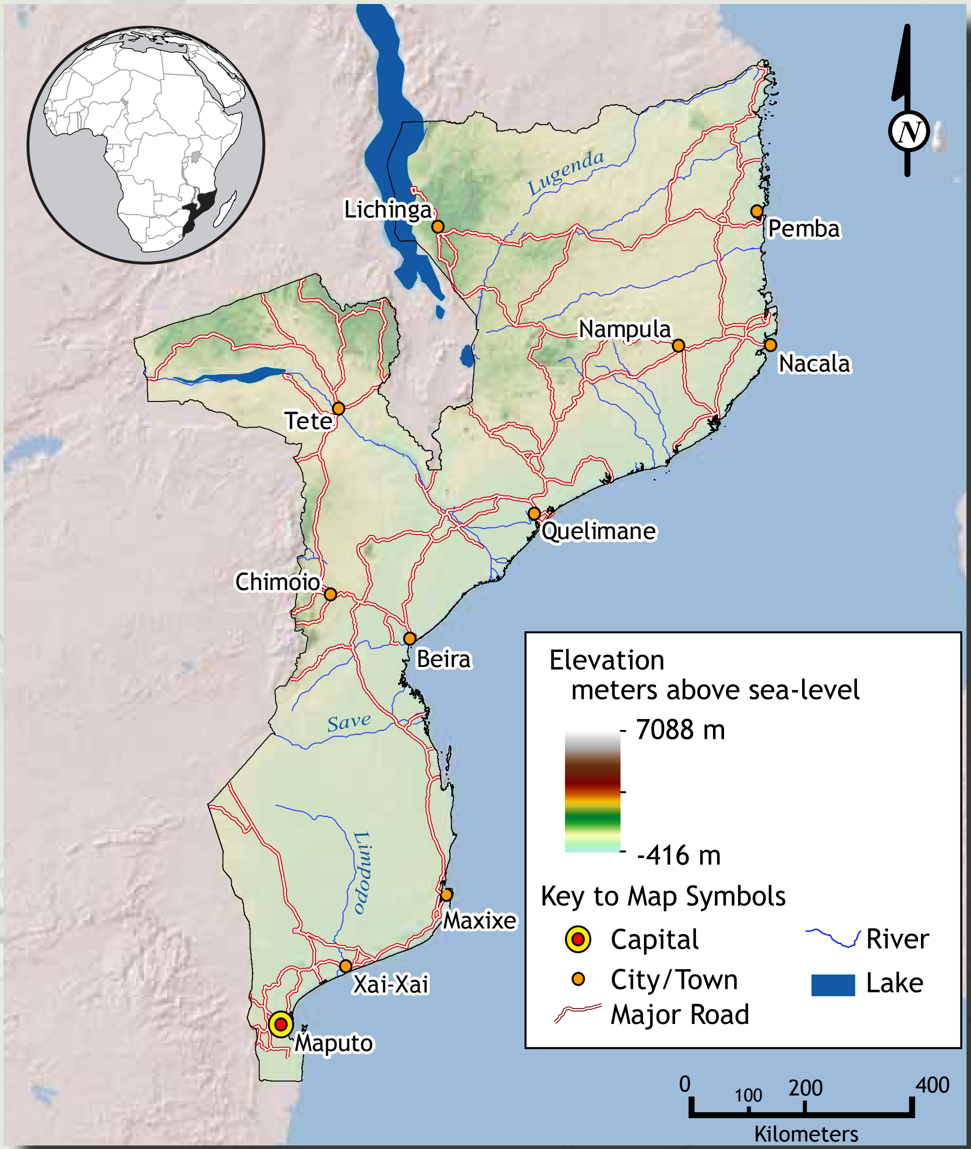

Vulnerability, Risk Reduction, and Adaptation to Climate Change

CLIMATE
DISASTER RISK REDUCTION
ADAPTATION

MOZAMBIQUE

GFDRR
Global Facility for Disaster Reduction and Recovery

Climate Investment Funds

Climate Change Team ENV

COUNTRY OVERVIEW

Mozambique is one of the poorest countries in the world. It faces many development challenges, including pronounced and widespread poverty, low life expectancy (Figure 1), and wide gaps in educational achievement. The country experiences high levels of climate variability and extreme weather events (i.e. droughts, floods, and tropical cyclones). Droughts are the most frequent disaster, occurring every three to four years, and pose a major constraint to development since most of the country's population, especially the poor, reside in rural areas and rely on rain-fed agriculture. Mozambique also lies at the end of numerous transnational river basins and flooding in its deltas is a perennial threat to both farmers and infrastructure, especially when coupled with cyclonic storm surges. Mozambique is already investing in prevention of natural hazards and improving its early warning systems. Adaptation measures are being implemented in the agriculture, fisheries, energy, environmental, and water sectors, with particular attention being paid to the coastal zones and erosion control.

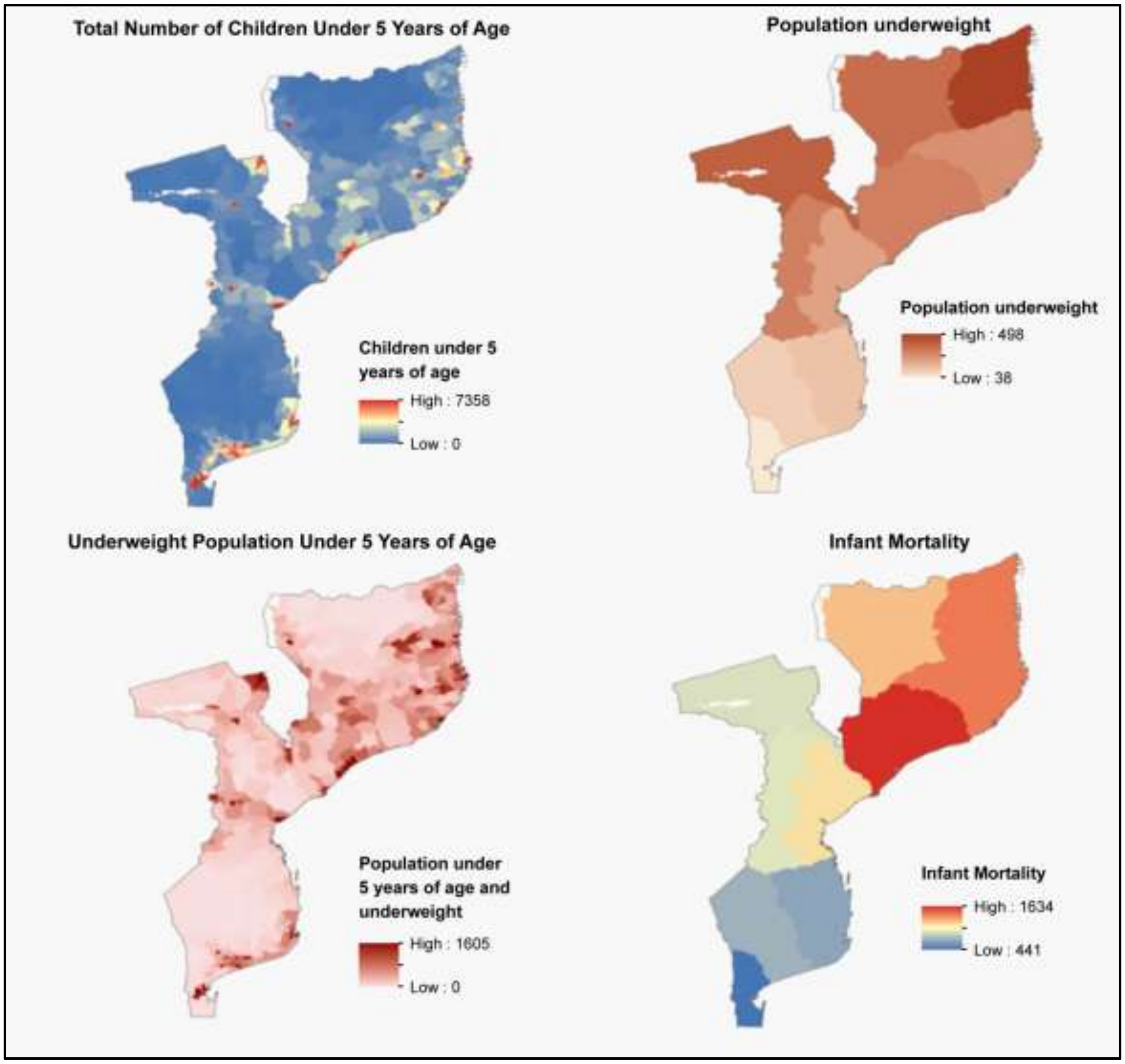

Figure 1: Social vulnerability.

PRIORITY ADAPTATION MEASURES

Priority Adaptation Projects
Improving early warning systems
Strengthening farmer coping capacities
Improving the knowledge and management of rivers
Limiting erosion
Developing sustainable fishing
Promoting public awareness of climate change
Improving agency coordination
Integrating climate change into decentralized district planning

Source: Mozambique National Adaptation Programme of Action and Adaptation Learning Mechanism.

The 2007 Mozambique National Adaptation Programme of Action (NAPA) used a consultative approach to identify urgent and immediate needs for adaptation action in several key areas. Agricultural sustainability, water resource management, public awareness, land use management, and institutional strengthening were all highlighted as priorities. A multi-criteria analysis was subsequently conducted to prioritize activities to be implemented, including: improving early warning systems, strengthening farmer coping capacities, improving the knowledge and management of rivers, limiting erosion, developing sustainable fishing, promoting public awareness of climate change, improving coordination among involved organizations, and integrating climate change into decentralized district planning.

CLIMATE BASELINE AND CLIMATE FUTURE

CLIMATE BASELINE

Major Climate Processes	Impacts on Climate
El Niño	*Warmer and drier than average conditions*
La Niña	*Cold and wet conditions*
ntertropical Convergence Zone (ITCZ)	*Drives rainfall*
rface temperatures in the Indian Ocean	

Mozambique is located on the eastern coast of southern Africa at 11-26° south of the equator, and has a tropical to sub-tropical climate that is moderated by its mountainous topography and influenced by the movement of the Inter-tropical Convergence Zone (ITCZ), *El Niño*, and surface temperatures in the Indian Ocean, all of which can vary from one year to another due to variations in patterns of atmospheric and oceanic circulation. The rainy season is a function of the southern migration of the ITCZ and corresponds to the warmest months of the year (Figure 2).

Inter-annual variability in wet-season rainfall in Mozambique is very high, particularly in the central and southern regions, often with negative effects on rain-fed agriculture. The severe droughts of 1982-83 and 1991-92, which spread famine across most of the southern Africa region, including southern and central Mozambique, were related to strong El Niño events. The catastrophic flooding that occurred during 2000 and 2001 was strongly linked to La Niña conditions, coupled with destructive cyclones occurring during the same period[1]. This variability causes severe stress on many sectors across the country. Floods and droughts are common occurrences in the central and southern regions, often occurring during the same year. Mozambique's long coastline facing the Indian Ocean places the country in the path of increasingly more intense cyclones.

[1] Mozambique's First National Communication to the UNFCCC.

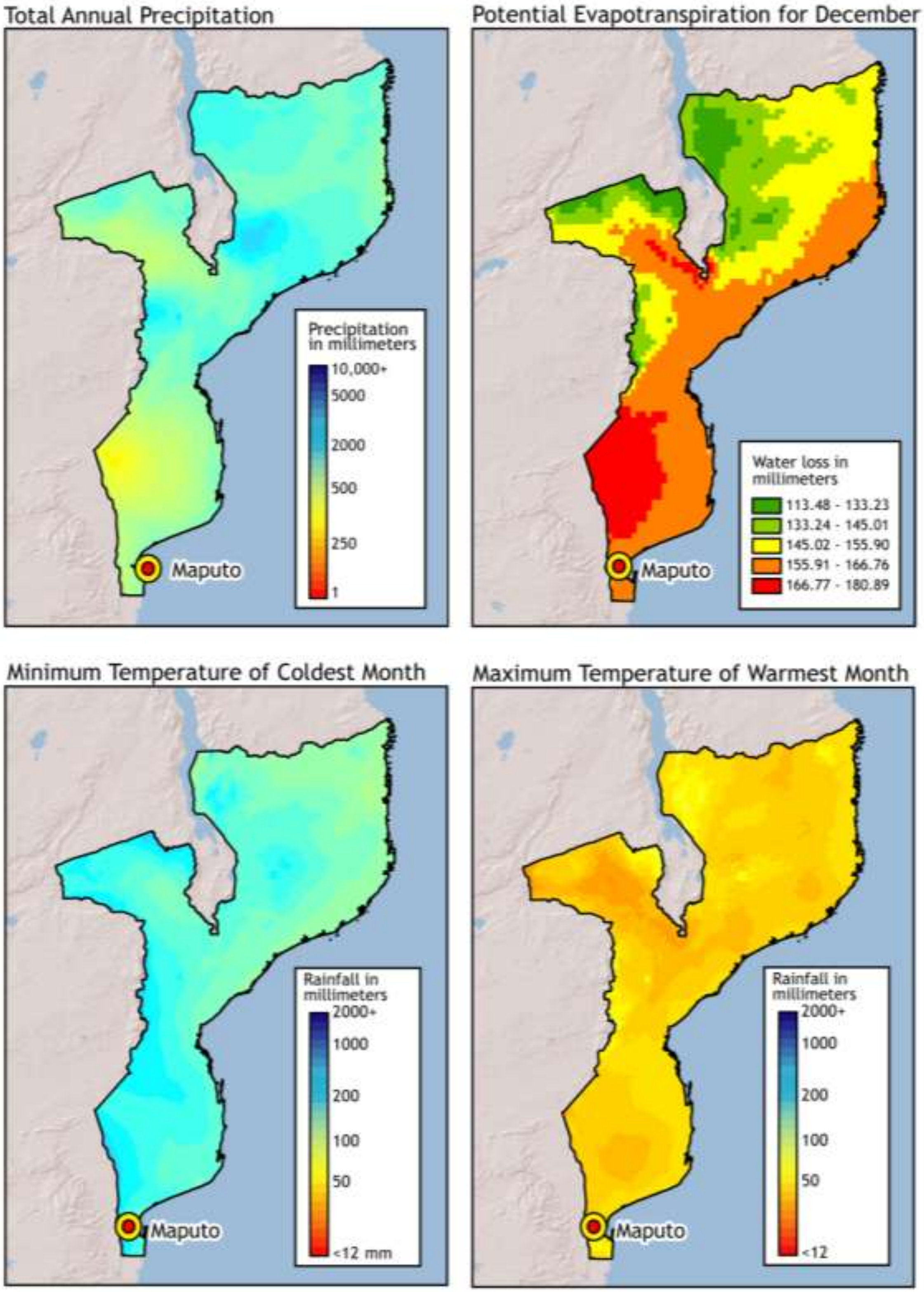

Figure 2: Climate baseline for Mozambique

Rainfall distribution in Mozambique follows a north-south gradient, with more rainfall along the coast, where the annual average varies between 800 and 1200 millimeters (mm). The inland high-altitude areas in the north and central regions receive approximately 1000 mm, whereas the inland central and south areas receive about 600 mm of rainfall. The south of Mozambique is generally drier, more so inland than towards the coast, with an average rainfall lower than 800 mm, decreasing to as low as 300 mm[2] . Temperatures are warmest near the coast, compared with colder temperatures higher inland. Typical average temperatures at the coast are 25-27°C in the summer and 20-23°C in winter. The average temperatures in the southern region are 24-26°C in summer and 20-22°C in winter.[3]

Recent Climate Trends [4]

- Since the 1960s, mean rainfall decreased by an average of 2.5 millimeters per month (3.1%) per decade. Spatial manifestations are varied, with increased rainfall over the northern regions, highly variable conditions in the central regions, and persistent drought periods coupled with episodic floods in the south.
- The proportion of days with heavy rainfall events increased by 2.6% per decade or 25 days per year[5].
- Mean temperatures across the country rose by an average of 0.9°C (0.15-0.16°C per decade), especially during the rainy season.
- The number of hot days (defined as the temperature exceeded on 10% of days or nights in the current climate of that region and season) increased by 25 in the last 40 years, and much of this has occurred during the southern hemisphere autumn. This corresponds to the first harvest cycle of many major grains across the country, with significant implications for agricultural pests and yields.

Climate Future

According to Mozambique's National Communication, if the current carbon dioxide emissions continue to increase at the expected 0.5%/year, temperatures across southern Africa are expected to increase by 1.8-3.2°C, and rainfall decreases of 2-9 percent are projected by 2060. These rainfall decreases, coupled with higher temperatures, are projected to increase evapotranspiration rates by 9-13 percent, with attendant implications for livelihoods dependent on the natural resource base. Global Climate Models (GCMs) are our primary source of information about future climate. GCMs comprise of simplified but systematically rigorous interacting mathematical descriptions of important physical and chemical processes governing climate, including the atmosphere, land, oceans, and biological processes.

Projections of future rainfall are less reliable under Global Circulation Models (in part due to their coarse spatial resolution, which fails to capture local processes driving rainfall dynamics such as feedbacks and convection). Their ability, however, to capture main climatic processes (e.g., Intertropical Convergence Zone) can offer insights on the future of rainfall conditions across Mozambique. Rainfall projections do not indicate significant changes in annual or monthly rainfall to 2049. Models, however, consistently project increases in the rainfall that falls in heavy events.

Climate change summary for Mozambique[6]:

- Temperatures are expected to increase by 1.4-3.7 °C by 2060, with warming more rapid in southern and coastal areas.
- Rainfall projections are less certain for the country as a whole and vary by region. Seasonal level projections are more certain and indicate decreased dry season rainfall (January-June) and increased wet season rainfall (July-September).

[2]INAM, 2009.
[3]National Disaster Management Institute Study of the Impacts of Climate Change, 2009 and BioCLIM Long Term Historical Surfaces.
[4] IPCC 4th Assessment Report and UNDP Climate Profiles.
[5] UNDP Mozambique Country Profile and World Bank Climate Change Data Portal.
[6].UNDP Mozambique Country Profile and World Bank Climate Change Data Portal.

- The number of heavy rainfall events (defined as a daily rainfall total which exceeds the threshold that is exceeded on 5% of rainy days in the current climate of that region or season) is projected to increase by 2060, particularly during the dry season (January-June).
- The number of hot days and nights (defined as the temperature exceeded on 10% of days or nights in the current climate of that region and season) are projected to increase throughout the country, hot days by 17-35% in 2060 and hot nights by 25-45% in 2060[7].
- The number of cold nights (defined as the temperature below which 10% of days or nights are recorded in the current climate of that region or season) is projected to steadily decrease.

CLIMATE CHANGE IMPACTS ON NATURAL HAZARD VULNERABILITY

Mozambique faces an array of natural hazards[8] (Figure 3) the most prominent being flooding, droughts, and cyclones[9]. With more than 2,700 kilometers (km) of coastline, nine international river basins, a high dependence on agricultural yields, a high level of poverty, and an inadequate infrastructure, Mozambique is extremely sensitive to such exogenous shocks. With most Mozambicans living along the low-lying coast, facing chronic poverty, inadequate health services, and heavy reliance on subsistence agriculture (80%), any changes to the nation's ecosystems have an immediate impact on its population.

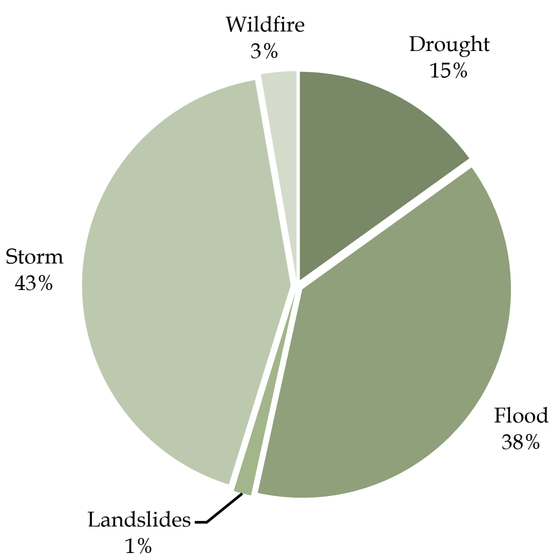

Figure 3: Natural Hazards by Type[18]

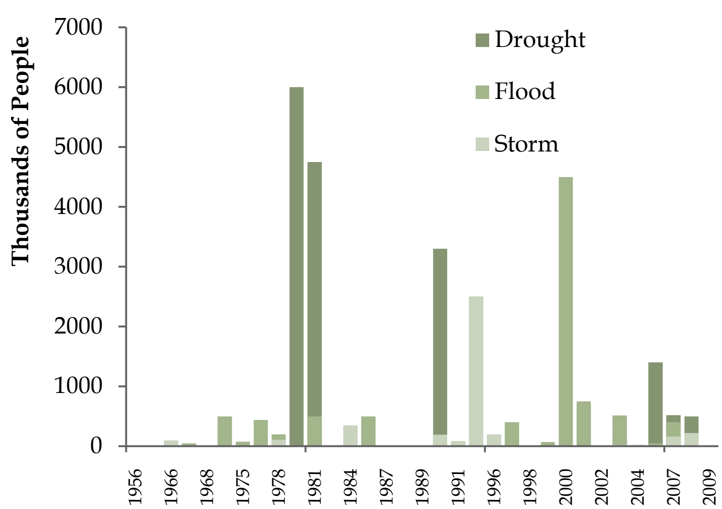

Figure 4: People Affected by the Top 3 Natural Hazards[17]

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[7] Ibid note 5.
[8] INGC Study of Impacts of Climate Change, 2009.
[9] Ibid

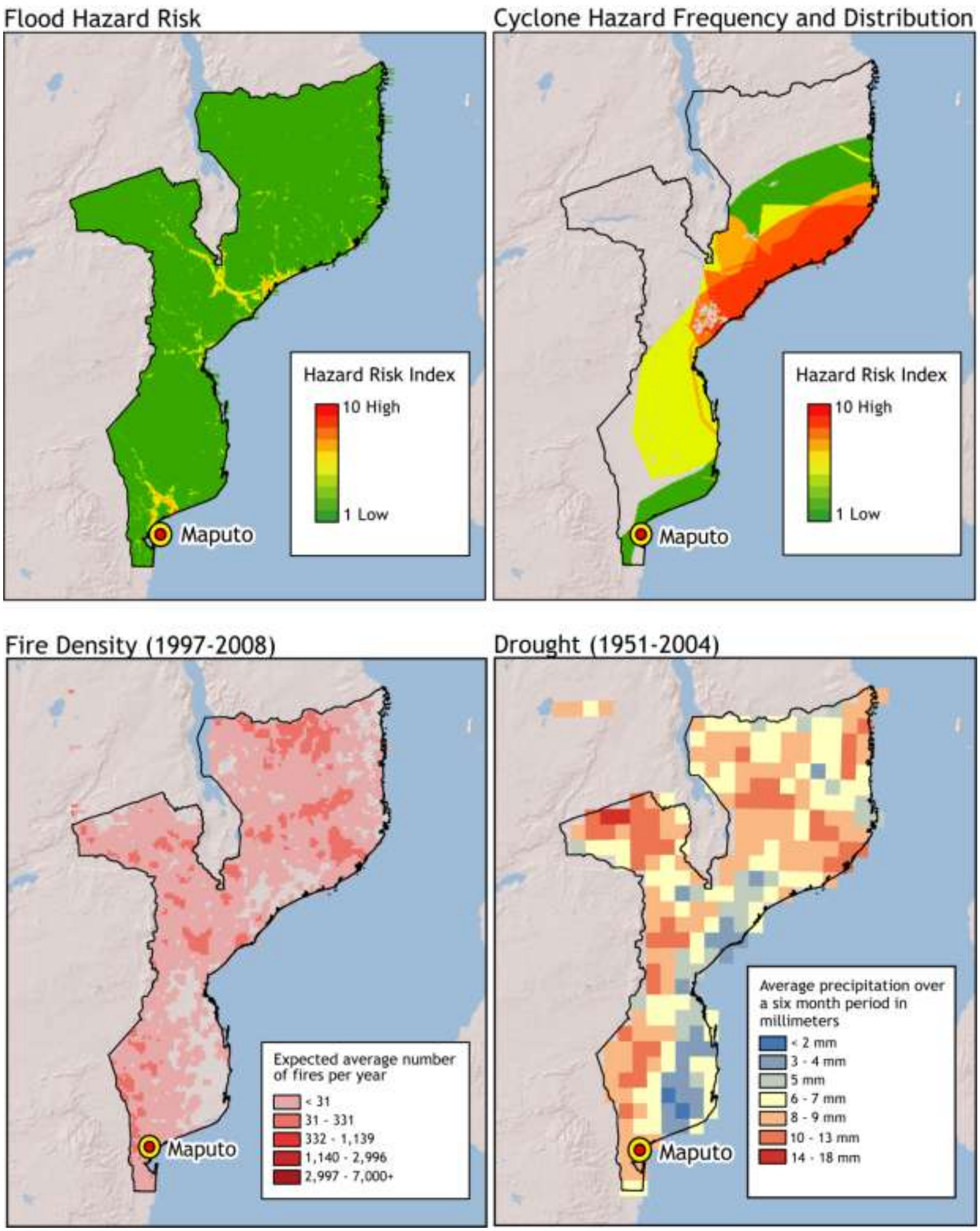

Figure 5: Exposure to climate-related hazards across Mozambique[10]

[10] UNEP's Global Risk Data Platform, Columbia University Center for Hazards and risk Research (CHRR) and Columbia University Center for International Earth Science Information Network (CIESIN).

Mozambique has a long history of catastrophic ***flooding***, which occurs almost annually during the rainy season, and is largely influenced by La Niña and the Inter Tropical Convergence Zone. Floods are a result of increased intensity rainfall events as well as occasional river discharges from neighboring countries. Between 1965 and 1998, Mozambique experienced 12 major floods[11]. During the floods of 2000-2001, an estimated 800 people died[12], 0.5 million people were affected, and US$750 million worth of property was destroyed[13]. The frequency and magnitude of these floods are well documented, and their impacts include[14]:

- loss of lives and property
- crop loss
- disease outbreaks
- displacement of people
- loss of biodiversity
- water pollution
- degradation of coastal and marine ecosystems
- loss of critical habitat (mangrove, coral, sea beds, wetlands)
- threats to endangered species

Droughts are also a recurring phenomenon. Major droughts occurred in 1980, 1983, 1985, and 1992 resulted in over 100,000 deaths and 17 million people affected[15]. Droughts are particularly frequent in the central and southern regions, with crop loss, reduction of primary productivity in coastal zones, reduction of grazing areas, increases in food imports, loss of human and animal life, outbreaks of disease, and loss of biodiversity[16].

Cyclones are common to the exposed coast line of Mozambique from October to April[17]. Strong winds, storm surges, and heavy rains from cyclones damage infrastructure, disrupt water sanitation and electricity supply systems, and degrade the coastal environment[18].

Proactively addressing all three of these hazards has been declared a priority in the World Bank's Country Assistance Strategy. In response to the severity and frequency of flooding, drought, and cyclones, Mozambique has established a National Disaster Management Institute (INGC). Working closely with Mozambique's National Meteorology Institute (INAM), INGC has created and continues to improve a disaster risk response and Early Warning System.

Implications for Disaster Risk Management[19]

- There is a high risk of increased-intensity storm surges along soft coastlines, which are already vulnerable to coastal erosion.
- The duration and timing of the rainy season are expected to change. It would start earlier over most of the country, though it is also expected to end earlier in the south and later in the far north, leading to longer rainy seasons in the north as well as southern regions near the coast. There could be, however, decreases in seasonal rainfall duration over the central regions and Zambezi valley, which could have major implications for agriculture.
- Hydrological modeling indicates that some areas in the north will experience floods more frequently.
- The central region requires greater monitoring for all types of natural hazards, and weather-related parameters in this region need to be extended and improved as a matter of urgency as climate change intensifies.

[11] Mozambique's National Communication to the UNFCCC.
[12] Mozambique's National Adaptation Programme of Action.
[13] Ibid note 2.
[14] Ibid notes 1 and 2.
[15] Mozambique's National Communication to the UNFCCC.
[16] Mozambique's National Adaptation Programme of Action.
[17] Ibid note 2.
[18] Ibid note 3.
[19] INGC Study of Impacts of Climate Change, 2009.

Sectoral Climate Risk Reduction Recommendations

Agriculture

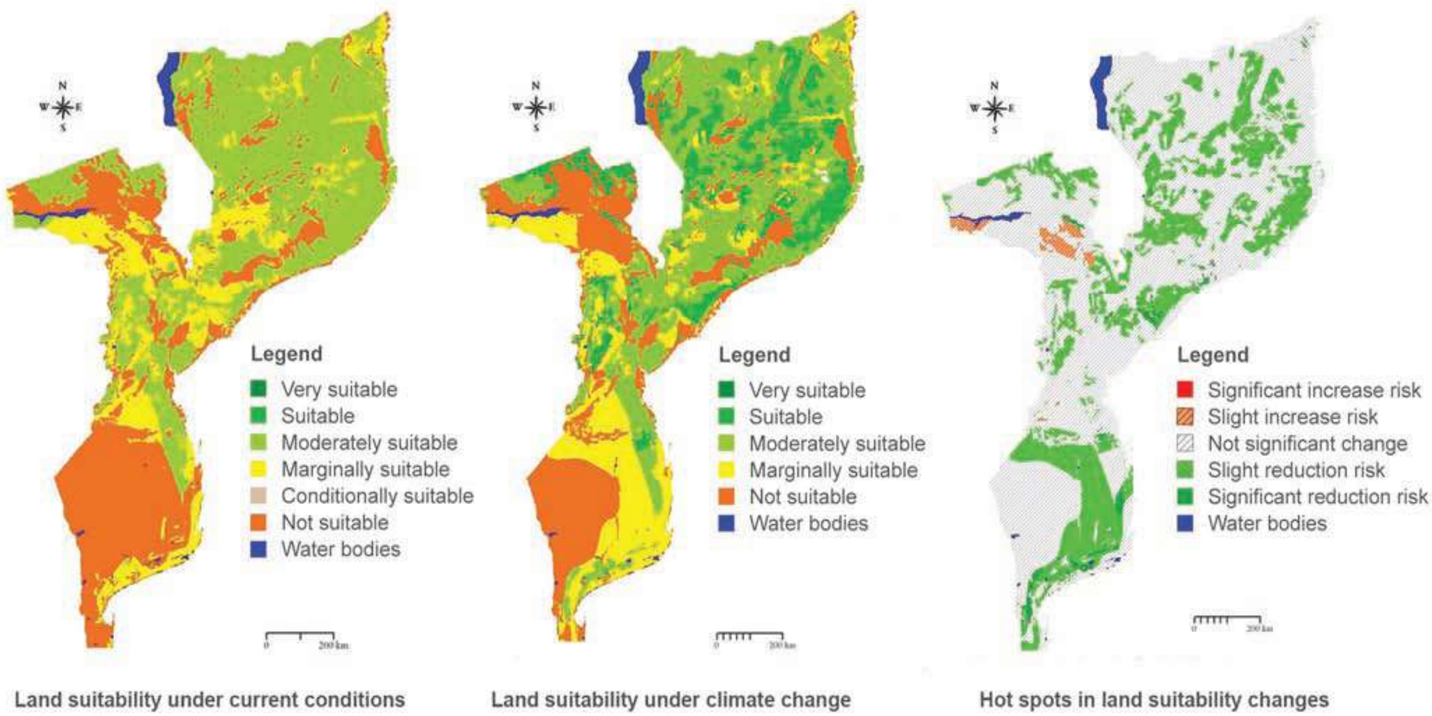

Figure 6: Projected changes in land suitability under climate change for maize production[20]

Agriculture is the mainstay of Mozambique's economy, contributing 28% of gross domestic product (GDP) and employing over 81% of the work force[21]. Much of the country's agricultural production is done by small-scale subsistence farmers and 95% of food production is rain-fed. Any climate variations will have an immediate impact on the agricultural sector. Not only will an increase in climatic natural hazards, such as cyclones and drought, have a direct impact on the agricultural production systems via crop loss, but also the onset of more subtle changes, such as groundwater salinization and higher soil temperatures, can lower yields.[22]. As the climate changes, the suitability of lands to harvest particular crops will shift and farmers will need to adjust their crops and seeds accordingly (Figure 6).

Table 1: Projected changes in rainfed maize yields across Mozambique under several management and future scenarios

Crop	Baseline Yield (1961 - 1990)	Future Projected Yield	Change %	Options
Maize	5955	5497	-7.69	High Input, 2020s
Maize	5955	5454	-8.41	High Input, 2050s
Maize	5955	5056	-15.1	High Input, 2080s
Maize	2131	1783	-16.33	Low Input, 2080s

Source: World Bank Climate Change Data Portal –Agricultural Model Generated by IIASA.

[20] INGC Study of Impacts of Climate Change, 2009.
[21] CIA Factbook 2009.
[22] INGC 2009.

Crop modeling conducted using input from climate projections suggests that in the northern part of the country a shift in agricultural practices will be required towards crops such as cassava, maize, and groundnut that can tolerate wetter conditions. A projected increase in 'water-logged' areas could allow for the introduction of rice cultivation in the north as well. Some models are projecting a decrease in water availability, with resulting chronic food shortages in the south. This situation will continue to encourage the use of drought-resistant crops. In the semi-arid central region, where many of the country's riparian networks traverse, the INGC study projects a significant decrease in suitable farm land, necessitating a shift to intensification practices to increase efficiency of available arable lands. Secondary impacts such as increased incidence of crop pests (e.g. locusts, rodents) are noted, although limited modeling efforts have been dedicated to this problem. Responding to these widespread changes will require actions at both the local and national levels.

Coastal Resources and Urban Areas

Mozambique's 2300 km coastline and the urban centers of Maputo and Beira are likely to face significant impacts under a changing climate[23] (Figure 7). Rising sea levels and increasing intensity of storm surges are projected to flood low-lying areas and erode existing coastlines, posing the risk of inundation of urban areas[24]. Mozambique's population remains largely rural, but a growing number of people are migrating to coastal urban areas. In Beira, a city just 4.9 meters above sea level and located in a cyclone-prone area, rising sea levels coupled with increased intensity of storm surges suggests the existing 3.4 meter seawall that protects much of the city's port and transport infrastructure is likely to be breached every year a cyclone makes landfall in the vicinity[25].

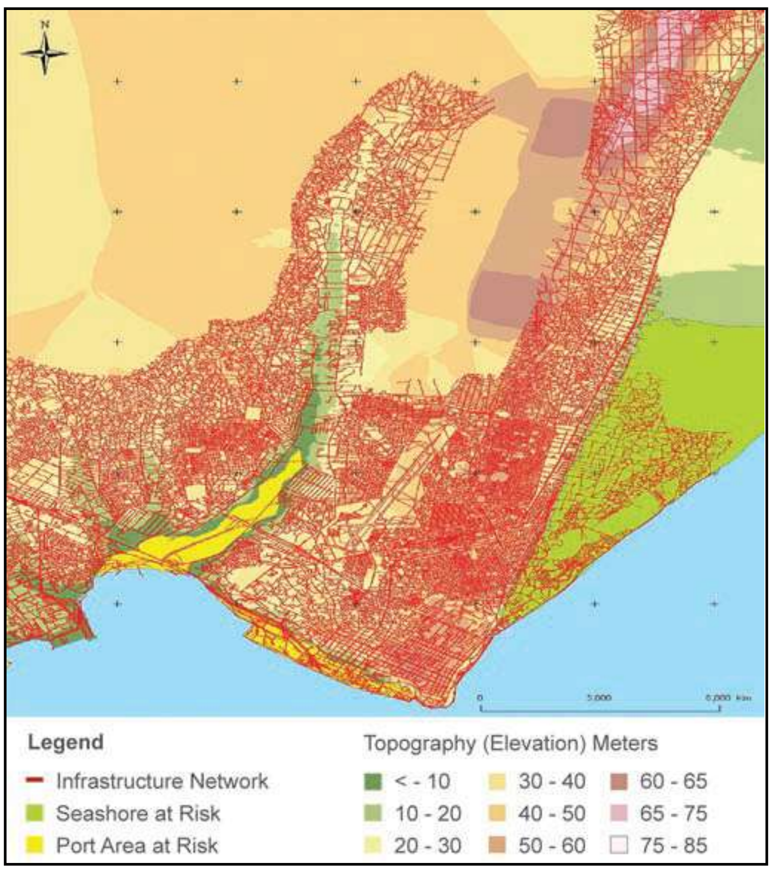

Figure 7: Maputo by 2030: the yellow area shows the port and railway area at risk; green represents the land at risk from an intense cyclone coupled with storm surge and (still) gradual sea level rise (below 10m); red is existing infrastructure.[26]

[23] Mozambique's National Communication to the UNFCCC.
[24] Ibid note9.
[25] INGC Study of Impacts of Climate Change, 2009.
[26] INCG Adaptation to Climate Change project.

Projected increases in sea surface temperature will negatively impact coral reefs that provide the vital nutrients required to support an active export fisheries sector, employing over 70,000 households. The impacts of all these projections will be compounded by the poor development practices along the coastline[27].

INFRASTRUCTURE

Infrastructure in Mozambique is generally poor and inadequate, particularly in many areas that were heavily affected by the country's civil war in the 1970s. Of the approximately 30,400 km of highways, only 6% are paved. In spite of significant efforts to improve the transportation network, large sections are virtually impassable during the rainy season. Projected increases in the intensity of storms and rainfall events threaten Mozambique's infrastructure[28] (Figure 8). Several initiatives are already underway to upgrade the nation's transportation infrastructure, but much remains to be done to build and climate proof the nation's communication, hydrological, and energy infrastructure. This has been identified as an essential requirement to reduce vulnerability.

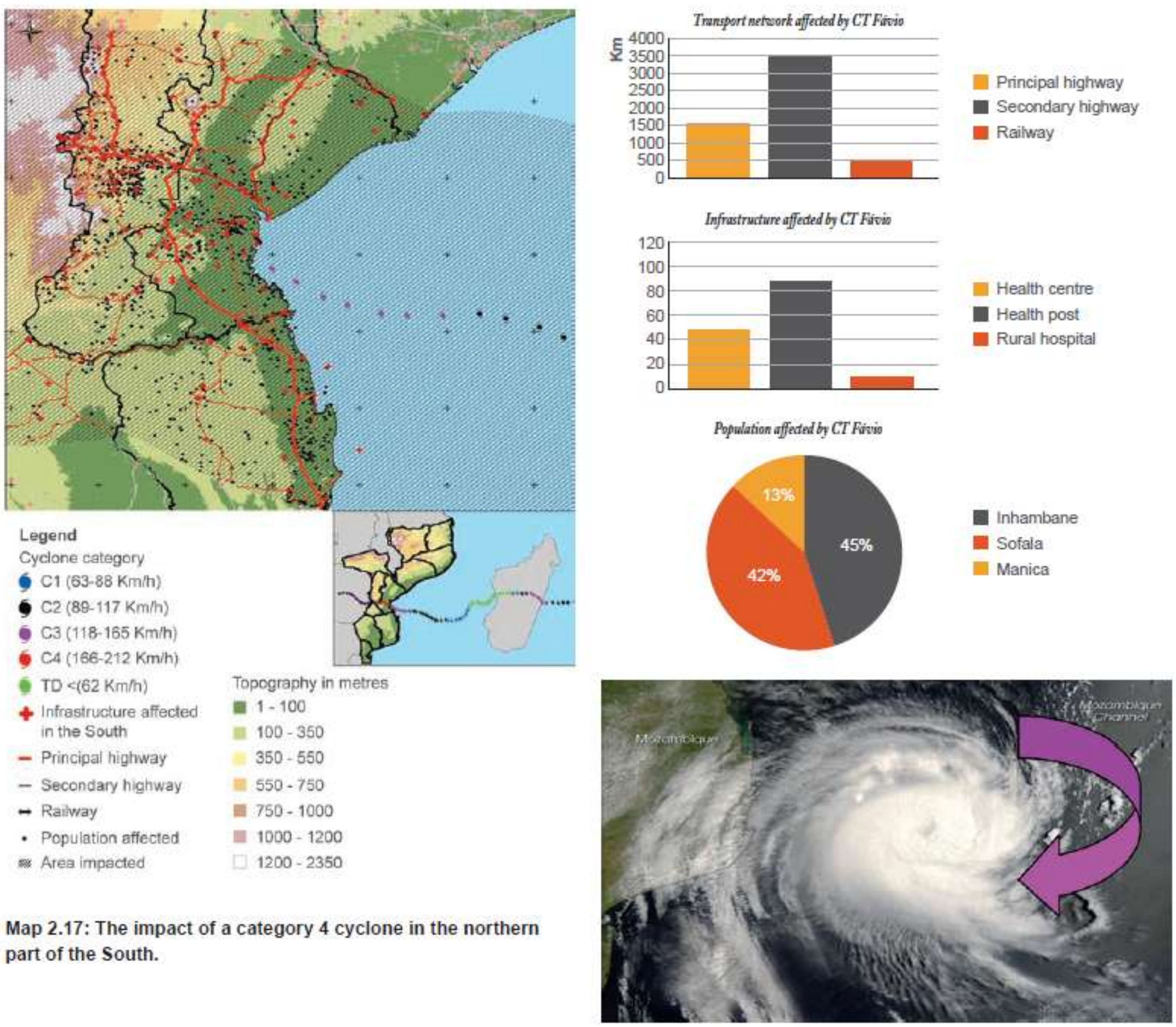

Figure 8: Impact from a category 4 cyclone in the north of Mozambique

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[27] Ibid note 9.
[28] INGC Study of Impacts of Climate Change, 2009.

Water

Rising temperature and the changing nature of drought periods will increase demand on water resources. Mozambique's water management and irrigation supply system remains limited—85% of the nation's agriculture is rain-fed. Climate change will likely result in increased water demand and bring additional stress to the limited existing system. Investment in modern agricultural technology is done only in small areas—mostly along the river banks and flood plains where there are rich soils. Flooding will destroy these advanced irrigation systems and possibly make agricultural production unsustainable.

Adaptation

It is important to note that all adaptation options take into account the role of multiple stressors in understanding vulnerability to climate variability and change. They require addressing issues often thought of as outside the narrow range of climate-related adjustments, issues such as institutional change and poverty alleviation. Such issues must be integral to adaptation and other strategies being developed to better 'manage' global environmental changes. Inter-sectoral collaboration among institutions at different scales is important in developing such an approach, although the differing objectives and scope of work of the various institutions involved might slow the development of real collaboration.

Adaptation Options by Sector

Sectors	Adaptation Options
Agriculture/Food Security	Switch to different cultivars (drought tolerant/shorter cycle)
	Improve and conserve soils
	Agricultural research and transfer of technology
	Establish seed banks
	Target degraded areas for new cultivars, including crops with shorter growing cycles
	Improved and expanded irrigation systems, monitoring and control of pests and diseases, improving grazing practices to conserve soil fertility, and promoting hay feeding
	Encourage community reforestation using native species
Coastal Zones and Marine Ecosyster	Develop Integrated Coastal Zone Management
	Develop/plan new investment requirements
	Research/monitor the coastal ecosystem
	Reforestation in logged mangrove zones
Water Resources	Increase water supply, e.g. by using groundwater, building reservoirs, improving or stabilizi watershed management, desalination
	Improve or develop water management, including monitoring tools for use by dam operato
	Establish a regulatory framework for dam and water-way security
Energy	Promotion of hydro and alternative energy sources as a means to meet some of the nation' mounting energy demands
	Advance bio-energy technology in rural areas
	Expand nation's energy grid
Infrastructure	Pre-investment studies of renewable resources
	Relocation of vulnerable housing and industrial zones
	Construction of durable and securely located buildings

	Building of dune barriers and fortified sea walls Dredging of critical canals Improved engineering standards of roads to sustain heavy rainfall
Urban Areas	Improve urban sanitation Combat water pollution in over-burdened and underutilized water systems Improve waste management

The relentless nature of climate impact in Mozambique is such that disaster risk management (DRM) is a dominant feature of the country's response to climate variability and change. Saving lives and property is a stated priority in many policy documents, which highlight the importance of establishing a timely and effective early warning system. An emphasis is placed on coastal areas due to their exposure to sea level rise, cyclones, storm surges, and delta flooding. With the majority of Mozambique's population living along the coast and reliant upon the coastal and riparian ecosystem for their livelihood (agriculture and fishing), many of the adaptation projects are focused on increasing the country's capacity to manage water resources.

Existing Adaptation Framework/Strategy/Policy and Institutional Setup

Mozambique has experienced social and political turmoil in the last decades. Despite the instability of the area, the effectiveness of the government and control of corruption has improved. An increased focus on food security has driven the establishment of more functional institutional frameworks that may facilitate a longer-term and holistic approach to addressing vulnerability. The Mozambique government has had a strong inter-ministerial and inter-sectoral approach to managing and responding to food security. Making the shift to address longer-term policy objectives, however, has its own problems. The underlying causes of the crisis, including failures of development, growing economic vulnerability of households, the impacts of the HIV/AIDS pandemic, and the failings of particular agricultural and food policies, are complementary but also sometimes competing and, thus, make a precise cause of vulnerability difficult to address.

Mozambique has a variety of institutions well versed in the issues of climate change and several of these are listed in Table 2. The World Bank's Pilot Program for Climate Resilience (PPCR) in Mozambique is currently conducting a comprehensive assessment of the country's institutions and capacities to identify potential areas of intervention.

Table 2: Relevant Institutions in Mozambique

Name	Area of Work	Projects
	Governmental	
INGC	National Disaster Management Institute	Phase I and Phase II study—four pilot projects on vulnerability reduction
MICOA	Ministry of the Environment	Coastal zone management
SETSAN	Implementing Mozambique's Food Security and Nutrition Strategy (ESAN) and requesting the Food and Agriculture Organization's (FAO's) assistance in choosing indicators to help monitor progress made in reducing hunger and malnutrition	In 2005, SETSAN launched a successful decentralization plan, in accordance with the government of Mozambique's decentralization policy
	International	
IFRC	Focus on disaster risk reduction and response	Disaster response
USAID	Focus on the following sectors: Agriculture, Health, HIV/AIDS, and Education	Zambezi Basin Initiative

While significant progress has been made in Mozambique to address disaster risk management, many major gaps and challenges exist to support a proactive and timely response and preparedness in light of future climate change. From an institutional perspective, these include:

- Expanding and strengthening dissemination and communication mechanisms available at the community and municipal level to implement early warning systems.
- Scaling up experiences of community-based disaster risk response projects and vulnerability reduction projects (particularly in drought-prone areas) to other communities, particularly those of the Buzi river project.
- Securing institutional cooperation—in particular the links between the Ministry of Environment and INAM—to safeguard a timely response, particularly with respect to social vulnerability.
- Improving coordination between the Disaster Risk Management Institute (INGC) and authorities responsible for Environment and Climate Change (MICOA), Food Security (SETSAN/FEWS), and others.

Research, Data and Information Gaps

Although significant progress has been made in Mozambique to capture the available historical records of climate and hazards, there are still large variations in the needs and quality of research, information, and data across the country.

Research Gaps

- Modeling of extreme events under a changing climate, including localized definitions of critical climate thresholds that may exacerbate natural hazards in the future, is required in order to better inform disaster management response.
- A coastal zone mapping and vulnerability baseline are required in order to support future environmental impact assessments and guide new developments. A plan has been in place in the Ministry of Environment to conduct this study for several years.
- Risk assessments considering the cumulative effects of multiple hazards and related vulnerability, particularly in the Limpopo basin, are needed.
- Limited attention has been paid to urban areas and future climate change—the potential risks to and responses by cities need to be understood.

Data and Information gaps

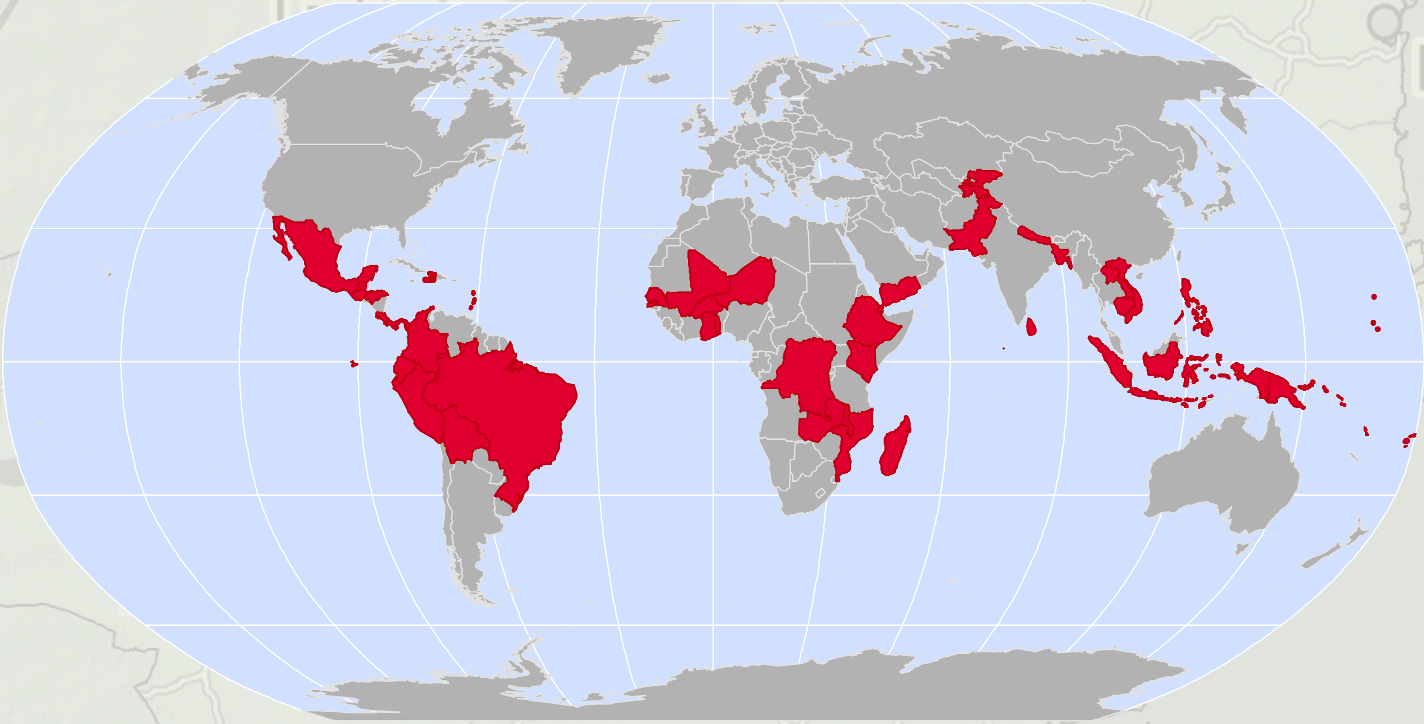
The following are major data needs which need to be addressed to support disaster risk management efforts:

- Early warning and mapping for flood and coastal infrastructure risks—including flood prediction and monitoring system for rivers in the central region and major cities at risk from storm surges/cyclones.
- Establishment and maintenance of an observation and data management system to support decision making in disaster management. This requires augmenting the decision critical points under the current CENOE model for response and monitoring program.
- Efforts to translate forecasts and meteorological data into actionable information at the local level.

Institutional and Policy Gaps

- Expand and strengthen dissemination and communication mechanisms available at the community and municipal level to implement early warnings.
- Scale up experiences of community based disaster risk response projects and vulnerability reduction projects (particularly in drought prone areas) to other communities, particularly those of the Buzi river project, to other areas.
- Securing institutional cooperation to safeguard timely response, particularly with respect to social vulnerability, in particular the links between the Ministry of Environment and INAM.
- Improved coordination between the Disaster Risk Management Institute (INGC) and authorities responsible for Environment and Climate Change (MICOA).

This Country Profile ***(http://countryadaptationprofiles.gfdrr.org)*** *is part of a series of 49 priority country briefs developed by the Global Facility for Disaster Reduction and Recovery (GFDRR) and the Global Support Program of the Climate Investment Funds (CIF). The profile synthesizes most relevant data and information for Disaster Risk Reduction and Adaptation to Climate Change and is designed as a quick reference source for development practitioners to better integrate climate resilience in development planning and operations. Sources on climate and climate-related information are linked through the country profile's online dashboard, which is periodically updated to reflect the most recent publicly available climate analysis.*



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1818 H Street, NW
Washington, DC 20433
Internet: www.worldbank.org
Contact: Milen Dyoulgerov,
mdyoulgerov@worldbank.org

GFDRR
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