnerable to climate change due to the projected increase in flooding, the low proportion of paved roads, their limited interconnectivity, and the vulnerability of ports to cyclones and storm surges. Damages to Mozambique's transport sector are likely to have knock-on effects to other sectors and can have significant regional implications, as the country serves as a conduit for landlocked neighboring countries. Infrastructure damages, alongside the projected coastal erosion, may severely affect the tourism sector. Furthermore, Mozambique's high dependence on hydropower exposes it to losses from rainfall variability, which is expected to increase. The country's largest hydropower plant is located downstream on the Zambezi River, which various studies project to dry up due to climate change. Increased water use in upstream countries (such as because of greater irrigation needs and in response to growing populations) could also pose risks to Mozambique's hydropower sector.

**Mozambique needs to manage risks to its economy because of global mitigation efforts.** This is because its main exports (aluminium, coal, and petroleum) are highly carbon-intensive. This poses risks to its trade balance and economic growth, given its already very limited fiscal space. While global mitigation efforts would be positive for the country because they would help limit the impact of the physical risks from climate change, the implications of a global transition to a low-carbon economy may pose more immediate risks.

**The Government of Mozambique (GoM) is taking steps to respond to climate change-related risks.** Various national-level climate change policies and the integration of climate resilience considerations in sectoral policies (such as agriculture) include the National Climate Change Adaptation and

Mitigation Strategy (2013–2025) and updated Nationally Determined Contributions (NDCs). The GoM has limited deforestation, which has adaptation and mitigation co-benefits. Notably, Mozambique is following a decentralized approach to climate adaptation, prioritizing the development of Local Adaptation Plans (such plans have been developed for 132 out of 154 districts as of 2021). These will inform the GoM's national-level climate adaptation and resilience strategy, including the ongoing development of its National Adaptation Plan (NAP). The key constraints to the country's climate change preparedness include limited technical capacity for policy formulation and implementation, difficulties in government coordination, as well as challenges in mobilizing funding for adaptation at the necessary scale (and mobilizing funding from the private sector in particular).

**This report proposes that climate adaptation and resilience efforts in Mozambique focus on ensuring the country can adopt a strategic, transformative, and coordinated approach at national and regional level.** More precisely, efforts include to: (i) strategically help the agriculture sector adapt to projected climatic changes to reduce food inflation and food security risks, including diversifying away from maize; (ii) prioritize improving the climate resilience of critical infrastructure, including improving road quality and use of ecosystem-based solutions along the coast; (iii) consider how to ensure that climate and economic resilience considerations are reflected in the national industrial strategy, including with respect to energy sector development; (iv) develop technical capacity and modes for accessing updated climate change-related data and modelling from global sources; and (v) facilitate policy coordination and effective strategy implementation of climate adaptation measures by developing a climate Adaptation and Resilience Investment Platform (ARIP) at national level so that mobilization of funding at scale can occur.

# LIST OF ACRONYMS

| | |
|---|---|
| ARIP | Adaptation and Resilience Investment Platform |
| CBAM | Carbon Border Adjustment Mechanism |
| CSA | Climate-smart agriculture |
| GoM | Government of Mozambique |
| GDP | Gross domestic product |
| GHG | Greenhouse gas |
| LAP | Local Adaptation Plan |
| NAP | National Adaptation Plan |
| NCCAMS | National Climate Change Adaptation and Mitigation Strategy |
| NDC | Nationally Determined Contribution |

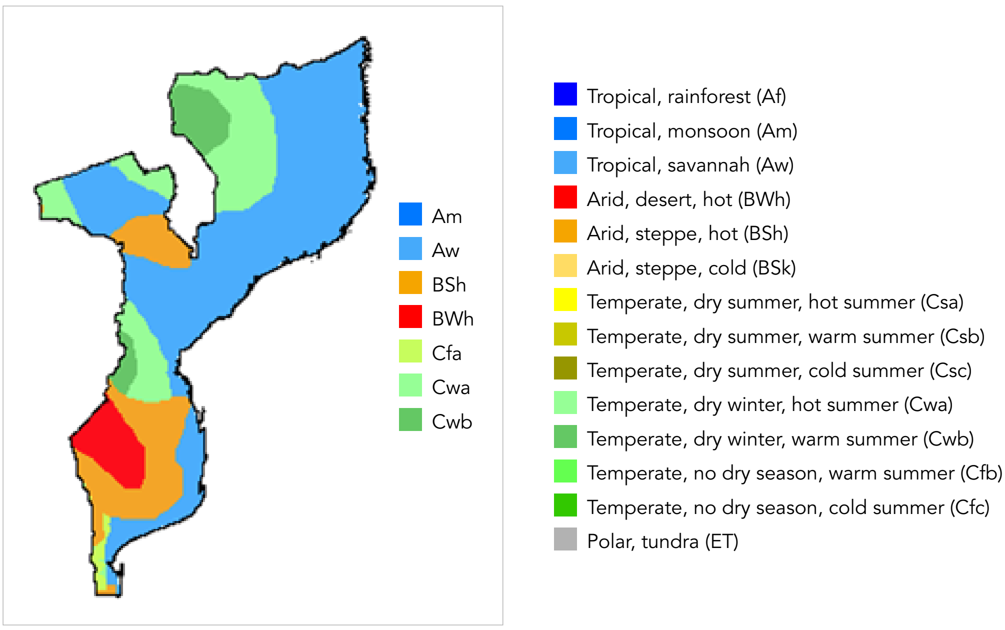
# 1. OVERVIEW OF CLIMATE CHANGE IMPACT ON MOZAMBIQUE

## Climate profile

Mozambique is located in southeastern Africa along the Indian Ocean, with a long coastline stretching over 2,500 kilometers (km) (World Bank 2023b). It shares borders with Tanzania, Malawi, Zambia, Zimbabwe, Eswatini, and South Africa. It is highly vulnerable to climate change, ranking 154 out of 185 on the 2021 Notre Dame Global Adaptation Initiative (ND-GAIN) index (ND-GAIN 2021).

**Mozambique has a tropical to subtropical climate across most of its geography.** The country features a vast expanse of low-lying grassland plateau that spans nearly one-half of the country's land area, starting from the coastal areas and gradually ascending toward the mountainous regions in the north and west. The plateau has a tropical savannah climate (Figure 1) and provides important habitat for wildlife and agricultural activities (World Bank n.d.-a). The country's abundant forests occupy 43 percent of its territory (World Bank 2018a). The north and central inland areas have relatively higher elevations where the climate is largely temperate, with a dry winter and a hot summer. These areas receive about 1,000 millimeters (mm) of average rainfall per year. Along the coast, the country receives relatively higher rainfall compared to inland areas, with annual average rainfall varying

**Figure 1:** Köppen-Geiger climate classification map for Mozambique (1951–2010)

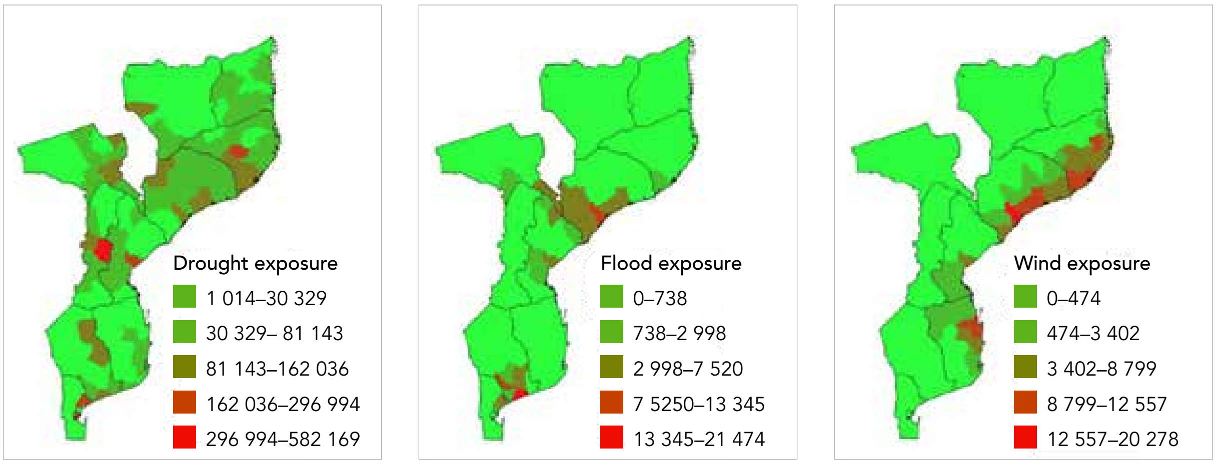



*Source: BGS (2015).*

between 800 and 1,200 mm. This region is the warmest in the country, with temperatures between 25°C (Celsius) to 27°C in the hot humid rainy season and 20°C–23°C in the cold dry season. The southcentral parts of Mozambique have a hot semi-arid climate due to their proximity to the desert belt of southern Africa. Overall, the south is much drier and cooler, with rainy seasons in December and March, and an average rainfall of 800 mm, or even 300 mm in some parts. Temperatures are usually between 24°C–26°C and 20°C–22°C in the rainy and dry seasons, respectively (World Bank n.d.-a).

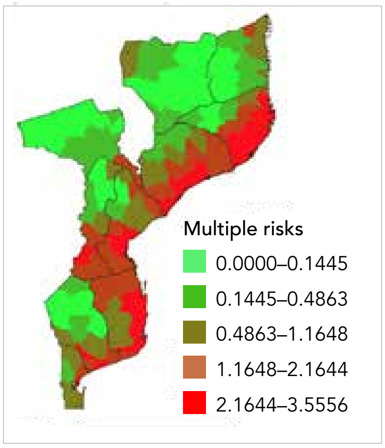
**Mozambique is prone to natural disasters, especially cyclones, floods, and droughts.** Between the period 1980–2019, the country experienced a total of 53 natural disaster events, comprising 21 tropical cyclones, 20 floods, and 12 drought occurrences (Mozambique, Ministry of Land and Environment 2021). For example, the El Niño drought of 2015/16 had a severe impact on food security and resulted in a 15 percent reduction in food production (USAID 2018). This also affected the following years, as over 2 million experienced food-related challenges and poor harvests in 2017 (USAID 2019). Following the drought, the rains of 2018 and Tropical Cyclones Desmond, Idai, and Kenneth in 2019 were the worst to hit the nation within the 39-year period (Mozambique, Ministry of Land and Environment 2021). According to the Global Climate Risk Index, Mozambique

**Figure 2:** Mozambique's exposure to extreme weather events




*Note: Unit is the expected average annual population (2010 as the year of reference) exposed (inhabitants). Raster data is averaged at the district level.*

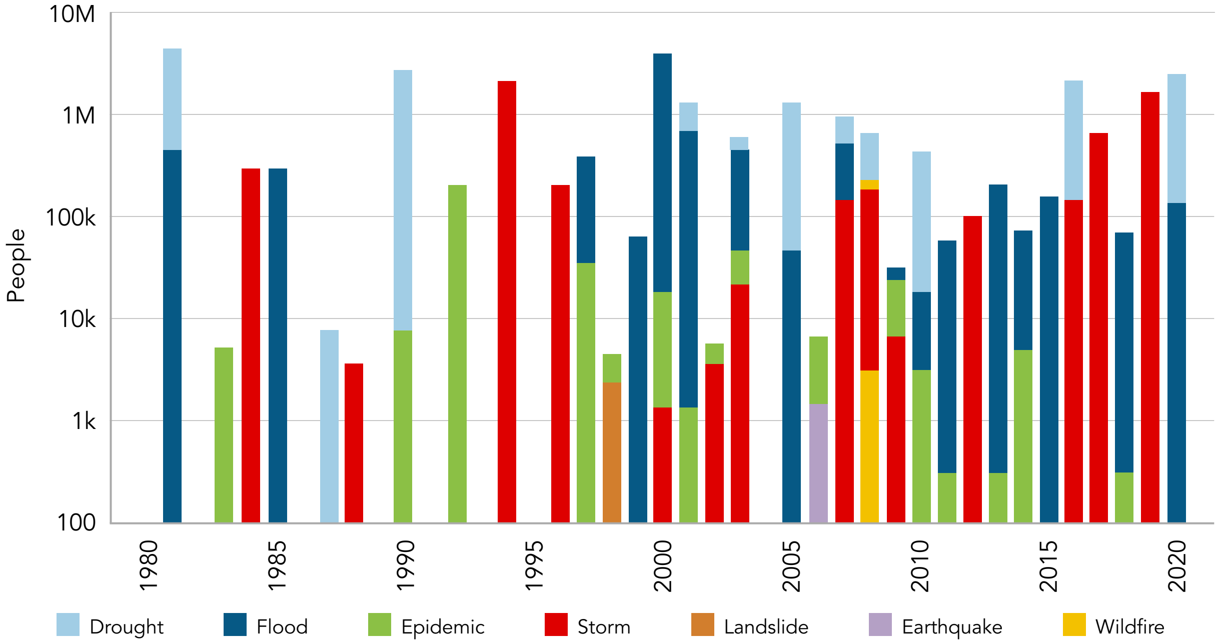
Risk of Multiple Adverse Events




*Note: This figure shows the geographical distribution of the global risk induced by multiple hazards: extreme winds, floods and landslides, induced by precipitations. Unit is the estimated risk index from 1 (low) to 5 (extreme). Raster data is averaged at the district level.*

*Source: Armand, Gomes, and Taveras (2019).*

Figure 3: Key natural hazard statistics in Mozambique, 1980–2020




*Source: World Bank Climate Change Knowledge Portal.*[3]

was the most affected country in the world by the impacts of extreme weather events in 2019, and the fifth most affected when considering the period 2000–2019 (Eckstein, Künzel, and Schäfer 2021). Furthermore, Tropical Cyclone Freddy hit Mozambique twice in 2023, causing widespread flooding around Zambezia Province (where a large part of the country's agricultural land is concentrated) (UNDRR 2023; Armand, Gomes, and Taveras 2019). The World Meteorological Organization is evaluating whether Freddy broke the record as the longest-lasting tropical cyclone on record (WMO 2023).[1] Figure 2 illustrates the areas most prone to extreme weather events.

## Recent trends

**A number of studies highlight the increase in intensity and frequency of extreme events, including droughts, floods, and cyclones, over the past 20 years in Mozambique** (Manuel et al. 2020; Mozambique, Government of Mozambique 2017; UNDP, UNEP, and GEF 2020). While historically floods have been the most frequent extreme weather events (based on data for 1980–2016), in recent years the frequency of cyclones significantly increased, making them the most common event for 1980–2019. Overall, recent trends suggest that Mozambique is affected by a tropical cyclone or a flood every two years on average, and by a drought every three years (Mozambique, Ministry of Land and Environment 2021).[2] USAID (2018) reports that since 1960, southern Mozambique has experienced more persistent droughts, while the coastal regions have had more episodic floods. Figure 3 illustrates the increased frequency of extreme weather events in Mozambique, according to the World Bank's data and classifications.

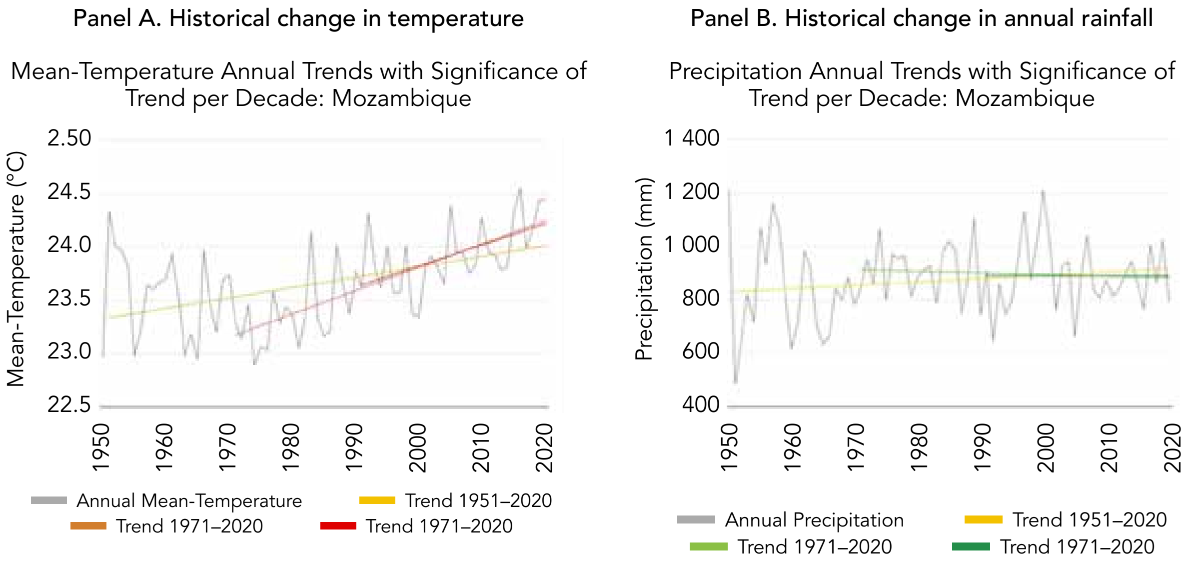
1 Northeast Zimbabwe, southeast Zambia, and Malawi also experienced destructive winds, storm surges, and extreme rainfall (WMO 2023).

2 Mozambique's Nationally Determined Contribution (Mozambique, Ministry of Land and Environment 2021) uses data from DeSinventar and reports from National Institute of Disaster Management (INGD), according to which Mozambique has experienced 21 cyclones, 20 floods, and 12 droughts over the period 1980–2019.

3 The World Bank reports 35 floods, 23 storms, and 13 droughts over the period 1980–2020 (World Bank n.d.-b).

**The last five decades witnessed stable and noticeable growth in Mozambique's average temperature.** According to the World Bank Climate Change Knowledge Portal, the mean temperature increased by 1.46°C from 1963 to 2020 (Panel A of Figure 4). Consequently, the number of days with a temperature higher than 35°C has expanded since the 1960s in Mozambique. In comparison, overall, annual rainfall has declined slightly since 1972 (World Bank n.d.-c). However, annual precipitation varies significantly across years (Panel B). Therefore, the occurrence of consecutive dry days has increased notably in Mozambique, especially in its central regions, such as Zambezia and Sofala (USAID 2018).

Figure 4: Historical change in Mozambique's weather conditions



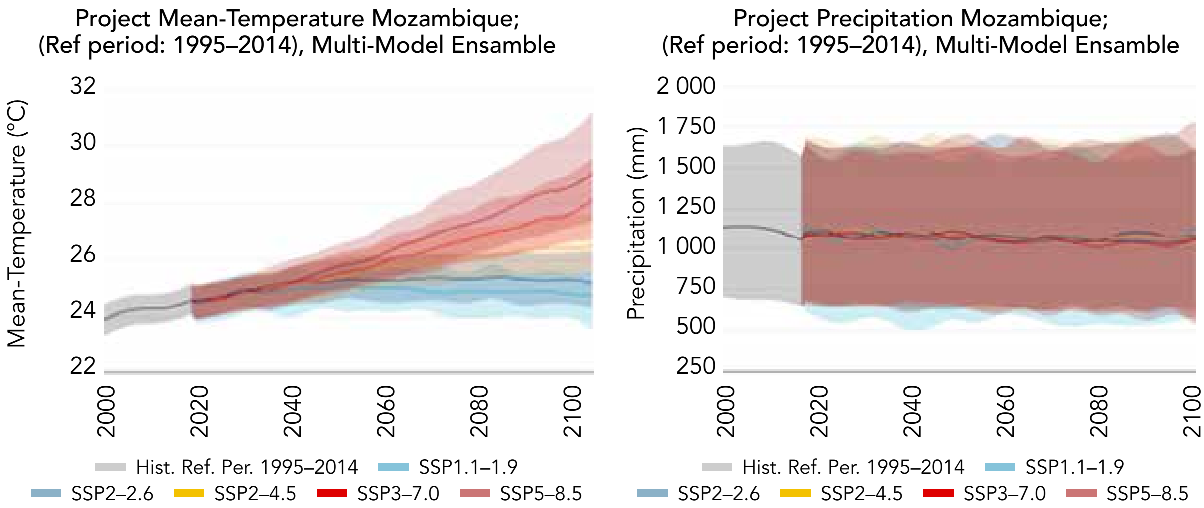

*Source: World Bank Climate Change Knowledge Portal.*

## Projected climate trends

**Temperatures are expected to continue rising across the country and rainfall to become more volatile, especially in the south of Mozambique.** Figure 5 shows the projected change in Mozambique's temperature and annual precipitation. Based on World Bank estimates, the increase in temperature is likely to continue until 2090 (Panel A), while annual rainfall does not vary significantly over time but is expected to have a higher variance relative to historical trends (Panel B).

Mozambique's NDC (Mozambique, Ministry of Land and Environment 2021), which refers to National Institute for Disaster Management (INGC 2009) modelling, similarly projects an increase in temperatures across the country, including more warm days. It also notes expected higher irregularity and intensity of rainfall. Mozambique's National Climate Change Adaptation and Mitigation Strategy (NCCAMS) (Mozambique, Ministry for the Coordination of the Environmental Affairs 2012) further references projections of a slight (2–9 percent) decrease in average precipitation by 2075. USAID (2018) and Irish Aid (2017) both expect temperatures (and the number of hot days) to increase on average but do not forecast significant changes in precipitation (apart from an increase in the intensity of rainfall events). Irish Aid (2017) projects dry seasons to be drier and rainy seasons wetter.

**Figure 5:** Predicted change in Mozambique's weather conditions at the national level




*Source: World Bank Climate Change Knowledge Portal.*

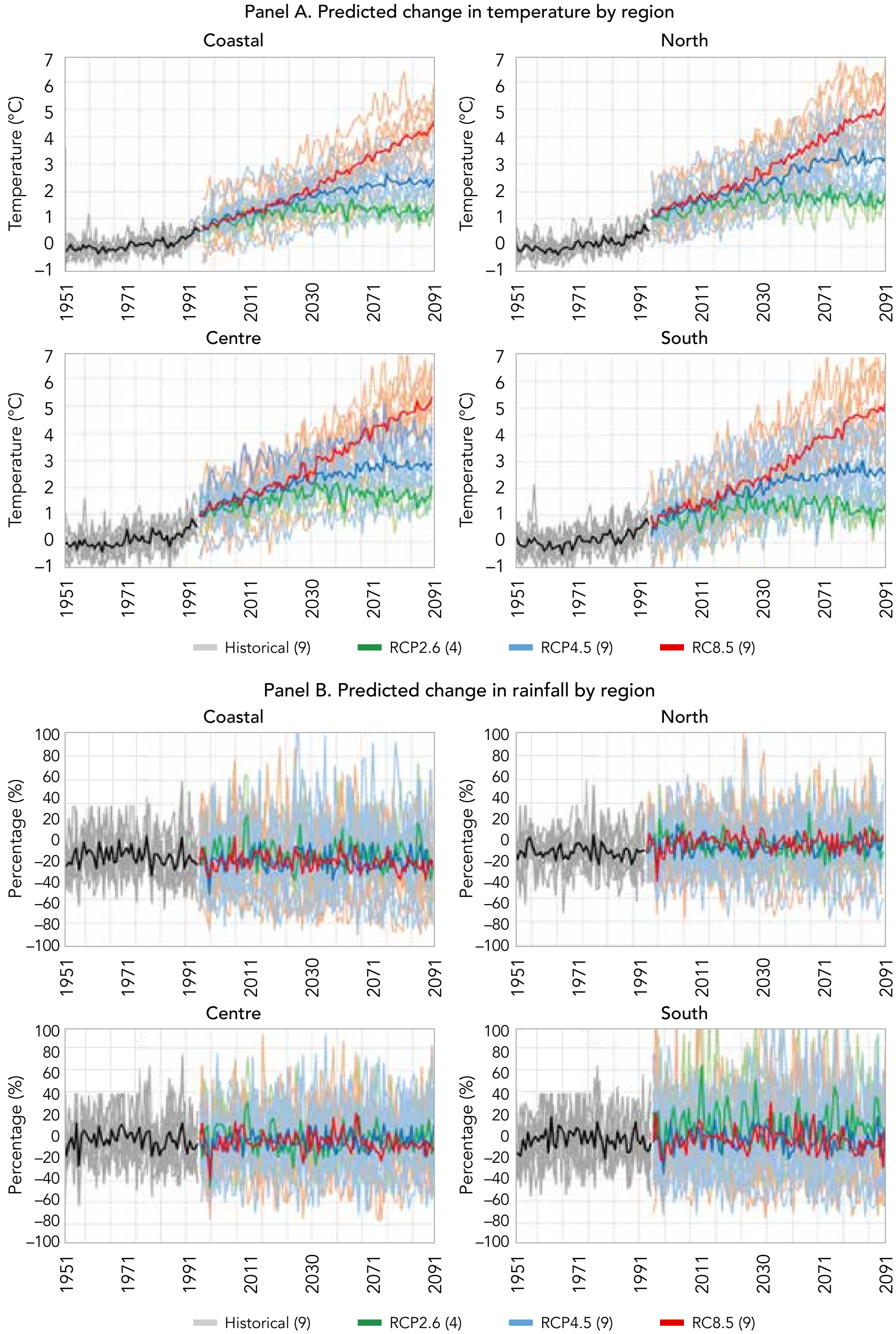
Figure 6 exhibits the predicted trend of Mozambique's weather conditions by region. Overall, the average temperature is projected to grow in a similar magnitude across all regions until 2091, albeit the central and southern areas might experience a marginally greater temperature increase in a high emissions scenario. Average annual rainfall overall does not differ significantly by region but the fluctuations in precipitation in the south region of Mozambique are noticeably higher than in other regions, irrespective of the hypothetical scenarios for global emissions.

Mozambique's NCCAMS (2012) projects more erratic rainfall in the south but expects that precipitation will decrease overall in the south and increase in the north. Mozambique's NDC (Mozambique, Ministry of Land and Environment 2021) does not make regional climate projection references. USAID (2018) projects more marked temperature increases in the interior (central), southern, and coastal areas (including an increase in droughts for the central and southern regions, as well as more floods during rainy seasons). It expects climate change to decrease the duration of the rainy season, particularly in the central region and Zambezi Valley. Irish Aid (2017) similarly notes a higher rate of warming in the interior (central) parts.

**The frequency and intensity of extreme weather events in Mozambique is expected to continue rising because of climate change** (UNDP, UNEP, and GEF 2020; Mozambique, Ministry of Land and Environment 2021). Increased river flows are projected to increase flood risk, particularly from January to March, while high intensity rainfall is likely to increase flash flooding along the coast. The magnitude of large flood peaks could increase by 25 percent along the main stems of both the Limpopo and Save Rivers in the south (USAID 2018). Fant, Gebretsadik, and Strzepek (2013) find that the recurrence of high-damage flood events, greater than the 50-year event intensity, could increase significantly in Mozambique, potentially tripling the base occurrence,[4] with a tail risk of six to eight times more high-damage flood events. Droughts are also expected to last longer (Mozambique, Ministry of Land and Environment 2021). Irish Aid (2017) expects tropical cyclones to become more intense due to climate change but notes uncertainty about the frequency of cyclones and storms and their interactions with other features of climate variability in the region (such as the El Niño Southern Oscillation).

4 The study assumes that one high-damage flood event occurs in the base scenario.

**Figure 6:** Predicted change in Mozambique's weather conditions by region




*Source: Mavume et al. (2021).*

**Sea levels are projected to continue rising substantially.** USAID (2018) estimates an additional sea level rise of 13–56 centimeters (cm) by 2090 while UNDP, UNEP, and GEF (2020) project 18–59 cm by 2090. This is consistent with a projected 45 cm rise by 2100 due to thermal expansion under Mozambique's NDC (Mozambique, Ministry of Land and Environment 2021).[5] Mucova et al. (2021) find that the mean sea level rise for the Mozambican coast is likely to be higher than the global average for all representative concentration pathways (RCPs), even those compatible with the Paris Climate Agreement goals—with projections of 54–55 cm (in more moderate climate scenarios; that is, RCP2.6, 4.5, and 6.0) and of 70 cm (in a high emissions scenario, RCP8.5) for 2081–2100 (relative to 1980–2005). Moreover, even small rises in sea levels are likely to dramatically increase the probability of severe storm surges (USAID 2018; World Bank Group 2010). Impacts are projected to materialize in the short to medium term as well, including potentially losing an estimated 4,850 km$^2$ of land to sea level rise by 2040 (USAID 2018).

5 Estimates increase substantially for sea level rise projections that take into account expected reduction of the continental icecaps: 15 cm, 110 cm, and 415 cm in 2030, 2060, and 2100, respectively.

# 2. CLIMATE CHANGE IMPACT ON KEY ECONOMIC SECTORS

**Mozambique is extremely sensitive to climate change risks because of its: (i) high reliance on natural resources (the agriculture sector in particular, as farming takes place in areas prone to drought and flooding); and (ii) critical infrastructure and population being situated along the coast, a high-risk area.** The World Bank Group (2010) identifies the agriculture, energy, and transport (road infrastructure) sectors and coastal areas to be most vulnerable to climate change in Mozambique. The agriculture sector accounts for 70 percent of total employment (among the highest proportions in the world) (World Bank n.d.-g); together with forestry and fisheries it accounted for 27.5 percent of total gross domestic product (GDP) in 2021 (World Bank n.d.-e). Similar to neighboring countries, it is predominantly rainfed, which makes it very sensitive to climate variability, in addition to the relatively higher risk of extreme weather events. Climate change is projected to reduce agricultural productivity in Mozambique, where it is already lower than the southern African region average (Manuel et al. 2020). Hydropower accounts for 78 percent of Mozambique's installed electricity generation capacity, and relies heavily on water availability in the Zambezi River Basin, which is projected to decline (ALER and AMER 2022; Uamusse, Tussupova, and Persson 2020). The tourism industry, which accounted for 6.2 percent of GDP in 2019, is extremely vulnerable to climate change due to the projected substantial erosion of coastal areas, as detailed below (WTTC 2022; Mucova et al. 2021).

**The rising frequency and intensity of extreme weather events is a key climate change-related risk for Mozambique's economy and society.** The GoM states that it lacks accurate data to estimate the precise value of direct and/or indirect economic losses associated with climate-related events (Mozambique, Ministry of Land and Environment 2021). According to a World Bank (2023a) analysis, climate shocks and security risks could lower Mozambique's GDP growth by 1.5 percent in 2023–2025. Arndt and Thurlow (2015) estimate that the economy of Mozambique could be up to 13 percent smaller in 2050, with 70 percent of the future climate scenario resulting in GDP losses of 0–5 percent. The study highlights agriculture, roads, hydropower, and the combination of sea level rise and cyclone strike as the major impact channels. Irish Aid (2017) posits that climate change may cause Mozambique's GDP to fall between 4 percent and 14 percent by 2050 and that the country will lose 1.1 percent of its GDP every year due to the economic impacts of droughts and floods.

**Mozambique's coastal regions are particularly vulnerable to climate change, with significant potential economic implications.** Mozambique has one of the longest coastlines in Africa and hosts 60 percent of the population within its low-lying coastal lands (USAID 2018). The key risks from climate change stem from the projected increase in sea levels and the associated higher frequency of extreme weather events. The World Bank Group (2010) estimates that this could force 916,000 people to migrate by 2040 (2.3 percent of the 2040s population). Zambezia, Nampula, Sofala, and Maputo Provinces are projected to suffer the greatest damages and costs, as they are low-lying and densely populated. The cyclone risk from even small sea level rises is projected to increase substantially for Beira and Maputo[6]

6 Mozambique's three most populous cities—Maputo, Matola, and Beira—are all located on the coast (World Population Review n.d.).

(even when assuming no change in the intensity or frequency of cyclones), with Beira estimated to be relatively more vulnerable (World Bank Group 2010). Coastal erosion (90 percent of which is attributed to climate change) will result in loss and damage to important ecosystems, such as coral reefs, mangroves, and seagrass, with implications for biodiversity (USAID 2018). The economic implications of the climate change-related damage on Mozambique's coastal areas are likely to be substantial, as detailed below. They include losses in tourism and agriculture (particularly cashews, coconuts, and fisheries). Climate change-related damages to critical infrastructure, such as ports, and to major cities would have knock-on implications for various sectors and the economy as a whole. The climate change impact on Mozambique's coasts is likely to have food security implications, as coastal fisheries (which depend strongly on coral reefs) provide a livelihood for 6.6 million people in Mozambique and one-half of the nation's animal protein (USAID 2018).

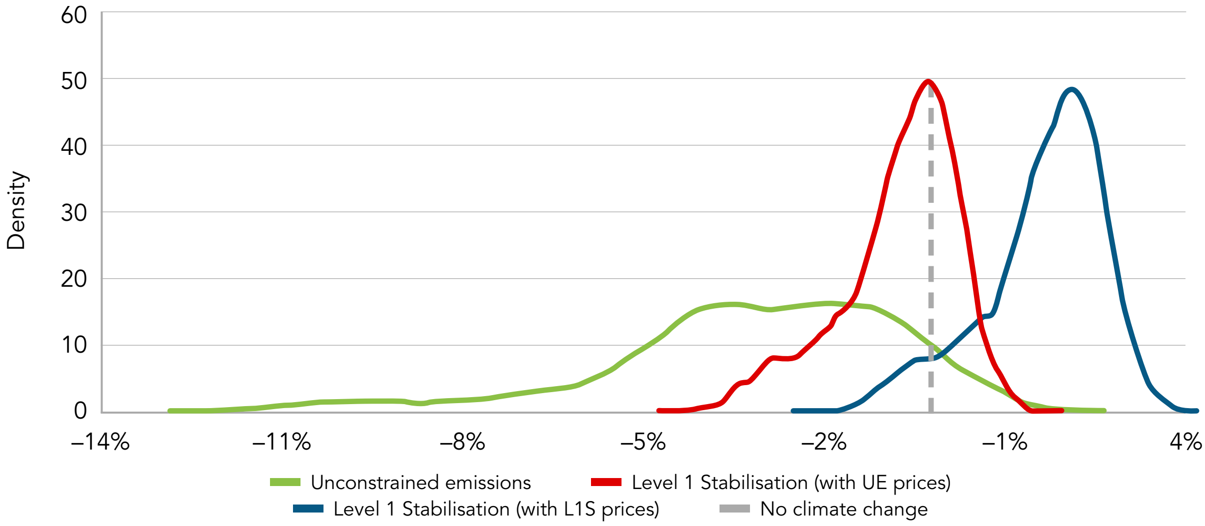
**Mozambique is exposed to risks from the transition of other countries to low-carbon economies. This is because it relies on carbon-intensive exports such as aluminium, coal, and petroleum.** Global measures to reduce greenhouse gas (GHG) emissions, such as the European Union (EU) Carbon Border Adjustment Mechanism (CBAM), could therefore adversely affect Mozambique's economic growth and trade balance, as detailed below (ACF and LSE 2023; Pleeck, Denton, and Mitchell 2022). That said, such measures would reduce the physical risks to the economy, so the net effect would depend on the approach and timeline of global transitions. For example, Manuel et al. (2020) find that in Mozambique, a scenario of aggressive emission reduction policies (L1S) generates positive impact compared to an assumption of unconstrained emissions, for roads, energy, sea level, and cyclone scenarios. This is corroborated by Arndt et al. (2019), as illustrated in Figure 7.

## Agriculture

**Mozambique's agriculture sector is characterized by a high proportion of smallholder farmers, limited arable land, and reliance on rainfall.** Agricultural land accounts for 52.7 percent of total land area (as of 2020; World Bank n.d.-d), while the rest of Mozambique's territory is covered with forest. However, only 7.2 percent of the total land is arable (World Bank n.d.-f), and less than 10 percent of the arable land is used, as a large proportion of farming takes place in flood- and drought-prone areas (FAO n.d.). The southern provinces need irrigation the most but have only a small share of land suitable for irrigation. Irrigation is predominantly used by commercial farmers who are largely in the southern region and focus on export crops such as cotton, cashew nuts, sugar cane, tobacco, and tea (FAO 2016). The main irrigated crops are sugar cane, vegetables, and rice (INIR 2013). Most irrigation schemes use surface water from rivers while groundwater is used to a very limited extent, mainly by the family smallholder sector (FAO 2016). Smallholder farmers—who produce 95 percent of the agricultural production—largely practice rainfed agriculture, which exposes them to climate variability (FAO n.d.). Maize is the main food crop, accounting for 72 percent of the total small and medium farming units, followed by cassava and beans (Manuel et al. 2020). Smallholder farmers also produce rice, pigeon peas and, to a lesser extent, some cash crops (cotton, tobacco, seeds, and tea) and tree crops (cashew and coconut). Subsistence farmers raise cattle, pigs, chickens, and goats but cattle production is limited by the prevalence of the tsetse fly in two-thirds of the country (USAID 2011). Fisheries are an important source of income and daily protein, given Mozambique's extensive coastline. The subsector represents around 2 percent of Mozambique's GDP but has much larger potential, as only 1 percent of suitable area is currently used for aquaculture production (World Bank Group 2021).

**Climate change is projected to significantly affect Mozambique's agriculture sector, mainly due to the projected frequency and intensity of extreme events.** This in turn is expected to result in inundation and waterlogging of low-lying crops, flooding of roads connecting crops to markets, and shifting growing seasons (USAID 2018). These impact channels could result in an agricultural GDP loss of 4.5–9.8 percent by 2050. The increased risk of floods due to climate change is expected to affect key value

**Figure 7:** GDP level projections (average 2046–2050) for Mozambique relative to a no climate change baseline




*Source: Arndt et al. (2019).*

*Note: The vertical axis presents a measure of likelihood (kernel density estimates) for the associated GDP outcome under climate change.*

chains, such as for soy, pigeon pea, and sesame, with adverse implications for local markets and farmers' income (USAID 2018). Baez, Caruso, and Niu (2020) find that a cyclone, flood, or drought event leads to a drop of up to 25–30 percent in per capita food consumption. Overall, the risks from the adverse impacts of extreme weather events on agricultural production are particularly acute in rural areas, where agriculture is the primary source of livelihood for 90 percent of the population (INE 2015). Mozambique's adaptive capacity for climate change risks is likely to be compromised by preexisting vulnerabilities in the agriculture sector. These include inadequate water infrastructure, power outages, inadequate storage and logistics facilities, and underinvestment (ITA 2022). The high proportion of smallholder farmers is likely to create implementation challenges for the adoption of adaptation measures and for the introduction of climate-smart agriculture (CSA) practices more broadly. While irrigation could help manage climate change-related risks, water availability is projected to decline and irrigation demands are likely to be unmet in Mozambique (Fant et al. 2015; USAID 2018).

### *Impact on crop yields*

**Projections regarding the overall impact of climate change on crop yields in Mozambique vary, and several studies predict expected high variance.** Arndt and Thurlow (2015) project that the average value added in agriculture for 2046–2050 is likely to decline by 4 percent, albeit declines of up to 10 percent are possible. Manuel et al. (2020) project the central region to be the most affected, with a likely decline in agricultural value added of 19 percent (and potentially up to 25 percent) by 2050, assuming global emissions are not constrained. On the other hand, the northern region is likely to be the least affected, with a mode of only 0.6 percent change but significant uncertainty (between -18.5 percent and +16.2 percent). The potential impact of climate change on agricultural production in the south is most uncertain, with outcomes running from -31 percent to +32 percent (Manuel et al. 2020). Arndt and Thurlow (2015) estimate that by 2050 yields will decline by about 3–4 percent on average across all climate scenarios relative to the baseline path. That said, declines of more than 10 percent are possible for some crops in specific climate scenarios. Similarly, the World Bank Group (2010) projects a 2–4 percent decline in the yield of major crops, which alongside the impact of more frequent flooding on rural roads, is expected to result in an agricultural GDP loss of 4.5 percent by 2050 (and potentially up to 9.8 percent). Mozambique's NDC (Mozambique, Ministry of Land and Environment 2021) suggests that climate change could reduce yields by as much as 25 percent, including a 20 percent yield reduction for the main crops for food security. Climate change is also projected to reduce the land available for agriculture in low-lying areas (where the majority of the population lives).

**Maize is likely to be most affected by climate change from the main crops in Mozambique.** Climate change will likely increase the frequency of low-yield events for maize, resulting in a potential decline of about 15 percent by 2050 under a high emissions scenario (Table 1) (based on the Decision Support System for Agrotechnology Transfer (DSSAT) crop model (Jones et al. 2003) and the Sixth Phase of the Coupled Model Intercomparison Project (CMIP6) climate models).[7] USAID (2018) projects maize yield to potentially decline by 11 percent on average (2046–2065). Fant, Gebretsadik, and Strzepek (2013) predict Mozambique to experience a worse decline in the yields of rainfed maize compared to Malawi and Zambia. This impact is likely to exacerbate Mozambique's food security risks and dependence on food imports, as detailed below, given the importance of maize to the Mozambican economy and diet.

**The average impact on other crops is likely to be lower, and there may even be some gains, particularly for rice.** Cassava is likely to be adversely affected, albeit to a lesser extent than maize. For example, USAID (2018) states that the yields of cassava, sorghum, soybeans, and groundnuts could decrease by 2–4 percent over the next 40 years. That said, Table 1 also shows potential yield increases in Mozambique, even in a high emissions scenario. In particular, rice production is likely to increase most significantly by 2050 among the major essential crops in Mozambique. In contrast to USAID (2018), this analysis anticipates that most regions in Mozambique will witness an increase in groundnut production in 2050 compared to their groundnut yield in 2005; sorghum yields will also increase slightly at the national level in 2050, with most agroecological zones in Mozambique experiencing a minor change in sorghum production (-2 percent to +2 percent).

**Table 1:** Yield impact of climate change on crops in 2050 under SSP5-85, relative to 2005 climate

| | Without $CO_2$ fertilization | | | | With $CO_2$ fertilization | | |
|---|---|---|---|---|---|---|---|
| | | Predicted yield change | | | | Predicted yield change | |
| Crop | Minimum | Median | Maximum | Crop | Minimum | Median | Maximum |
| Groundnuts | – 23.58 | –16.49 | –10.42 | Groundnuts | –5.83 | 2.61 | 9.91 |
| Maize | –26.62 | –14.38 | –7.07 | Maize | –27.07 | –15.09 | –7.84 |
| Rice | –5.24 | 1.70 | 5.29 | Rice | 4.79 | 11.96 | 16.32 |
| Sorghum | –11.42 | –1.07 | 2.77 | Sorghum | –9.92 | 0.14 | 3.64 |

*Source: Authors' estimates.*

*Note: Only the yield change for major food crops in Mozambique is projected.*

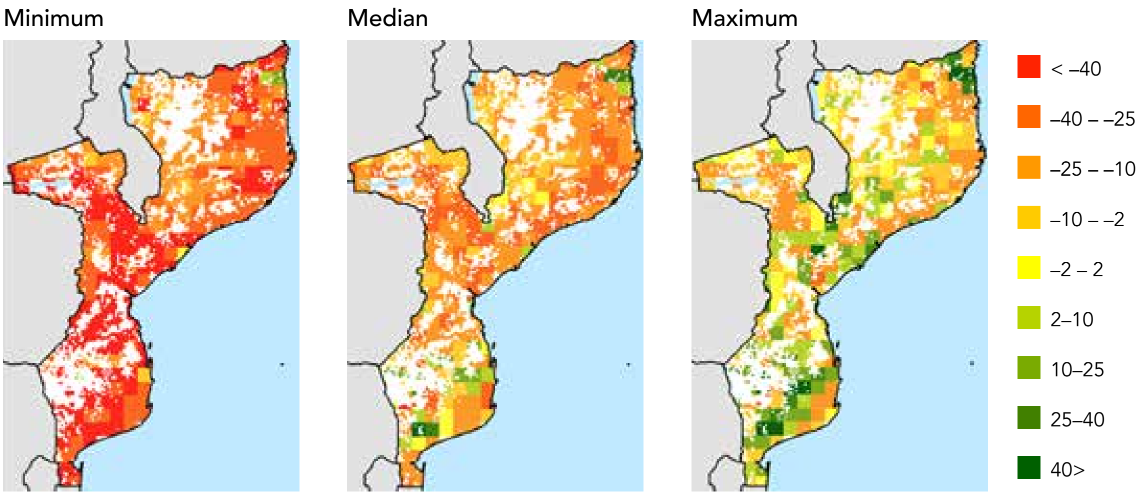
**The projected adverse impacts of climate change on maize yields vary considerably across agroecological zones in Mozambique.** Maize yield is predicted to reduce by more than 25 percent in Sofala (in the center) and Nampula (in the north) in 2050 compared to their counterparts in 2005 under the "Median" scenario

7 Table 1 presents results for the yield impact with and without $CO_2$ fertilization. Climate change elevates the levels of $CO_2$ fertilization, which increase in photosynthesis in some plants. This can have a positive impact on plant growth, depending on other factors, including nutrient availability (LBNL 2021; Kirschbaum 2011). While the results "with $CO_2$ fertilization" are overall more likely, the impact may vary by crop, so Table 1 provides results for both scenarios for clarity.

(Figure 8). In stark comparison, the projected loss in maize yield in Inhambane and Cabo Delgado (southern and northern coastal areas, respectively) is noticeably lower. Some subregions within Inhambane and Cabo Delgado are even expected to experience 2–10 percent growth in maize yield under the "Median" scenario. USAID (2018) finds that climate change could reduce maize yields up to 45 percent in some regions, such as Tete Province (Zambezi River Basin). Manuel et al. (2020) project climate change to reduce maize yields particularly in the south where the (mode) impact is expected to reach –10.2 percent by 2050 if global emissions are not constrained (but with significant uncertainty, implying that the change in yields could range between -20 percent and +40 percent). The northern and central regions are also expected to be adversely affected, though the most likely projected impact is lower: -1.5 percent and -3.5 percent, respectively. That said, the study finds an overall likely positive impact from climate change on maize production in the north (in terms of real gross value added), as smallholder farmers could expand their production area to compensate for the projected (relatively low) negative change in yields. The southern region is already a net maize importer (while the north and central regions produce surplus maize) (Manuel et al. 2020). Climate change is therefore likely to exacerbate regional food security dependencies.

**For other crops, several studies project the central region, including Zambezia, to be the most adversely affected by climate change. But positive gains are possible in various areas.** Zambezia will likely experience a reduction in the yield of sorghum, most notably in 2050 (Figure 9). On the other hand, growth in groundnut yield is projected to be particularly outstanding in Inhambane, where groundnut output is likely to expand by more than 40 percent, whereas Zambezia and Tefe are predicted to experience major losses in groundnut production (Figure 10). USAID (2018) similarly projects sorghum and groundnut production in the central region to be most adversely affected. Manuel et al. (2020) project the greatest adverse impact from climate change on root crop yields to be in the center, albeit the southern region shows the highest variance in possible outcomes (and some cassava production takes place along the southern coast). The north region—where a large part of cassava production takes place—is expected to be negatively affected but to a lower extent. Growth in rice production in Sofala and Inhambane is likely to be most outstanding compared with that in other regions, while Nampula is among the few agroecological zones that will experience a loss in rice yields (Figure 11).[8] Traditionally, rice is a main source of income, particularly in Inhambane and southern Zambezia (FEWS NET 2014). Extreme weather events also pose risks to cashew and coconut production, as they are usually raised in coastal areas (USAID 2011, 2018).

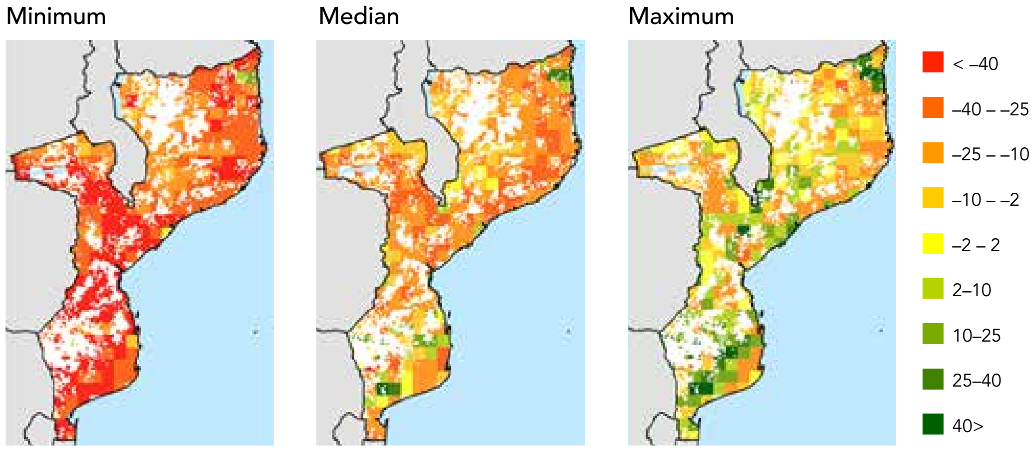
**Figure 8:** Percent yield change, rainfed maize, 2005–2050, RCP8.5, with $CO_2$ fertilization, across 5 ISIMIP GCMs, CMIP6




*Source: Authors' estimates.*

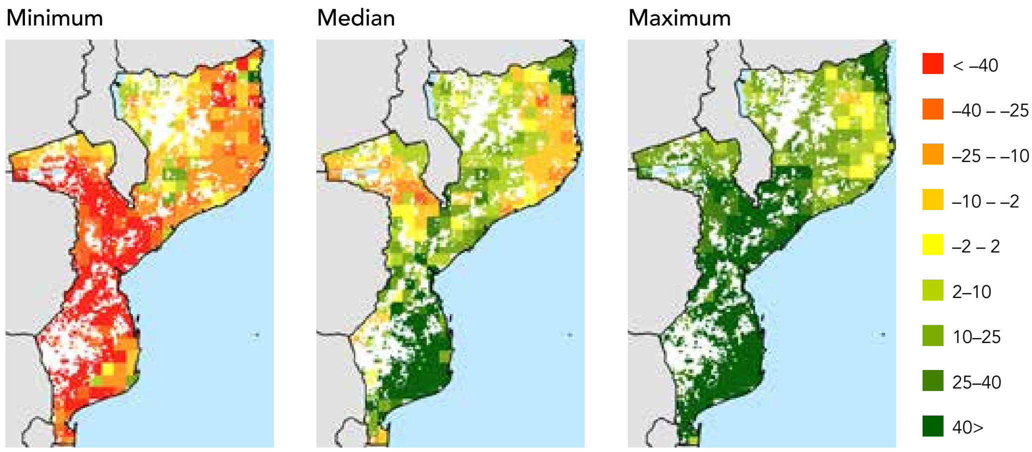
8 The reference is to the estimates in the "Median" scenario.

**Figure 9:** Percent yield change, rainfed sorghum, 2005–2050, RCP8.5, with $CO_2$ fertilization, across 5 ISIMIP GCMs, CMIP6



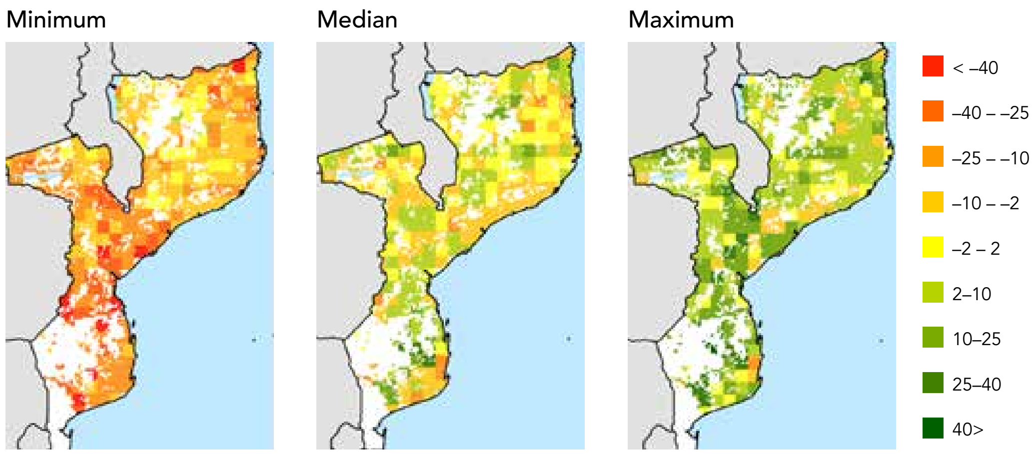

*Source: Authors' estimates.*

**Figure 10:** Percent yield change, rainfed groundnuts, 2005–2050, RCP8.5, with $CO_2$ fertilization, across 5 ISIMIP GCMs, CMIP6




*Source: Authors' estimates.*

**Figure 11:** Percent yield change, rainfed rice, 2005–2050, RCP8.5, with $CO_2$ fertilization, across 5 ISIMIP GCMs, CMIP6




*Source: Authors' estimates.*

## Hydropower

**Hydropower currently dominates Mozambique's energy sector.** Hydropower represents 78 percent of Mozambique's installed capacity as of end-2022, followed by gas (16 percent), heavy fuel oil (4 percent), and solar energy (2 percent) (ALER and AMER 2022). Mozambique is a net exporter of electricity, largely due to production along the Zambezi River Basin (OEC n.d.; USAID 2018). Indeed, only 39 percent of the installed capacity is available for national consumption. The on-grid electrification rate stands at 40.8 percent due to an underdeveloped transmission and distribution network, but has steadily increased since 2016 (ALER and AMER 2022; ITA 2022). The largest hydropower plant in Mozambique (and in southern Africa) is located on the Cahora Bassa Lake on the Zambezi River. It represents almost 95 percent of Mozambique's hydropower sector installed capacity and accounted for 51 percent of total electricity production in 2021 (ALER and AMER 2022; Energy Capital & Power 2021). Other minor hydropower plants are located in the central and southern parts of the country (Uamusse, Tussupova, and Persson 2020).

**Hydropower generation is projected to increase and to continue driving Mozambique's energy sector.** Mozambique's hydropower potential is estimated at 18,000 megawatts (MW) (compared to 2,189 MW installed capacity), with more than 80 percent of that potential located in the Zambezi River Basin (Uamusse, Tussupova, and Persson 2020; ALER and AMER 2022).[9] The GoM plans to more than double installed hydropower capacity in the country by 2030 (albeit the relative share of hydropower is projected to slightly decline from 78 percent of total generation capacity in 2022 to 72 percent in 2030). Most large hydropower plants are planned to be developed in Tete Province, at the Zambezi River Basin (Power Technology 2023). However, according to Uamusse, Tussupova, and Persson (2020), current feasibility studies for hydropower plants rarely reflect potential climate change effects. Moreover, the chairman of EDM, Mozambique's state-owned energy company, announced plans earlier this year to increase exports to the Southern African Development Community (CCI France Mozambique 2023).

**Climate change is generally expected to reduce Mozambique's hydropower capacity.** Uamusse, Tussupova, and Persson (2020) project that reduced runoff to hydropower stations due to climate change make it impossible to use their maximum capacities, resulting in a 10–20 percent decline in total power generation available annually in the 21st century. In particular, the study estimates that electricity output of the Cahora Bassa hydropower plant will be reduced by 20 percent until 2100. When also considering the hydropower plants under development, hydropower energy generation in practice may constitute 70–80 percent of the planned hydropower capacity for the country. Similarly, Spalding-Fecher, Joyce, and Winkler (2017) estimate that output from major Zambezi hydropower plants could decline by 10–20 percent due to climate change under drying scenarios (while wetter scenarios would result in only a marginal increase). Moreover, Mozambique could be particularly vulnerable to increases in electricity generation costs, potentially reaching 20–30 percent in the near term, due to its high hydropower dependence. The World Bank Group (2010) also expects a significant energy deficit due to climate change relative to base generation potential in Mozambique by 2050. In contrast, Arndt et al. (2019) do not predict a change on average in the runoff for Cahora Bassa by 2050, albeit extremes could reach ±20 percent. The analysis suggests that the overall impact on hydropower generation in Mozambique may be mild due to a portfolio-type effect stemming from a large contributing area. Fant, Gebretsadik, and Strzepek (2013) state that the reservoirs behind Mozambique's hydropower plants have significant storage and are located downstream, which makes them less sensitive to changes in runoff. Hydropower demand is also small in proportion to the generating capacity in Mozambique—albeit that may change when taking into account regional trade and opportunities for export. The following paragraphs set out in more detail the vulnerabilities of Mozambique's hydropower sector to climate change.

9 Mozambique has 13 major river basins (listed from south to north): Maputo, Umbeluzi, Incomati, Limpopo, Save, Buzi, Pungwe, Zambezi, Licungo, Ligonha, Lúrio, Messalo, and Rovuma (Uamusse, Tussupova, and Persson 2020).

**Climate change may affect Mozambique's hydropower sector due to increased rainfall variability and frequency of extreme weather events.** Hydropower generation is dependent on a predictably steady precipitation pattern (Uamusse, Tussupova, and Persson 2020). While precipitation in Mozambique is overall not projected to change significantly, several studies find that climate change is likely to lead to higher evaporation and more variable rainfall, which would adversely affect hydropower generation in Mozambique (USAID 2018; Uamusse, Tussupova, and Persson 2020). Mozambique already experiences frequent power shortages, mainly due to extreme weather events (ITA 2022). Climate change increases the probability of drought events, which could reduce electricity generation (Uamusse, Tussupova, and Persson 2020). For example, the 2015/16 major drought led to an unprecedented reduction in the water levels at the Cahora Bassa Dam reservoir to about one-third of total capacity (Kuo 2016). USAID (2018) projects climate change to increase droughts in the central regions. Several studies report that climate change increases the risk of large-scale, high-damage flood events in Mozambique that could impact hydropower infrastructure (Arndt et al. 2019; Fant, Gebretsadik, and Strzepek, 2013; Uamusse, Tussupova, and Persson 2020). Fant et al. (2015) conclude that such events are more likely in Mozambique than in other countries in the Zambezi River Basin. Operational risks may be exacerbated by the regional concentration of hydropower plants and main grids in the central (western) parts of the country.

**The climate change impact on neighboring countries could create additional risks for Mozambique's hydropower sector.** While Mozambique has abundant water resources, many of its major rivers originate outside of the country, which makes it vulnerable to increases in demand for water in upstream countries (FAO 2016; NEPAD 2013). Water availability in the Zambezi River Basin—which Mozambique shares with Angola, Botswana, Malawi, Namibia, Tanzania, Zambia, and Zimbabwe—is projected to decrease (FAO 2016; Arndt et al. 2019; Spalding-Fecher, Joyce, and Winkler 2017; Hamududu and Ngoma 2020; Fant, Gebretsadik, and Strzepek 2013; Fant et al. 2015; Uamusse, Tussupova, and Persson 2020). USAID (2018) estimates that flows of the Zambezi River could be reduced by up to 15 percent (not taking into account drought risk and population growth). Growing populations, alongside climate change risks, in neighboring countries are likely to increase irrigation demands and need for further hydropower development, which could have implications for water availability in Mozambique and hydropower generation (USAID 2018).

## Roads and infrastructure

**The underdevelopment of Mozambique's road network makes it vulnerable to climate change.** First, this is because of the large proportion of unpaved roads. Mozambique's road network spans 30,562 km, with approximately only 20 percent (5,958 km) being paved. The remaining 80 percent is nonpaved, comprising secondary and tertiary roads (DLCA 2018a).[10] This exposes the country to climate change risks because unpaved roads are susceptible to increases in precipitation (such as because of flooding or heavy rainfall), as well as traffic increases (for example, if traffic needs to be redirected due to climate change damage to other roads in the areas) (Chinowsky et al. 2015). The country has other means of transportation, including a limited railway network (2,500 km long and primarily used for goods transportation), a number of airports (including several international ones), and five ports[11] (DLCA 2023, 2018b). However, road transportation remains the dominant means of moving people and goods in the country (ITA 2022). The road network (as well as the rail network) is focused around three main logistics corridors (Maputo, Beira, and Nacala), with limited linkages between the corridors and between urban and economic clusters (PwC 2013). This is likely to

10 In a recent interview, Mozambican President Filipe Niusy said that the country's inadequate road network is a major constraint to its economic development. He was quoted specifying that 27 percent of roads are paved, and that 69 percent of roads are in a "reasonable" condition, but the remaining 31 percent are in a poor or "impassable" condition (Club of Mozambique 2023a).

11 The major ones are Maputo, Beira, and Nacala (DLCA 2023).

exacerbate the economic implications of climate change-related damage to the road network, including knock-on effects to other sectors. For example, Espinet et al. (2018) assert that accessibility to rural areas is currently low due to lack of road infrastructure, especially in Zambezia and Nampula Provinces. This disconnects farmers from large urban markets and could affect food security and inflation under climate shocks. The World Bank (2018b) also notes that fiscal constraints in developing road infrastructure and the effects of recurring natural disasters limit the agricultural productivity of rural communities and contribute to poverty.

**Climate change is projected to damage Mozambique's road network—mainly due to increased heavy rainfall, flooding, and cyclones—with significant economic implications.** The World Bank Group (2010) notes the vulnerability of the country's road infrastructure to flooding; climate change is expected to increase the frequency and intensity of floods and heavy rainfall, as discussed above. For example, the severe floods in 2000 cut national and regional roads, including the rail line to Zimbabwe, which led to a decline in economic growth of 1 percent (Arndt et al. 2011). Absent adaptation measures, Chinowsky et al. (2015) estimate that Mozambique could face a potential opportunity cost of 15 percent under median climate scenarios, translating into a lost potential of expanding the existing paved road network or upgrading unpaved roads in the country by 3,213 km of paved road. The impact is likely to be compounded by the projected increased frequency and intensity of tropical cyclones. During Cyclone Idai in 2019, for example, damage to road infrastructure limited humanitarian interventions from Beira into the northern hinterland, as sections of primary roads and many secondary were cut off (Comino 2021; Petricola et al. 2022). Cyclone Freddy in 2023 caused severe damages to the road infrastructure in the provinces of Zambezia, Nampula, Manica, Tete and part of Sofala (ANE 2023).

**Climate change-related damage to Mozambique's road infrastructure is likely to have regional impacts but its vulnerability varies by area.** In southern Mozambique, flooding—such as due to storm surge, cyclones, and sea level rise (particularly after 2030)—could damage road links with the rest of the country. The plain of the lower Limpopo River southeast of Xai Xai, the lower Incomati River northeast of Maputo, and the estuary at Maputo and the lower Maputo River are the most vulnerable to flooding (INGC 2009). This could have implications for one of Mozambique's three main "growth" corridors:[12] the Maputo Corridor, the main one in the south, passing through landlocked regions and connecting the country to South Africa (Gauteng Province), as well as to Swaziland (Arup and Cities Alliance 2016; PwC 2013). In particular, while most of Maputo City is positioned on high ground, which provides some protection from extreme weather events, the Port of Maputo, its rail links, and its oil facilities are situated on the nearby estuary (INGC 2009). The projected higher risk of flooding in Maputo Province (World Bank Group 2010) also means that climate change increases the likelihood of flood-related damages to the national highway (NH1), which runs north-south, connecting the capital city, Maputo, with major cities northward. This risk was highlighted during the recent flooding in the area (Club of Mozambique 2023b; ACAPS 2023). Indeed, the GoM has been considering building an alternative road, linking Maputo Province to Manica, to connect the country in flood situations when the NH1 is damaged (Artigo 2022).

The second major transport link—Beira Corridor (in the center, connecting the port city of Beira to Tete Province, and internationally to Harare, Zimbabwe, and Lusaka, Zambia, as well as Democratic Republic of the Congo (DRC) and Angola)—is particularly vulnerable to climate change. This is in part due to the risks to Beira City from cyclones and sea level rises (discussed above), and in part because of the risk of flooding in some parts of Tete and Sofala Provinces. Finally, the northern regions have the major routes moving east to west, from large port cities into provinces, with some connecting cities like Blantyre in Malawi (DLCA 2018a).

12 Taking into account the role of the transport corridor in logistics coordination, trade facilitation, and impacts on other economic dimensions and on human development (Arup and Cities Alliance 2016).

Northern Mozambique is relatively less vulnerable to sea level rise and cyclones because the coastal zone is on higher ground, with fewer rivers, compared to the central and southern regions (INGC 2009). This implies that risks to the third key growth link—the Nacala Corridor (which passes through Nampula and links Mozambique to Malawi and Zambia, as well as the north of Mozambique to Tete Province)—are relatively lower. That said, the national-level roads that link Zambezia to international corridors are at risk, given the high susceptibility of the region to flooding, which could affect national and international trade, particularly harming the agriculture sector. Notably, damage to Mozambique's transport infrastructure is likely to have regional impacts, as the country is an important conduit for access to global markets, especially as four of its six neighboring countries are landlocked (UNDP, UNEP, and GEF 2020).

**Similarly, Mozambique's port infrastructure, an important component of the national and regional economy, is at risk from climate shocks.** Mozambique has five ports, in Maputo, Beira, Nacala, Quilimane, and Pemba. The Port of Maputo is the largest in Mozambique and offers an important access route for import and export cargoes from South Africa, Swaziland, Zimbabwe, and Botswana (DLCA 2023).[13] However, as discussed above, it is highly vulnerable to flooding (INGC 2009). The Port of Beira is the second largest in Mozambique, and the main port for exports and imports from Sofala, Manica, and Tete Provinces, and is a strategic gateway for the landlocked countries in southeast Africa. It particularly serves transit cargoes, such as copper, tobacco, chrome, timber, and consumer goods, to/from Zimbabwe, Malawi, Zambia, Botswana, and DRC. A fuel pipeline links the port to Zimbabwe (DLCA 2023). This port, however, is vulnerable to flooding and requires adaptation measures even under more moderate projections for sea level rises (INGC 2009). The current seawall (3.4 meters) and the vegetative dune barrier that protects the port and city would be unable to withstand coastal erosion under a high sea level rise scenario, or intense cyclones, thus putting the port and maritime infrastructure at risk (INGC 2009). Similar to the road infrastructure, increased climate shocks on Mozambique's port infrastructure would disrupt regional trade, particularly affecting neighboring nations (Meeuws 2004).

## Broader key macroeconomic impacts and vulnerabilities

**Food inflation due to climate change is likely to exacerbate food security risks in Mozambique.** Mozambique is a net importer of food and is ranked 94 out of 113 on the 2022 Global Food Security Index[14] (ITA 2022; Economist Impact 2022). Its main food imports include rice, wheat, palm oil, sugar, and maize. Its main food exports are tobacco, sugar, legumes, soybeans, seeds, and nuts (cashew, coconut, and Brazil nuts) (FAO 2021; OEC n.d.). Odongo et al. (2022) find that rainfall and temperature variability significantly increase both food and overall inflation in the country. Temperature variability affects Mozambique's capacity to generate electricity, which has implications for food prices (as well as other items in the consumer basket). Baez, Caruso, and Niu (2020) find that maize prices in particular exhibit higher volatility in food markets that are close to areas affected by extreme weather events—which could further increase food security risks for vulnerable communities. Odongo et al. (2022) find a strong transmission of foreign inflation through imported prices to domestic prices. Mozambique predominantly relies on the regional market for some of its key food imports, such as wheat, suggesting that extreme events with regional impact would exacerbate food inflation and, therefore, food security risks in Mozambique. The projected lower yields for maize in Mozambique could increase the country's reliance on maize imports, which are likely to become more expensive, as climate change is also expected to negatively affect maize production in most parts of neighboring countries, such as Zambia and Malawi (Ngoma et al. 2021; Thomas et al. 2022). That said, the climate

13 More than 80 percent of handled cargo is in transit to/from neighboring countries.
14 Benchmarking criteria include: affordability, availability, quality and safety, and sustainability and adaptation.

change impact will vary by crop; for example, the projected improvement in rice yields could create opportunities to reduce Mozambique's dependence on rice imports. Overall, given Mozambique's poverty challenges (more than 60 percent of people live in poverty [World Bank 2023b] and the country ranked 106 of 116 on the 2021 Global Hunger Index [Concern Worldwide and Welthungerhilfe 2021]), food inflation is likely to significantly affect its already vulnerable population.

**Mozambique's dependence on exports with high carbon emissions exposes it to risks from global climate change mitigation efforts.** In particular, its main goods exports are: (i) mineral fuels, mineral oil, and products of their distillation—over 40 percent of total goods exports (largely petroleum gas and coal briquettes, as well as some coke and refined petroleum); and (ii) aluminium articles—about 25 percent of total goods exports (predominantly raw aluminium).[15] This exposes it to international price volatility, while global mitigation policies are projected to relatively reduce fossil fuel prices (Bauer et al. 2016; Carney 2015). Mozambique is expected to be affected by the introduction of the EU's CBAM. According to UNCTAD (2021), it is the 12th most exposed country in the world and second most exposed in Africa (after South Africa), based on the 2019 aggregated value of exports to the EU in sectors considered to be in the CBAM. The CBAM will enter into force in its transition phase as of October 1, 2023, and will apply to imports of cement, iron and steel, electricity, aluminium, hydrogen, and fertilizers. When fully operational, EU importers of goods covered by the CBAM will need to buy CBAM certificates (linked to the EU Emissions Trading System) whose price will be calculated depending on the emissions embedded in the relevant products (Ivleva, Månberger, and Kirr 2022; EC n.d.). For Mozambique, the impact is driven by its aluminium exports, 54 percent of which went to the EU in 2019, amounting to 7 percent of the country's GDP in 2020 (Pleeck, Denton, and Mitchell 2022). Estimates of the CBAM's impact on Mozambique's economy vary: Pleeck, Denton, and Mitchell (2022) calculate that the CBAM could increase the cost of aluminium exports by 39 percent and lead Mozambique's GDP to fall by 1.6 percent (if demand follows the price change). ACF and LSE (2023) expect Mozambique to be affected by the policy but estimate the cost to represent only 0.07 percent of GDP. The impact of the policy will depend on various factors, such as the price of carbon, Mozambique's ability to divert production to non-EU countries, etc. Overall, global transition efforts are likely to pose challenges for Mozambique's mining industry and the risks should be managed strategically to limit the adverse impact on the economy. However, such efforts would help minimize the physical risks from climate change, which are expected to have profound economic and social impacts on the country, as this report illustrates.

**Mozambique has limited fiscal space to take climate adaptation actions, similar to other countries in southern Africa.** Its government debt stood at 102.6 percent in 2022 and interest payments comprised 10.7 percent of revenues in 2022 (AfDB 2023a; Fitch Ratings 2023). Mozambique is exposed to currency risk as 71.0 percent of its total debt stock is foreign exchange-dominated (Fitch Ratings 2023). As described above, climate change could adversely affect its trade balance in the future. Mozambique's fiscal vulnerability could be exacerbated by the ongoing conflict in the northern parts of the country, which creates challenges for political stability and requires increased security spending while disrupting investment flows and tourism activity (AfDB 2023a). While taking adaptation measures could be more cost-effective than frequent disaster relief (Aligishiev, Bellon, and Massetti 2022), it is also likely to have significant implications for Mozambique's fiscal positions under the current climate finance architecture. That said, the recent offer by the Belgian government of a €2.4 million "debt-for-climate swap" could be a positive step toward improving climate and economic resilience in Mozambique (Belgian News Agency 2023).[16]

15 The proportions are based on exports for 2017–2021 (OEC n.d.).

16 Under the proposed swap, the €500,000 that Mozambique pays yearly to the Belgian state would go instead to the Belgian development agency, Enabel, which would use the proceeds for Belgian climate change projects in Mozambique.

# 3. MOZAMBIQUE'S CLIMATE ADAPTATION AND RESILIENCE PLANNING AND PREPAREDNESS

## Climate change policies and government's response

**Mozambique has developed various policies and frameworks to guide its response to climate change.** In 2012, the GoM published its **National Climate Change Adaptation and Mitigation Strategy (2013–2025)**, which outlines implementation mechanisms for coordination, monitoring and evaluation (M&E), and financing. Its **NDC**, first published in 2018 and updated in 2021, aims to reduce GHG by 40 mtCO2e by 2025 and highlights disaster risk management, agriculture, livestock and pastoralism, fisheries, water, infrastructure, tourism, and food systems as some of the key sectors for adaptation and resilience. Mozambique is in the process of establishing a National Climate Change Monitoring and Evaluation System (AfDB and GGGI 2022).

**Climate change is reflected in Mozambique's industrial strategy documents.** The GoM's **National Development Strategy (2015–2035)** (Mozambique, Government of Mozambique 2014), its long-term development framework, underscores the impact of climate change on overall development, particularly in agriculture, infrastructure, and tourism. It contains the mechanisms to cushion the risks in farming and livestock through credit guarantees, crop insurance, and buffer stocks. The government's Five-year Government Program (**2020–2024**) (Mozambique, Government of Mozambique 2020), its medium-term development plan, lists climate change—including implementing Local Adaptation Plans (LAPs), disaster risk management, and water resource management—as one of eight priority areas. It aims to increase its climate-resilient infrastructure by 2024 and to increase the length of dykes from 74 km to 107 km to reduce the vulnerability of communities and the economy to climate risks. In addition, AfDB (2023b) notes that Mozambique has developed climate-informed macroeconomic forecasts, which should also support its policy preparedness to manage climate change-related risks and the integration of climate considerations into other regulatory actions.

**Mozambique is in the process of developing its National Adaptation Plan (NAP).** In 2017, the country, with the support of the National Adaptation Plan Global Support Programme (NAP-GSP), commenced development of a roadmap to develop Mozambique's NAP (UNDP, UNEP, and GEF 2020; Irish Aid 2017). It also produced a stocktaking report that analyzed the information and knowledge gaps and the barriers: (i) financial; (ii) technological and knowledge; and (iii) political and institutional (UNDP n.d.). However, achieving further progress has been challenging. As of 2019, Mozambique indicated to the NDC Partnership a gap in support in the NAP process in the following areas: adaptation M&E; climate risk and vulnerability assessment; proposal development; resource mobilization strategies; adaptation investment plans; and NAP development (Murphy 2019). The NAP will build on the **National Adaptation Programme of Action (NAPA)** (Mozambique, Ministry for the Coordination of the Environmental Affairs 2007), which details short- and long-term actions in four key areas: strengthening early warning systems; strengthening agricultural producers' capacities to cope with a changing climate; reducing climate change impacts on coastal zones; and managing water resources.

**The country has prioritized the development of LAPs,** which offer a decentralized and inclusive approach to adaptation planning at the district level. Mozambique's LAPs focus on early warning systems, floodplain and biodiversity protection, food security, countering soil degradation, green innovation and technologies, and climate resilience in hotspots: urban, tourist, and coastal areas. As of 2021, 132 districts of the 154 districts had formulated LAPs (Mozambique, Ministry of Land and Environment 2021). These LAPs will inform the development of Mozambique's strategy to climate adaptation and resilience at the national level (UNDP, UNEP, and GEF 2020).

**The GoM's focus on limiting deforestation is likely to yield adaptation and mitigation co-benefits.** A recent assessment by AfDB and GGGI (2022) of Mozambique's green growth readiness, alongside Gabon, Kenya, Morocco, Rwanda, Senegal, and Tunisia, finds the GoM's proactive approach to limiting deforestation to be an example of best practices. This includes development of a Forest Investment Plan focused on implementing the national Reducing Emissions from Deforestation and Forest Degradation (REDD+) strategy, which includes a reform of the forestry sector. The forestry sector generates 80 percent of the country's total GHG emissions. The assessment overall finds that Mozambique has been successful in delivering green growth outcomes relative to the state of its enabling environment, primarily because of prioritizing issues linked to livelihoods (such as deforestation) and adopting green growth and climate-resilient economy strategies.

## Climate adaptation preparedness

Annex A summarizes the GoM's climate change governance framework and highlights a number of key projects. Other measures in key climate-sensitive sectors are detailed below.

### *Agriculture*

**The GoM has taken steps to enhance its preparedness for climate change in agriculture.** Its approach focuses on: (i) the overall development of the agricultural value chain as captured in the **Strategic Plan for the Development of the Agriculture Sector (PEDSA II, 2030)** (Mozambique, Ministry of Agriculture and Rural Development 2022); and (ii) the strengthening of food and nutritional security, as outlined in the **Food Security and Nutrition Strategy** (ESAN III). More specifically, planned interventions in the crop subsector include: (i) improving irrigation by building and rehabilitating irrigation systems, strengthening irrigation management, and using sustainable low-cost irrigation technologies; (ii) promoting CSA practices among farmers; (iii) doubling the number of small and medium-sized farmers who use improved agricultural inputs such as seeds, fertilizers, and pesticides; and (iv) developing improved harvesting, transportation, processing, and storage of products from strategic value chains, reducing postharvest losses in maize (13.4 percent to 6.7 percent), rice (21.2 percent to 10.6 percent by 2030), and tomatoes (40 percent to 15 percent) between 2022 and 2030. Strategies to increase the resilience of fisheries include regeneration of aquatic breeding areas, corals, and mangroves and marine ecosystem management (Mozambique, Ministry of Agriculture and Rural Development 2022).

Mozambique's industrialization program, **PRONAI** (2021), aims to increase domestic agricultural production of value-added products while selectively substituting imports. It includes establishing 24 special economic zones for agriculture and identifies several priority subsectors—including horticulture, rice, soya beans, sesame, wheat, cashew nuts, maize, poultry, and livestock—as key areas for development (ITA 2022).[17]

17 The project is financed by the African Development Bank. It will be implemented over a five-year period, starting in 2022, with a total cost of US$47 million.

CIAT and World Bank (2017) cite the need for better sectoral coordination of CSA activities and to target the most vulnerable smallholder farmers. Increased private sector participation is needed to scale CSA practices in Mozambique. Annexes A and B detail existing initiatives and funding mechanisms for sustainable agriculture in Mozambique.

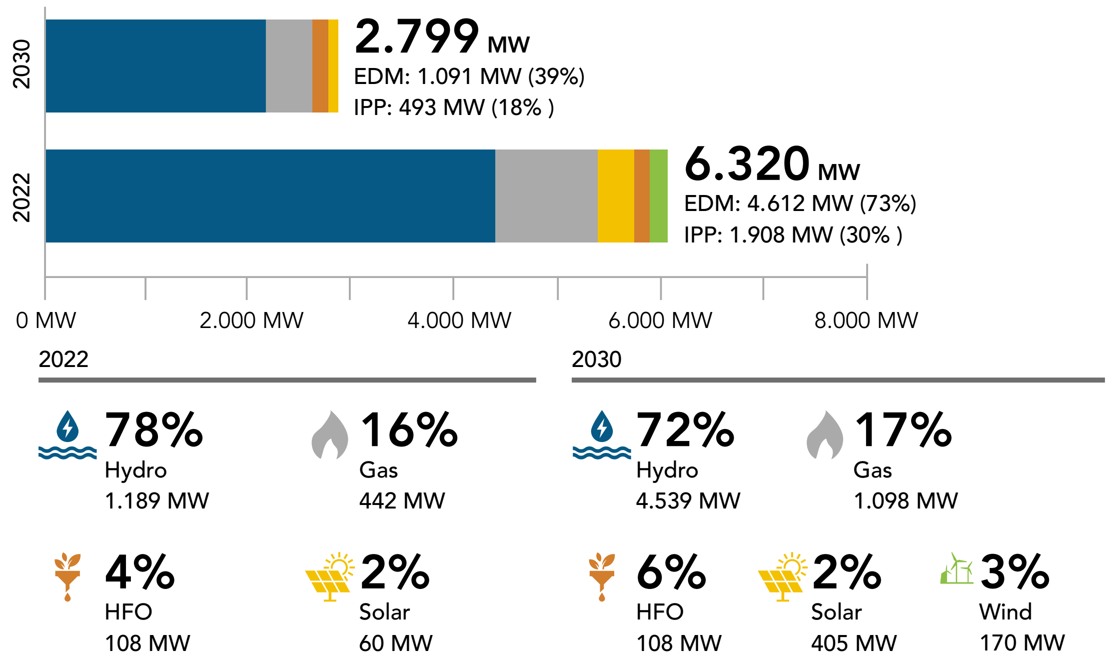
### *Energy*

**Mozambique has been working on various initiatives to enhance its preparedness in the energy sector,** particularly in response to the challenges posed by climate change and the need for sustainable energy development. **The Integrated Power Sector Master Plan** (2018–2043) is Mozambique's primary policy framework for the power sector. It aims to achieve specific targets, including increasing installed capacity to 6 gigawatts (GW) by 2030 and integrating 20 percent of renewable energy—excluding large hydro plants—into the energy mix (Energypedia 2023). Figure 12 illustrates the GoM's plans for the country's energy mix by 2030. Mozambique is gradually abolishing fossil fuel subsidies and increasing electricity prices to reflect commercial realities in the sector (AfDB and GGGI 2022).

With regard to hydropower development, Mozambique's **National Development Strategy** highlights the country's hydropower potential given the presence of rivers, including the Zambezi and Limpopo. The GoM's Five-Year Plan envisages increasing installed hydropower capacity from 2,189 MW in 2022 to 4,539 MW in 2030 (ALER and AMER 2022). The NDC outlines the country's intention to add over 5 GW of hydropower, but this could have impacts on other irrigation and blue economy projects, as well as regional implications in southern Africa (Mozambique, Ministry of Land and Environment 2021; Uamusse, Tussupova, and Persson 2020).

With regard to renewable energy, the **National Electrification Strategy** (ENE) aims to provide affordable and sustainable energy, with 30 percent from off-grid sources—solar, wind, and mini-hydro—by 2030. Objectives of the **New and Renewable Energy Development Strategy** (2011–2025)

**Figure 12:** Mozambique's installed capacity for 2022 and (projected) 2030, by energy source




*Source: ALER and AMER (2022), representing data from Mozambican Electricity Company (EDM).*

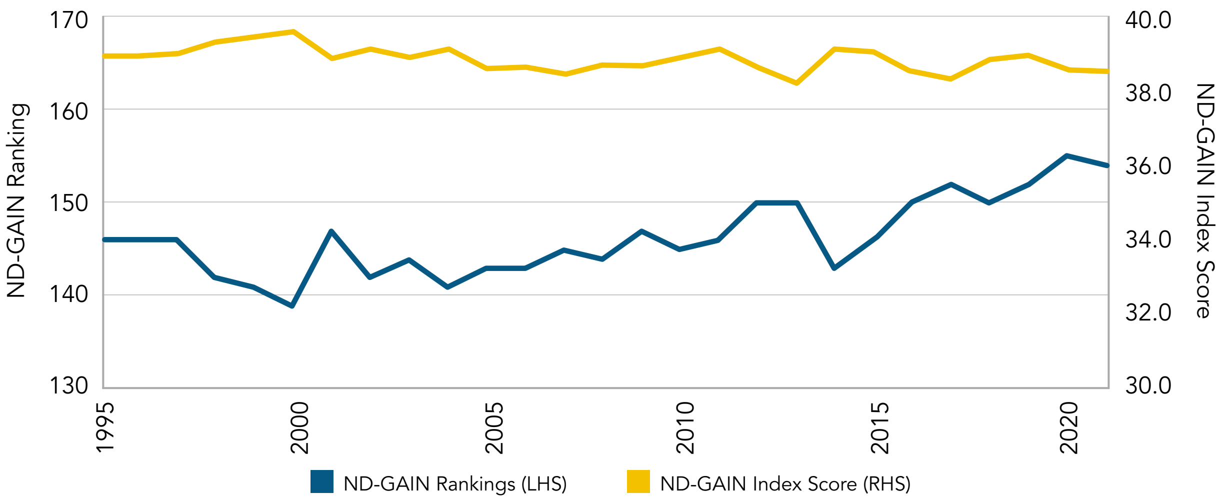
*Note: IIP = Independent Power Producer* for both off-grid and on-grid systems are to: (i) improve energy access through renewable energy; (ii) develop renewable energy technologies; and (iii) accelerate private capital into renewable energy. The strategy itemizes various incentives—import tax exemptions, value-added tax (VAT) exemptions for rural electrification, and corporate tax exemptions for foreign enterprises expanding access to electrification for rural communities—to scale off-grid adoption in Mozambique (Nachmany et al. 2015). Mozambique was one of the first countries to set up a rural energy fund, FUNAE, which supports renewable energy access. However, attracting private sector capital and scaling up green growth has been a challenge (AfDB and GGGI 2022).

## Challenges to country preparedness

**Mozambique remains highly vulnerable to a changing climate, with limited capacity to adapt to impacts.** The country's rank on the ND-GAIN Index declined over the last decade: 146 in 2011, 150 in 2016, and 154 as of 2021—with a score of 38.5 (Figure 13). Currently, this southeastern African nation is the 50th most vulnerable and the 173rd least ready country in the world. Mozambique's key vulnerabilities are the projected impact on the cereal yields (particularly maize); low technology adoption in agriculture; and the low number of medical staff in the country. The country's readiness remains low as a result of poor social readiness in education and innovation.

**A number of structural and other prevailing gaps limit climate adaptation preparedness in Mozambique.** The National Climate Change Adaptation and Mitigation Strategy lists some barriers to climate response and governance, including: (i) **complex institutional and multisectoral coordination** that limits the mainstreaming and implementation of climate policies; (ii) **lack of data** and systematic observation to determine real impacts of climate change; and (iii) **limited knowledge, financial resources, and technology** for climate change response at the central and local level, in communities, and among the private sector. The knowledge gap was also listed in the NDC as a barrier to setting up a functional Measurement, Reporting, and Verification (MRV) system (Mozambique, Ministry of Land and Environment 2021).

**Figure 13:** ND-GAIN Index for Mozambique, 1995–2021




*Source: Notre Dame Global Adaptation Initiative (ND-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.*

UNDP, UNEP, and GEF (2020) underscore the **lack of technical capacity** to mainstream climate change in national, provincial, and district planning and budgeting systems as a huge limitation to scaling adaptation in Mozambique. On-farm adoption of CSA practices and technologies by small-scale farmers is generally hindered by low access to knowledge and technology, high investment costs (especially in the case of multifunctional boreholes), as well as limited opportunities for credit and insurance access (CIAT and World Bank 2017). More broadly, AfDB and GGGI (2022) find the limited capacity for and experience in formulating and enforcing green growth legislation and standards to be a key constraint to Mozambique's green growth readiness. Low human capacity is identified as a critical challenge for the implementation of NDCs and Sustainable Development Goals in Mozambique, especially for scaling up private sector involvement.

**Mozambique faces significant challenges to closing the substantial funding gap for climate adaptation measures.** These include the limited capacity and coordination to drive a national framework to mobilize and raise funds; insufficient coordination between public and private sectors; low awareness of green finance; and limited dissemination of information on programs and policies, including insurance schemes (EED Advisory 2021; Tafese 2016). Structural constraints, such as Mozambique's fiscal position and the underdevelopment of its financial sector, exacerbate these challenges. Annex B provides an overview of Mozambique's climate finance landscape.

# 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 Mozambique, investment would be particularly important with respect to adapting the agriculture sector to projected changes in the climate in the country (with focus on food security) and to improving the resilience of critical infrastructure. The latter will also help reduce adverse knock-on effects from climate change to other sectors, as well as to other economies in southern Africa, given Mozambique's role as a conduit for regional and international trade. Overall, this report underscores the importance of a broader approach to climate adaptation that also helps achieve industrial diversification and structurally reduce Mozambique's exposure to climate-sensitive sectors. A potential ARIP could help support future adaptation efforts, such as by facilitating:

**Adaptation of the agriculture sector, including diversification away from maize production.** This could help reduce food security risks in Mozambique, as well as take advantage of new opportunities where changing climate conditions can have a positive impact on other food crops. A strategic approach may also require further cost-benefit analysis and consideration of what the impact of climate change on agricultural production regionally would mean for Mozambique, given its dependence on food imports. Improved regional coordination on climate change adaptation for agriculture, which platforms like ARIP could help facilitate, could help address food security risks at regional level (particularly as maize production is likely to be adversely affected by climate change in neighboring countries) and identify comparative advantages under the changing climate conditions. For example, Odongo et al. (2022) suggest development of coordinated climate action strategies, including a continental green growth investment package with clear responsibilities across African countries to address food import dependencies. Adaptation measures for the agriculture sector include improved use of irrigation, which would help manage drought periods, particularly in areas where agricultural production takes place in arid or semi-arid lands. However, the increased occurrence of floods from heavy rainfall and cyclones requires an ambitious consideration of how to improve the sector's climate resilience, including through improved use of agricultural insurance. In addition, Manuel et al. (2020) report evidence of lack of coordination between different initiatives in the agriculture sector, which results in overlaps.

**Improvement of the climate resilience of critical infrastructure.** The GoM's efforts to improve early warning systems have already yielded important benefits, as they helped reduce the casualties during Cyclone Freddy (UNDRR 2023). But more consideration of how best to limit the economic costs of increasingly frequent and intense extreme weather events would support economic resilience. Such measures include sealing unpaved roads and strategically expanding the road network to offer alternatives to transportation in flood-prone areas and with respect to international corridors' interconnectedness. With regard to coastal climate resilience, the World Bank Group (2010) highlights the likely high costs and therefore recommends focusing on vital coastal infrastructure (such as key ports) and on reducing the impact on people (rather than the loss of land). It also suggests that the relocation of critical infrastructure may ultimately be necessary. Mucova et al. (2021) recommend the use of ecosystem-based adaptation to address coastal erosion. This includes protecting mangroves, as well as planting other species along the coast that help capture and stabilize coastal sediments, to serve as a natural barrier to strong winds, dampening the rise of seawaters and safeguarding biodiversity. Such measures are likely to yield adaptation, conservation, and mitigation co-benefits. Overall, given the regional and international benefits of Mozambique's transport infrastructure, funding mechanisms could be explored on a regional basis and with more engagement with the private sector, given the potential climate risk management benefits particularly for export-oriented companies, as well as broader environmental benefits of ecosystem-based adaptation.

A strategic approach to climate adaptation, ensuring that climate considerations are integrated in the nation's industrial strategy. This could, for example, involve consideration of how climate change may affect the development of Mozambique's hydropower sector, building on the observations in this report and on the adaptation and mitigation strategies of neighboring countries. Uamusse, Tussupova, and Persson (2020) note the need for strong and cooperative governance arrangements, including at regional level, to manage shared water resources, particularly given the likely expansion of irrigation, planned hydropower capacity improvement, and the projected increased precipitation variability due to climate change. They also suggest increasing transmission capacity within and between countries (such as through initiatives akin to the joint European electricity market). Odongo et al. (2022) recommend focusing on expanding solar and wind sources to reduce reliance on hydroelectricity, which is expected to help reduce electricity prices and inflation. Similarly, while Mozambique's industrial strategy considers agricultural priorities, ensuring that these reflect robust, up-to-date climate projections would support their effectiveness. Overall, a national-level, cross-sectoral climate adaptation and investment strategy could facilitate such considerations. This vision is particularly important given Mozambique's decentralized approach to climate adaptation. While the approach presents an interesting case study for the benefits of a locally led adaptation response, it may need to be supplemented with more analysis to identify strategic opportunities for transformative adaptation (that is, going beyond disaster risk management and exploring opportunities for climate and economic resilience).

Development of technical capacity and improved access to robust, up-to-date climate projections. An ARIP could support the development of Mozambique's climate adaptation and resilience strategy, including its NAP process, by facilitating access to technical expertise and relevant data and modelling. This could help address the capacity challenges to the GoM's response, as noted above. It could also help ensure that climate-related policies, as well as industrial policies such as PRONAI, reflect the latest projections of the potential impact of climate change in Mozambique. Support with technical capacity could also help the GoM and relevant regulatory bodies in developing a green finance framework, including supporting policies and guidelines.

Mobilization of finance for adaptation at scale that delivers a consistent and effective climate adaptation response. Mozambique's limited fiscal space and challenges in mobilizing investment from the private sector represent key constraints to its ability to take climate and resilience adaptation measures, including the recommendations in this report. An ARIP should therefore prioritize efforts for mobilization of funding for climate adaptation and resilience. A national-level adaptation and resilience strategy, including an investment plan and a pipeline of projects, could facilitate the country's ability to engage with donors and investors. It could also help reduce duplication and maladaptation risks. For example, Manuel et al. (2020) find evidence of poor communication and knowledge-sharing between resilience initiatives in the agriculture sector in Mozambique. A national-level investment plan could help ensure that funding mobilized through different initiatives (such as through debt-for-climate swaps) is implemented in a manner that supports the national adaptation strategy.

# REFERENCES


ACAPS. 2023. *Flooding in Maputo Province and City*. Briefing Note. Geneva: ACAPS. https://reliefweb.int/report/mozambique/acaps-briefing-note-flooding-maputo-province-and-city-23-february-2023

ACF (African Climate Foundation) and LSE (London School of Economics and Political Science). 2023. *Implications for African Countries of a Carbon Border Adjustment Mechanism in the EU*. Cape Town, South Africa: African Climate Foundation; London: London Schools of Economics and Political Science. https://www.lse.ac.uk/africa/assets/Documents/AFC-and-LSE-Report-Implications-for-Africa-of-a-CBAM-in-the-EU.pdf

AfDB (African Development Bank). 2023a. "Private Sector Financing for Climate Action and Green Growth in Africa." In *Africa Economic Outlook,* Chapter 2, 61–108. Abidjan, Côte d'Ivoire: AfDB. https://www.afdb.org/sites/default/files/aeo_2023-chap2-en.pdf

AfDB. 2023b. "Mozambique Economic Outlook." Retrieved July 19, 2023, from https://www.afdb.org/en/countries/southern-africa/mozambique/mozambique-economic-outlook#:~:text=The%20fiscal%20deficit%20is%20projected,of%20liquefied%20natural%20gas%20projects

AfDB. 2023c. "Mozambique—Climate Insurance Finance and Resilience Project (CLINFIREP)." Retrieved July 22, 2023, from https://projectsportal.afdb.org/dataportal/VProject/show/P-MZ-AAG-008

AfDB and GGGI (Global Green Growth Institute). 2022. *Africa Green Growth Readiness Assessment*. Abidjan, Côte d'Ivoire: AfDB; Seoul: GGGI. https://www.afdb.org/en/documents/africa-green-growth-readiness-assessment

ALER (Associação Lusófona de Energias Renováveis) and AMER (Associação Moçambicana de Energias Renováveis). 2022. *Renewables in Mozambique*. Briefing Note. Lisbon: ALER; Maputo, Mozambique: AMER. https://mocambique.lerenovaveis.org/contents/lerpublication/a4_resumo_renov_moz_2022_vfinal.pdf

Aligishiev, Z., M. Bellon, and E. Massetti. 2022. *Macro-fiscal Implications of Adaptation to Climate Change*. IMF Staff Climate Note 2022/002. Washington, DC: International Monetary Fund (IMF). https://www.imf.org/-/media/Files/Publications/Staff-Climate-Notes/2022/English/CLNEA2022002.ashx

ANE (Administração Nacional de Estradas). 2023. "Destroyed by 'FREDDY' 18.3 Million Needed for Road Rehabilitation." *ANE News*, June 15. https://ane.gov.mz/destruidas-pelo-freddy-necessarios-18-3-milhoes-para-reabilitacao-de-estradas/

Armand, A., J.F. Gomez, and I.K. Taveras. 2019. *Managing Agricultural Risk in Mozambique*. Project Report. London: International Growth Centre. https://www.theigc.org/publications/managing-agricultural-risk-mozambique

Arndt, C., P. Chinowsky, C. Fant, S. Paltsev, C.A. Schlosser, K. Strzepek, F. Tarp, and J. Thurlow. 2019. "Climate Change and Developing Country Growth: The Cases of Malawi, Mozambique, and Zambia." *Climatic Change* 154 (3–4): 335–349. https://doi.org/10.1007/s10584-019-02428-3

Arndt, C., P. Chinowsky, K. Strzepek, and J. Thurlow. 2011. "Climate Change and Infrastructure Investment in Developing Countries: The Case of Mozambique." WIDER Working Paper No. 2011/92. United Nations University World Institute for Development Economics Research (UNU-WIDER), Helsinki, Finland. http://hdl.handle.net/10419/81011

Arndt, C., and J. Thurlow. 2015. "Climate Uncertainty and Economic Development: Evaluating the Case of Mozambique to 2050." *Climatic Change* 130 (1): 63–75. https://doi.org/10.1007/s10584-014-1294-x

Artigo, O.E. 2022. "Mozambique Will Have an Alternative Highway to N1." *360Mozambique*, October 21. https://360mozambique.com/business/infrastructures/mozambique-will-have-an-alternative-highway-to-n1/

Arup and Cities Alliance. 2016. *Mozambique—Growth Corridors*. Washington, DC: Arup; Brussels: Cities Alliance. https://www.arup.com/-/media/arup/files/publications/f/future-cities-africa--mozambique.pdf

Baez, J.E., G. Caruso, and C. Niu. 2020. "Extreme Weather and Poverty Risk: Evidence from Multiple Shocks in Mozambique." *Economics of Disasters and Climate Change* 4 (1): 103–127. https://doi.org/10.1007/s41885-019-00049-9

Bari, M., and S. Dessus. 2022. "Adapting to Natural Disasters in Africa: What's in it for the Private Sector?" Working Paper. International Finance Corporation, Washington, DC. https://www.developmentaid.org/api/frontend/cms/file/2022/11/Working-Paper-Adapting-to-Natural-Disasters-in-Africa-1.pdf

Bauer, N., I. Mouratiadou, G. Luderer, L. Baumstark, R.J. Brecha, O. Edenhofer, and E. Kriegler. 2016. "Global Fossil Energy Markets and Climate Change Mitigation – An Analysis with REMIND." *Climatic Change* 136 (1): 69–82. https://doi.org/10.1007/s10584-013-0901-6

Belgian News Agency. 2023. "Belgium Offers Mozambique 2.4m Euro Debt-for-Climate Swap." *Belgian News Agency*, June 23. https://www.belganewsagency.eu/belgium-offers-mozambique-24-million-debt-for-climate-swap

BGS (British Geological Society). 2015. "Mozambique Climate Zones." Retrieved July 15, 2023, from https://earthwise.bgs.ac.uk/index.php/File:Mozambique_ClimateZones.png

Carney, M. 2015. "Breaking the Tragedy of the Horizon—Climate Change and Financial Stability." Speech given at Lloyd's of London, London, September 29. https://www.bankofengland.co.uk/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability

CCI France Mozambique (Chamber of Commerce France Mozambique). 2023. "EDM Plans to Increase Electricity Exports to SADC Countries." *CCI France Mozambique News*, January 11. https://www.cciframoz.fr/actualites/n/news/edm-plans-to-increase-electricity-exports-to-sadc-countries.html

Chen, C., I. Noble, J. Hellmann, J. Coffee, M. Murillo, and N. Chawla. 2015. *University of Notre Dame Global Adaptation Index*. Country Index Technical Report. Notre Dame, IN: University of Notre Dame. https://gain.nd.edu/assets/254377/nd_gain_technical_document_2015.pdf

Chinowsky, P.S., A.E. Schweikert, N.L. Strzepek, and K. Strzepek. 2015. "Infrastructure and Climate Change: A Study of Impacts and Adaptations in Malawi, Mozambique, and Zambia." *Climatic Change* 130 (1): 49–62. https://doi.org/10.1007/s10584-014-1219-8

CIAT (International Center for Tropical Agriculture) and World Bank. 2017. *Climate-Smart Agriculture in Mozambique*. CSA Country Profiles for Africa Series. Cali, Colombia: CIAT; Washington, DC: World Bank. https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA-in-Mozambique.pdf

Club of Mozambique. 2023a. "Lack of Decent Roads Hinders Development." *Club of Mozambique*, April 5. https://clubofmozambique.com/news/lack-of-decent-roads-hinders-development-235493/

Club of Mozambique. 2023b. "Mozambique: Floods Threaten National Highway Number 1." *Club of Mozambique*, February 14. https://clubofmozambique.com/news/mozambique-floods-threaten-national-highway-number-1-233746/

Comino, J. 2021. "Beira-Mozambique, After the Storm. A GIS-based Application of Multisource Data Collection and Tropical Cyclone Idai Damage Assessment." Master's thesis, Interuniversity Department of Regional and Urban Studies and Planning, Politecnico di Torino, Torino, Italy. https://webthesis.biblio.polito.it/secure/20954/1/tesi.pdf

Concern Worldwide and Welthungerhilfe. 2021. Global Hunger Index. Dublin: Concern Worldwide; Bonn, Germany: Welthungerhilfe. https://www.globalhungerindex.org/pdf/en/2021.pdf

DLCA (Digital Logistics Capacity Assessments). 2018a. "2.4 Mozambique Railway Assessment." Retrieved July 24, 2023, https://dlca.logcluster.org/24-mozambique-railway-assessment

DLCA. 2018b. "2.3 Mozambique Road Assessment." Retrieved July 24, 2023, https://dlca.logcluster.org/display/DLCA/2.3+Mozambique+Road+Assessment

DLCA. 2023. "2.1 Mozambique Port Assessment." Retrieved July 24, 2023, https://dlca.logcluster.org/display/DLCA/2.1+Mozambique+Port+Assessment

EC (European Commission). n.d. "Carbon Border Adjustment Mechanism." Retrieved July 24, 2023, https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en

Eckstein, D., V. Künzel, and L. Schäfer. 2021. *Global Climate Risk Index 2021*. Bonn, Germany: GermanWatch. Retrieved July 20, 2023, https://www.germanwatch.org/en/19777

Economist Impact. 2022. "Global Food Security Index 2022." The Economist. https://impact.economist.com/sustainability/project/food-security-index/

EED Advisory. 2021. *An Assessment of the Financial Sector and Green Finance Policy Landscape in Mozambique*. Nairobi, Kenya: EED Advisory. https://eedadvisory.com/wp-content/uploads/2022/08/An-Assessment-of-the-Financial-Sector-and-Green-Finance-Policy-Landscape-in-Mozambique.pdf

Energy Capital & Power. 2021. "Top 10 Hydropower Plants in Africa." *Energy Capital & Power News*, July 1. https://energycapitalpower.com/top-10-hydropower-plants-in-africa/

Energypedia. 2023. "Policy Framework and Energy Access Strategies in Mozambique." Retrieved July 19, 2023 from https://energypedia.info/wiki/Policy_Framework_and_Energy_Access_Strategies_in_Mozambique#cite_ref-10

Espinet, X.A., J. Rozenberg, K. Singh, and S. Ogita. 2018. "Piloting the Use of Network Analysis and Decision-Making Under Uncertainty in Transport Operations: Preparation and Appraisal of a Rural Roads Project in Mozambique Under Changing Flood Risk and Other Deep Uncertainties." World Bank Policy Research Working Paper No. 8490. World Bank, Washington, DC. https://ssrn.com/abstract=3238328

Fant, C., Y. Gebretsadik, A. McCluskey, and K. Strzepek. 2015. "An Uncertainty Approach to Assessment of Climate Change Impacts on the Zambezi River Basin." *Climatic Change* 130 (1): 35–48. https://doi.org/10.1007/s10584-014-1314-x

Fant, C., Y. Gebretsadik, and K. Strzepek. 2013. "Impacts of Climate Change on Crops, Irrigation and Hydropower in the Zambezi River Basin." WIDER Working Paper 2013/039. World Institute for Development Economics Research, Helsinki, Finland. https://www.wider.unu.edu/sites/default/files/WP2013-039.pdf

FAO (Food and Agriculture Organization of the United Nations). n.d. "FAO in Mozambique: Mozambique at a Glance." Retrieved July 26, 2023, https://www.fao.org/mozambique/fao-in-mozambique/mozambique-at-a-glance/en/

FAO. 2016. *Country Profile—Mozambique*. FAO Aquastat Reports. Rome: FAO. https://www.fao.org/3/i9805en/I9805EN.pdf

FAO. 2021. "FAOSTAT: Commodities by Country." Retrieved July 26, 2023, http://www.fao.org/faostat/en/#rankings/commodities_by_country_imports

FEWS NET (Famine Early Warning Systems Network). 2014. *Mozambique: Livelihood Zone Descriptions*. Washington, DC: USAID. https://fews.net/southern-africa/mozambique/livelihood-description/august-2014

Fitch Ratings. 2023. "Fitch Affirms Mozambique at 'CCC+'." *Fitch Ratings*, February 17. https://www.fitchratings.com/research/sovereigns/fitch-affirms-mozambique-at-ccc-17-02-2023

GIZ (Deutsche Gesellschaft Für Internationale Zusammenarbeit). n.d. "Adaptation to Climate Change." Retrieved July 24, 2023, https://www.giz.de/projektdaten/projects.action?request_locale=en_GB&pn=201422831

Hamududu, B.H., and H. Ngoma. 2020. "Impacts of Climate Change on Water Resources Availability in Zambia: Implications for Irrigation Development." *Environment, Development and Sustainability* 22 (4): 2817–2838. https://doi.org/10.1007/s10668-019-00320-9

INE (Instituto Nacional de Estatísticas). 2015. *Relatório Final do Inquérito ao Orçamento Familiar – IOF 2014/15*. Maputo, Mozambique: INE. http://mozdata.microdatahub.com/index.php/catalog/19

INGC (National Institute for Disaster Management). 2009. *Study on the Impact of Climate Change on Disaster Risk in Mozambique*. Synthesis Report. Maputo, Mozambique: INGC. https://www.biofund.org.mz/wp-content/uploads/2018/10/F2346.National-Institute-for-Disaster-ManagementStudy-on-the-Impact-of-Climate-Change--Ingc-Altera--Oes-Climaticas-En.pdf

INIR (Instituto Nacional de Irrigação). 2013. *A Perspectiva das Instituições Contratantes*. Maputo, Mozambique: INIR. http://www.ppa.pt/wp-content/uploads/2013/06/INIR_PM_Perspectiva_contrat_20130531.pdf

Irish Aid. 2017. *Mozambique Climate Action Report for 2016*. Dublin: Irish Aid. https://www.irishaid.ie/media/irishaid/allwebsitemedia/30whatwedo/climatechange/Mozambique-Country-Climate-Action-Report-for-2016.pdf

ITA (International Trade Administration). 2022. "Mozambique—Country Commercial Guide." Retrieved July 20, 2023, https://www.trade.gov/country-commercial-guides/mozambique-agricultural-sectors

Ivleva, D., A. Månberger, and J. Kirr. 2022. *A Game Changing? The Geopolitics of Decarbonisation through the Lens of Trade*. Adelphi, MD: Adelphi Research. https://www.researchgate.net/publication/357880052_A_game_changing_The_geopolitics_of_decarbonisation_through_the_lens_of_trade

Jones, J.W., G. Hoogenboom, C.H. Porter, K.J. Boote, W.D. Batchelor, L.A. Hunt, P.W. Wilkens, U. Singh, A.J. Gijsman, and J.T. Ritchie. 2003. "The DSSAT Cropping System Model." *European Journal of Agronomy* 18 (3–4): 235–265. https://doi.org/10.1016/S1161-0301(02)00107-7

Kirschbaum, M.U.F. 2011. "Does Enhanced Photosynthesis Enhance Growth? Lessons Learned from $CO_2$ Enrichment Studies." *Plant Physiology* 155 (1): 117–124. https://doi.org/10.1104/pp.110.166819

Kuo, L. 2016. "Africa's Biggest Hydropower Plant May Soon Run Out of Water." *Quartz*, December 14. https://qz.com/africa/862789/mozambiques-hydropower-dam-supplies-south-africa-and-zimbabwe-may-soon-run-out-of-water

LBNL (Lawrence Berkeley National Laboratory). 2021. "New Research Shows Plants Are Photosynthesizing More in Response to More $CO_2$ in the Atmosphere." *ScitechDaily*, December 17. https://scitechdaily.com/new-research-shows-plants-are-photosynthesizing-more-in-response-to-more-co2-in-the-atmosphere/

Manuel, L., E. Tostão, O. Vilanculos, G. Mandlhate, and F. Hartley. 2020. "Economic Implications of Climate Change in Mozambique." SA-TIED Working Paper No. 136. UNU-WIDER, Helsinki, Finland. https://sa-tied-archive.wider.unu.edu/article/economic-implications-climate-change-in-mozambique

Mavume, A.F., B.E. Banze, O.A. Macie, and A.J. Queface. 2021. "Analysis of Climate Change Projections for Mozambique Under the Representative Concentration Pathways." *Atmosphere* 12 (5): 588. https://doi.org/10.3390/atmos12050588

Meeuws, R. 2004. *Mozambique—Trade and Transport Facilitation Audit*. Rijswijk, The Netherlands: World Bank. https://documents1.worldbank.org/curated/zh/491651468280489181/pdf/477850WP0MZ0Tr10Box338866B01PUBLIC1.pdf

Mozambique, Government of Mozambique. 2014. *National Development Strategy (2015–2035).* Maputo. https://www.mef.gov.mz/index.php/publicacoes/estrategias/397-estrategia-nacional-de-desenvolvimento/file

Mozambique, Government of Mozambique. 2020. *Five-Year Government Program: 2020-2024*. Maputo. http://www.ts.gov.mz/images/PQG_2020.2024_Versao_AR__02042020-min.pdf

Mozambique, Government of Mozambique, Council of Ministers. 2017. *National Disaster Risk Reduction Master Plan 2017–2030*. Maputo: Republic of Mozambique. https://www.preventionweb.net/files/64564_planodirectorparareducaodoriscodede.pdf

Mozambique, Ministry for the Coordination of the Environmental Affairs. 2007. *National Adaptation Programme of Action (NAPA)*. Maputo. https://unfccc.int/resource/docs/napa/moz01.pdf

Mozambique, Ministry for the Coordination of the Environmental Affairs. 2012. *National Climate Change Adaptation and Mitigation Strategy*. Maputo. https://www.greenpolicyplatform.org/sites/default/files/downloads/policy-database//MOZAMBIQUE%29%20National%20Climate%20Change%20Adaptation%20and%20Mitigation%20Strategy.pdf

Mozambique, Ministry of Agriculture and Rural Development. 2022. *Strategic Plan for the Development of the Agriculture Sector (PEDSA II, 2030)*. Maputo. https://faolex.fao.org/docs/pdf/moz214715.pdf

Mozambique, Ministry of Land and Environment. n.d. "Pilot Climate Resilience Program (PPCR)." https://www.mta.gov.mz/en/climate-changes/adaptation-and-mitigation/

Mozambique, Ministry of Land and Environment. 2021. *Updated First National Determined Contribution of Mozambique*. Maputo. https://unfccc.int/sites/default/files/NDC/2022-06/NDC_EN_Final.pdf

Mucova, S.A.R., U.M. Azeiteiro, W.L. Filho, C.L. Lopes, J.M. Dias, and M.J. Pereira. 2021. "Approaching Sea-Level Rise (SLR) Change: Strengthening Local Responses to Sea-Level Rise and Coping with Climate Change in Northern Mozambique." *Journal of Marine Science and Engineering* 9 (2): 205. https://doi.org/10.3390/jmse9020205

Murphy, D. 2019. "Adaptation Actions in NDC Partnership Plans: Opportunities for Alignment with NAP Processes." *NDC Partnership Partner Blogs*, June 4. https://ndcpartnership.org/news/adaptation-actions-ndc-partnership-plans-opportunities-alignment-nap-processes?fbclid=IwAR0UylDHumXL4U-3e--2kBkcGaZmheRLJvnUipP0iqMjonzRSdAjYt09k-s

Nachmany, M., S. Fankhauser, J. Davidová, N. Kingsmill, T. Landesman, H. Roppongi, P. Schleifer, et al. 2015. *Climate Change Legislation in Mozambique*. London: Grantham Institute. https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/05/MOZAMBIQUE.pdf

ND-GAIN (Notre Dame Global Adaptation Initiative). 2021. "ND-GAIN Country Index, Vulnerability and Readiness." Retrieved July 15, 2023, https://gain.nd.edu/our-work/country-index/rankings/

NEPAD (New Partnership for Africa's Development). 2013. *Country Water Resource Profile: Mozambique*. Lusaka, Zambia: NEPAD. https://www.nepad.org/file-download/download/public/14255

Ngoma, H., P. Lupiya, M. Kabisa, and F. Hartley. 2021. "Impacts of Climate Change on Agriculture and Household Welfare in Zambia: An Economy-Wide Analysis." *Climatic Change* 167 (3–4): 55. https://doi.org/10.1007/s10584-021-03168-z

Odongo, M.T., R.N. Misati, A.W. Kamau, and K.N. Kisingu. 2022. "Climate Change and Inflation in Eastern and Southern Africa." *Sustainability* 14 (22): 14764. https://doi.org/10.3390/su142214764

OEC (Observatory of Economic Complexity). n.d. "Mozambique." Retrieved July 21, 2023, https://oec.world/en/profile/country/moz

Petricola, S., M. Reinmuth, S. Lautenbach, C. Hatfield, and A. Zipf. 2022. "Assessing Road Criticality and Loss of Healthcare Accessibility during Floods: The Case of Cyclone Idai, Mozambique 2019." *International Journal of Health Geographics* 21 (1): 14. https://doi.org/10.1186/s12942-022-00315-2

Pleeck, S., F. Denton, and I. Mitchell. 2022. "An EU Tax on African Carbon – Assessing the Impact and Ways Forward." *Centre for Global Development Blog*, February 10. https://cgdev.org/blog/eu-tax-african-carbon-assessing-impact-and-ways-forward

Power Technology. 2023. "Top Five Hydro Power Plants in Development in Mozambique." Last updated July 19. https://www.power-technology.com/data-insights/top-5-hydro-power-plants-in-development-in-mozambique/

PwC (PricewaterhouseCoopers). 2013. *Africa Gearing Up: Future Prospects in Africa for the Transportation & Logistics Industry – Mozambique*. London: PwC. https://www.pwc.com/gx/en/transportation-logistics/publications/africa-infrastructure-investment/assets/mozambique.pdf

Spalding-Fecher, R., B. Joyce, and H. Winkler. 2017. "Climate Change and Hydropower in the Southern African Power Pool and Zambezi River Basin: System-Wide Impacts and Policy Implications." *Energy Policy* 103: 84–97. https://doi.org/10.1016/j.enpol.2016.12.009

Tafese, S.M. 2016. "Willingness to Pay for Tomato Insurance: The Case Study of Moamba District, Mozambique." Master's thesis, Department of Economics and Agricultural Development, Universidade Eduardo Mondlane, Maputo, Mozambique. http://www.repositorio.uem.mz:8080/xmlui/handle/258/482

Thomas, T.S., R.D. Robertson, K. Strzepek, and C. Arndt. 2022. "Extreme Events and Production Shocks for Key Crops in Southern Africa Under Climate Change." *Frontiers in Climate* 4: 787582. https://doi.org/10.3389/fclim.2022.787582

Uamusse, M.M., K. Tussupova, and K.M. Persson. 2020. "Climate Change Effects on Hydropower in Mozambique." *Applied Sciences* 10 (14): 4842. https://doi.org/10.3390/app10144842

UNCDF (United Nations Capital Development Fund). 2023. "Mozambique Expands Locally-Led Climate Resilience, with Support from the European Union." *UNCDF News*, March 23. https://www.uncdf.org/article/8187/mozambique-expands-locally-led-climate-resilience-with-support-from-the-european-union

UNCTAD (United Nations Conference on Trade and Development). 2021. "EU Should Consider Trade Impacts of New Climate Change Mechanism." *UNCTAD News*, July 14. https://unctad.org/news/eu-should-consider-trade-impacts-new-climate-change-mechanism

UNCTAD. 2022. "Investment Flows to Africa Reached a Record $83 Billion in 2021." *UNCTAD News*, June 9. https://unctad.org/news/investment-flows-africa-reached-record-83-billion-2021

UNDP (United Nations Development Programme). n.d. "Supporting Mozambique to Advance Their NAP Process." Retrieved July 24, 2023, https://www.adaptation-undp.org/projects/mozambique-nap-process

UNDP, UNEP (United Nations Environment Programme), and GEF (Global Environment Facility). 2020. *National Adaptation Plans in Focus: Lessons from Mozambique.* New York: UNDP; Nairobi, Kenya: UNEP; Washington, DC: GEF. https://www.globalsupportprogramme.org/resources/project-brief-fact-sheet/national-adaptation-plans-focus-lessons-mozambique

UNDRR (United Nations Office for Disaster Risk Reduction). 2023. "Cyclone Freddy Puts Mozambique's Early Warning System to the Test." Retrieved July 22, 2023,https://www.undrr.org/feature/cyclone-freddy-puts-mozambique-s-early-warning-system-to-the-test

UNFCCC (United Nations Framework Convention on Climate Change). n.d. "Designated National Authorities (DNA) for Mozambique." Retrieved July 28, 2023, https://cdm.unfccc.int/DNA/DNA/view.html?CID=147

USAID (United States Agency for International Development). 2011. *Property Rights and Resource Governance Country Profile: Mozambique*. Washington, DC: USAID. https://land-links.org/wp-content/uploads/2011/02/USAID-Land-Tenure-Mozambique-Profile-FINAL.pdf

USAID. 2018. *Climate Risk Profile: Mozambique*. Washington, DC: USAID. https://www.climatelinks.org/sites/default/files/asset/document/2018_USAID-ATLAS-Project_Climate-Risk-Profile-Mozambique.pdf

USAID. 2019. "Disaster Response Factsheet: Mozambique." Washington, DC: USAID. https://www.usaid.gov/sites/default/files/2023-02/DISASTER_RESPONSE_Sector_Briefer_-_v5%20%281%29.pdf

WMO (World Meteorological Organization). 2023. "Tropical Cyclone Freddy May Set New Record." *WMO News*, March 10. https://public.wmo.int/en/media/news/tropical-cyclone-freddy-may-set-new-record

World Bank. n.d.-a. "Climate Change Knowledge Portal: Mozambique." Retrieved July 27, 2023, https://climateknowledgeportal.worldbank.org/country/mozambique

World Bank n.d.-b. "Mozambique Vulnerabilities and Historical Hazards." Retrieved July 27, 2023, https://climateknowledgeportal.worldbank.org/country/mozambique/vulnerability

World Bank. n.d.-c. "Mozambique—Trends and Significant Change against Natural Variability." Retrieved July 27, 2023, https://climateknowledgeportal.worldbank.org/country/mozambique/trends-variability-historical

World Bank. n.d.-d. "Agricultural Land (% of Land Area)—Mozambique." World Bank Data. Retrieved August 25, 2023, from https://data.worldbank.org/indicator/AG.LND.AGRI.ZS?locations=MZ

World Bank. n.d.-e "Agriculture, Forestry, and Fishing, Value Added (% of GDP)—Mozambique." World Bank Data. Retrieved August 25, 2023, from https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=MZ

World Bank. n.d.-f. "Arable Land (% of Land Area)—Mozambique." World Bank Data. Retrieved August 25, 2023, from https://data.worldbank.org/indicator/AG.LND.ARBL.ZS?locations=MZ

World Bank. n.d.-g. "Employment in Agriculture (% of Total Employment) (Modeled ILO Estimate)—Mozambique." World Bank Data. Retrieved August 25, 2023, from https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=MZ

World Bank. 2018a. "Forests in Mozambique: A Snapshot." *World Bank Infographics*, December 12. https://www.worldbank.org/en/news/infographic/2018/12/12/forests-of-mozambique-a-snapshot

World Bank. 2018b. "Mozambique Gets $150 Million for Rural Roads in Support of Agricultural Productivity." *World Bank Press Release*, May 8. https://www.worldbank.org/en/news/press-release/2018/05/08/mozambique-gets-150-million-for-rural-roads-in-support-of-agricultural-productivity

World Bank. 2023a. "Mozambique Country Economic Update." *World Bank Press Release*, March 10. https://www.worldbank.org/en/news/press-release/2023/03/10/mozambique-afe-economic-update-why-services-matter-for-growth-jobs

World Bank. 2023b. "Mozambique Overview." Retrieved July 18, 2023, from https://www.worldbank.org/en/country/mozambique/overview

World Bank Group. 2010. *Mozambique—Economics of Adaptation to Climate Change*. Washington, DC: World Bank Group. http://documents.worldbank.org/curated/en/978481468178764388/Mozambique-Economics-of-adaptation-to-climate-change

World Bank Group. 2021. *Fisheries in Mozambique: A Snapshot*. Washington, DC: World Bank Group. http://documents.worldbank.org/curated/en/342481619154376842/Fisheries-in-Mozambique-A-Snapshot

World Population Review. n.d. "Population of Cities in Mozambique 2023." Retrieved July 27, 2023, from https://worldpopulationreview.com/countries/cities/mozambique

WTTC (World Travel and Tourism Council). 2022. *Mozambique 2022 Annual Research: Key Highlights*. London: WTTC. https://wttc.org/DesktopModules/MVC/FactSheets/pdf/704/166_20220613164947_Mozambique2022_.pdf

# ANNEX A: CLIMATE CHANGE GOVERNANCE FRAMEWORK AND INITIATIVES

The Ministry of Land and Environment (MTA) serves as the core governmental body responsible for overseeing and executing policies related to land management, environment, and climate change. As directed by the government, the MTA is tasked with implementation of the NCCAMS. It is also Mozambique's Designated National Authority on climate change for Mozambique under the United Nations Framework Convention on Climate Change (UNFCCC), with the National Director for Environment serving as the focal person (UNFCCC n.d.).

In 2014 the Climate Change Unit (CCU) was established to strengthen intersectoral coordination, strategic orientation, and M&E. The CCU is housed in the National Council for Sustainable Development (CONDES) Secretariat (Mozambique, Ministry for the Coordination of the Environmental Affairs 2012).

The GoM has partnered with various organizations to strengthen Mozambique's adaptation and resilience. Some notable examples of climate change-related programs and projects include:

- MERCIM: Created in 2019 by the Ministry of Land and Environment, the program aims to support locally led adaptation, using performance-based climate grants. It initially focused on districts in Zambezia and Nampula Provinces but has expanded to 10 districts, including some in Cabo Delgado and Sofala. The selection of infrastructure projects was informed by the Local Adaptation Plans (LAPs). Furthermore, the GoM and the EU signed a €10 million agreement for a 4.5-year horizon to expand climate finance in the country through the MERCIM program (UNCDF 2023).

- SUSTENTA: Launched in 2020 by the GoM, with support from the World Bank, the program is worth US$500 million in grants to support training for farmers on sustainable agriculture practices and forest-based value chains. According to the Ministry of Agriculture, crop production increased from 14 to 16 million tons from 2020–2021 because of SUSTENTA (ITA 2022).

- Adapting to Climate Change, GIZ (2012–2020): The program aims to improve adaptation to climate change impacts on water resources of the national framework and the actions taken by relevant stakeholders in the Rio Búzi catchment area (GIZ n.d.).

- Mozambique Coastal City Adaptation Project, USAID (2014–2019): The project is focused on two vulnerable cities along Mozambique's coastline; its goal is to improve their municipal planning processes and their ability to adapt to climate change.

- Cities and Climate Change – Pilot Program for Climate Resilience of Mozambique, World Bank (2012–2019): The program aims to strengthen municipal capacity for sustainable urban infrastructure provision and environmental management, which enhance resilience to climate-related risks.

- Climate Resilience: Transforming Hydro-Meteorological Services Project for Mozambique, World Bank (2013–2019): The objective of the initiative is to strengthen hydrological and meteorological information services to deliver reliable and timely climate information to local communities and to support economic development (UNDP, UNEP, and GEF 2020).

- Pilot Program for Climate Resilience (PPCR): Deployed by the Climate Investment Fund (CIF) and MTA, it covers drought insurance, smallholder irrigation, and land and water resource management across the country.[18] The US$89 million PPCR investment plan also supports upgrading infrastructure, enhancing climate services, and developing its local and national capacities for climate-resilient planning and action (Mozambique, Ministry of Land and Environment n.d.).

- Nature, People and Climate investment program: In 2022, the African Zambezi River Basin Region was selected as one of the first participants in the program, under which Mozambique (as well as Malawi, Namibia, Tanzania, and Zambia) will seek finance to support restoration of 30,000 hectares of degraded wetlands along the Zambezi River Basin.[19]

18 The PPCR is part of CIF's Strategic Climate Fund (SCF) – https://www.cif.org/country/mozambique
19 This is also deployed by CIF – https://www.cif.org/nature-people-climate-program

# ANNEX B:
# CLIMATE FINANCE IN MOZAMBIQUE

**Mozambique faces a significant climate finance gap.** According to AfDB, the total funding required by the country for this decade amounts to US$53 billion—about three times its GDP. This significantly surpasses the US$3.7 billion mobilized during 2011–2020 (AfDB 2023a). Adaptation finance remains important given the need to prioritize adaptation across key sectors. For example, Mozambique needs 14.1 percent of its GDP in upfront private investment to adapt to flooding. The proposed investment, with a stream of revenue equal to the expected GDP losses from floods and droughts, would yield an internal rate of return of 8 percent (Bari and Dessus 2022). Funding is also needed for mitigation actions: AfDB (2023b) estimates that Mozambique needs about US$0.25 trillion to phase out coal and adopt renewables between 2024–2050.

**Currently, climate funding takes different forms and splits across key sectors.** According to a study by EED Advisory (2021), between 2011–2018 about US$1.25 billion was estimated as climate finance inflow into Mozambique, US$0.74 billion and 0.51 billion in loans and grants, respectively. This went into different climate uses in various sectors, such as: energy; agriculture, fishing, and forestry; environmental protection; and other climate-related interventions. Almost one-half (48 percent) was recorded as adaptation finance, 41 percent as mitigation investments, and 11 percent was categorized as cross-cutting during this period. Most of the loans went into mitigation projects.

**The GoM has taken a number of actions to support climate finance market development and to facilitate mobilization of funding for climate change measures.** The GoM set up the Blue Economy Development Fund, FP-ProAzul, to promote development of the blue economy by investing in sustainable fishing and supporting vulnerable regions.[20] The AfDB is currently working with the GoM to promote insurance programs and policies under the Climate Insurance, Finance and Resilience Project (CLINFIREP, 2021–2026). The five-year project seeks to promote climate-resilient, income-generating activities, strengthen food security and nutrition, and enhance insurance mechanisms against climate-related disasters (AfDB 2023c). As discussed above, the GoM has prioritized mobilizing investment to limit deforestation. In agriculture, the government has partnered and accessed funds from the Global Environment Facility's (GEF) Least Developed Countries Fund (LDCF) and World Bank to advance CSA (CIAT and World Bank 2017), noting that the Agricultural Development Fund (ADF) can mainstream adaptation financing into its existing work. More broadly, the Green Economy Action Plan (2013) outlined the role of microfinance and other financial products, but Mozambique has experienced challenges in advancing green finance policies and does not currently have a climate change-specific national fund (EED Advisory 2021). That said, the report states that Mozambique is taking steps to establish green finance policy frameworks. Expansion of the MERCIM program (Annex A) will also support climate finance in the country.

20 ProAzul – https://www.proazul.gov.mz/publicacoes/

**Opportunity exists for the private sector to play a larger role in funding mitigation and adaptation measures.** According to the AfDB (2023b), Mozambique attracted 3.9 percent of private climate investments in Africa between 2019 and 2020, making it one of the top eight destinations on the continent. Furthermore, Mozambique experienced a 68 percent increase in foreign direct investments in 2021 due to a rise in greenfield projects (UNCTAD 2022). That said, further incentives and proactive engagement with the private sector will be necessary to support development of the climate finance market in Mozambique.

THE AFRICAN CLIMATE FOUNDATION

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

CGIAR
INITIATIVE ON Foresight