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Climate Security

INITIATIVE ON
Fragility, Conflict, and Migration

SYSTEMS ANALYSIS TO SUPPORT WFP REGIONAL ACTION ON CLIMATE RESILIENCE FOR MOZAMBIQUE

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Photo: Sofala, Eftych

TECHNICAL REPORT

INTRODUCTION

For the 1.5 billion people living in fragile and conflict-affected settings, livelihood challenges are compounded by climate change, unsustainable resource consumption, poor governance, and weak social cohesion. In Mozambique, a significant 45% of its inhabitants live below the poverty line, and a staggering 80% rely on subsistence agriculture, a sector highly susceptible to climate change. Socio-ecological risks have therefore become increasingly prevalent along with environmental degradation and conflict. Within the framework of the Mozambique government's Area Based Management Plan, WFP aims to build climate resilient communities through activities revolving around ecosystem-based adaptation, integrated water resource management and community-based conservation in the Sofala province. Through this analysis and technical report, CGIAR is supporting WFP's efforts in collaboration with the Gorongosa Restoration Project and UN Habitat, by providing climate and socio-ecological analyses of the region. The key focus is around the Urema river sub-basin, a home to the Gorongosa National Park, located within Sofala province.

CONTEXT

Mozambique has approximately 45% of its population living below the poverty line and additionally is amongst the most climatically challenged countries. With approximately 80% of its population relying on subsistence agriculture, this sector is the cornerstone of the country's economy. Cropland areas are interspaced with forests and shrubland (Figure 1), spanning limited regions across the southern coastal area, the central Manica province, the western part of Sofala, as well as the coastal part of Zambezia, Nampula and Cabo Delgado in the north (Figure 2). The majority of Mozambique's cropland is dedicated to growing staple crops such as rice, maize, sorghum, and cassava, all of which rely on key climatic conditions for productivity. Recently, the rise in extreme climatic events such as floods, drought and severe heat have strained agricultural resources, making it challenging for farmers to maintain their livelihoods (*1*). Sofala province, mostly acclimated for maize production often faces climate-induced challenges such as more frequent and extreme drought and flood events, affecting food security and the people's livelihoods.

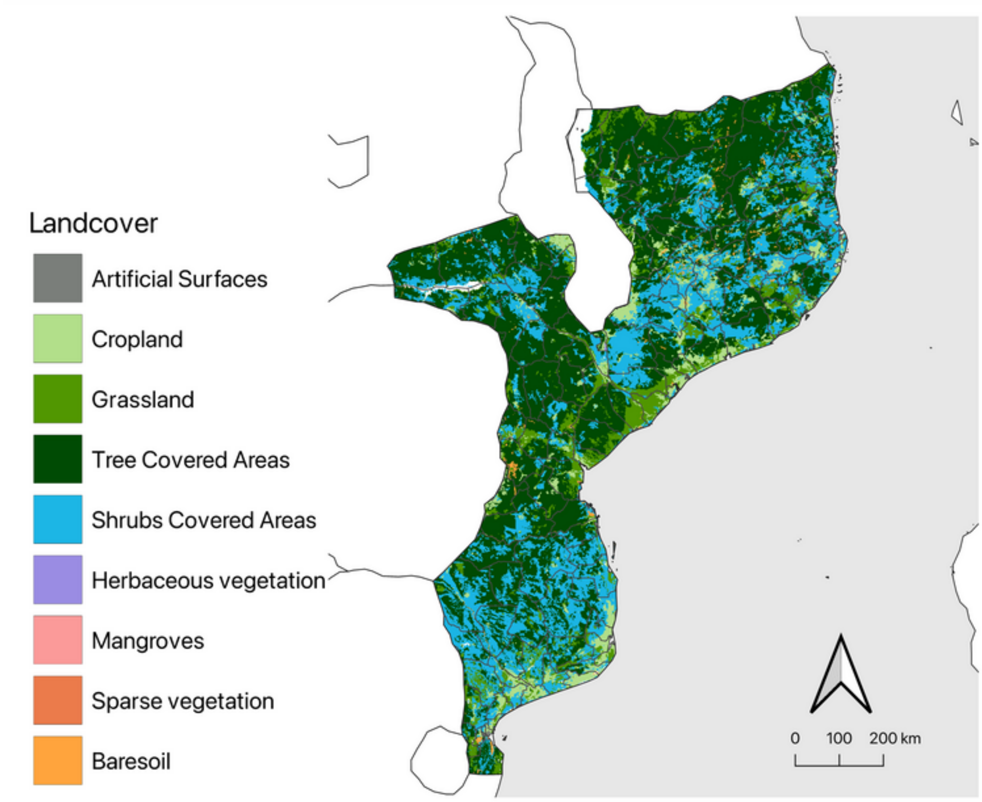

Figure 1: Landcover types

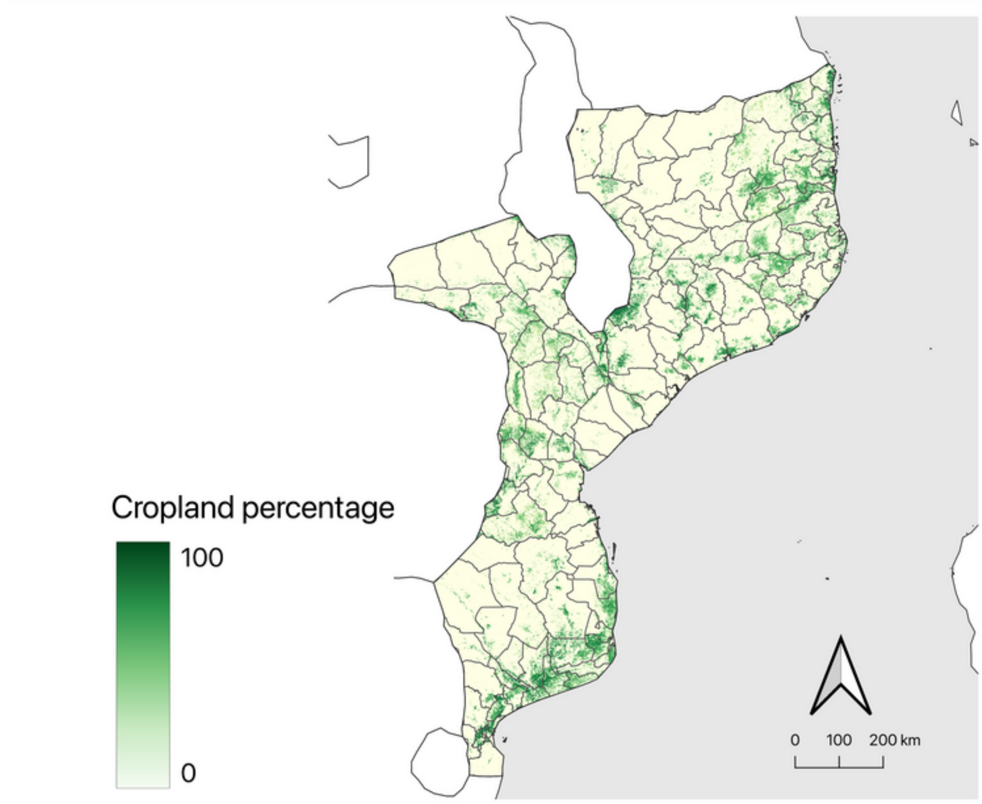

Figure 2: Cropland percentage

In terms of climate-related risks, Mozambique is one of the most exposed African countries. The country is characterized by a tropical to sub-tropical climate. With its extensive coastline supporting over 60% of its population, Mozambique is highly vulnerable to tropical cyclones and flooding. The country is also very prone to extreme hydrological events such as droughts which is compounded by low water infrastructure and a lack of monitoring systems (*2,3*). Weather extremes including droughts, floods and cyclones frequently result in severe disasters in Mozambique, hampering the country's economy which is heavily reliant on rain-fed agriculture and thus amplifying its climate-sensitivity (*1,4*). Central Mozambique, in particular the Urema river sub-basin, experienced severe impacts from the 2019 tropical cyclone Idai. This event resulted in heavy flooding with more than 30,000 people severely affected and a substantial loss of wildlife in a region classified as a key biodiversity area (*5*).

REGIONAL CLIMATE DRIVERS

Mozambique is predominantly a summer rainfall region that experiences considerable inter-annual climate variability. Such variability, characterized by seasonal precipitation anomalies is primarily influenced by regional climate drivers such as El Niño Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD), or the North Atlantic Oscillation (NAO) (*2,6*). ENSO, characterized by the periodic warming (El Niño) and cooling (La Niña) of sea surface temperatures in the tropical Pacific Ocean, can lead to droughts or excessive rainfall in different parts of Mozambique (*2,7*). Similarly, the Indian Ocean Dipole (IOD), which refers to the temperature gradient between the eastern and western Indian Ocean, affects monsoon patterns and rainfall distribution, impacting agricultural activities. Additionally, the North Atlantic Oscillation (NAO), a fluctuation in atmospheric pressure over the North Atlantic region, influences winter climate variability, potentially leading to extreme weather events like storms and prolonged periods of rainfall or droughts (*7*). Together with the Pacific Decadal Oscillation (PDO), a long-lived El Niño-like oscillatory pattern of climate variability based on switching ocean temperature anomalies, the Atlantic Multidecadal Oscillation (AMO) which represents low-frequency ocean cycle as well as solar activity changes (SUN), these large-scale climate drivers and their interactions shape Mozambique's long-term climate variabilities and extremes (Figure 3).

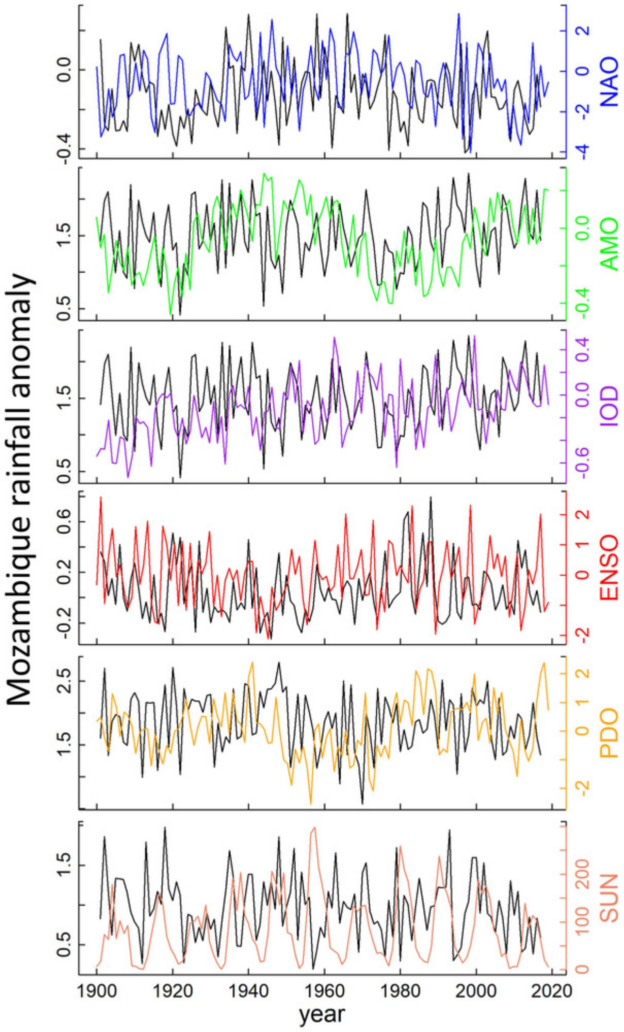

Figure 3: Time series illustrating the relationship between large-scale climate drivers and Mozambiques rainfall anomaly

PAST, CURRENT AND FUTURE CLIMATE VULNERABILITIES

Mozambique has experienced discernible shifts in climate patterns, leading to adverse impacts to communities, livelihoods and environmental degradation. This region is highly vulnerable to climate-induced shocks and crises, with cyclones, floods and droughts being the most prominent occurrences. In particular, the Urema river sub-basin area is currently highly vulnerable to flooding, but also shows the highest risk of drought and heat within Mozambique (Figure 4, a), making it a hotspot of compound climate hazards (Figure 4, b). These conditions are expected to worsen in the future with increased risk of drought, heat and flood events (Figure 4, a). Notably, heightened vulnerability to drought and heat events is observed along the Eastern Coast with a concentration in Central Mozambique and Sofala province under future conditions (Figure 4, a).

We can also expect an incremental increase in flood events across the entirety of Mozambique under future conditions, but particularly along the Western part of Mozambique (Figure 4, a).

The compound impact of these climate-related hazards such as simultaneous droughts and heatwaves or floods can result in substantial loss and damage (Figure 4, b) (*8*). The greatest exposure to compound hazards currently occurs in the Western to Central and Southern region of Mozambique but has a substantial regional spread with a nucleus on the coastline in future (Figure 4, b). All of Mozambique will be subject to medium to high-risk compound hazards in future (Figure 4, b).

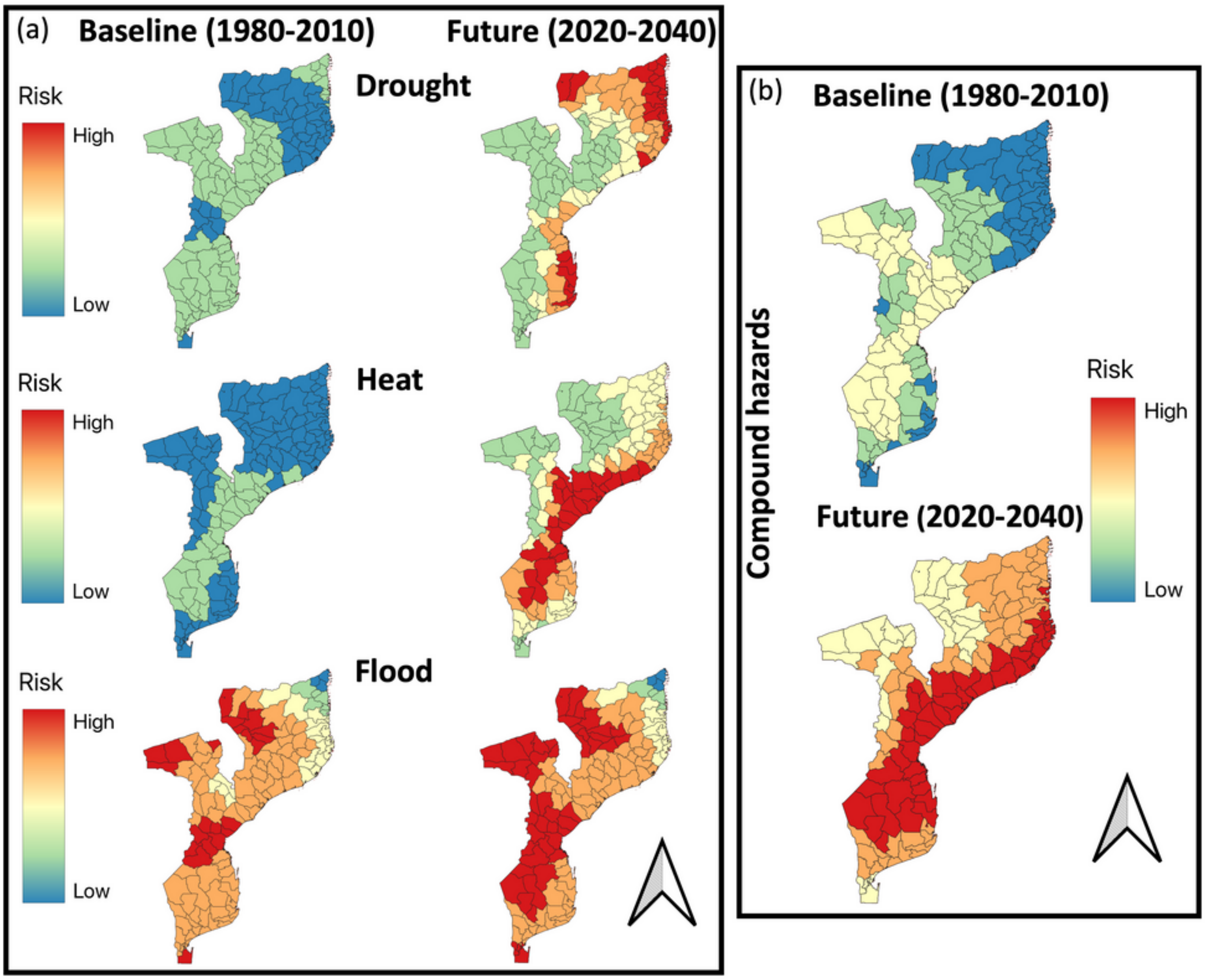

Figure 4: baseline (1980-2010) and future (2020-2040) climate hazards including drought, heat, flood (a) and compound hazards (b). Compound hazards are considered as the composite risk of heat, drought, and flood to determine the cumulative impact of multiple hazards. An ensemble of 27 general circulation models from different modelling centres globally is used to develop the indices. Climate data are sourced from the 6th Coupled Model Intercomparison Project (CMIP6). The climate pathway with high radiative forcing (SSP585) was used for the future climate projection.

SOCIO-ECONOMIC VULNERABILITIES

The agricultural sector is highly gendered, with women accounting for the majority of the labour force. In 2019, the sector employed 80% of female labour force (*9*). Gender equity disparities are evident across various regions in Mozambique (Figure 5). Sofala is characterized by the lowest level of gender equity, with Nampula, Manica also displaying relatively lower levels of gender equity, followed by Tete and Gaza. Although these regions demonstrate comparatively lower levels of gender equity, they still fall within the medium range on a global scale (Figure 5). Provinces with the highest gender equity include Inhambane, Maputo, Zambezia and Niassa (Figure 5). These spatial variations in gender equity highlight the need for targeted interventions to promote equal opportunities. In regions where gender disparities are more pronounced, focused interventions aimed at enhancing access to education, resources and market opportunities could play a pivotal role in fostering greater gender parity.

Moreover, discrepancies such as market access add to the challenges faced by the communities to efficiently build climate change resilience. Nampula and Zambezia provinces display the lowest level of proximity to market indicating a market isolation, increasing the cost of inputs and transportation for farmers (Figure 6). The profound impacts of climate change, coupled with limited resilience and heightened vulnerability of these populations to environmental shocks needs to be considered when planning Ecosystem-Based Adaptation and Nature-Based Solutions approaches.

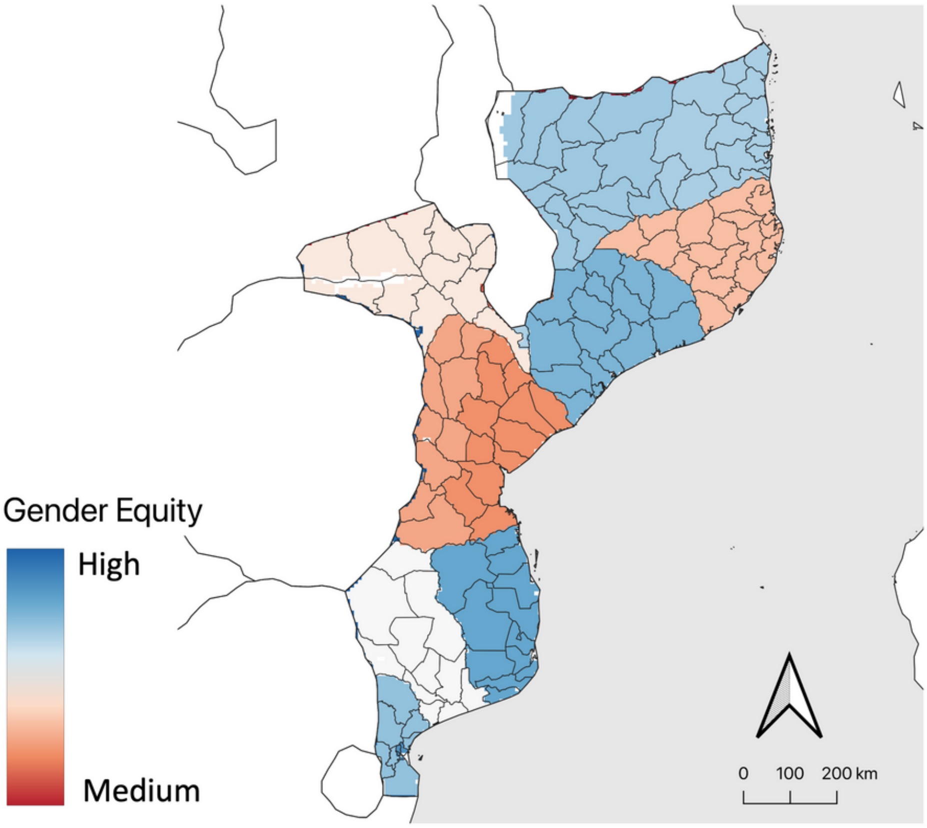

Figure 5: Gender equity

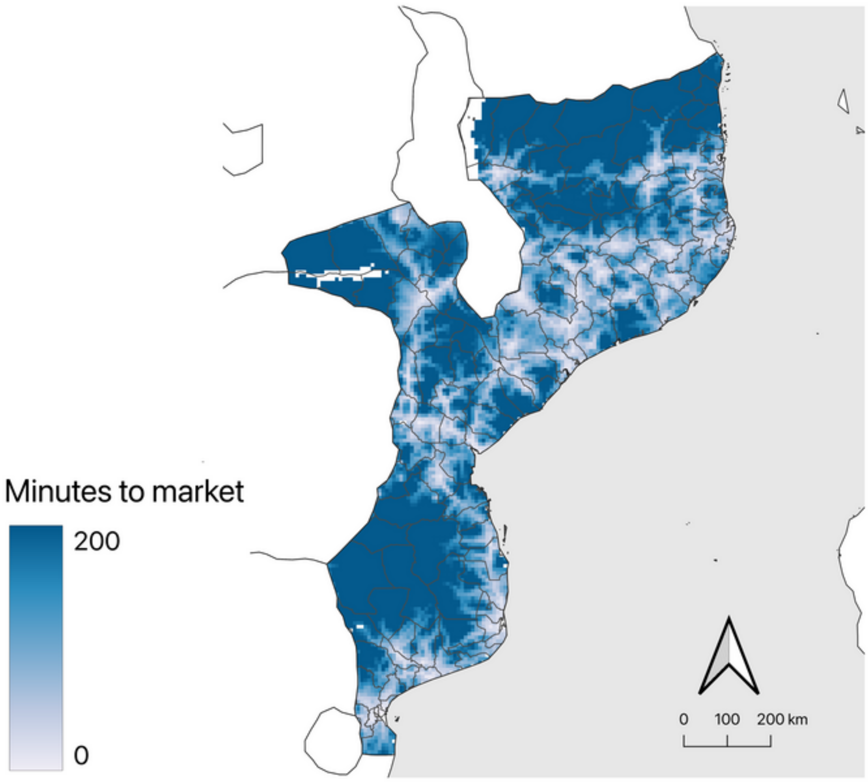

Figure 6: Market access

CLIMATE SMART SYSTEMS USING NATURE-BASED SOLUTIONS

Based on the climate and socio-ecological risk assessment, several zones can be identified which exhibit high risk of compound events and low coping capacity (Figure 7). While multiple regions of Mozambique experience different combinations of risk, these hotspots occur within Zambezia, Nampula, Tete as well as Sofala and Maputo. Sofala has a particular exposure to some of the highest compound risks (Figure 7, zone 2). There is a high risk of both coastal and riverine flooding due to periods of intense rainfall and to the impacts of tropical cyclones. Being a low-lying coastal area, it is vulnerable to compound flood events occurring from combinations of fluvial, pluvial and coastal drivers (*10*). Following recurring devastating floods, there is a growing awareness locally of the necessity to implement climate adaptation measures. Adding to the devastating impact of flooding, drought events are also more recurrent in Sofala. With the projected increase in the frequency of heat waves over this province (Figure 2), projection of the compound effects of climate hazards shows an alarming climate future requiring urgent and more sustainable adaptation and mitigation strategies, such as integrated water resource management and ecosystem-based solutions.

In addition to the climate-induced biophysical impacts, adaptation strategies should also place socio-economic vulnerabilities front and centre within the region, in order to address the high gender disparities and low market access for livelihood systems in the Urema river basin (Figure 5, 6). The development of targeted climate-smart agricultural systems which foster regenerative agriculture and protection of riverine systems should be prioritized. The practices should be tailored to achieve sustainable and equitable climate action by promoting positive peace and creating shared values. Additionally, a focus on nature-based solutions can be used to foster cooperation on natural resource management by promoting joint decision-making, encouraging sustainable practices, and facilitating knowledge sharing among diverse stakeholders, ultimately reducing conflicts over scarce natural resources, and enhancing community resilience. Furthermore, by ensuring that marginalised and vulnerable groups, such as women, youth and ethnic minorities have access to resources, technologies, and decision-making processes, nature-based solutions can contribute to dismantling the systemic barriers that perpetuate social inequalities and exclusion in climate action.

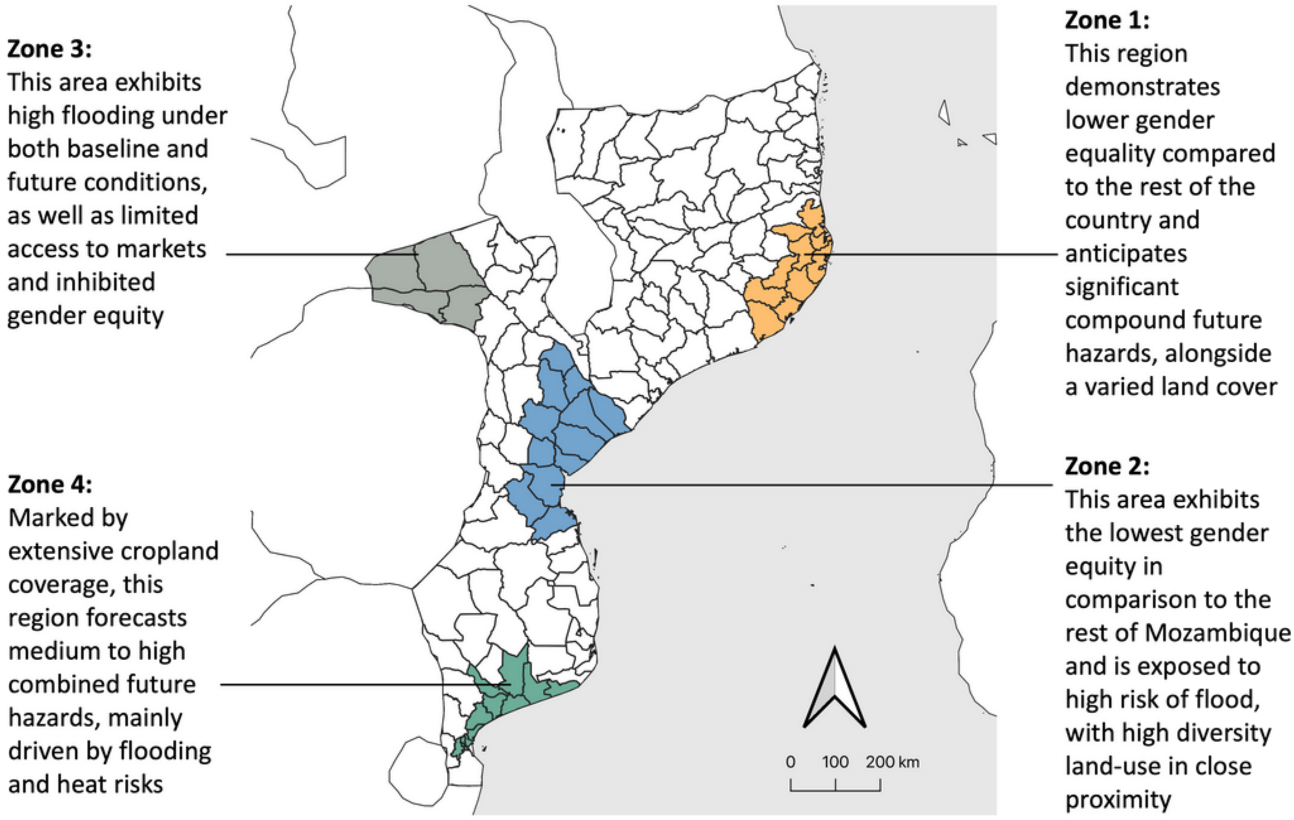

Figure 7: Compound socio-ecological vulnerability in Mozambique

REFERENCES

1. Arndt, C. & Thurlow, J. Climate uncertainty and economic development: evaluating the case of Mozambique to 2050. Climatic Change 130, 63–75 (2015).
2. Araneda-Cabrera, R. J., Bermudez, M. & Puertas, J. Revealing the spatio-temporal characteristics of drought in Mozambique and their relationship with large-scale climate variability. Journal of Hydrology: Regional Studies 38, 100938 (2021).
3. Osbahr, H., Twyman, C., Neil Adger, W. & Thomas, D. S. G. Effective livelihood adaptation to climate change disturbance: Scale dimensions of practice in Mozambique. Geoforum 39, 1951–1964 (2008).
4. Sietz, D., Boschütz, M. & Klein, R. J. T. Mainstreaming climate adaptation into development assistance: rationale, institutional barriers and opportunities in Mozambique. Environmental Science & Policy 14, 493–502 (2011).
5. Kunedzimwe, F. et al. Impact of Cyclone Idai on Biodiversity and Natural Resources in Chimanimani District, Zimbabwe. in Cyclones in Southern Africa: Volume 3: Implications for the Sustainable Development Goals (eds. Nhamo, G. & Chikodzi, D.) 229–244 (Springer International Publishing, 2021). doi:10.1007/978-3-030-74303-1_15.
6. Driver, P., Abiodun, B. & Reason, C. J. C. Modelling the precipitation response over southern Africa to the 2009–2010 El Niño using a stretched grid global atmospheric model. Clim Dyn52, 3929–3949 (2019).
7. Lüdecke, H.-J., Müller-Plath, G., Wallace, M. G. & Lüning, S. Decadal and multidecadal natural variability of African rainfall. Journal of Hydrology: Regional Studies 34, 100795 (2021).
8. AghaKouchak, A. et al. Climate Extremes and Compound Hazards in a Warming World. Annual Review of Earth and Planetary Sciences 48, 519–548 (2020).
9. World Bank Open Data. World Bank Open Data https://data.worldbank.org.
10. Eilander, D. et al. Modeling compound flood risk and risk reduction using a globally applicable framework: a pilot in the Sofala province of Mozambique. Natural Hazards and Earth System Sciences 23, 2251–2272 (2023).

SUGGESTED CITATION

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