Multi-Hazard Risk Atlas MALAWI

Department of Disaster Management Affairs

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A flooded creek, at the start of the rainy season in Malawi.
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Department of Disaster Management Affairs

Acknowledgements

Recognising the growing frequency and severity of disasters, the Malawi Government conducted a nationwide probabilistic risk assessment, resulting in the Multi-Hazard Risk Atlas for Malawi. This comprehensive resource highlights key information on major hazards, vulnerabilities, exposure and risks.

The Malawi Government through the Department of Disaster Management Affairs (DoDMA) with financial support from the World Bank engaged a consortium led by CIMA Research Foundation and comprised the Malawi University of Business and Applied Sciences, British Geological Survey and Global Earthquake Model to develop this risk atlas.

This risk atlas was developed through collaboration among government ministries, departments and agencies, and academia. DoDMA would like to acknowledge contributions from the Ministry of Water and Sanitation, Ministry of Agriculture, Ministry of Health, Ministry of Education, Ministry of Local Government, Ministry of Information and Digitalization, Ministry of Gender, Community Development and Social Welfare, Environmental Affairs Department, Department of Geological Surveys, Malawi Vulnerability Assessment Committee, Department of Climate Change and Meteorological Services, Department of Surveys, National Statistical Office, and Department of Urban Development. DoDMA would like to further acknowledge The Lilongwe University of Agriculture and Natural Resources and the Malawi University of Science and Technology for providing technical input to ensure that the Atlas is valid and usable by various stakeholders at all levels.

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Rev. Moses Chimphepo
Commissioner for Department of Disaster Management Affairs

Consultants:
CIMA Research Foundation · GEM Global Earthquake Model · Malawi University of Business and Applied Sciences MUBAS · BGS British Geological Survey

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Foreword

Disasters driven by natural hazards have increased in occurrence and severity of damage with time. Common disasters are floods, droughts, dry spells, earthquakes and landslides. In recent years, Malawi has been affected by at least a disaster every year be it floods, droughts, dry spells or earthquakes. Floods and droughts have become an annual event causing significant disruption to life and livelihood. Tropical cyclones such as Anna, Gombe, Idai, Freddy have claimed lives of people and livestock, destroyed private and public infrastructure, damaged crops and disrupted ecosystems. Post Disaster Needs Assessments (PDNA) have shown substantial economic value of loss and damage and even more substantial monetary value of recovery interventions. In addition to economic costs, there are social and psychological costs.

Social costs arise on account of people not being able to access services such as healthcare, education, markets, etc., when infrastructure is damaged, service delivery is disrupted, villages are destroyed among other issues. Psychological costs arise on account of trauma from experience of losing loved ones, property, getting displaced from usual homes to camps and families being separated while living in camps.

PDNAs often take account of direct losses. For example, in case of floods and drought, often a PDNA considers crop area that is affected, number of farming households affected, and potential yield lost. However, the assessment does not consider inputs wasted i.e. labour, fertilizer and seeds. Given the huge investment in farm input subsidies that the government has been putting in and the fact that most often drought and floods come when fertilizer application has already been done, the loss on inputs is quite significant to be omitted in accounting costs. Regarding opportunity cost, an occurrence of disaster puts everything on a standstill. Government, development partners, private sector and individuals' direct energy and resources towards responding to the disaster. Often the national budget is affected immediately as financial resources that would otherwise be used for routine service delivery are redirected to disaster response. Malawi being an agro-based economy suffers from reduced output hence reduced economic growth. Exports also get affected and depending on magnitude of impact, at times results in worsening balance of payments position and subjects the country to resort to borrowing thereby increasing public debt.

The case in point is that the imperative for intervening to mitigate effects of disasters cannot be overemphasized as the cost of inaction is too severe to be ignored. The development of the multi-hazard risk atlas aims at helping Malawi Government and all relevant stakeholders to have localized knowledge of potential disasters and the likelihood of occurrence and severity in each area. If well used, the atlas will make disaster response more relevant to locations and hence more impactful.

Preface

In the past fifty years, disasters driven by natural hazards have frequently disrupted development efforts, exacerbating poverty and hampering progress toward shared prosperity. This is true globally and even more so in sub-Saharan Africa. These disasters not only cause physical damage to infrastructure and essential services, but they also result in profound human, financial, cultural, and environmental losses. The close relationship between disasters and development underscores the need for sustainable planning. Poorly managed development can, in fact, heighten disaster risks, increasing the vulnerability of communities and economic systems and perpetuating cycles of poverty. Moreover, limited resources for disaster risk reduction and recovery amplify these vulnerabilities, particularly for marginalized and impoverished populations.

In the aftermath of disasters, national development funds are often diverted, or international aid is required for recovery efforts, which can undermine long-term poverty reduction and development goals of Malawi Government. However, the impact of disasters can be mitigated through advanced scientific sound risk assessment, including effective dissemination of risk data, and building institutional and community preparedness. By embedding risk assessment into disaster risk reduction and climate adaptation strategies, it is possible to anticipate and respond to the increasing frequency and intensity of natural hazards, especially those exacerbated by climate change.

Risk reduction strategies must emphasize the effective communication and application of risk data to achieve sustainable development goals. Strengthening institutional and human capacities is vital for decision-making that integrates risk considerations and enhances resilience across various socio-economic sectors. This requires harnessing scientific data to analyse hazards, exposures, and vulnerabilities, enabling more accurate assessments of disaster impacts, population dynamics, and economic losses across different regions and industries.

In today's context, a comprehensive risk assessment must account for the multi-hazard nature of a country's landscape. This requires a holistic analysis that compares and quantifies various risks to inform disaster risk management strategies. As emphasized by de Ruiter et al. (2021), the United Nations Office for Disaster Risk Reduction (UNDRR) has called for a deeper understanding of the complexities surrounding multi-hazard risks. Furthermore, the Sendai Framework for Disaster Risk Reduction strongly advocates for adopting multi-risk perspectives to better address these challenges. In this regard, the Malawi risk profile serves as one of the earliest and pioneering examples of multi-hazard risk assessments.

This document serves as an atlas of disaster risks, categorizing common hazards by district. It is the result of a thorough rigorous analysis of historical events to project the likelihood of future disasters across various scenarios and return periods. The assessment was based on secondary data from reputable sources, including the National Statistics Office (NSO), the Annual Economic Reports for Malawi, and other relevant datasets. While districts compile their own Socio-Economic Profiles, this assessment primarily relied on national survey reports from the NSO, as these provide more reliable and comparable data at the national level.

The analysis considered the influence of socio-economic factors on disaster vulnerability. For example, investment in resilience-building measures can significantly reduce the impact of hazards, even when exposure levels remain unchanged. The atlas offers detailed information on each district, including its geographic location, disaster risks, socio-economic variables such as poverty prevalence, economic and social infrastructure, housing types, and dominant crops. This data is intended to help users better understand the relationship between potential hazards, a community's capacity to withstand disasters, and agricultural production at risk during such events.

This Atlas was created using a fully probabilistic approach, enabling the quantification of all possible risks across multiple sectors and the most relevant hazards for Malawi.

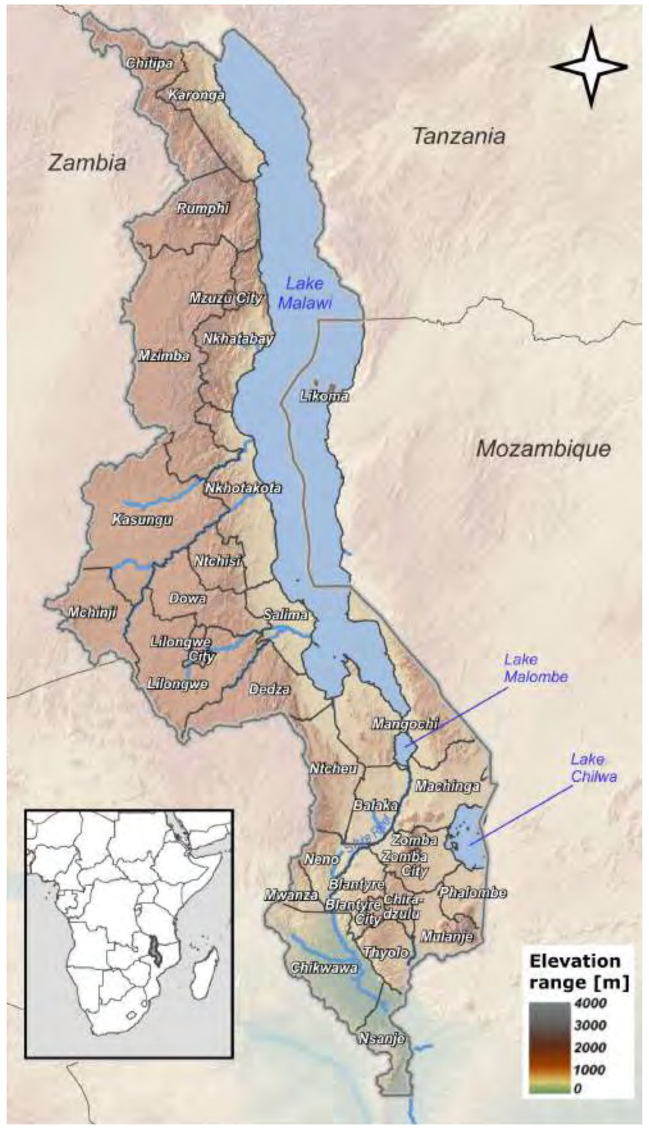
In its development, careful attention was given to ensuring that the Atlas remains accessible to a wide audience, including officials from both central and local governments, non-governmental organizations, the media, and development partners.

List of Acronyms

AAH	Average Annual Number of Homeless People
AAHR	Average Annualized Homeless Ratio
AAL	Average Annual Losses
AALR	Average Annualized Loss Ratio
APES	Agriculture Production Estimates Survey
BGS	British Geological Survey
CBDRM	Community-Based Disaster Risk Management
CC	Climate Change
CIMA	Centro Internazionale in Monitoraggio Ambientale
EM-DAT	Emergency Events Database
DEM	Digital Elevation Model
DoDMA	Department of Disaster Management Affairs
DRM	Disaster Risk Management
DRMKC	Disaster Risk Management Knowledge Centre
DRR	Disaster Risk Reduction
EARS	East African Rift System
FIRP	Food Insecurity Response Programme
GCM	Global Circulation Model
GDP	Gross Domestic Product
GEM	Global Earthquake Model
GIS	Geographic Information System
HFA	Hyogo Framework for Action
IDF	Intensity Duration Frequency (curve)
IPCC	Intergovernmental Panel on Climate Change
IPSL	Institute Pierre-Simon Laplace
ITCZ	Inter-Tropical Convergence Zone
IWRM	Integrated Water Resources Management
MUBAS	Malawi University of Business and Applied Sciences
MVAC	Malawi Vulnerability Assessment Committee
NDRMP	National Disaster Risk Management Policy
NRS	National Resilience Strategy
NSO	National Statistics Office
NUP	National Urban Policy
OQ	OpenQuake-Engine
PDNA	Post Disaster Needs Assessment
PGA	Peak Ground Acceleration
PMHRA	Probabilistic Multi-Hazard Risk Assessment
PML	Probable Maximum Loss
PRA	Probabilistic Risk Assessment
PSHA	Probabilistic seismic hazard analysis
RA	Risk Assessment
RP	Risk Profile
SMA	Soil Moisture Anomaly
SMAPI	Soil Moisture Anomaly Percentage Index
SPI	Standardised Precipitation Index
SRTM	Shuttle Radar Topography Mission
SSI	Standardised Streamflow index
SSP	Shared Socioeconomic Pathways
UNDRR	United Nations Office for Disaster Risk Reduction

Crops – Freepik

Introduction



Map of Malawi: Geographical location of Malawi and its neighbouring countries.

Malawi, is frequently affected by recurrent disasters, including floods, droughts, epidemics, and earthquakes. The historical record of these disasters highlights the country's vulnerability and underscores the urgent need for comprehensive risk assessment and mitigation strategies.

For the past 40 years, Malawi has faced the consequences of natural and man-made disasters. The country is vulnerable to a wide range of hazards, including floods caused by heavy rainfall, droughts intensified by climate variability, stormy rains, accidents, hailstorms, disease epidemics and pest infestations. Additionally, geological hazards such as earthquakes and landslides, although infrequent, significantly contribute to the overall risk landscape.

Malawi has seen a troubling increase in the frequency, intensity, and scale of extreme weather events, posing a major challenge for the nation. Since 1980, the country has experienced over 50 disasters caused by hydrometeorological phenomena, such as storms, cyclones, floods, landslides, and droughts, affecting millions of people. Alarmingly, the past decade alone has witnessed more than 25 such disasters, reflecting a concerning upward trend in both their occurrence and severity, particularly in terms of human lives lost, agricultural damage, and infrastructure destruction.

The trend has been attributed to factors such as climate change, population growth, urbanization, and environmental degradation, among other factors. In Malawi, approximately 50.7% of the population live below the national poverty line (National Statistics Office, 2021). The 2023 INFORM Risk Index (DRMKC, 2023) ranks Malawi 54th out of 191 countries, primarily due to its high socio-economic vulnerability and low institutional and infrastructure coping capacity.

The 2023 Cyclone Freddy, the deadliest in recent history, resulted in disaster damage and losses estimated at $503.7 million, with recovery and reconstruction costs projected at $640.4 million. This event contributed to a 0.5% reduction in the national GDP. In total, 2,267,458 people were affected, with 679 lives lost, 537 reported missing, 659,278 displaced, and 2,186 injured (Government of Malawi, 2023). This catastrophic event mirrors the impacts of Cyclone Idai in 2019. The damage and losses from Cyclone Idai, along with the recovery and reconstruction needs, were estimated at $220 million and $370 million, respectively, accounting for 5.8% of Malawi's GDP. The cyclone affected approximately 975,000 people, with 60 fatalities, 3 missing, 86,976 displaced, and 672 injured (Government of Malawi, 2019).

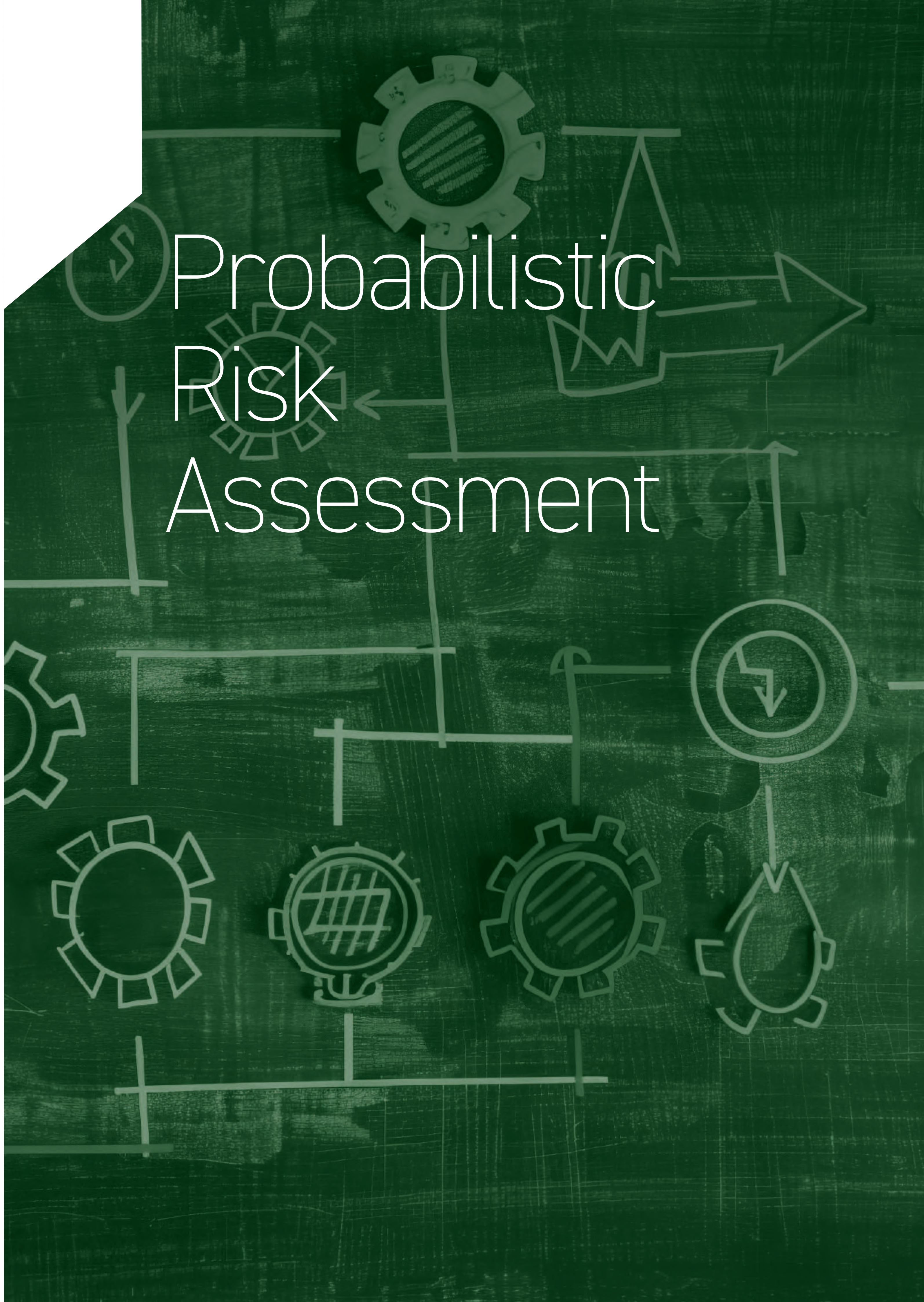
Disaster Risk Management (DRM) is very critical for Malawi to safeguard the economic gains that the country has achieved this far. Since the adoption of

Hyogo Framework for Action (HFA 2005 - 2015), the Government of Malawi through the Department of Disaster Management Affairs (DoDMA) has considerably endeavoured to promote a nationwide proactive approach to disaster management through risk management. Key initiatives under this area have been institutional capacity building of central and local government structures in disaster risk management; integrating DRM into multi-sectoral development planning including primary and tertiary education; developing critical national guiding instruments for DRM work including the National Resilience Strategy (NRS), National Disaster Risk Management Policy (NDRMP 2015); devolution of DRM functions to the local authorities and provision of financial support for community based disaster risk management initiatives (CBDRM), among other initiatives.

Under the Sendai Framework for Disaster Risk Reduction 2015-2030, the Government of Malawi has made significant strides in disaster risk reduction. Key initiatives include the development of the National Disaster Risk Management Policy (NDRMP 2015), the devolution of DRM functions and responsibilities to local authorities, and the creation of guidelines in 2018 for developing DRM plans. These guidelines provide a conceptual and practical framework for standardizing disaster risk management plans at the village, district, town, municipal, city, and national levels. Additionally, the repeal of the Disaster Preparedness and Relief Act of 1991 led to the establishment of the Disaster Risk Management Act, 2023. The government has also approved several important policies, including the National Urban Policy (NUP 2019), the National Resilience Strategy (NRS), the National Climate Change Management Policy, and recently revised its Nationally Determined Contributions (NDCs), all of which guide climate resilience efforts in the country. The DRM Act, 2023 seeks to provide guidance for the implementation of DRM related activities down to the local level.

The increasing disaster risk has prompted the Malawi Government to undertake several initiatives. One significant milestone in disaster risk reduction is the comprehensive multi-hazard probabilistic risk assessment project, which covers the entire country. Supported by the World Bank under the Malawi Resilience and Disaster Risk Management Project (MRDRMP), this project aims to develop detailed risk profiles to raise public awareness about existing hazards. Additionally, it supports the implementation of various resilience-building interventions by providing both communities and government institutions with evidence-based information.

Island in Lake Malawi - via Wikimedia Commons



Probabilistic Risk Assessment

Risk Assessment Methodology

Different and complementary methods and tools are available for analysing risk. These range from qualitative to semi-quantitative and quantitative methods.
The choice of the method depends on a number of factors including the intended use of the risk assessment, data demands and implementation cost.

The Probabilistic Risk Assessment approach (PRA), was used to develop the disaster risk profile in this project. Probabilistic disaster risk profiles scrutinize all conceivable scenarios within a given geographic area. This entails calculating events with varying frequencies and magnitudes, alongside their probabilities of occurrence including their variability and uncertainty ranges. Therefore, these probabilistic assessments not only incorporate events not historically recorded, but also those plausible under present or projected climate conditions, a critical feature amid the escalating uncertainty spurred by climate change.

Risk is computed as a function of the hazard, exposure, vulnerability and capacity (Eq. 1) (UNDRR, 2016[1])

$$Risk = \frac{Hazard \times Exposure \times Vulnerability}{Capacity}$$

Equation1

While Hazard, Exposure and Vulnerability are the basis of the quantitative approach proposed by the PRA, the element of Capacity is often difficult to capture in quantitative terms. In this study, elements of Capacity are accounted for in the socio-economic vulnerability assessment.

Probabilistic analysis emerges as the indispensable tool, providing a quantitative means to navigate uncertainty and offering a prospective look into the analysed risk-scape.


Depiction of Strong Winds - DoDMA

1. UNDRR, Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction, 2016, https://www.undrr.org/quick/11605

Risk Metrics

Risk is expressed as anticipated direct impacts of disasters through economic loss and number of affected people, both aggregated at national level and disaggregated at district level.

According to the Sendai Framework definition, "Affected People" refers to individuals that are directly impacted by a disaster. This typically includes casualties, those suffering direct injuries, individuals displaced and people who lost their houses and livelihood. Based on this definition, this assessment calculates the number of affected people as those whose houses are damaged, as they are likely to experience injury and displacement, as well as those who lose their livelihoods, particularly those dependent on agriculture. This relates to the Sendai indicator B1[2].

Assessing the number of affected people in a disaster is crucial for several reasons (Sendai Framework, UNDRR, 2015[3]):

01

Humanitarian Response

Understanding the scale of impact helps in mobilizing and directing appropriate humanitarian aid and resources to those in need. It ensures that relief efforts are targeted and effective, providing essential goods and services like food, water, shelter, and medical care to the affected populations.

02

Resource Allocation

Accurate data on affected individuals aids in efficient resource allocation. Governments and international agencies can better plan and distribute financial and material resources to areas with the greatest need, optimizing the overall response and recovery process.

03

Risk Reduction and Preparedness

Assessing the number of affected people helps identify vulnerable populations and areas. This information is vital for developing and implementing risk reduction strategies and preparedness plans, aimed at minimizing future disaster impacts and enhancing community resilience.

04

Policy and Planning

Reliable data on disaster-affected populations informs policy-making and long-term development planning. It enables governments and organizations to design policies and programs that address the root causes of vulnerability, improve infrastructure, and enhance disaster risk management frameworks.

05

Monitoring and Evaluation

Tracking the number of affected individuals over time allows for monitoring and evaluating the effectiveness of disaster response and recovery efforts. It provides insights into the success of interventions and highlights areas for improvement in future disaster management practices.

06

Global Reporting and Accountability

Accurate assessment aligns with international frameworks, such as the Sendai Framework for Disaster Risk Reduction. It helps countries report on their progress in reducing disaster risk and achieving global targets, fostering accountability and encouraging international cooperation.

2. United Nations Office for Disaster Risk Reduction, 2015. Sendai Framework for Disaster Risk Reduction 2015-2030. United Nations. Available at: https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015
3. United Nations Office for Disaster Risk Reduction. (2015). Sendai Framework for Disaster Risk Reduction 2015-2030. Geneva, Switzerland: United Nations.

Economic Loss is evaluated as the total direct economic loss due to disasters in line with the indicator C1[4] of the Sendai Framework.
This metric is crucial for a number of reasons:

01 Impact Assessment

By measuring direct economic losses in relation to global GDP, this indicator helps to understand the scale and severity of the economic impact of disasters for the country. It highlights how disasters can affect economic stability and growth.

02 Comparative Analysis

Relating economic losses to national GDP allows for comparisons across different time periods (Present and possible futures including climate change) and districts. It helps to contextualize the economic burden of disasters relative to the overall size of the national economy.

03 Policy and Planning

This indicator informs policymakers and planners about the economic vulnerabilities associated with disasters. It underscores the need for investment in disaster risk reduction and resilience-building measures to mitigate economic losses.

04 Resource Allocation

Understanding the economic impact of disasters can guide the allocation of resources for disaster response and recovery. It emphasizes the importance of funding for rebuilding and recovery efforts.

05 Global Reporting and Accountability

Indicator C1 is part of the global targets set by the Sendai Framework. It facilitates international reporting and accountability, enabling countries to track and report their progress in reducing economic losses due to disasters.

Economic losses have been measured in accumulated terms, disaggregated by hazard and sector, both in the current and projected climate conditions.

Two risk metrics are employed: the **Annual Average Loss (AAL)** and the **Probable Maximum Loss curve (PML)**.

The **AAL** is the expected loss per year, averaged over many years. While there may be little or no loss over short periods, AAL also accounts for larger and less frequent losses. The AAL represents the funds required annually to cover the cumulative average disaster loss over time. Analysing AAL is critical within probabilistic risk assessment for Disaster Risk Reduction (DRR). AAL provides a comprehensive and quantitative measure of the average economic losses a society can expect to face due to various hazard events over a long period of time, rescaled on an annual basis. This metric is essential for policymakers, helping them to prioritize interventions and allocate resources effectively. By quantifying the expected losses, decision-makers gain valuable insights into the magnitude of the risk landscape and can make informed decisions regarding risk reduction strategies, investment in resilience-building measures, and the development of contingency plans. Additionally, AAL facilitates cost-benefit analyses, allowing stakeholders to assess the economic viability of different risk management options and prioritize actions that yield the greatest reduction in expected losses per unit investment. Ultimately, a thorough analysis of AAL strengthens the resilience of communities and economies by guiding proactive measures that mitigate the impact of disasters and safeguard lives, livelihoods, and infrastructure against future hazards.

4. United Nations Office for Disaster Risk Reduction, 2015. Sendai Framework for Disaster Risk Reduction 2015-2030. United Nations. Available at: https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015

The second metric, the **PML** curve, illustrates the potential loss which could be expected corresponding to a given likelihood. It is expressed in terms of annual probability of exceedance or its reciprocal, the return period. The PML is typically used to define the size of reserves, which insurance companies or a government should have available to manage losses. Understanding the PML curve is essential for assessing the potential economic impact of large-scale natural hazards. Not all hazards result in significant economic losses; for example, an event in a sparsely populated desert may result in minimal losses due to the lack of exposure. Therefore, it is crucial to estimate losses associated with different scenarios.
The PML curve can be divided into different risk layers, each corresponding one related to a specific information (Figure 1).

Typically, four main layers can be identified:

- The Extensive Risk Layer: This layer encompasses risks that happen frequently and are typically addressed through risk reduction measures like flood defenses and vulnerability reduction interventions.
- The Mid Risk Layer: Here, higher and rarer losses are managed using financial resources at the country level, such as contingency funds.
- The Intensive Risk Layer: Reserved for severe and infrequent hazard events, this layer is often managed through risk transfer mechanisms like insurance and reinsurance.
- The Residual Risk, pertaining to catastrophic events, represents the risk deemed acceptable due to their extreme rarity. Given their infrequency, concrete actions to mitigate such risks beyond preparedness efforts, such as civil protection actions and humanitarian aid coordination, are typically limited.

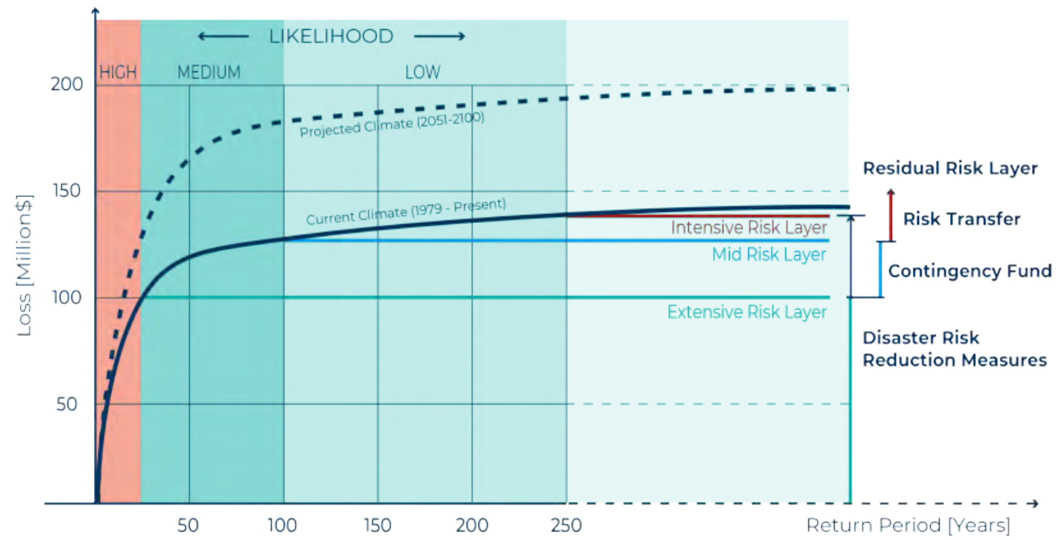


Figure 1. PML curve can be divided into different risk layers.

PRA, considers the full spectrum of possible scenarios and unlike other methodologies, gives insight into all these risk layers. At both national and sectoral levels, these analyses furnish invaluable insights, enabling geographic and quantitative comparisons of disaster losses. Such studies are pivotal in fostering risk awareness and galvanizing efforts toward risk reduction, adaptation, and management mechanisms. For detailed information on the methodology used, please refer to the Documents section of the online platform complementing the Atlas (http://malawi.is-portal.org).

Climate Analysis

The climate analysis in this Risk Atlas has been presented using both historical and future projections. This approach provides a comprehensive understanding of the existing climate conditions, patterns and trends, and how future climate conditions would affect Malawi.

The following hazards were analysed under climate change: riverine and localized flash flooding, strong winds and droughts. To support this in a consistent way, a strong and reliable dataset for present and projected climate was developed as a nodal component of this study.

The climate analysis was performed in two steps:
1. **Climate reanalysis** – datasets that combine past observations with models to generate consistent time series of multiple climate variables were used as data source for a statistical downscaling of climate projection fields on Malawi;
2. **Bias correction** - a bias removal technique was applied to such projections using local data whenever available.

Reanalysis datasets provide the most complete picture currently possible of past weather and climate. They are a blend of observations with past short-range weather forecasts rerun with the most updated weather forecasting models. They are globally complete and consistent in time hence sometimes referred to as 'maps without gaps'.

The meteorological dataset used for the simulation of basins' response over Malawi in present climate conditions (historical period) is W5E5[5] climate data of precipitation, air temperature, air humidity, wind velocity and solar radiation.

The W5E5 dataset was compiled to support the bias adjustment of climate input data for the impact assessments carried out in phase 3b of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP3b), therefore guaranteeing consistency between the present climate forcing and the projected climate forcing used in this study.

For the future climate, the ISIMIP3b dataset[6] has been selected as a state-of-the-art climate projection. Several General Circulation Models (GCM) are available for 3 different Shared Socioeconomic Pathways (SSPs) scenarios (i.e., SSP1, SSP3, SSP5), forming an ensemble of 15 combinations of models and scenarios (5 GCMs available for each of 3 SSP scenarios).

Figure 3 shows projected global air temperature trends under different SSPs and GCMsfrom 1980 to 2100. The figure compares historical data (W5E5 dataset) with future scenarios, illustrating how temperature increases over time with respect to the baseline. The projections vary depending on emission scenarios; with higher emissions (red lines) leading to more significant warming, while lower emissions (green lines) resulting in smaller temperature increases. This highlights the impact of different socioeconomic pathways and emission reduction strategies on future global temperatures as well as the uncertainty introduced by the different climate models used.

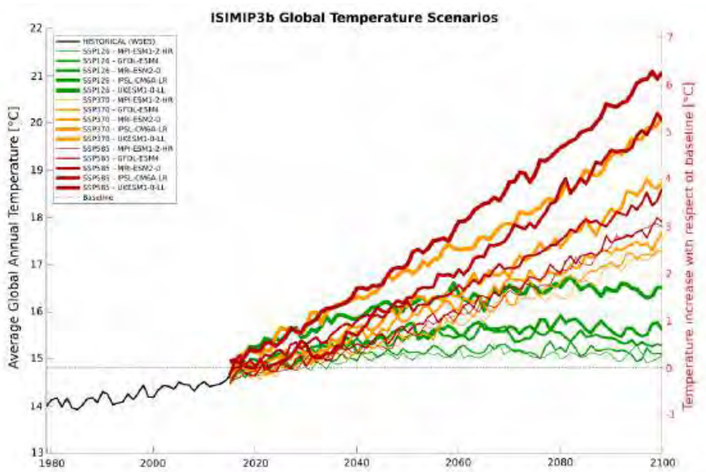


Figure 2. Trends of global air temperature according to the available Global Circulation Models/SSP scenarios combinations.

5. https://dataservices.gfz-potsdam.de/pik/showshort.php?id=escidoc:4855898
6. https://www.isimip.org/about/#simulation-rounds

Temperature and Precipitation represent the main drivers of climate extremes. Precipitation trends are highly correlated with the trends in temperature for all the different models and SSPs. Therefore, two scenarios were chosen, by adopting a statistical selection criterion based on the percentiles of the ensemble of temperature trajectories. For each year under future projection period (2017-2100), the 20-percentile and 80-percentile of the ensemble of average world temperature on land were computed, yielding two additional temperatures trajectories: the 20-percentile and 80-percentile ensemble mean. Then, among the model runs available, the closest simulation to each one of the two percentile trajectories was selected. These identified simulations were used to characterize the climate change variability without having to deal with the whole ensemble. This approach allows us to bound the risk figures considering the uncertainty in the climate simulations that derives from both the SSP and the climate model considered.

The selected simulations were SSP126/IPSL-CM6A-LR for 20-percentile (low emissions scenario) and SSP585/IPSL-CM6A-LR for 80-percentile (high emissions scenario). To summarize, three different climate scenarios were considered:

- **under current climate conditions** - with disaster risk assessed using the observed climate conditions in the 1981 - 2061 period;
- **under projected climate conditions, upper boundary, high emissions scenario** - with disaster risk being assessed under projected climate conditions between 2061- 2100, considering the IPCC SSP5-RCP8.5 scenario, which foresees high radiative forcing by the end of century, driven by the economic success of industrialized and emerging economies, coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. **This is referred to as the PESSIMISTIC Scenario in the Atlas.**
- **under projected climate conditions, lower boundary, low emission scenario** - with disaster risk being assessed under projected climate conditions between 2061-2100, considering the IPCC SSP1-RCP2.6 scenario, designed with the aim of simulating a development that is compatible with the global 2°C target, assuming climate mitigation measures being taken. **This is referred to as OPTIMISTIC Scenario in the Atlas.**

The reanalysis data already considers observations for consistency and bias correction. However, a bias correction was done with in situ observations provided by Malawian institutions to validate the reliability of the meteorological fields.

Although W5E5 and the ISIMIP3b datasets represent the state-of-the-art climatological data currently available to scientists, they are available at a relatively low resolution (0.5° spatial resolution). While this resolution is appropriate to capture extremes for certain hazards (e.g., Riverine Floods or Drought), they fail to capture more localized features that are of extreme importance for others (i.e. Flash Floods and Strong Wind).
For this purpose, those fields have been interpolated onto a regular "fine grid" covering Malawi with resolution 0.020 degrees in longitude and latitude, corresponding to about 2.2 km in both directions in the latitude range of Malawi. Optimal Interpolation (OI) was used in this case to statistically downscale the dataset, considering a high-resolution Digital Surface Model[7] (DSM) to factor in orographic effects onto the climatological variables. The projected climate change scenarios have been also bias-corrected in their downscaled form.

The meteo-climatic variables derived from GCM cannot capture all complexities of the water cycle, especially when hydrological extremes are of concern (e.g. for floods and drought). Therefore, they are used as input for a fully distributed, physically based, continuous hydrological model[8] able to capture all the non-linearities of the hydrologic cycle.

7. FAB-DEM (Forest And Buildings removed Copernicus 30m Digital Elevation Model) has been used with different levels of aggregation in the study; Hawker, L., Uhe, P., Paulo, L., Sosa, J., Savage, J., Sampson, C., Smith, A., & Neal, J. (2022). FABDEM: A 30 m global map of elevation with forests and buildings removed. Environmental Research Letters, 17(2), 024016. https://doi.org/10.1088/1748-9326/ac5c18

8. The open source continuum model was implemented in all catchments in Malawi and used for the study. Silvestro, F, Gabellani S., Delogu F., Rudari R., and Boni G.: Exploiting remote sensing land surface temperature in distributed hydrological modelling: the example of the Continuum model, Hydrol. Earth Syst. Sci. (2013), 17, 39-62, doi:10.5194/hess-17-39-2013

Past Events Analysis

Malawi's history has been shaped by a series of disasters driven by natural hazards that have profoundly impacted its socio-economic and environmental landscape. Since 1980, the country has faced over 50 extreme weather events, including devastating floods, droughts, and cyclones, which have displaced millions and caused extensive damage to infrastructure, homes, and agriculture. Additionally, damaging earthquakes have also been recorded, further highlighting the country's susceptibility to geophysical risks.
Analysing past events is a fundamental aspect of risk assessment, as it provides an initial understanding of the risk landscape and establishes a solid foundation for calibrating and validating risk models.

EM-DAT: This database includes information on the occurrence and impacts of significant disasters, reporting on the number of people killed, missing, injured, displaced, or evacuated, along with economic damages.

Economic damages are recorded only in cases where certain thresholds are exceeded . EM-DAT documents 48 disasters caused by natural hazards among the ones considered in this atlas, as summarized in Table 1.

Table 1 presents disaster data for Malawi from 2000 to 2024, compiled from EM-DAT. It includes various types of natural disasters such as riverine floods, flash floods, wind events (storms, cyclones, lightning), droughts, landslides, and earthquakes. Riverine floods were the most frequent, occurring 26 times and affecting over 2.5 million people, with significant economic damage totalling $503 million. Wind events impacted over 3.2 million people, while flash floods, though less frequent, caused 21 injuries. Other disasters like droughts and landslides also caused notable human and economic losses. However, no earthquake events were recorded during this period. This data underscores the substantial impact of these hazards on Malawi's population and economy.

Table 1. Disaster events and indicators recorded in EM-DAT for Malawi, from 2000 to 2024,'-' is used whenever the specific data is not available.

HAZARDS	NUMBER OF EVENTS	YEARS	POPULATION			ECONOMIC
			Deaths	Injured	Total affected	Total Damage ['000 US$]
Riverine Floods	26	2000 -2024	438	1507	2 550 365	503 141
Flash Floods	5	2003-2018	21	0	192 246	-
Strong Winds Lightning Thunderstorms Storm, Cyclone	7	2005-2023	1309	2451	3 274 686	-
Droughts	7	2002-2024	500	0	25 827 628	-
Landslides Ground movement	1	2019	8	9	109	-
Earthquakes	2	2009	4	186	20550	-

DesInventar: This database is the official database of Malawi and it is maintained by DoDMA. It compiles data on small, medium, and large-scale disasters, focusing on the number of houses damaged, as well as deaths and injuries. It contains 1,603 records related to the hazards analysed in this study, as detailed in Table 2. A record may represent a single event, or multiple records may be linked to a single event if it is disaggregated across different geographical units.

These data sources have been complemented with data provided by stakeholders and institutions in Malawi.

A comparison of these observed events in Table 1 with the modelled results depicted in Figure 3 and Figure 4 respectively, provides valuable insights into the disaster risk landscape in Malawi.

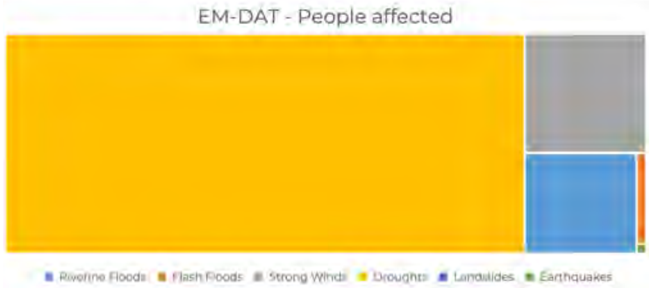


Figure 3. Distribution of people affected under different hazards in the EM-DAT database. The figure shows the relative impact of different hazards.

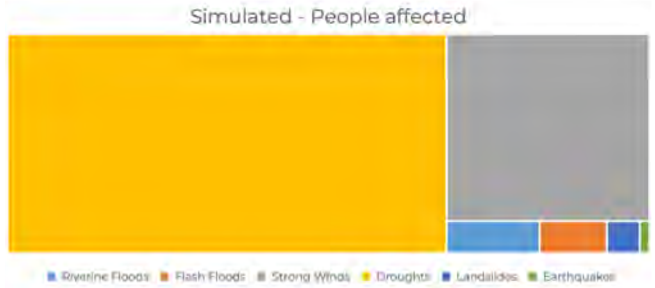


Figure 4. Distribution of people affected under different hazards under this risk assessment study. The figure shows the relative impact of different hazards.

Figures 3 and 4 indicate that weather-related hazards, particularly floods, are the most frequent type of disaster in Malawi, with 26 recorded events. However, despite their frequency, floods do not represent the highest risk in terms of the total number of people affected. Instead, droughts, although less frequent with only seven events recorded, have a far more substantial impact on the population, affecting over 25 million people, according to the EM-DAT records. This trend is similarly reflected in the PRA study results presented in Figure 4, which highlights droughts as the most significant hazard in terms of the affected population.

A comparative analysis of the distribution of people affected by different hazards reveals a consistent pattern between the observed and modelled data, with both indicating that droughts pose the greatest risk to the population. However, the modelled data suggest a slightly higher impact from floods than what is observed in the historical data from EM-DAT.

While EM-DAT records substantial economic damages from both general and riverine floods (over $500 million), there is a notable absence of economic data for other hazards like droughts and windstorms. This lack of economic impact data for certain hazards in the observed records contrasts with the modelled outcomes, which estimate broader economic consequences. These discrepancies emphasize the importance of improving data collection on one hand and employing a structured modelling approach on the other to fill gaps in the data and obtain a more accurate risk assessment and economic loss estimation.

Table 2. Disaster events and indicators recorded in the DesInventar Database for Malawi, from 1899 to 2018, '-' is used whenever the specific data is not available.

HAZARDS	NUMBER OF RECORDS	YEARS	HOUSES DAMAGED*	POPULATION		
				Deaths	Injured	People affected
Riverine Floods	595	1899-2018	112781	20	16	563 905
Flash Floods	26	1899-2018	28019	501	0	140 094
Strong Winds Cyclone, Heavy rains, Storms, Hail storms	965	1899-2018	20036	61	318	100 180
Droughts Dry Spells	10	1899-2008		0	0	10 469
Landslides	-	-	-	-	-	-
Earthquakes	7	1905, 2009, 2010	9950	2	100	49 750

* Obtained by dividing by 5 (assuming as the average number of inhabitants) the number of people affected

The consistency between observed and modelled data reinforces the validity of the PRA study findings, supporting the prioritization of drought risk in national disaster management strategies. While the historical data provides a solid foundation for understanding the risk landscape in Malawi, the modelled results offer a more detailed perspective that can inform future risk mitigation and preparedness efforts.

The DesInventar database, summarized in Table 2 and Figure 5, complements the insights provided by EM-DAT. One key distinction between the two is that DesInventar includes small and medium-scale disasters, which are typically not captured in EM-DAT. This inclusion provides a more comprehensive view of disaster impacts, particularly in rural or less monitored areas where smaller events have significant cumulative effects. The presence of these smaller events in the DesInventar database highlights the importance of considering a wide range of disaster scales in risk assessments.

According to DesInventar, wind-related hazards (cyclones, heavy rains, storms, hailstorms) are the most frequently recorded, with 965 events, followed closely by riverine floods with 595 records. Despite their smaller scale, these events have had considerable impacts, having accumulated over 500,000 damaged houses and having affected millions of people across the different hazards. From numerical simulations (Figure 7), the same 3 hazards (wind-related hazards, riverine floods and flash floods) were obtained as prevalent as far as damage to the houses is concerned, albeit, in a different order.

The comparison between observed and modelled data across both databases reveals a generally consistent pattern, with droughts identified as the most significant hazard for population impact and floods (both riverine and flash floods) as the leading cause of economic and housing damage. However, the variations in the data highlight the complexity of accurately modelling disaster risk, particularly when considering events of different scales. The inclusion of small and medium-sized disasters in DesInventar emphasizes the need for comprehensive data collection to inform more accurate and effective risk management strategies.

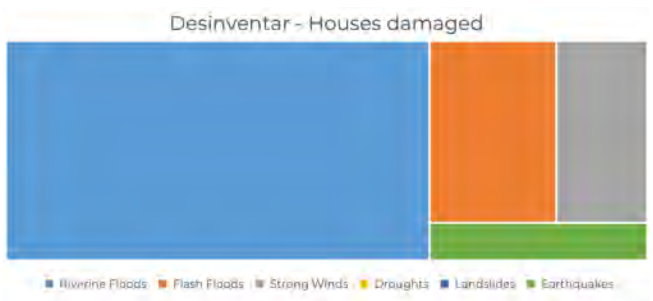


Figure 5. Distribution of houses damaged under different hazards according to the DesInventar database. The figure shows the relative impact of different hazards.

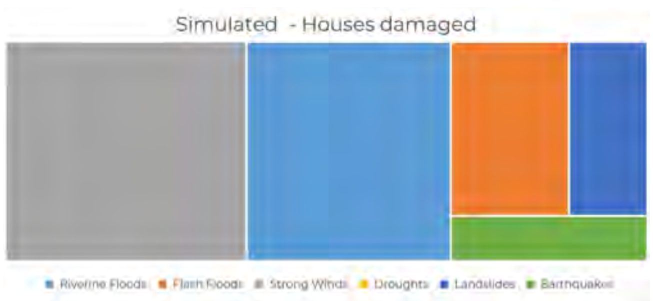


Figure 6. Distribution of houses damaged under different hazards based on this risk assessment study here presented. The figure shows the relative impact of different hazards.

Depiction of disaster impact-showing coffins carrying the remains of people who died during Cyclone Freddy - DoDMA

Riverine Floods

Malawi's vulnerability to extreme weather events has become an increasingly pressing concern, with riverine floods being a major contributor. These events have inflicted significant socio-economic and environmental consequences, making floods one of the country's top priority hazards. The last decade alone has seen over 25 severe rainfall-related disasters (EM-DAT), highlighting an alarming upward trend in the number of people affected. Malawi's susceptibility to riverine floods is driven by several factors. The country's undulating terrain, which includes river valleys, lakes, and plateaus, plays a significant role in flood risk. The Great Rift Valley, which runs through Malawi, influences the distribution and intensity of rainfall, further exacerbating the risk of localized flooding. The primary rainfall-bearing system in Malawi is the Inter-Tropical Convergence Zone (ITCZ), which, along with cyclonic activity from the Mozambique Channel in the Indian Ocean, intensifies rainfall in some years. This results in an average rainfall of 1,200 mm during the rainy season (November to April), with highland plateaus receiving over 3,000 mm. More than 90% of this rainfall occurs from December to March.

Compounding the flood risk is Malawi's population which is largely rural (85%) and predominantly dependent on rainfed agriculture. Widespread land conversion from forested areas to agricultural land, driven by the need to support subsistence farming, has contributed to significant deforestation. Other causes of deforestation include charcoal production, uncontrolled bushfires, and tobacco curing. Additionally, the susceptibility of agriculture to erratic rainfall patterns and extreme weather events, exacerbated by climate change, makes floodplains an important source of livelihoods, thereby increasing exposure. Beyond physical exposure, Malawi's socio-economic vulnerability is also critical, as over 50.78% of the population lives below the national poverty line, with 20.5% in extreme poverty (Malawi Poverty Report, 2020).

Flash Floods

Alongside with riverine floods, flash and urban flooding are significant challenges in Malawi due to intense rainfall, rapid urbanization, poor waste management and inadequate drainage infrastructure. Flash floods occur when heavy rains exceed soil absorption capacity, leading to runoff and flooding, especially in low-lying areas. The country's varied topography and distinct rainy season, which runs from November to April, heighten these risks. Urban areas, with their impermeable surfaces and poor drainage systems, are especially vulnerable.

Notable incidents include the January 2015 floods, exacerbated by Tropical Storm Chedza, which displaced thousands and damaged infrastructure. Similarly, in March 2019, heavy rains breached urban drainage systems in cities like Blantyre and Lilongwe, causing widespread disruption. In March 2023, Tropical Cyclone Freddy brought damaging flash flooding to the cities of Blantyre and Zomba.

Strong Winds

While various types of floods are a major concern in Malawi, the past decade has seen several devastating wind events, highlighting the need for enhanced resilience and preparedness. Strong winds exceeding 100 mph, brought by Cyclone Idai in March 2019, were particularly catastrophic, killing over 60 people, displacing 86,000, and damaging infrastructure, homes, and crops. Similarly, Cyclone Chedza in January 2015 brought severe winds and rainfall, destroying homes, agricultural land, and infrastructure, severely impacting food security and livelihoods. It is important to note that strong winds are not only associated with tropical storm systems; devastating wind events have also been experienced during the dry season (such as micro-scale whirlwinds) and from high-pressure systems driven by south-easterly winds.

These events underscore Malawi's vulnerability to wind-related disasters and the importance of proactive measures, such as resilient building practices, early warning systems, and disaster preparedness plans.

Droughts

Droughts have a significant impact on Malawi's agrarian economy, where over 85% of the population relies on subsistence farming. According to the Malawi Vulnerability Assessment Committee (MVAC), which informed the development of the Food Insecurity Response Programme (FIRP), the 2015-2016 drought, coupled with flooding, caused widespread crop failures, leaving 6.7 million people food insecure. The effects of droughts extend beyond agriculture, impacting non-agricultural sectors and households through economic linkages. Unfortunately, projections suggest that extreme weather events will persist in Malawi, with their frequency and severity expected to increase. Factors such as high rates of deforestation, land degradation, and poor watershed management further amplify the risks of floods and landslides.

Landslides

Malawi experienced several significant landslide events, often triggered by heavy rainfall, steep terrain, and deforestation. These landslides have caused considerable damage to infrastructure, and human settlements, leading to loss of life and displacement. The typically affected regions are mountainous and hilly areas, where vulnerable populations reside.

These events highlight the critical need for disaster risk reduction strategies, particularly in areas prone to landslides, to protect lives and property.

Earthquakes

Earthquakes are a significant geophysical risk in Sub-Saharan Africa, particularly along the East African Rift System (EARS), which stretches from Ethiopia to Mozambique. Within this system, the Western Rift runs through Malawi and has shown the highest seismic activity in the region. In recent years, moderate earthquakes have caused notable damage in Malawi, including the 1989 MW6.3 Salima earthquake and the 2009 MW6.0 Karonga earthquake sequence. The 1989 Salima earthquake resulted in 9 deaths, approximately 100 injuries, and displaced about 50,000 people. The 2009 Karonga earthquake sequence killed 4 people and injured approximatively 200. While more deadly earthquakes have occurred in other parts of the world, Malawi remains vulnerable to larger magnitude earthquakes, which, coupled with rapid population growth, could result in even greater damage and casualties in the future.

Cyclone Freddy seen from satellite - Pierre Markuse - via Wikimedia Commons

Relevant Recent Disaster Events in Malawi

Floods · Droughts · Landslides · Earthquakes

2015 | Floods
In 2015, continuous heavy rains caused widespread flooding across Malawi, affecting an estimated 276,000 people, particularly in the Southern Region, including Nsanje, Chikwawa, and Phalombe districts. The floods caused loss of life and significant property damage. The floods resulted in loss of life and significant property damage. The causes of these losses were not limited to the floods; cyclonic winds also caused damage to assets, particularly in the southern part of the country (PDNA 2015).

2019 | Floods
Early 2019 floods, triggered by heavy rains, affected over 800,000 people, causing displacement and damaging infrastructure, crops, and livestock, particularly in Southern Malawi, including Chikwawa, Zomba, and Nsanje districts. Causes of losses were not limited to floods, cyclonic winds also caused damages to assets especially in the southern part of the country (PDNA 2019).

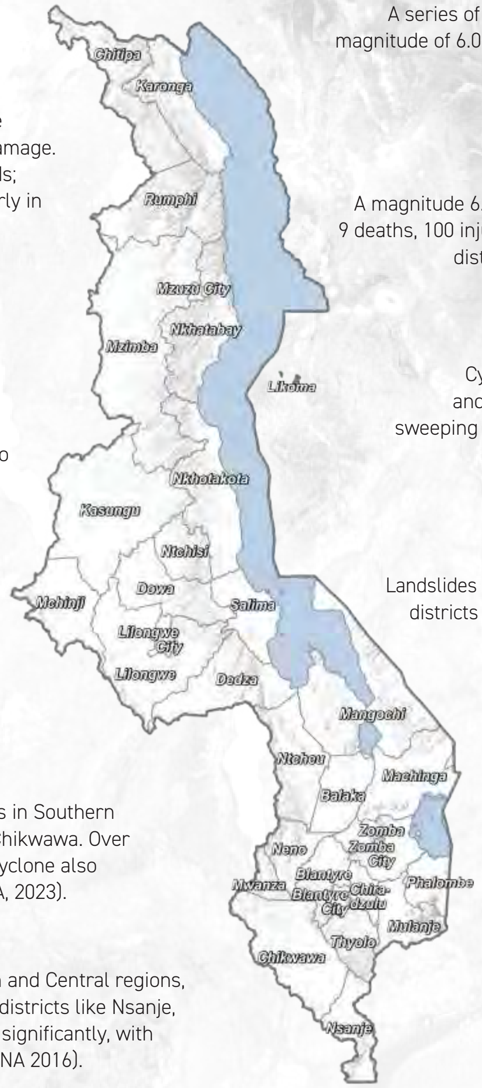
2022 | Floods - Tropical Storm Gombe & Cyclone Ana
In January 2022, Tropical Storm Ana caused severe flooding, primarily affecting the southern districts of Chikwawa, Phalombe, and Nsanje. Over 945,000 people were impacted, with 46 reported deaths, over 200 injuries, and 67,800 households displaced (IFRC, 2022).

2023 | Floods - Cyclone Freddy
Cyclone Freddy in 2023 exacerbated ongoing challenges in Southern Malawi, particularly affecting districts like Nsanje and Chikwawa. Over 3.8 million people faced acute food insecurity, and the cyclone also worsened the cholera outbreak (FEWS NET, 2023; PDNA, 2023).

2015-2016 | Prolonged Drought
The 2015-2016 drought severely impacted the Southern and Central regions, leaving 6.7 million people food insecure, particularly in districts like Nsanje, Dedza, and Chikwawa. Agricultural production dropped significantly, with damages estimated at USD 370 million (MVAC 2016, PDNA 2016).

2018-2019 | Drought during El Niño
The El Niño-induced drought led to reduced maize production, exacerbating food insecurity in districts like Balaka and Salima. The drought caused food prices to spike and left rural communities vulnerable (World Bank, 2019).

2021-2022 | Dry spells during growing season
Erratic rainfall during the 2021-2022 growing season caused crop failures, particularly in maize and legumes, affecting food prices and food security across central and southern Malawi, including Dedza and Zomba (FEWSNET, 2022).



December 6-20, 2009 | Earthquake
A series of earthquakes in Karonga district, with a peak magnitude of 6.0, caused 4 deaths, 300 injuries, and damaged over 4,000 houses, displacing thousands (UN OFFICE RC, 2009).

March 10, 1989 | Earthquake
A magnitude 6.3 earthquake struck central Malawi, causing 9 deaths, 100 injuries, and leaving 50,000 people homeless in districts like Salima and Kasungu (USGS, 1989).

March 2023 | Landslides
Cyclone Freddy-induced landslides in Blantyre and Chiradzulu districts caused severe damage, sweeping away villages, killing dozens, and destroying infrastructure (PDNA 2023).

January 2019 | Landslides
Landslides triggered by flooding in Chikwawa and Nsanje districts damaged agricultural land and infrastructure, displacing thousands (PDNA 2019).

March 2015 | Landslides
Following severe floods, landslides in Phalombe and Mulanje districts destroyed homes, displaced residents, and caused several fatalities (PDNA 2015).

March 1991 | Landslides
Heavy rains triggered landslides in Mulanje and Phalombe districts, damaging tea plantations and local infrastructure (Thiery et al., 2024).

2023-2024 | El Niño -induced Drought
The El Niño-induced drought of 2023-2024 caused severe water shortages and reduced agricultural yields, forcing the government to declare a state of disaster in 23 districts, including Mangochi, Dedza, and Nsanje (UNOCHA, 2024).

Figure 7. Past Event Analysis – Reference map for districts.

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Hazard

Hazard is a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption, or environmental degradation

UNDRR Terminology, 2017

For more methodological details on this section please refer to the Hazard report downloadable from: http://malawi.is-portal.org/#/documents

Riverine Floods

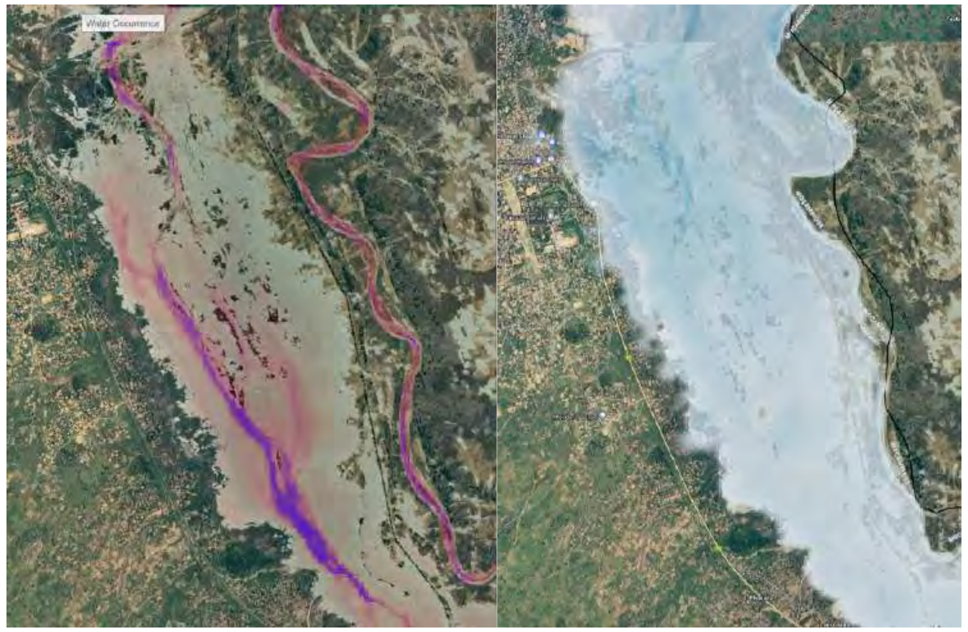


Figure 8. Flood extent around Bangula, Nsanje District as observed from Landsat (32 years of observations), and the 50-year return period flood hazard map (right).

The Riverine flood risk assessment aims to understand the magnitudes of damaging riverine floods at various return periods, both in current and projected climate conditions. This involves creating hazard maps based on past events and future projections. These hazard maps are then used to produce a series of possible hazardous events that are in turn used for the impacts and eventually the risk computation. A modelling chain consisting of climate, hydrological, and hydraulic models combined with available information on rainfall, temperature, humidity, wind and solar radiation, has been used. A set of mutually exclusive and collectively exhaustive possible hazard scenarios that may occur in Malawi, including the most catastrophic ones, is generated and expressed in terms of frequency, extent of the affected area and intensity in different locations.

The workflow began by bias-correcting Global Circulation Model (GCM) fields for both current and projected climates, which were then used as inputs to the Continuum hydrological model[10] to produce a 120-year continuous simulation (1981-2100).
The discharge values generated from these simulations were validated against historical river discharge observations. These validated values were then used to calculate flow quantiles for various return periods ranging from 2 to 1000 years. The resulting quantiles were fed into hydraulic models to generate 30-meter resolution flood maps[11] for the different return periods. The hydraulic model used in the project is the REFLEX model[12]. These maps were validated with satellite data, showing good agreement with 32 years of Landsat observations (see, Figure 8), as well as with the past 6 years of observation from the Copernicus Sentinel-1 satellite. The hydrological modelling was applied to the entire territory of Malawi while the hydraulic modelling to produce the hazard maps considered major rivers only with drainage areas larger than 500 Km^2. Therefore, while comprehensive at national level, smaller tributaries might be excluded by the assessment.

The time series of river flows generated by the model were used to identify independent flood events. This was done to simulate floods that have not yet been observed, both in terms of their intensity and how they might affect different geographic areas. By applying a multivariate statistical analysis, we were able to simulate a range of potential flood events. These events are described

10. https://fp-hyde.readthedocs.io/en/latest/intro.html; https://github.com/c-hydro/hmc-dev
11. For the study the 30 m FABDEM was used; Hawker, L., Uhe, P., Paulo, L. et al., (2022). "A 30 m global map of elevation with forests and buildings removed". Environmental Research Letters, 17(2), 024028. DOI:10.1088/1748-9326/ac4d4c.
12. The DEM was used as an input for the simlified flood model REFLEX that has been extensively used in several studies in Africa as well as globally; Arcorace, M., Libertino, A., Alfieri, L., Gabellani, S., Matanò, A., Masoero, A., Basso, V., Boni, G. (2024). REFLEX—A novel method for the rapid estimation of flood extent. Journal of Flood Risk Management. 17. 10.1111/jfr3.13034.

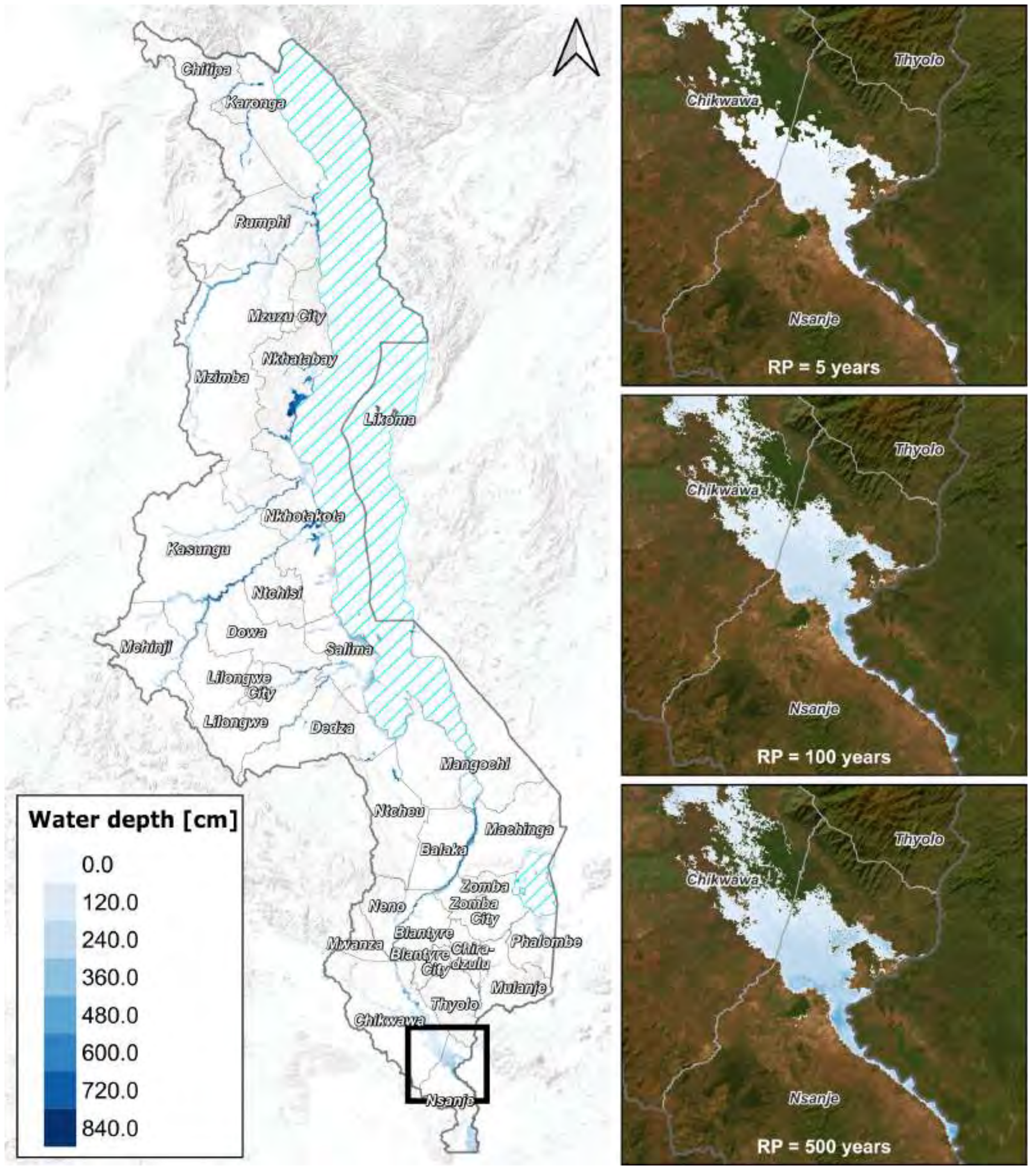


Figure 9. Hazard Map of River Floods (water depth in cm) for the Lower Shire Valley for a 100-year return period (RP) under current climate conditions. On the right hand side is the detail for three different return periods (5, 100, 500 years).

by their intensity, measured as return periods, at the sub-catchment level. A catalogue of possible flood scenarios was then created by combining the intensity of these events with detailed hazard maps, providing a comprehensive set of flood scenarios that have been used for the final risk analysis.

Figure 9 presents the flood hazard across the country. The maps illustrate areas of potential flood risk shown by water depth (cm) and extent of inundation for a given likelihood of occurrence of an event (RP). The maps are a critical tool for planning purposes related to flood mitigation, infrastructure development, and climate change adaptation. The map (right) shows the flood hazard at three different return periods (5, 100, and 500 years) for the area around Nsanje.

Key Components of the Map:
Main Map (Left):
Water Depth Scale: Shows intensity of the flood hazard with lighter blue colours indicating lower depths and darker blue colours representing deeper water.
Insets Satellite Images (Right side):

- RP = 5 years: This inset shows potential flood hazard risk projections for a flood event with a 20% chance of occurrence in a given year.
- RP = 100 years: This inset represents flood hazard risk projections for a flood event with a 1% chance of occurrence in a given year. A 100-year return period is considered a high-risk event.
- RP = 500 years: This inset shows an extreme flood event with a 1 in 500 years (0.2%) annual chance of occurring.

Areas particularly around the southern parts of Malawi, including Nsanje, Chikwawa, and Thyolo are particularly prone to flood hazard. The potential for food risk increases as the return period (RP) increases, with areas like Nsanje being more prone to flooding in the future.

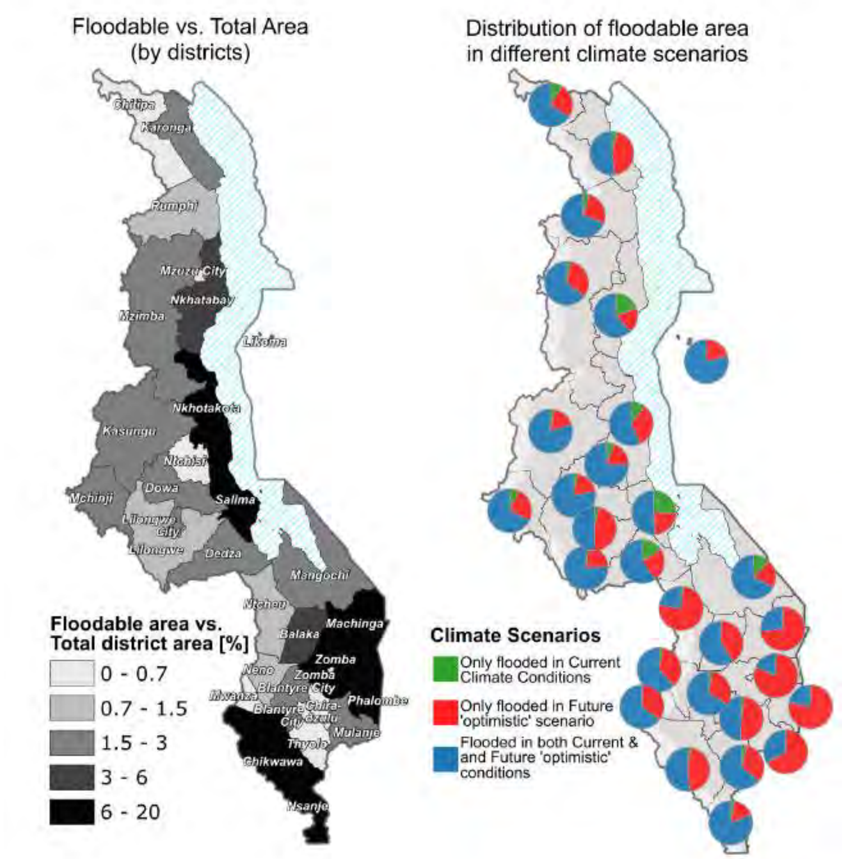


Figure 10. Percentage of each district's area that is prone to river floods (darker colours mean more flood-prone areas). The pie charts for each district break down the flood-prone areas into three categories: areas that will stay flood-prone under both current and future climate conditions (blue), areas that are flood-prone now but will not be under future conditions (green), and areas that are not flood-prone now but will become so in the future (red), based on an optimistic climate scenario.

Figure 10 shows a significant variation in floodable areas across different districts in Malawi. The darker shaded areas represent districts with a higher proportion of floodable land relative to their total area, indicating regions that are more susceptible to flooding. The map clearly illustrates that, even under an optimistic climate scenario, flood-prone areas are expected to expand, particularly in the southern regions of Malawi, as indicated by the larger red portion in the pie charts of the figure.

The maps show that most of the flood-prone areas are concentrated in the southern part of Malawi, along the lower Shire River. However, all major river systems in other parts of Malawi are also flood-prone, with considerable expansion in floodable areas under higher return periods. While the larger flood expansion areas are primarily confined to rural parts of the country or lowland areas near the lake, urban centres such as Lilongwe, as well as lakeshore districts like Karonga, Salima, and Mangochi, are also affected by flooding from major river systems.

Looking at specific districts, Nsanje, located in the southernmost part of Malawi in the Lower Shire Valley, is particularly vulnerable to flooding across all return periods. The flood extent and depth increase significantly from the 5-year to the 500-year scenario (Figure 9). As climate change may increase the frequency and intensity of extreme weather events, Nsanje and other districts in Malawi could experience more frequent and severe floods. The increase in water depth and flood extent in higher return periods indicates a high risk of inundation, which could displace large populations, damage infrastructure, and severely impact agriculture.

Similarly, Chikwawa, also located in the Lower Shire Valley, exhibits significant flood risk, especially in the 100-year and 500-year return periods (Figure 9). The flooding extends over a large area, suggesting that major portions of the district could be underwater during extreme flood events. The district's exposure to both current and projected flood risks will likely be exacerbated by climate change. Increased flooding could lead to repeated crop failures, food insecurity, and economic losses, making it crucial for disaster preparedness and mitigation strategies to be prioritized in Chikwawa.

Phalombe also shows significant flood risk, especially in higher return periods. The northern parts of the district could experience significant flooding in the 100-year and 500-year scenarios. As climate change intensifies, Phalombe may see more frequent and severe flood events, even in areas that currently experience less flooding. These effects could be detrimental to agriculture and housing, with long-term consequences for the local economy and livelihoods.

Blantyre, being slightly more elevated and not directly in the floodplain, shows less immediate risk in the maps. However, parts of the surrounding districts may still experience flooding, particularly in extreme scenarios like the 500-year return period.

Flash Floods

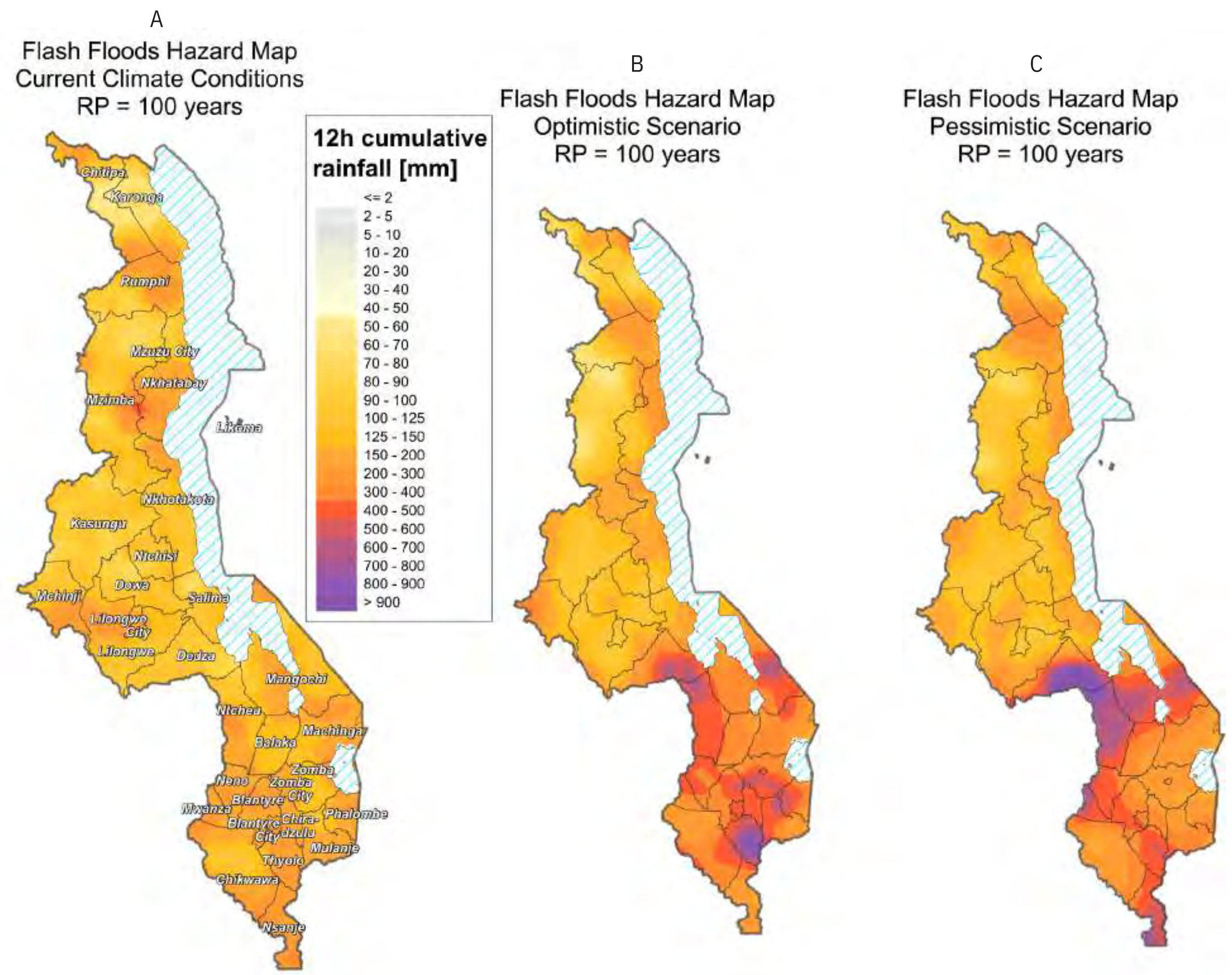


Figure 11. Flash hazard maps for a 100-year return period (RP) in the present and projected climate conditions: A) current; B) optimistic; C) pessimistic.

Flash flooding and urban flooding in Malawi, driven by intense rainfall and rapid urbanization, pose significant challenges to communities, the economy, and the environment. Flash flooding occurs when heavy rainfall exceeds soil absorption, leading to surface runoff and flooding of low-lying areas. Malawi's varied topography, with mountains, plateaus, and valleys, increases this vulnerability. The rainy season, from November to April, heightens the risk, especially in urban areas with poor drainage.

To assess rainfall hazards across Malawi, Rainfall Intensity–Duration–Frequency (IDF) curves were developed for each grid cell. These curves capture the likelihood of specific rainfall intensities occurring over various durations at any location, offering a detailed look at rainfall patterns. Utilizing the IDF data, high-resolution (2 km) rainfall hazard maps were created. These maps illustrate how intense rainfall, a key driver of flash floods, varies across Malawi. While in present climate conditions several districts experience strong rainfall intensities (e.g. Nkhatabay, Phalombe), the southern region experiences rainfall peaks in a more diffused and homogeneous manner, especially for high return periods, likely influenced by cyclones from the Indian Ocean. This trend becomes more pronounced under climate change scenarios.

Figure 11 displays hazard maps for flash floods in Malawi, indicating the expected flood risks over a 100-year return

period (RP) under different climate conditions.
The map is divided into three cases:

Current Climate Conditions (A): This map shows the present risk of flash flooding, highlighting areas in Malawi that are prone to flooding in the current climate conditions. These areas are marked based on their susceptibility to flash floods, with darker shades indicating higher risk zones.
Optimistic Scenario (B): The section reflects the projected flash flood risks under an optimistic climate scenario, suggesting that the impacts of flash floods may be less severe than in a pessimistic scenario but could still see an expansion in flood-prone areas.

Pessimistic Scenario (C): This map shows the projected flash flood risk under a pessimistic climate scenario, highlighting the areas expected to face the most severe impacts. These areas are likely to experience more frequent and extensive flooding as a result of worsening climate conditions.

While Figure 11 shows the 100-year hazard map for the 12 h duration, conditions for all durations (1-24h) have been analysed and similar hazard maps have been produced that have been in turn used for the risk computation.

(for more details refer to the Hazard Report available at http://malawi.is-portal.org/#/documents).


Flooding in Malawi - George Ntonya - UNDP

Strong Winds

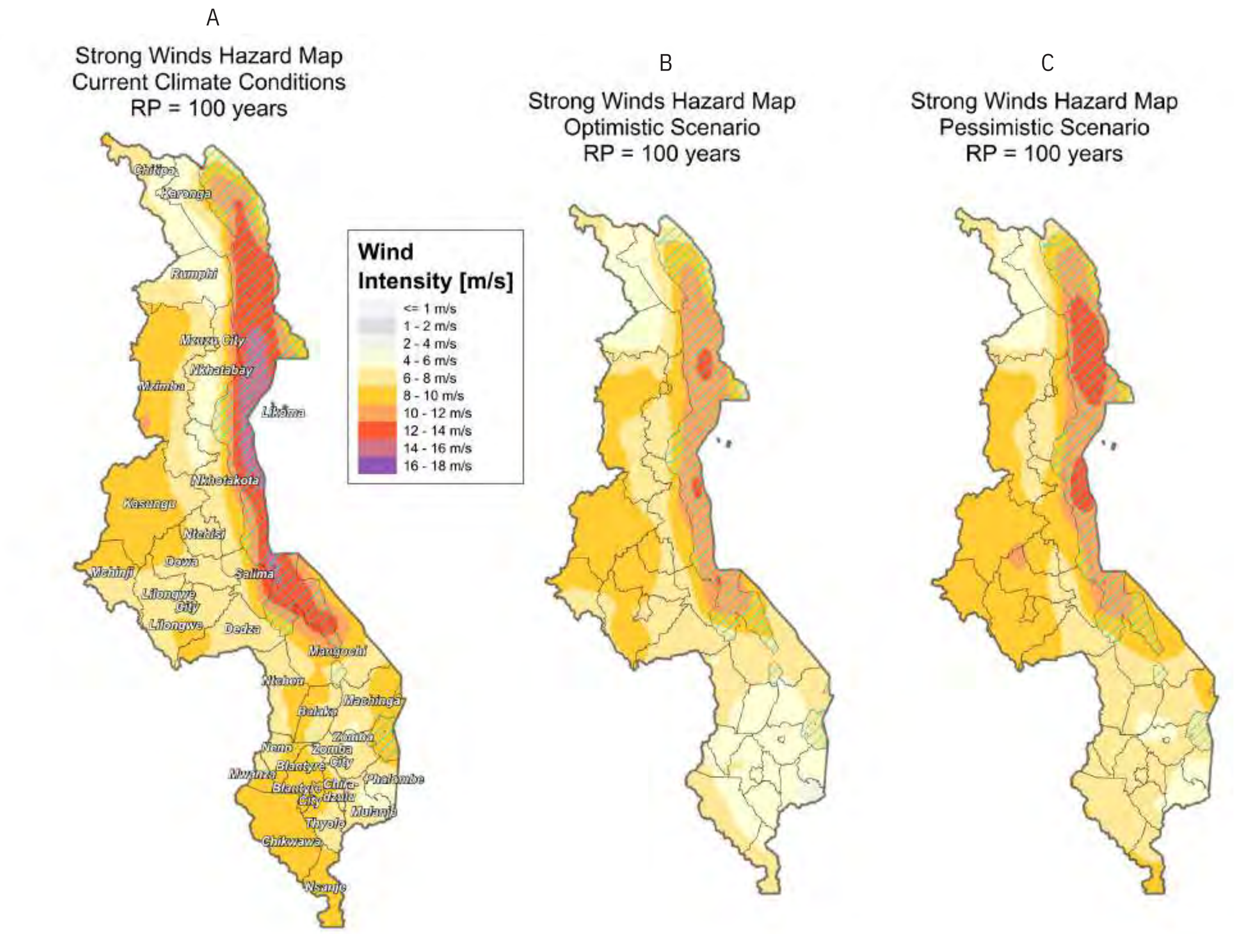


Figure 12. Hazard maps for 100 years return period (RP) in the present and projected climate conditions: A) current; B) optimistic; C) pessimistic.

The wind hazard assessment focused on strong winds under current and projected climate conditions at country scale; providing an estimate of wind speed at 2 km resolution for given frequency of occurrence and expressed in terms of return period. Wind speed data had an original cell resolution of 10 km that was downscaled using observations and machine learning techniques to a 2 km resolution.

For each grid point, annual maxima of the wind speed at 10 meters above the earth's surface were used in an extreme value analysis. From this analysis, the wind values for different return periods were derived at any location in Malawi, and different hazard maps for the reference return periods produced.

Current Climate Conditions (A): The northern region of Malawi experiences the most intense winds, along the Lake shores with strong winds reaching up to 12-14 m/s. The central region also faces moderate to strong winds particularly in Kasungu and parts of Mchinji, Dowa and Lilongwe. Moderate winds are also observed in the northern region, especially in the west of Mzimba district. The Southern part, including Nsanje and Chikwawa, tends to show a moderate wind intensity, although there are variations.
Optimistic Scenario (B): This scenario suggests a decrease in wind intensity across much of the country, with an exception in the central part that shows an overall increase in intensities. The reduction in intensity implies that in a less severe climate change future, wind hazards would be less pronounced.
Pessimistic Scenario (C): The pessimistic scenario shows an increase in wind intensity, particularly in the northern and central regions,) suggesting that stronger winds may occur under higher levels of climate change. The southern part of Malawi seems to experience a decrease of wind intensities.

Compound Fast Onset Weather-related Hazards (Riverine Floods, Flash Floods & Strong Winds)

Figure 13. Percentage of multi-hazard events with respect to the total number of events in the event-set in the corresponding district.

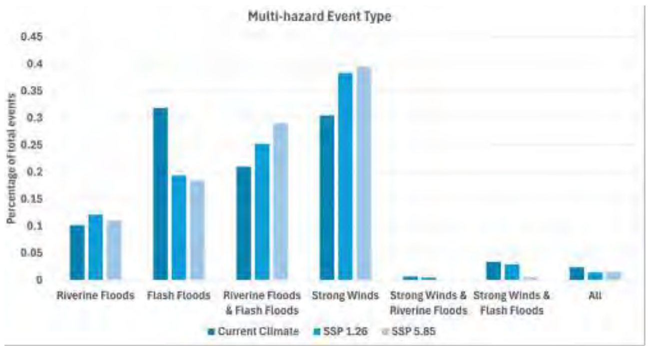


Figure 14. Distribution of the selected events typologies (Riverine Floods, Flash Floods, Strong Winds) in current and projected climate conditions.

Understanding the relationship between different types of events is essential in the PRA process. While hazard maps provide information for various return periods, they do not represent specific events. Instead, they show a combination of all possible events and their probabilities. The main difference between a hazard map and a hazard scenario is their level of detail: hazard maps give a broad overview, while hazard scenarios focus on how specific events might impact different parts of a region at varying intensities.

For small areas, risk estimates based on hazard maps (also called semi-probabilistic assessments) can be accurate. However, for larger areas like entire countries, this approach may introduce biases and overestimate risk. This is because larger-scale assessments must account for spatial correlations—how hazard intensities are linked across different locations. These correlations become even more critical in multi-hazard analyses, where compound events are considered.

A compound weather-related extreme event occurs when multiple hazards (e.g., flash floods, riverine floods, strong winds) are caused by a shared climatic driver, such as a cyclone or severe storm. These hazards are interconnected and can amplify impacts when they occur simultaneously or in sequence, increasing vulnerabilities and overall risk. For instance, the same storm can trigger riverine flooding in one area, flash flooding in another, and wind damage elsewhere. Recognizing these temporal and spatial correlations is vital, as they can result in compound effects that significantly alter risk assessments.

However, not all hazards are interconnected. For example, floods and droughts are typically independent and analysed separately.

For Malawi, weather-related hazard scenarios were generated using a combined framework that accounts for both spatial and temporal correlations among various hazardous events. This novel methodology is a key feature of this assessment. The output is a multi-hazard event catalogue for Malawi spanning 3,000 years. Three distinct multi-hazard event sets were created: one based on current climate conditions and two incorporating climate projections, one optimistic and one pessimistic. Each event is characterized by the return periods of flood, rainfall (used as an indicator for flash floods) and wind in specific areas. The event generation process employs a multivariate statistical approach. This approach uses selected events as input and preserves their spatial correlations to simulate both observed and unobserved events, considering their intensities and geographical distributions. The process has two main components: event definition and selection, and probabilistic event generation. From a multivariate perspective, an event is defined as a combination of hazard intensities across different locations. For example, an event might involve only fluvial floods, or it could include flash floods and fluvial floods in locations affected by hazard intensities exceeding a 5-year return period, or even multiple locations experiencing all three hazards simultaneously. An event is considered to have occurred if the intensity threshold is surpassed at least in one location.

Figure 13 describes the spatial distribution of compound hazard events while Figure 14 illustrates the percentage breakdown of different hazard combinations within the simulation. This statistical distribution is based on observed data and reproduced using multivariate simulation techniques Figure 14 illustrates the distribution of selected event types—riverine floods, flash floods, and strong winds—under both current and projected climate conditions, shown for two future scenarios: SSP1.26 (a lower emissions pathway) and SSP5.85 (a higher emissions pathway). The chart shows the percentage distribution of these events under each climate scenario.

From the figure, strong winds are the dominant event type, with a significantly higher proportion of events occurring under both current and projected conditions, particularly in the SSP5.85 scenario. This suggests that strong winds are expected to increase in both frequency and intensity, especially under more extreme climate scenarios.

In contrast, riverine flood events and flash floods events individually show a more moderate distribution. Under current climate conditions, flood and flash flood events occur at relatively similar levels, but the projected future scenarios (SSP1.26 and SSP5.85) show a rise in the frequency of both flood types, especially in the SSP5.85 scenario. The combined events (e.g., "Wind & Riverine Flood," "Wind & Flash Flood") appear less frequently, and these combinations show a slight increase in the projected future scenarios, indicating potential interactions between these types of extreme weather events.

The proportion of events categorized as floods or wind-related events is expected to rise with more severe climate scenarios (SSP5.85), reinforcing the anticipated increase in the intensity of extreme weather events due to climate change.

Depiction of combined impact of disasters and affected population - DoDMA

Droughts

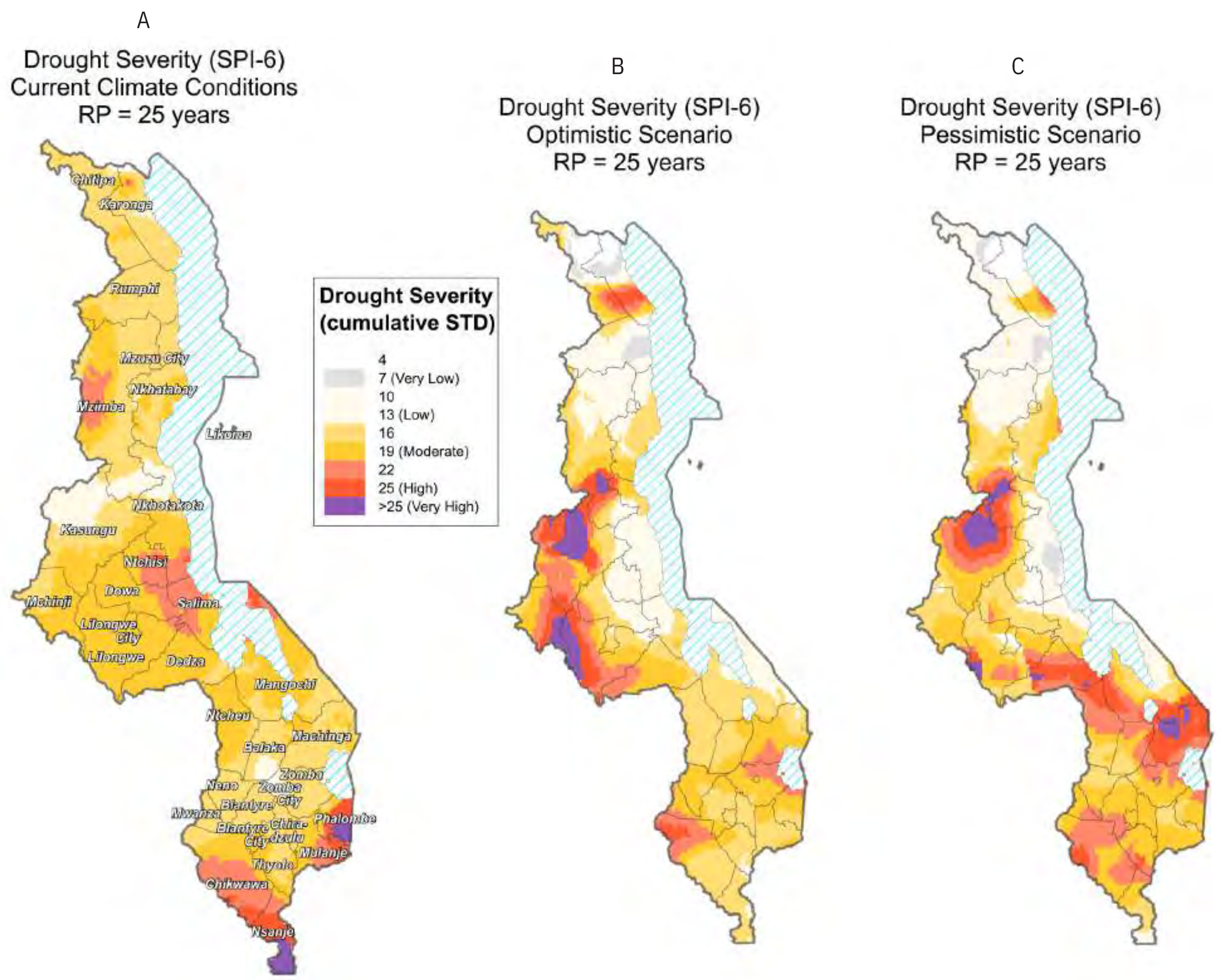


Figure 15. Drought severity under SPI-6 at 25 years return periods in the present and projected climate conditions: A) current; B) optimistic; C) pessimistic.

A drought generally refers to a period of water deficit from normal conditions. Drought hazard refers to the possible future occurrence of drought events, which can vary in intensity, duration, frequency and spatial extent. Quantifying drought hazard is a critical component of assessing overall drought risk.

Drought hazard estimation was based on a comprehensive approach that simultaneously considered data on precipitation, soil moisture and streamflow in rivers exploiting the implementation of a fully distributed and physically based model that enables the derivation of complex state variables to be extensively measured. 3 indices were adopted: the Standardized Precipitation Index (SPI) based on the meteorological forcing (precipitation) and the Soil Moisture Anomaly Percentage Index (SMAPI) and Standardized Streamflow Index (SSI) based on water balance outputs (soil moisture and streamflow respectively) derived from the hydrological model. The combined use of these three indicators allows for accounting for the main temporal scales and processes affecting the propagation of drought events, providing the necessary flexibility to reproduce drought impacts in different sectors.

The SPI is computed on three different time scales (3-months: SPI-3, 6-months: SPI-6 and 12 months: SPI-12) to account for short-to-medium-to-long-term variations in water availability and is particularly suited to detect drought occurring at a seasonal scale. The SMAPI aims

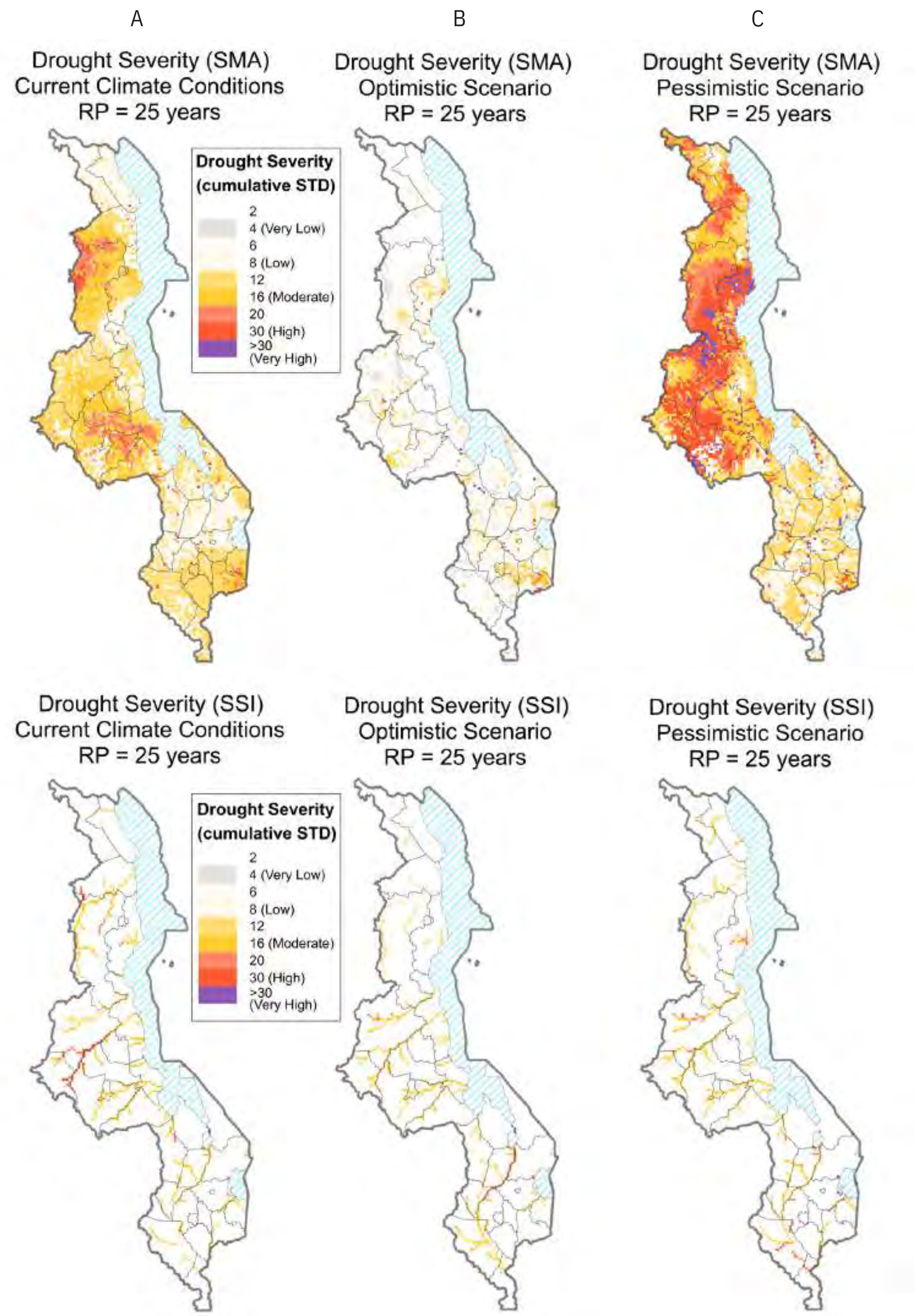


Figure 16. Drought severity under SMA and SSI indices at 25 years return periods in the present and projected climate conditions: A) current; B) optimistic; C) pessimistic.

to capture the short-term effects of droughts commonly relevant for agricultural studies. Lastly, the SSI captures the dynamics of hydrological droughts commonly associated with medium-term dynamics of the water cycle.

The advantage of all these indexes is that, since they are expressed in units of standard deviation from the long-term mean, they can be used to compare anomalies across different geographic locations. Figure 15 shows the SPI computed over a medium accumulation period (i.e. SPI-6) that is considered an indicator for reduced stream flow and reservoir storage. As with other weather-related hazards, drought hazard maps were developed for current climate conditions, optimistic and pessimistic climate scenarios. Drought severity (absolute cumulated standard deviations) has been used as the metric with outputs at different return periods (5, 10 and 25 years). Considering the 25-year return under current conditions, hotspots are clearly emerging. The southern part of the country experiences the most severe droughts when the rarest events are considered, with the districts of Chikwawa and Nsanje presenting the most severe conditions. This is evident even across the other two indices. When climate change is factored in, severity tends to exacerbate throughout the country. However, the difference in severity between current conditions and under climate change is more marked for the central and northern parts particularly when the SMA indicator is considered and for the southern part, downstream Lake Malawi, when SSI is analysed.

Figure 15 displays the spatial distribution of drought severity across Malawi using the Standardized Precipitation Index for 6 months metric (SPI-6), which measures drought conditions over a 25-year return period. The map is divided into three; A) current; B) optimistic; C) pessimistic.

Current Climate Conditions (A): This map shows the current drought severity across Malawi based on historical data. The severity index ranges from very low to very high (coloured from light grey to dark purple). Regions in the southern and central parts of Malawi show higher drought severity (in the red and orange zones), suggesting these areas experience more frequent and intense drought conditions. The northern regions appear relatively less severely affected by drought, with low to moderate severity levels.

Optimistic Scenario (B): This map projects drought severity under an optimistic future climate scenario. Under this scenario, the overall severity of droughts appears to increase in many areas, particularly in the southern parts of the country. Some regions that were previously experiencing low or moderate drought severity are now projected to face more severe drought conditions (indicated by darker colours, such as yellow and red). This reflects the potential impact of climate change under a positive future scenario.

Pessimistic Scenario (C): This map presents the projected drought severity under a pessimistic climate scenario. The results indicate a more dramatic increase in drought severity compared to the optimistic scenario, particularly in the central and southern regions of Malawi. These areas are projected to experience very high drought conditions (dark red and purple zones), suggesting a significant intensification of droughts due to more extreme climate change effects.

Figure 16 presents maps illustrating the drought severity across Malawi, using two different drought indices: SMA (Standardized Moisture Anomaly) and SSI (Standardized Soil Moisture Index). These maps show the severity of droughts over a 25-year return period under both current and projected climate conditions.

Current Climate Conditions (A1 & A2): The first set of maps represents the current state of drought severity based on both the SMA and SSI indices. In these maps, the SMA index shows the current drought severity across Malawi, where areas in the southern and central regions of the country experience high to very high drought severity (indicated by red to dark purple). The SSI index similarly indicates drought severity, with the highest levels in the central and southern parts of the country. The maps suggest that these areas are currently experiencing more significant drought conditions.

Optimistic Scenario (B1 & B2): These maps illustrate the projected drought severity in an optimistic future climate scenario, showing potential improvements or stabilizations in drought conditions. The SMA index predicts that many regions, especially in the southern and central regions, will continue to face high drought severity, but there may be some relief in parts of the northern region. The SSI index under this scenario suggests a more moderate drought severity overall, although some regions will still face severe conditions, particularly in the south.

Pessimistic Scenario (C1 & C2): In this scenario, the severity of droughts is projected to increase under pessimistic climate conditions. Both the SMA and SSI indices indicate that much of the country, particularly the central and southern regions, will experience very high drought severity in the future. This scenario reflects the likely worsening of drought conditions under the assumption of continued climate change. These maps indicate that drought severity is projected to become more widespread and intense, particularly in the southern regions.

Landslides

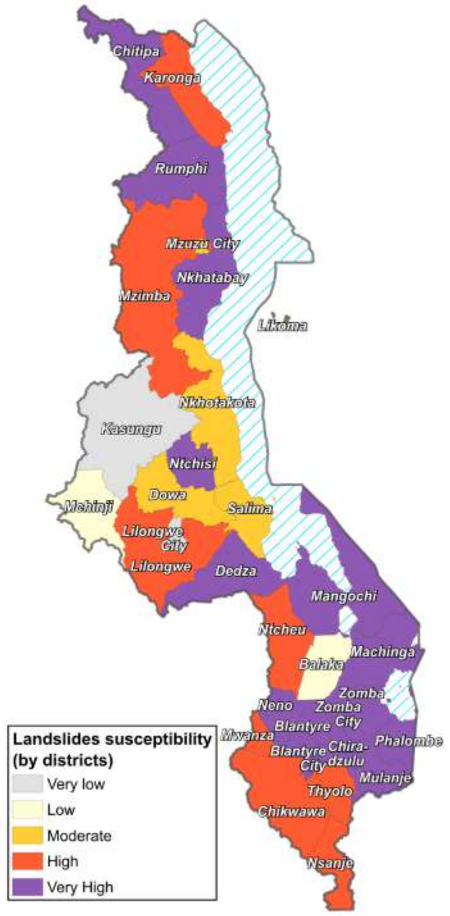


Figure 17. Landslide susceptibility at district level.

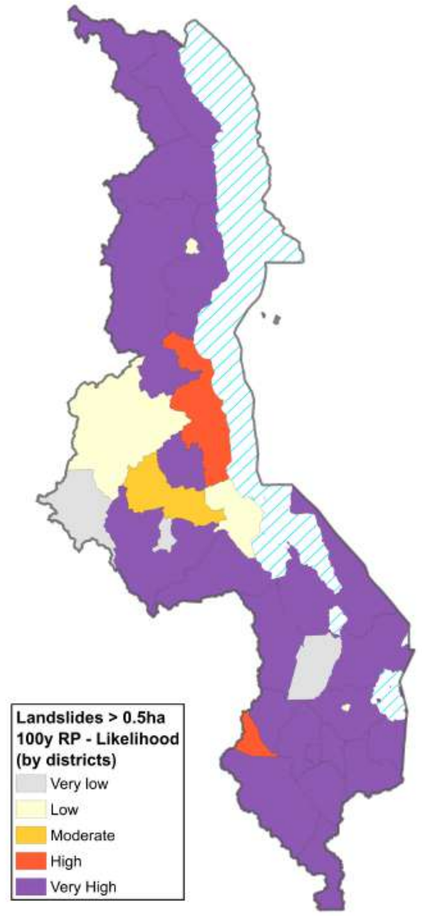


Figure 18. Landslide hazard map at district levels for landslides greater than 0.5 ha, 100 years RP.

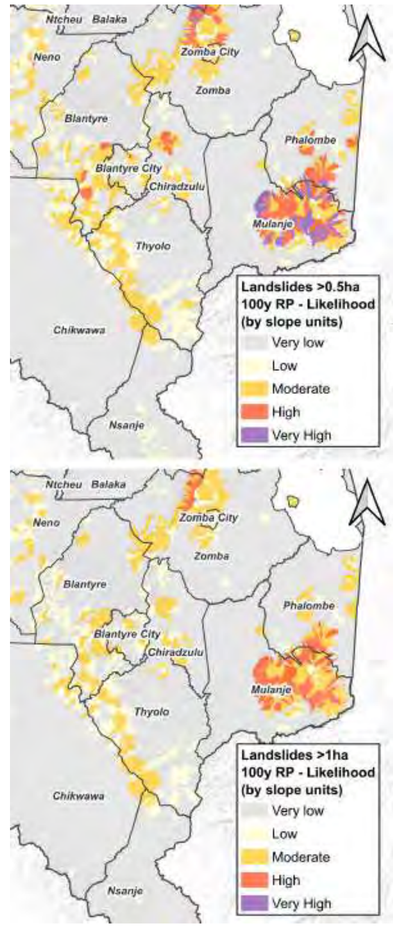


Figure 19. Landslide hazard maps at slope unit levels for landslides greater than 0.5ha and 1ha, at 100 years RP. Detail is provided for southern districts prone to landslides.

Landslide hazard describes a condition with the potential for a landslide to occur. It is often defined as the probability of occurrence of a potentially damaging landslide of a given magnitude in a given period and within an area. Landslide hazard assessment was conducted using a globally recognized and widely employed statistical approach (Guzzetti, 1999; Guzzetti, 2005) that combines three key elements: the conditional probability of landslide spatial occurrence, the conditional probability of landslide temporal occurrence, and the landslide size.

Two landslide inventories were generated by gathering data from various sources, including web-based information, satellite imagery such as Google Earth and Sentinel 2, and other available landslide data. In addition, freely accessible web data sources were used for the landslide conditional and triggering factors, such as ground conditions and rainfall.

Machine learning techniques and statistical tools were used to derive a landslide susceptibility map, a probability distribution, expressing the likelihood of one or more landslides occurring within specific time intervals, and an estimation of the probability of future landslides of specific sizes in the area covered by mapped landslides.

By combining these three factors, various landslide hazard maps were generated for different landslide sizes and return periods (from 5 to 500 years. Two levels of analysis are presented: a broader district scale and a finer sub-district level using slope units. The resulting maps identify areas where landslides of specific sizes and return periods are more likely to occur, with a particular emphasis on mountainous regions in the North and South of Malawi.

Figure 17 presents a map of landslide susceptibility in Malawi at the district level, which is categorized into five distinct levels: Very Low, Low, Moderate, High, and Very High. These categories reflect the varying degrees of vulnerability to landslides across the country.
Very Low (Grey): Districts in this category are least susceptible to landslides. These areas are typically flatter or have stable geological conditions, reducing the likelihood of landslide occurrences.
Low (Yellow): These areas exhibit minimal susceptibility to landslides. While the potential risk is low, some geographical or environmental factors may slightly increase the possibility of landslides in the event of heavy rainfall or other triggers.
Moderate (Orange): Districts in the moderate category are at a moderate risk of landslides. These areas may have some topographical features such as slopes or unstable soil, which could lead to landslides under certain conditions, like intense rainfall or seismic activity.
High (Red): High susceptibility indicates a significant risk of landslides. These districts have steep slopes, unstable soils, or other conditions that make them prone to landslides, especially during heavy rainfall or after significant land disturbances.
Very High (Purple): These areas are the most vulnerable to landslides. They are typically characterized by steep terrain, loose soil, and frequent rainfall, making them highly susceptible to landslides, which can cause significant damage to infrastructure, agriculture, wildlife and humans.

Figure 18 presents a landslide hazard map for Malawi at the district level, specifically focusing on landslides greater than 0.5 hectares within a 100-year return period (RP) i.e. for an event with probability of occurrence of once in 100 years:
Very Low (Grey): Districts in this category have the least likelihood of experiencing landslides greater than 0.5 hectares occurring. These areas typically have stable geological conditions, flat topography, and minimal exposure to landslide triggers.
Low (Yellow): Districts categorized as low risk have a relatively small chance of experiencing large landslides, though some factors such as moderate slopes or occasional heavy rainfall may slightly increase the likelihood.
Moderate (Orange): Areas in this category have a moderate chance of landslides greater than 0.5 hectares occurring. These regions may have unstable soil, steeper slopes as factors that contribute to a higher risk of landslides, especially under certain conditions like heavy rainfall or seismic activity.
High (Red): Districts in the high-risk category face a significant likelihood of large landslides (greater than 0.5 hectares) occurring. These areas typically feature steep terrain, weak soil, and frequent rainfall, making them prone to more severe landslides.
Very High (Purple): The highest-risk areas, marked in purple, are the most likely to experience large landslides. These regions are characterized by extremely steep slopes, loose soils, frequent rainfall, and other geological factors that make them highly susceptible to large-scale landslides. These areas pose considerable threats to human safety, infrastructure, and agriculture.

Figure 19 presents landslide hazard maps at the slope unit level for two scenarios: landslides greater than 0.5 hectares (upper map) and greater than 1 hectare (lower map), considering a 100-year return period (RP) in both cases. These maps focus on the southern districts of Malawi, areas that are particularly prone to landslides. The maps are color-coded to represent the likelihood of landslides occurring based on slope units, with the following categories:
Very Low (Grey): Districts in this category have a very low likelihood of experiencing landslides larger than 0.5 or 1 hectare. These areas are typically characterized by stable slopes, low precipitation, or other factors that minimize the risk of landslides.
Low (Yellow): These districts have a low chance of landslides, though some may face risk due to factors such as moderate slopes, occasional rainfall, or minor geological instability.
Moderate (Orange): Districts in the moderate risk category face a greater likelihood of landslides, especially in areas with steeper slopes or a combination of slopes and heavy rainfall.
High (Red): High-risk areas are more likely to experience significant landslides (greater than 0.5ha or 1ha) due to steep slopes, weakened soil, or persistent weather patterns that contribute to slope instability.
Very High (Purple): These areas face the highest likelihood of experiencing large landslides. They are typically characterized by very steep slopes, unstable soil, frequent heavy rainfall, or other factors that make them extremely prone to large-scale landslides.

Southern districts, particularly around Zomba and Mulanje, are marked as high to very high risk areas due to steep terrain and geological conditions. Mulanje, in particular, shows a significant concentration of very high likelihood landslides, making it a priority area for mitigation and preparedness measures.

The areas around Blantyre City, Chiradzulu, and Phalombe also show high to moderate risk, with terrain prone to landslide events.

The lower map (focusing on landslides greater than 1 hectare) further emphasizes the risks in these southern regions, showing an even greater concentration of very high risk zones.


A collapsed road in Blantyre in the aftermath of cyclone Freddy - UNDP Malawi

Earthquakes

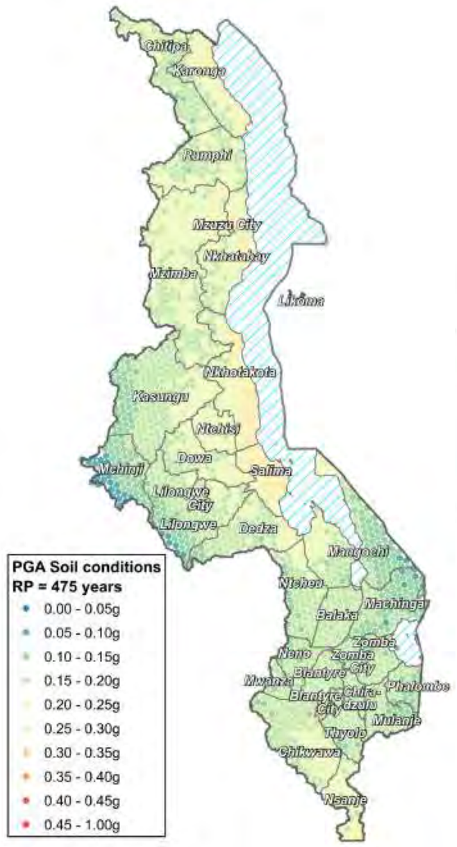


Figure 20. Seismic hazard map, PGA at 475-year RP on soil.

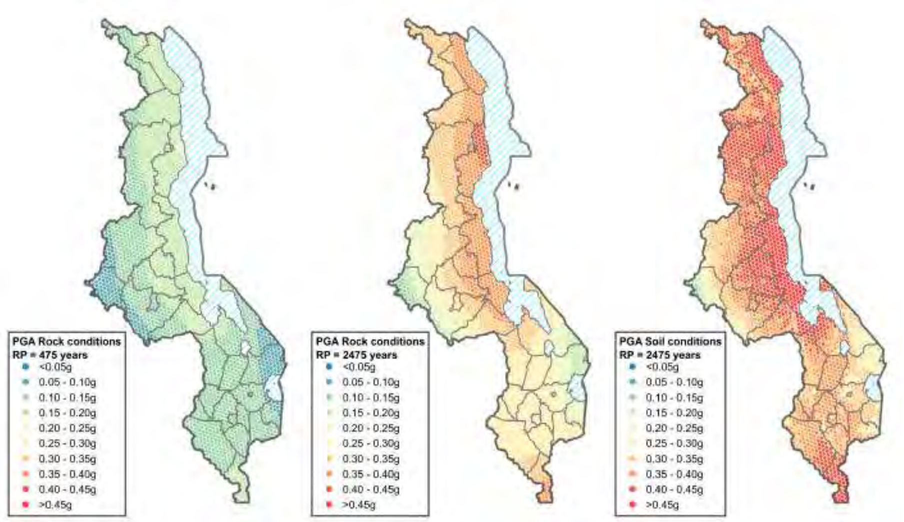


Figure 21. Seismic hazard maps, PGA at: 475-year RP on rock (A), 2475-year RP on rock (B), and 2475-year RP on soil (C).

Monte Carlo simulations for generating stochastic events, i.e., a list of all the possible ruptures that can occur in the region of interest with the associated probability of occurrence in each time span, was used. For each event, a set of ground motion fields, or ground shaking intensity fields, are simulated through a dedicated ground shaking intensity model. The epistemic uncertainty related to the choice of the seismic source model to generate the stochastic event-set and/or to the choice of the suitable ground motion model is incorporated in this process using logic trees.

The seismic hazard analysis involved definition of the seismic source characterization and selection of the ground motion models for the country. Based on these data, OpenQuake-engine (OQ) developed by the GEM Foundation, conducted the probabilistic seismic hazard analysis (PSHA). Key outputs of the PSHA are hazard maps and hazard curves. These models were then used to produce stochastic event sets to conduct the earthquake risk assessment.

Hazard maps represent a uniform return period of ground shaking, which for earthquakes is typically the 475-year (10% probability of being equalled or exceeded in 50 years) and the 2475-year (2% probability of being equalled or exceeded in 50 years) return periods. These results are presented for both rock and soil conditions

Figure 20 displays a seismic hazard map for Malawi, based on the peak ground acceleration (PGA) at a 475-year return period (RP) on soil conditions. PGA is a measure of the intensity of ground shaking during an earthquake, indicating how much the ground moves in terms of acceleration, which is a critical factor for assessing potential earthquake damage.

The map shows the intensity of seismic activity in various regions, with each colour corresponding to a specific range of PGA values:

Dark Blue (0.00 - 0.05g): This represents areas with very low seismic activity, where the peak ground acceleration is minimal, and the risk of significant ground shaking is low.

Light Blue to Green (0.05 - 0.15g): These areas experience relatively low to moderate seismic activity. The ground shaking is somewhat more pronounced but is still considered to be of lower risk.

Yellow to Orange (0.20 - 0.40g): These regions face moderate seismic activity, with stronger shaking, potentially affecting infrastructure and buildings more severely.

Red (0.45 - 1.00g): The red areas represent the highest seismic hazard zones, where significant ground shaking could occur, resulting in considerable damage in the event of a large earthquake.

Southern Malawi and the areas along the lake exhibit higher PGA values, indicating a higher likelihood of significant seismic shaking. Parts of the central region, in particular, the western regions of Kasungu, Mchinji and Lilongwe, and the eastern region of Malawi show lower seismic hazard levels, with much of the area experiencing very low to moderate ground acceleration during seismic events. Consideration of the soil conditions tends to increase the seismic hazard relative to rock conditions. Thus, it will be important to consider soil conditions in the subsequent risk analysis.

Figure 21 displays three more seismic hazard maps for Malawi, for various return periods (RP) on rock and soil conditions.

PGA Rock conditions, 475-year RP (A):
This map shows seismic hazard data for rock conditions at a 475-year return period (RP). It represents expected ground shaking levels for an event with a 10% probability of being exceeded in 50 years), which is a medium-term estimate. Most of the country, particularly the western regions, exhibits low to moderate ground acceleration, while the areas along the Lake Malawi shore experience higher PGA values.

PGA Rock conditions, 2475-year RP (B):
This map focuses on rock conditions but for a 2475-year return period, representing a much rarer but more severe event, typically associated with a 2% chance of occurrence in a 50-year period. The colour scale is more intense than the previous map, showing higher PGA values along the Lake Malawi shore and northern parts. The southern regions remain at moderate to high risk.

PGA Soil conditions, 2475-year RP (C):
This map shows seismic hazards for soil conditions at a 2475-year return period. The soil conditions play a significant role in the level of ground shaking because soils tend to amplify seismic waves. As expected, the PGA values are higher along the lake and northern Malawi. The soil composition here causes more amplification of seismic waves, which increases the potential for significant ground shaking during rare seismic events.

The southern and southwestern parts of Malawi generally have low to moderate PGA values, indicating relatively lower seismic hazard in these areas.

Lakeshore areas exhibit higher seismic hazards in all three scenarios, particularly on soil, where the amplification effect of seismic waves is significant.

The 2475-year RP maps, both on rock and soil, indicate that Malawi could experience significant ground shaking in certain regions, which could have substantial consequences for infrastructure and population resilience.

Stock & Exposure

Exposure represents people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses

UNDRR Terminology, 2017

For more methodological details on this section please refer to the Exposure and Vulnerability report downloadable from http://malawi.is-portal.org/#/documents

Stock & Exposure

In a multi-hazard context, hazard zones can be identified for each one of the hazards considered. For this reason, an evaluation of all the relevant elements (in this context population, property and systems) distributed within Malawi is presented here, independently from their location in specific hazard zones. The analysis is crucial for understanding the spatial distribution, and the values at stake. Such information serves as input for risk analysis.

An exposure model is critical for the assessment of disaster risk, as a hazard has the potential to incur damage and losses only if there are assets exposed to that hazard. Exposure models encompass the location, quantity, value, and characteristics of assets exposed to natural hazards. Such assets may include buildings (e.g., residences, schools), infrastructure (e.g., roadways, railways), and agricultural production (e.g., crops, livestock). Wherever possible, the exposure ideally contains some information about the asset's characteristics to allow relating them to relevant fragility or vulnerability models. For example, information about the building construction (e.g., age, material, number of storeys) gives an indication as to its potential for damage in a hazard event. In this manner, the exposure and vulnerability components are inextricably linked.

The following categories of exposure are included within this study:

Buildings include residential, commercial, industrial, schools, government offices and healthcare facilities. Notably, the exposed population is considered in reference to the residential building stock. Where datasets permitted, the population associated with other building types (e.g., students and teachers in school buildings) was also included.
Infrastructure has considered roadways and railways. Although buildings such as schools and healthcare facilities can also be considered as 'critical infrastructure', they are included in the building section of the exposure model, as the process to estimate risk for buildings is notably different as compared with linear/distributed infrastructure.
Agriculture includes crops and livestock, considering their spatial distribution and, for crops, the corresponding average production (Figure 22 reports the maize annual production as an example).

The M1 between Blantyre and Lilongwe – via Wikimedia Commons

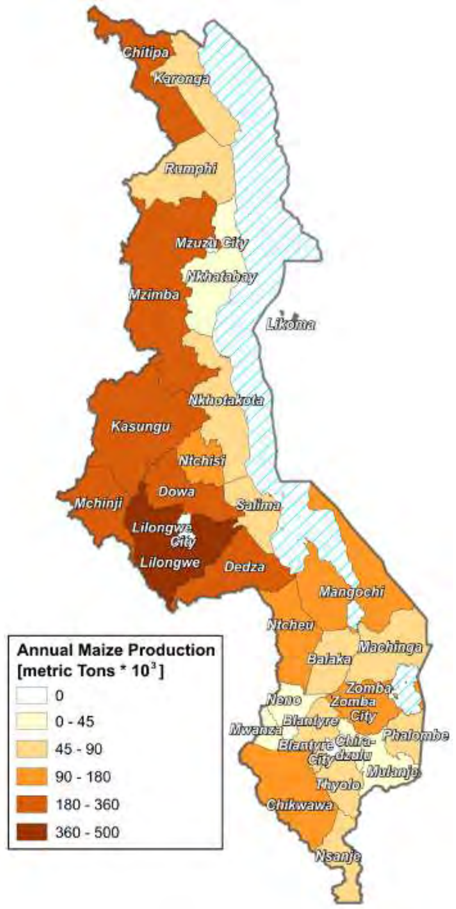


Figure 22. Annual maize production at district level (Source: APES data for 2022-2023 from the Ministry of agriculture, Irrigation and Water Development in Malawi).

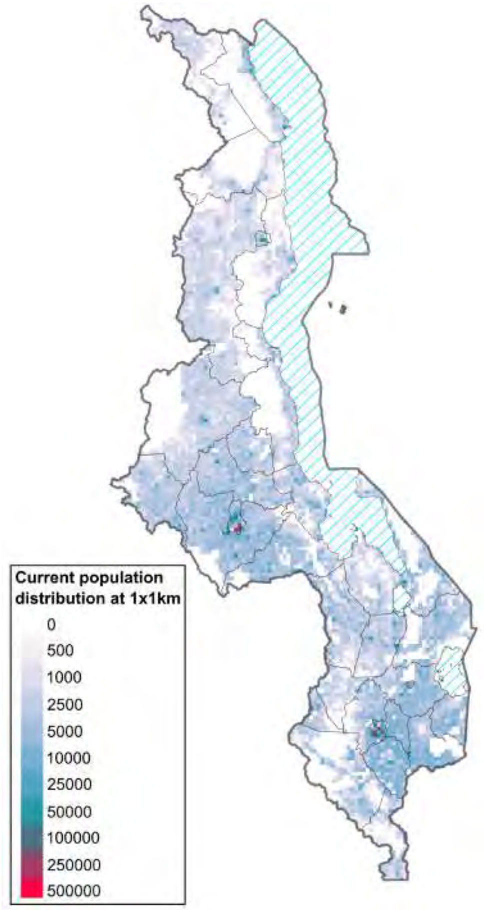


Figure 23. Current population distribution at 1km resolution - CIESIN Columbia University, February 2020.

Wherever possible, local datasets are used to derive exposure models (e.g., database of schools, GIS layers of railway lines). Such datasets often have better locational accuracy but may lack details to facilitate mapping to the vulnerability factors.

Figure 22 provides an annual maize production pattern in Malawi at district level.
Light Yellow (<45x 10^3 tons): Districts with the lowest maize production.
Orange: 45-90 (10^3 tons): Districts with moderate production levels.
Dark Orange: 90-180 (10^3 tons): Districts with medium production levels.
Brown: 180-360 (10^3 tons): Areas with significant maize production.
Dark Brown: 360-500 (10^3 tons): Districts with the highest maize production.

The map indicates that some districts in the northern and central parts of Malawi (particularly the central region) show higher production levels while southern and some northern regions exhibit lower maize production levels (indicated by light yellow and orange).

Figure 23 provides a fine-grained representation of how population is distributed across Malawi, highlighting urban concentration and offering insights for planning related to infrastructure, public services, and disaster risk management. It is particularly useful in assessing the areas that are most vulnerable to the impacts of extreme events such as flooding or droughts, given the potential for higher exposure in densely populated regions. It presents the current population distribution across Malawi at a 1x1 km resolution, based on data from CIESIN Columbia University (February 2020).

Southern Malawi: The southern region, particularly around urban centres like Blantyre, shows higher population density, with the most densely populated areas marked in red.
Central Malawi: The central districts, such as Lilongwe, also have notable population clusters, though densities tend to be somewhat lower than in the south.
Northern Malawi: The northern regions exhibit lower population densities.

Table 4 summarises all stock categories and their data sources.

Table 4. Stock categories and their data sources.

CATEGORY	SUB-CATEGORY	DATA SOURCE
Residential buildings	-	Population and Housing Census (NSO 2018)
Non-residential buildings	Commercial, Industrial, Healthcare, Education, Government	Integration of data provided by the Department of Surveys, the Ministry of Education, the Ministry of Health, and the National Statistics Office, and the Fifth Integrated Household Survey (NSO 2020)
Roads	Primary, secondary,tertiary	No local data was provided on this project; therefore, two alternate global sources were considered: • Global Roads Inventory Project (GRIP4) • OpenStreetMap
Railways	-	Provided by the Department of Surveys and the Department of Railways
Agriculture crop	Maize, cassava, chickpeas, cow peas, groundnuts, lentils, pigeon peas, potatoes, rice, small millet, sorghum, wheat	Agricultural Crop Production Estimates (APES), spatial distribution of crops derived from Spatial Production Allocation Model, Crop calendar information extracted from the Crop Calendar Dataset developed by the Center for Sustainability and the Global Environment (Sacks et al., 2010), cropland coverage derived from JRC-ASAP (Anomaly Hotspots of Agricultural Production)
Agriculture livestock	Malawi zebu, dairy cattle, goat, sheep, pigs, indigenous chickens, rabbits	District level livestock census, made available by the Ministry of Agriculture, grazing-land coverage derived from JRC-ASAP (Anomaly Hotspots of Agricultural Production)
Population including projections	Current population, population projections for 2050, 2070, and 2100 for SSP1 and SSP5	Population and Housing Census (NSO 2018) and SEDAC DB[13], Wang et al., 2022[14]

13. SEDAC, Global 1-km Downscaled Population Base Year and Projection Grids Based on the SSPs https://sedac.ciesin.columbia.edu/data/set/popdynamics-1-km-downscaled-pop-base-year-projection-ssp-2000-2100-rev01

14. Wang, X., Meng, X., & Long, Y. (2022). Projecting 1 km-grid population distributions from 2020 to 2100 globally under shared socioeconomic pathways. Scientific Data, 9(1), 563.

Depiction of buildings previously affected by disasters - DoDMA

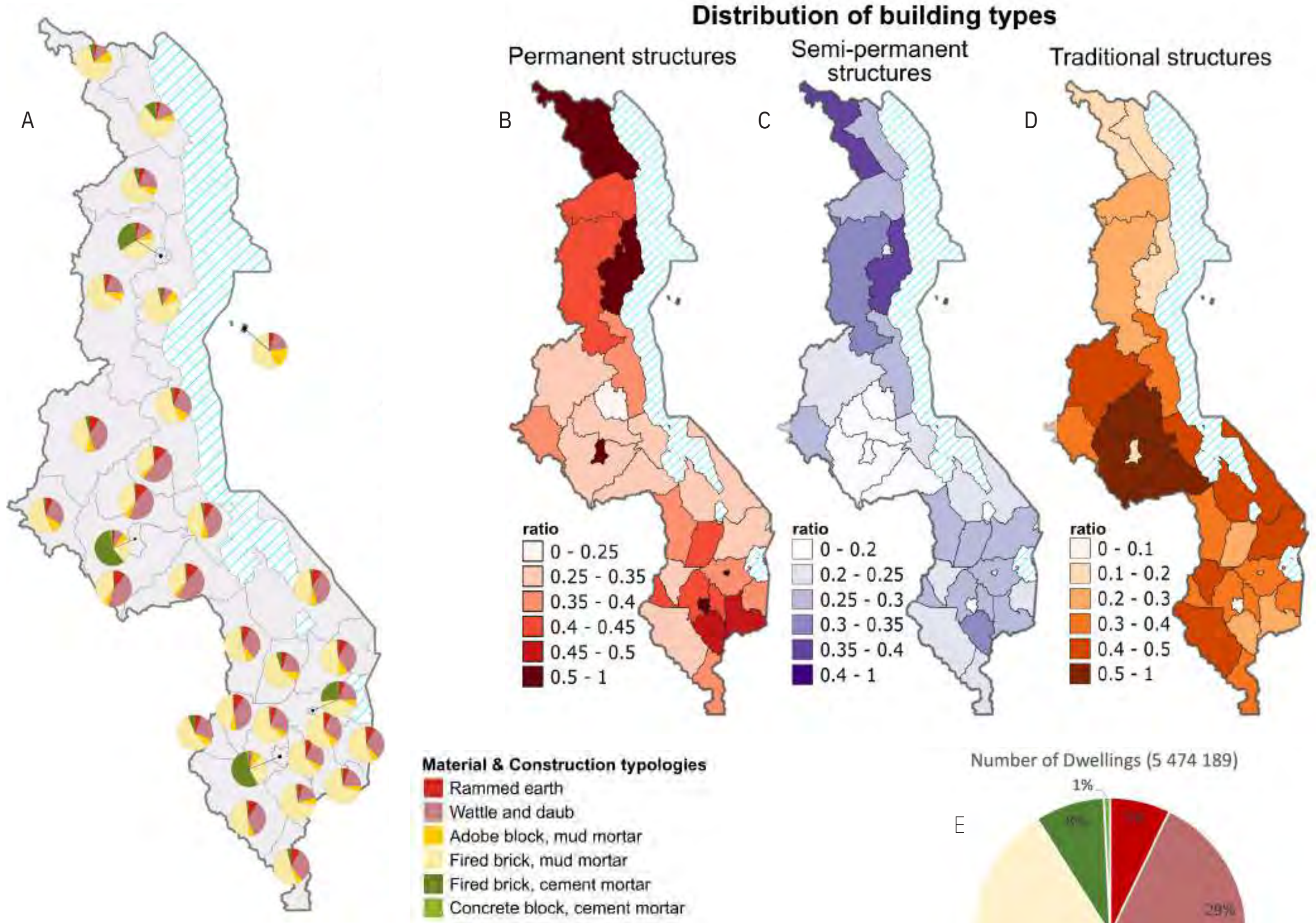
Vulnerability

Vulnerability is the condition determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards

UNDRR Terminology, 2017

For more methodological details on this section please refer to the Exposure and Vulnerability report downloadable from http://malawi.is-portal.org/#/documents

Overview of Physical Vulnerability in Malawi



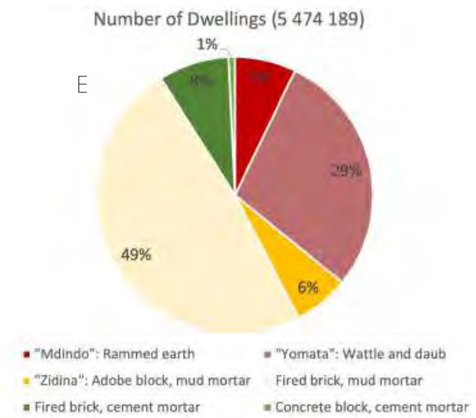


Figure 24. Physical vulnerability and distribution of building materials and typologies; A) distribution of building material and construction typologies at district level; B) Dwelling typology percentage for traditional, C) semi-permanent and D) permanent dwellings; E) proportion of building material and construction typologies at national level.

Physical vulnerability describes the likelihood of damage or loss for specific assets e.g., housing) under the action of a certain level of intensity of a given hazard (e.g., flood depth, wind speed, peak ground acceleration). In this assessment, vulnerability has been assessed through indices, fragility functions, and vulnerability functions tailored to different hazards[15].

Vulnerability indices help identify and prioritize regions, sectors, or population groups that are most at risk (Nguyen et al., 2016). Fragility functions assess the probability of exceeding various damage states (e.g., slight damage, moderate damage, collapse) for a given hazard intensity. These damage states can then be related to loss ratios or distributions. Vulnerability functions integrate these elements to directly quantify the average damage or loss ratio for a specific hazard intensity. Fragility curves were used for earthquakes, vulnerability functions for weather-related hazards, and vulnerability indicators for droughts and landslides. Specifically, for droughts, the selected indicators include social, economic, and infrastructural components. The fragility and vulnerability curves adopted in this study are functions of the most common building typologies in Malawi.

Figure 24 provides an analysis of the physical vulnerability and distribution of building typologies across Malawi, showcasing how different building types correlate with vulnerability levels to natural hazards.

Key Components of the Map:
Dwelling Typologies:
Permanent buildings (B -represented in red shades): These buildings are typically made of durable roofing materials such as iron sheets and strong walling materials such as burned bricks and concrete hollow blocks bonded with cement mortar. They are generally associated with lower vulnerability to natural hazards.
Semi-Permanent Buildings (C -represented in blue shades): These buildings lack one of the materials of the permanent structure such as having a roof made of iron sheets with the wall made up of unburned bricks, and they exhibit moderate vulnerability due to their susceptibility to wind and fire damage.
Traditional Structures (D -represented in orange shades): these buildings lack both materials of the permanent structure. For example, a grass thatched house having its walls made of unburned bricks is regarded as a traditional structure, these buildings are highly vulnerable to extreme weather events, particularly floods and strong winds.

Pie Charts (A & E):
The dwelling typologies are then mapped on different construction typologies and construction materials according to mapping schemes. The material and construction typologies are the characteristics directly linked with the physical vulnerability curves for the different hazards. The pie charts overlaid on the map show the distribution by percentage of six representative construction materials and construction typologies within each district. from the most vulnerable (represented in red, to the least vulnerable represented in green). Both the national and district distributions have been provided.

The Southern and northern regions of Malawi exhibit a higher concentration of permanent and semipermanent structures, indicating a lower vulnerability to natural hazards with respect to the central region that is dominated by traditional dwelling types. The Central areas are at greater risk due to the fragile nature of earthen construction materials.

The dominant construction material and typologies at national level are the one exhibiting moderate physical vulnerability, while this distribution changes among the different districts and between rural and urban areas.

Traditional earthen houses are the dominant construction typology outside urban centres. Urban centres are the only locations where masonry buildings are prevalent. The central rural parts of Malawi presents the highest physical vulnerability especially to hazards such as floods, strong winds and landslides.

Overview of Socio-economic Vulnerability in Malawi:

The analysis of impacts on assets, people and the economy is cognisant that vulnerability is shaped by a multitude of economic, social, cultural, environmental, institutional, political, and psychological factors that influence individuals' lives and their surroundings, beyond physical vulnerability. Vulnerability has therefore been assessed using data on various socio-economic factors to provide a comprehensive understanding of vulnerability. About 50 indicators have been evaluated under the categories of population, economy, education, health, infrastructures and institutional organization. Data have been derived from different sources, as shown in Table 5. The spatial distribution of such vulnerability indicators at district level is instead provided in Figures from 25 to 30.

15. To access details on the vulnerability and fragility curves used the reader is directed to the specific Exposure and Vulnerability Report in the documents section of the online portal, http://malawi.is-portal.org/#/documents.

Table 5. Indicators of social vulnerability for Malawi and corresponding sources.

CATEGORY	VARIABLE	DESCRIPTION	SOURCE
Population	POP_AG60	People aged 60 years and above (%)	Malawi Census, 2018 - Table A6
Population	POP_AG14	People aged 14 years and below (%)	Malawi Census, 2018 - Table A6
Population	POP_AG04	People aged 4 years and below (%)	Malawi Census, 2018 - Table A6
Population	POP_FMHH	Percent households headed by females (%)	IHS5 2020 - Table A2.2
Population	POP_AVHH	Average household size	IHS5 2020 - Table A2.1
Population	POP_ORPH	Proportion of orphans (%)	IHS5 2020 - Table A2.4
Population	POP_FEML	Female population (%)	Malawi Census, 2018 - Table A3
Population	POP_DSB1	Persons with at least one type of deficiency; Washington Group definition (%)	Malawi Census, 2018 - Table G6a
Population	POP_CHRN	Persons with chronic illness (%)	IHS5 2020 - Table A4.3
Population	POP_RURL	Proportion of population rural (%)	Malawi Census, 2018 - Table A3
Population	POP_DSTY	Population density (people/km^2)	Malawi Census, 2018 - Table 2.5
Population	POP_BOMW	Born outside Malawi (%)	Malawi Census, 2018 - Table F1
Population	POP_NMWP	Non-Malawian population (%)	Malawi Census, 2018 - Table F1
Economy	ECO_POVT	Poverty prevalence (%)	Malawi Poverty Report, 2020 - Table A3
Economy	ECO_UPOV	Ultra poverty prevalence (%)	Malawi Poverty Report, 2020 - Table A3
Economy	ECO_AGRF	Proportion of individuals engaged in household agriculture/fishing activities (%)	IHS5 2020 - Table A6.7
Economy	ECO_NINC	Proportion of individuals not engaged in income-generating tasks 15-64 (%)	IHS5 2020 - Table A6.7
Economy	ECO_UEMP	Proportion of population 15-64 unemployed (%)	Statistical Yearbook 2021 - Table 6.1
Economy	ECO_RENT	Proportion of dwelling units that are rented (%)	IHS5 2020 - Table A7.1
Economy	ECO_FREE	Proportion of dwelling units occupied free, authorized or unauthorized (%)	IHS5 2020 - Table A7.1
Economy	ECO_FSEC	Proportion of households with inadequate food security (%)	IHS5 2020 - Table A9.1
Economy	ECO_LVST	Households with livestock (%)	Malawi Census, 2018 - Table I22
Economy	ECO_NSAV	Proportion of households that did not use personal savings to overcome shocks (%)	IHS5 2020 - Table A9.8
Economy	ECO_GNGO	Proportion of households with help from government/NGOs/etc (%)	IHS5 2020 - Table A9.8
Education	EDU_PRNE	Net un-enrolment rate primary (%)	IHS5 2020 - Table A3.5
Education	EDU_PRDR	Drop-out rate (%)	Education Statistics Bulletin 2022 - Table 6
Education	EDU_PRCI	Percentage of schools not connected to the internet (%)	Education Statistics Bulletin 2022 - Table 12
Education	EDU_PRCR	Pupil permanent classroom ratio (PpCR) - enrolment/permanent classrooms	Education Statistics Bulletin 2022 - Table 21
Education	EDU_PRTR	Pupil to teacher rate (PTR)	Education Statistics Bulletin 2022 - Table 20
Education	EDU_PRQR	Pupil to qualified teacher rate (PqTR)	Education Statistics Bulletin 2022 - Table 20
Education	EDU_SCNR	Net un-enrolment rate secondary (%)	IHS5 2020 - Table A3.6
Education	EDU_SCRA	Inaccessibility during rainy season (%)	Education Statistics Bulletin 2022 - Table 27
Education	EDU_TERT	Proportion of population without higher/ tertiary education (older than 15 years) (%)	IHS5 2020 - Table A3.9
Education	EDU_LITR	Proportion of population illiterate (older than 5 years) (%)	IHS5 2020 - Table A3.1
Education	EDU_ATTN	Proportion of population never attended school (>15 years) (%)	IHS5 2020 - Table A3.4
Health	HLT_STNT	Prevalence of stunting, severe (%)	IHS5 2020 - Table A11.1
Health	HLT_LWBW	Prevalence of infants with low birth weight, severe (%)	IHS5 2020 - Table A11.1
Health	HLT_HIVP	Prevalence HIV+ (15-49yo) (%)	Malawi DHS 2015-16 - Table A14.3
Health	HLT_MTU5	Under 5 mortality rate; rate per 1,000 births	Malawi DHS 2015-16 - Table A8.2
Health	HLT_MTML	Malaria case fatality rate per 1,000	NSO of Malawi 2021 - Health – Open Data for Africa
Health	HLT_HLCA	Proportion of population with inadequate access to healthcare (%)	IHS5 2020 - Table A9.1
Health	HLT_SPND	Health spending per capita (MK)	District Profiles Malawi HHFA 2018/19
Health	HLT_CASE	Caseload (average outpatients per health worker per day)	District Profiles Malawi HHFA 2018/19
Health	HLT_ABST	Health worker absenteeism (%)	District Profiles Malawi HHFA 2018/19
Health	HLT_WFDT	Population per health worker	District Profiles Malawi HHFA 2018/19
Health	HLT_CVAC	Children without all basic vaccinations (%)	Malawi DHS2015-16 - Table A10.3
Infrastructure	INF_HSAN	Households without access to improved sanitation facility (%)	IHS5 2020 - Table A7.7
Infrastructure	INF_HWAT	Proportion of households without improved water source (%)	IHS5 2020 - Table A7.6
Infrastructure	INF_HELE	Proportion of households without electricity (%)	IHS5 2020 - Table A7.4
Infrastructure	INF_HFUE	Proportion of households using solid fuel (%)	IHS5 2020 - Table A7.5
Infrastructure	INF_CRAD	Proportion of households without radio (%)	IHS5 2020 - Table A7.9
Infrastructure	INF_CTVA	Proportion of households without TV (%)	IHS5 2020 - Table A7.9
Infrastructure	INF_CINT	Percent of households without internet access (%)	Malawi Census, 2018 - Table I18
Infrastructure	INF_CPLL	Percent of households without landline (%)	Malawi Census, 2018 - Table I18
Infrastructure	INF_CMOB	Percent of households without mobile phone (%)	Malawi Census, 2018 - Table I18
Institutional organization	INS_RGEN	Percent enterprises not registered (%)	IHS5 2020 - Table A6.5
Institutional organization	INS_BCRT	Percentage of children (<5 years) without birth certificate (%)	Malawi DHS 2015-16 - Table A2.10.1

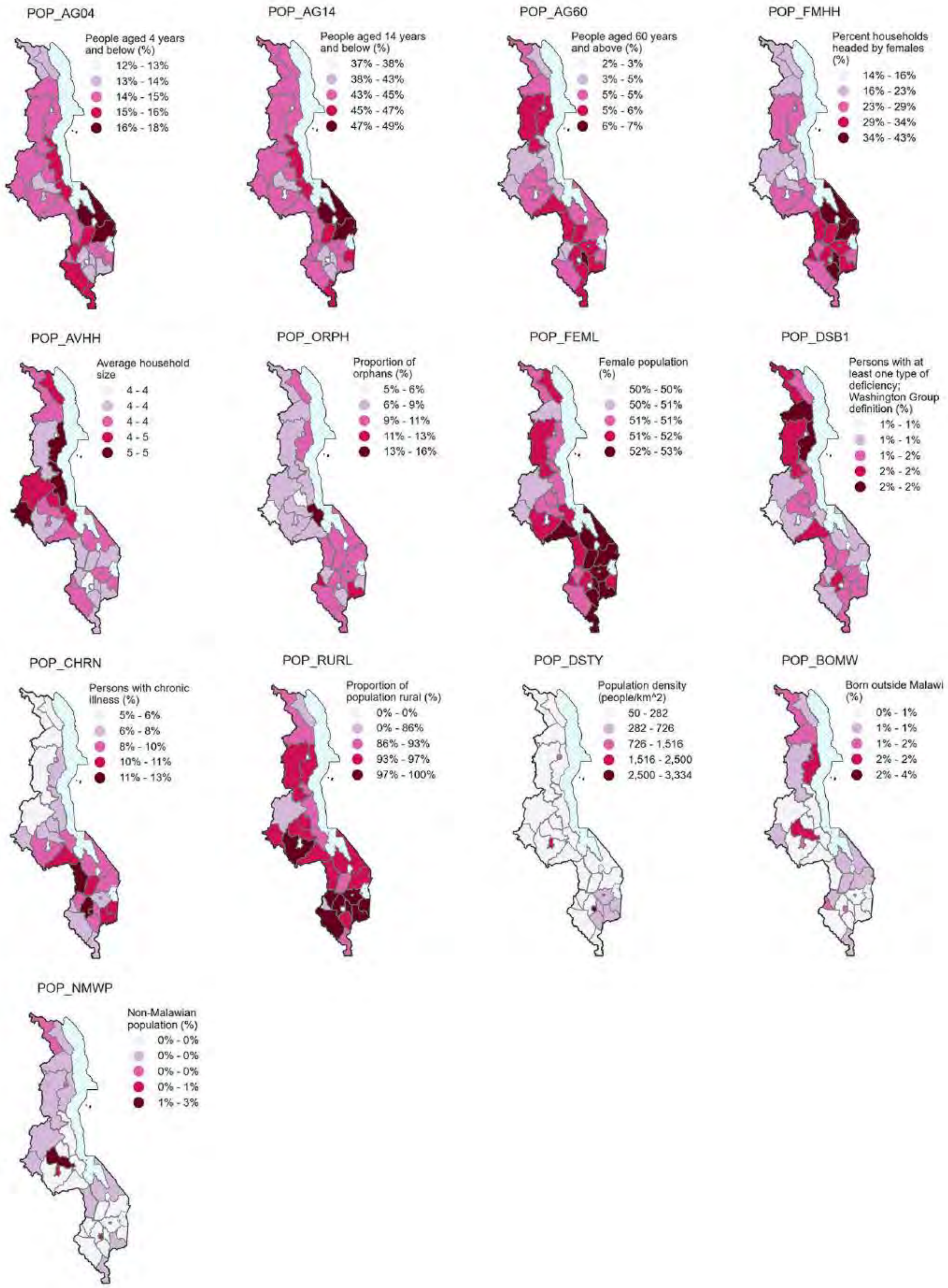


Figure 25. Spatial distribution of social vulnerability indicators for Malawi – Population category.

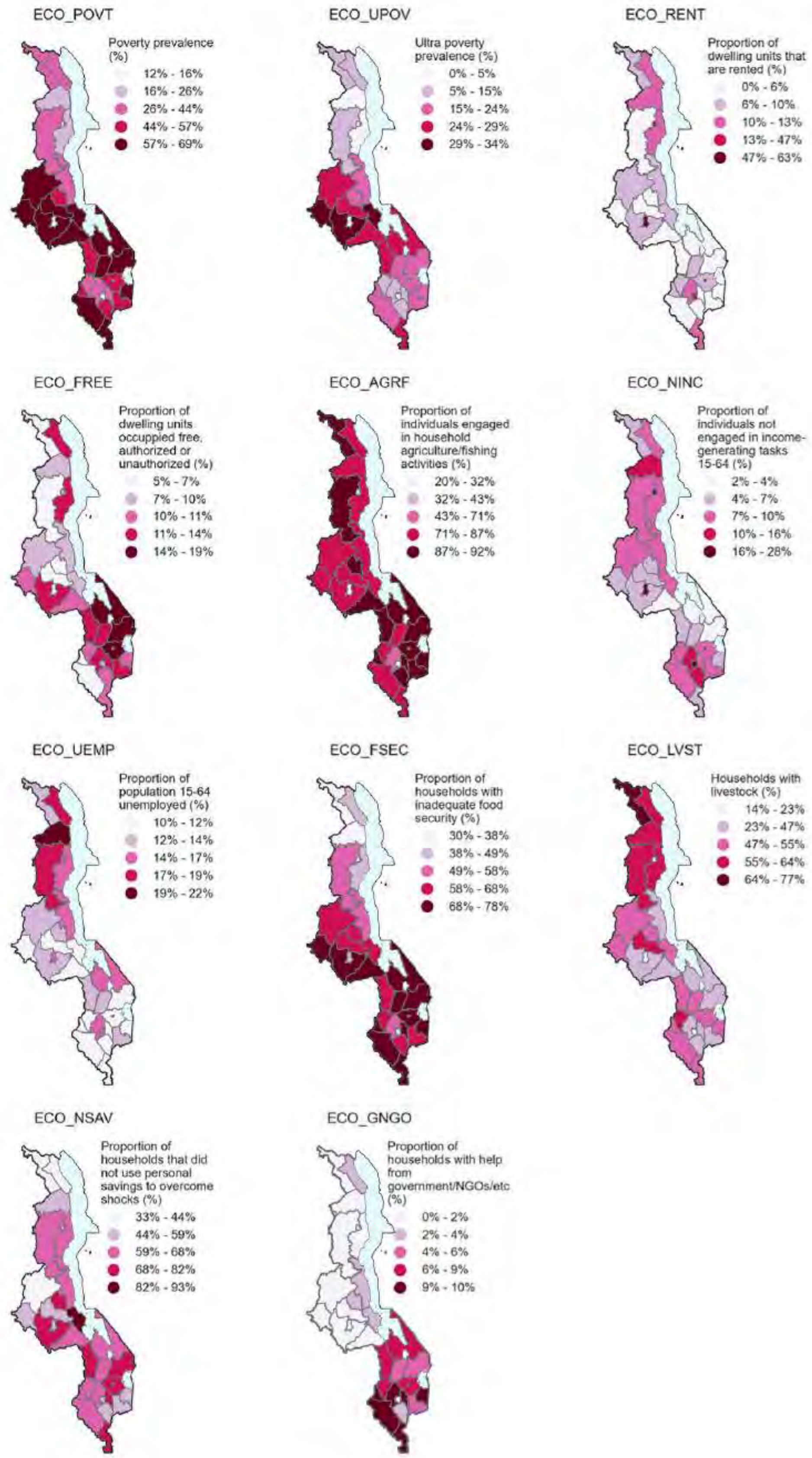


Figure 26. Spatial distribution of social vulnerability indicators for Malawi – Economy category.

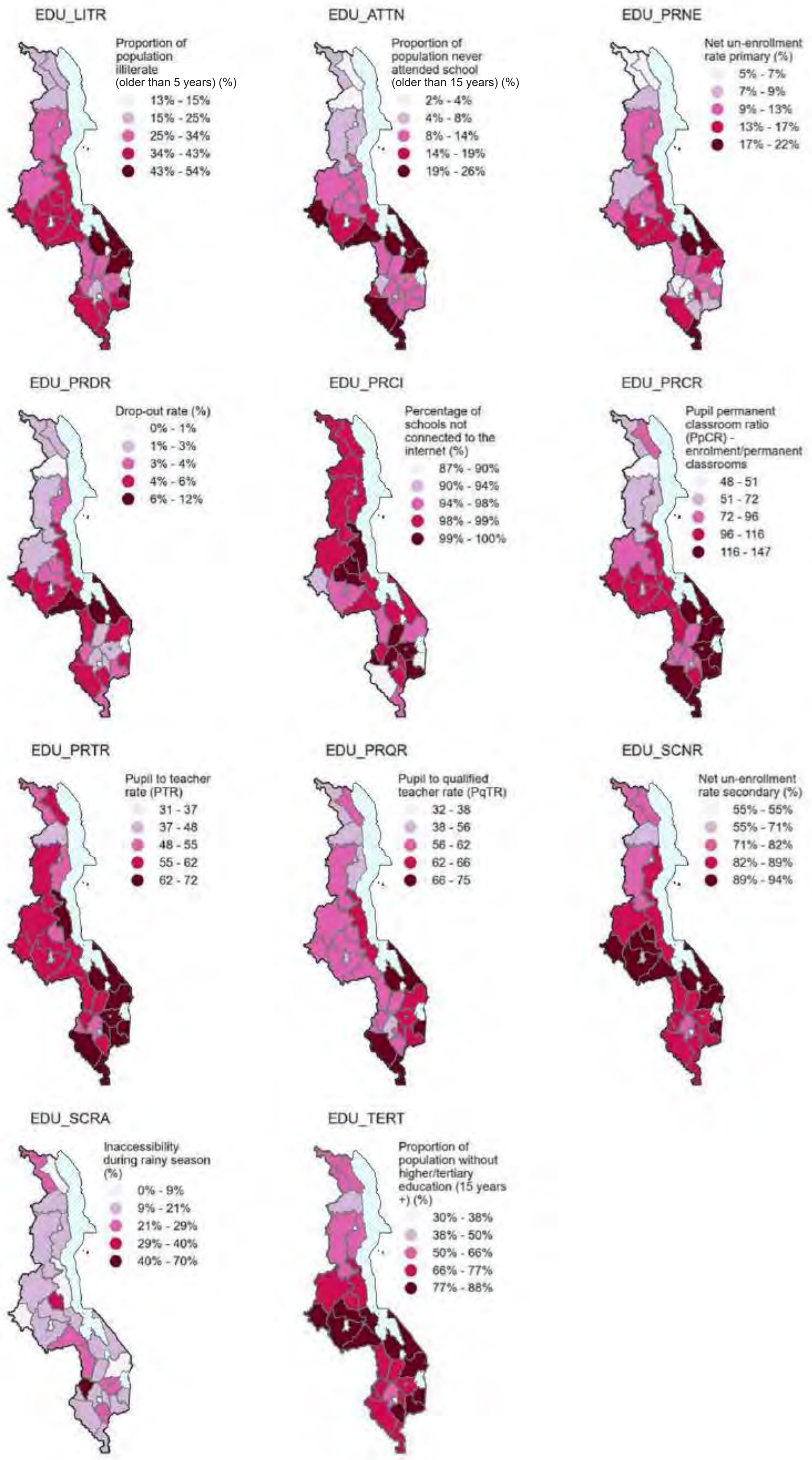


Figure 27. Spatial distribution of social vulnerability indicators for Malawi – Education category.

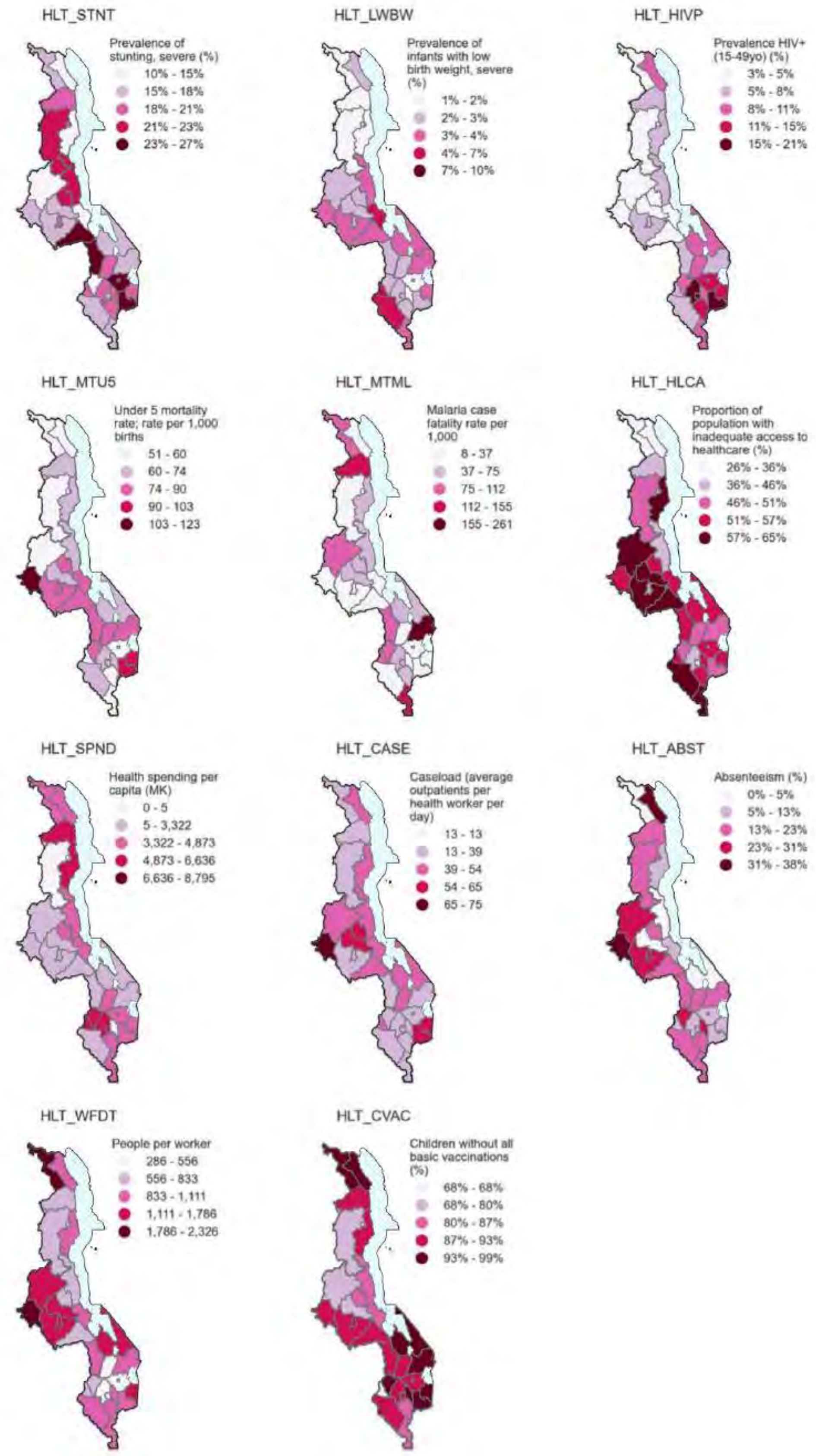


Figure 28. Spatial distribution of social vulnerability indicators for Malawi – Health category.

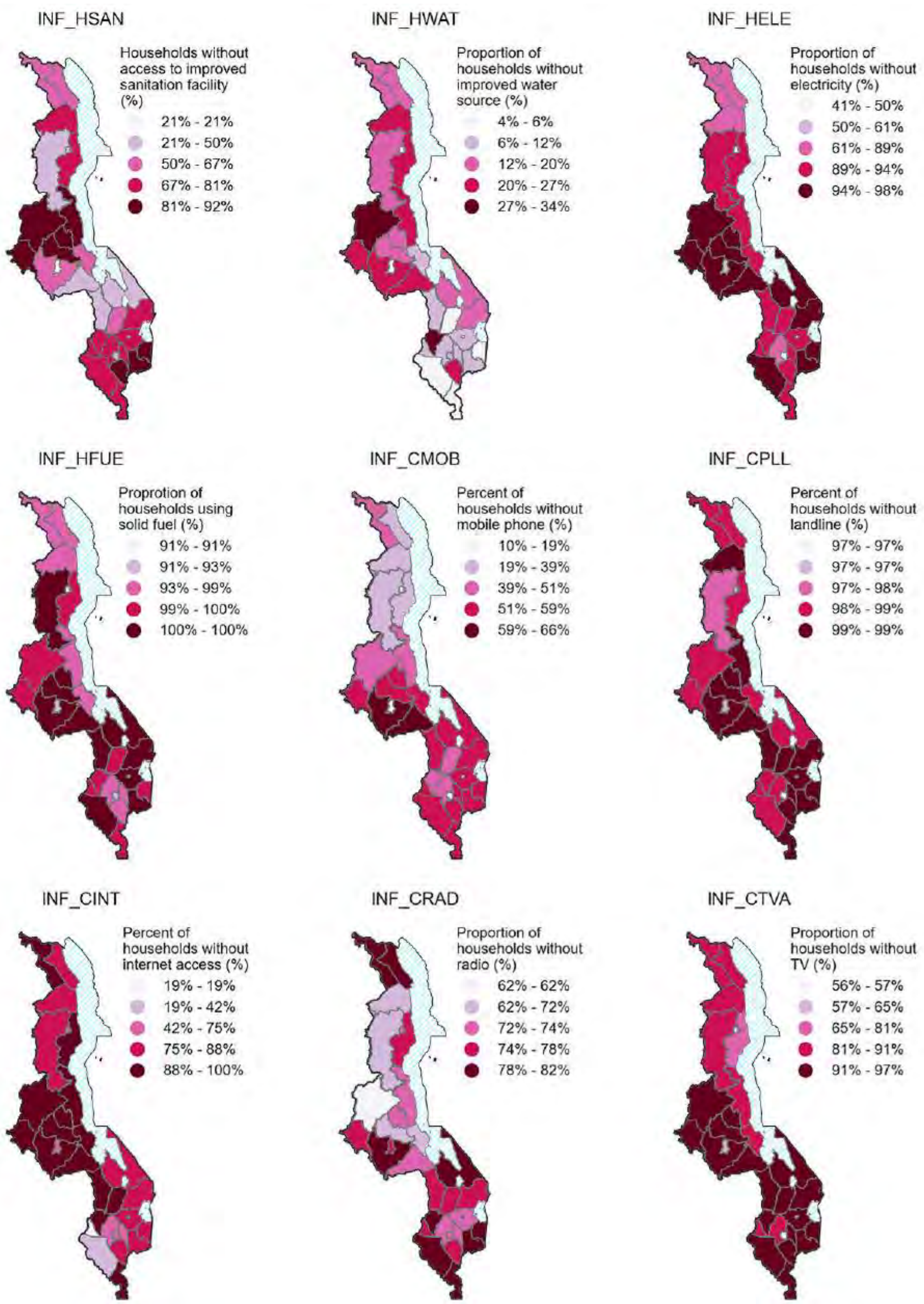


Figure 29. Spatial distribution of social vulnerability indicators for Malawi – Infrastructure category.

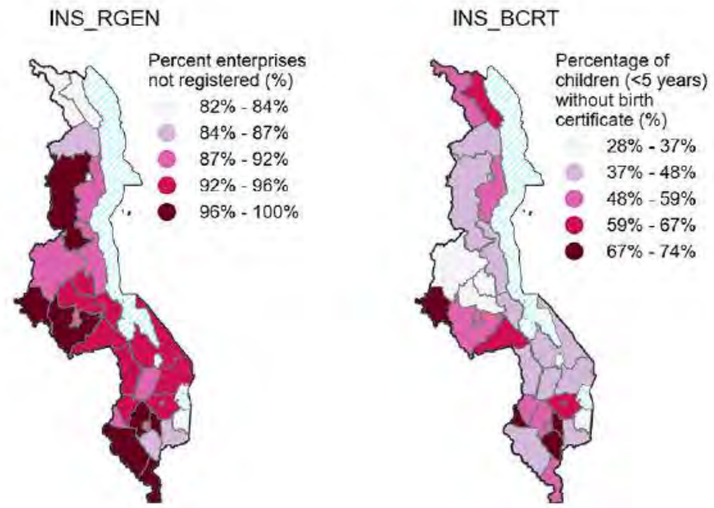


Figure 30. Spatial distribution of social vulnerability indicators for Malawi – Institutional organization category.

Unlike other hazards where the physical damage to assets is readily measurable, the effects of drought are multifaceted and deeply intertwined with socio-economic factors. These factors include, but are not limited to, agricultural productivity, water availability, and economic stability, which together shape the broader impact on communities. Because of that, in the drought risk assessment, the socio-economic component of vulnerability has been directly integrated into the risk computation process. This approach is essential because droughts interact with people in complex ways, and their secondary impacts often play a dominant role in determining overall losses.

For other types of hazards, where the direct physical impact on assets is more apparent, the socio-economic dimension serves a different purpose. In these cases, socio-economic data is used to refine and contextualize the risk figures derived from physical risk analyses. Among the different social vulnerability indicators, 3 were selected for their potential worsening effect in connection to the lack of capacity towards response and recovery from disasters.

Groundnut harvesting at an agricultural research station in Malawi – via Wikimedia Commons

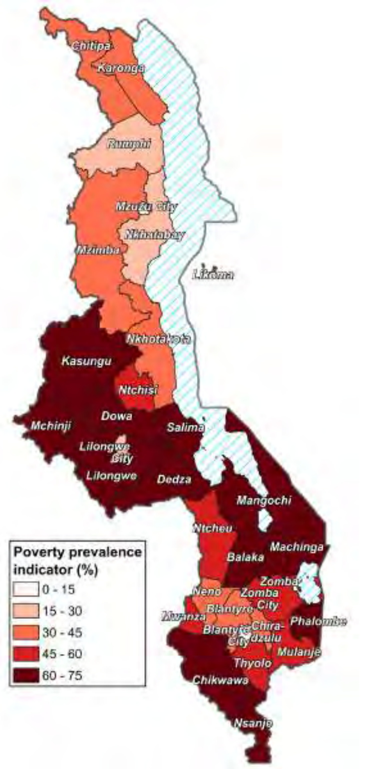


Figure 31. Poverty prevalence indicator at district level. Data source: Malawi Poverty Report, 2020 - Table A3

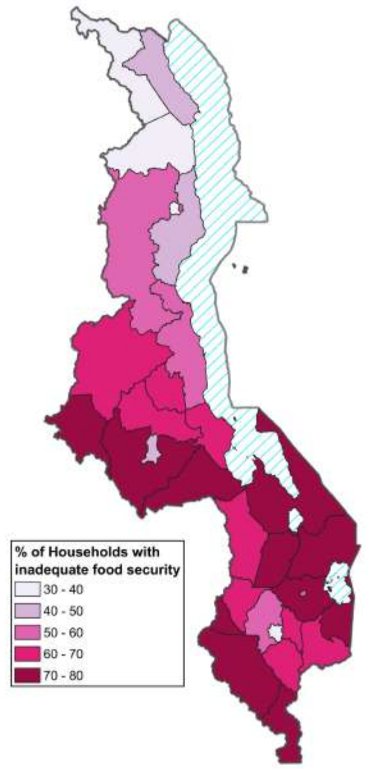


Figure 32. Food insecurity index at district level. Data source: IHS5, 2020 - Table A9.1

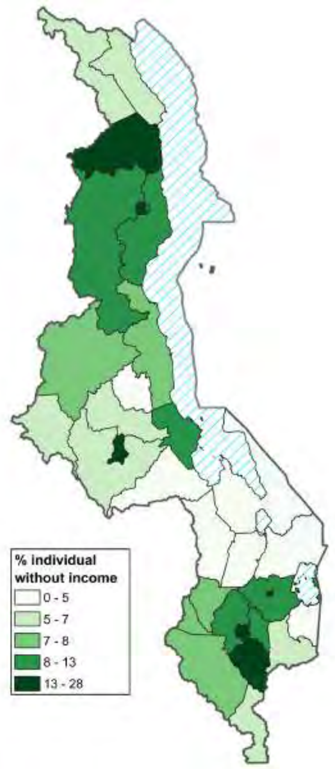


Figure 33. Inactive population index at district level. Data source: Statistical Yearbook 2021 - Table 6.1

Figure 31 displays the poverty prevalence indicator across various districts of Malawi, with values ranging from 0 to 100, where 0 represents the lowest prevalence of poverty and 100 represents the highest. The data is classified into five colour-coded categories based on the percentage of poverty prevalence:
0–15% (lightest shade): Districts with the lowest poverty prevalence.
15–30% (light orange): Areas with relatively low poverty prevalence.
30–45% (medium orange): Districts with moderate levels of poverty.
45–60% (dark orange): Areas with high poverty prevalence.
60–75% (dark red): Districts experiencing the highest levels of poverty.

Insights from the map:

- **Southern regions** (e.g., Nsanje, Chikwawa, Thyolo, and Mulanje, Phalombe and in general the eastern region) show higher poverty prevalence (dark red), indicating severe poverty challenges in these areas.
- **Central region** has generally high levels of poverty prevalence, with pockets of low poverty in areas such as some Lilongwe City and Nkhotakpota.
- **Northern regions** display moderate to lower poverty prevalence, with some areas falling in the 15–30% range.

Figure 32 illustrates the food insecurity index at the district level across Malawi. The values range from 0 to 100, where 0 represents the lowest percentage of households experiencing food insecurity (indicating better food security), and 100 represents the highest percentage of households with inadequate food security (indicating severe food insecurity).

The legend is classified into five distinct categories, represented by a gradient of colours:
30–40% (lightest shade of pink): Districts with the lowest percentage of households experiencing food insecurity, indicating relatively better food security.
40–50% (light pink): Districts with moderately low levels of food insecurity.
50–60% (medium pink): Areas with a moderate percentage of households experiencing food insecurity.
60–70% (dark pink): Districts with high levels of food insecurity.
70–80% (darkest shade of pink): Areas with the highest percentage of households facing inadequate food security.

Insights from the map:

- **Southern districts,** such as Nsanje, Chikwawa and the eastern region exhibit the highest levels of food insecurity (70–80%), as represented by the darkest shades of pink.
- **Central districts**, show moderate to high levels of food insecurity
- **Northern districts**, with the exception of Mzimba, display lower levels of food insecurity (30–40%), indicating better food security conditions compared to other regions.

The crosshatched areas likely indicate districts where data is unavailable or where conditions are not clearly defined. The map underscores significant geographic disparities in household food security across Malawi. The southern regions appear to be the most vulnerable, facing higher food insecurity challenges, while the northern regions tend to experience better food security conditions.

Figure 33 depicts the inactive population index at the district level in Malawi, showing the percentage of individuals without income. The index ranges from 0 to 100, with 0 representing no inactive individuals and 100 representing the highest percentage of inactive individuals. The legend is classified into five categories, represented by a gradient of green shades:
0–5% (lightest green): Districts with the lowest percentage of individuals without income, indicating relatively higher economic activity and engagement.
5–7% (light green): Districts with a moderately low percentage of inactive individuals.
7–8% (medium green): Districts where the inactive population falls within the moderate range.
8–13% (dark green): Districts with a high percentage of inactive individuals, indicating reduced economic engagement.
13–28% (darkest green): Districts with the highest percentage of individuals without income, signifying significant economic inactivity.

Insights from the map:

- **Northern districts**, such as Chitipa and Karonga show low levels of economic inactivity (0–5%), as represented by the lightest shades of green. This indicates that a higher proportion of individuals in these areas are engaged in income-generating activities. NkhataBay, Mzimba and Rumbi present higher levels of inactivity.
- **Central districts**, generally exhibit moderate levels of economic inactivity (5–8%) except for Lilongwe City and Salima which show high levels of inactivity.
- **Southern districts,** particularly Thyolo, eBlantyre, Chiradzulu and Zomba, have higher levels of economic inactivity, with 13–28% of individuals reported as without income (dark green).

Crosshatched areas indicate districts where data might be unavailable or where specific conditions make it challenging to classify economic inactivity accurately.

The map highlights regional disparities in economic activity, with northern districts demonstrating greater economic participation, while southern districts experience significant levels of inactivity.

State of Vulnerability

Overall, integrating socio-economic considerations helps to provide a more comprehensive assessment of risk, capturing both the direct and indirect impacts of hazards and ensuring that the analyses reflect the true extent of potential losses and vulnerabilities.

Concentration of Vulnerability in the Central and Southern Region:
The central and southern regions of Malawi do not only present the highest physical vulnerability, they also exhibit the highest levels of poverty, food insecurity, except for inactive population which is prevalent in some parts of the north and south. This concentration of vulnerability creates a cycle where disasters exacerbate poverty and food insecurity, further deepening the region's socio-economic challenges.

Link between Poverty and Food Insecurity:
There is a clear correlation between high poverty levels and severe food insecurity across many districts, particularly in the central and southern regions. Poverty limits the capacity of households to invest in resilient agricultural practices, diversify income sources, or access emergency resources during disasters. As a result, these populations are less able to cope with and recover from climate-related shocks, increasing their long-term vulnerability to disasters.

Impact of Inactive Population on Disaster Resilience:
Districts with a high proportion of inactive populations, particularly in the southern and some parts of northern and central regions, are likely to have lower resilience to disasters. An inactive population often indicates a higher dependency ratio, with fewer people engaged in productive economic activities. This can lead to lower household incomes and reduced capacity to anticipate, respond to and recover from disasters, further entrenching socio-economic vulnerability in these regions.

Risk

The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity

UNDRR Terminology, 2017

For more methodological details on this section please refer to the Risk Final report downloadable from http://malawi.is-portal.org/#/documents

Introduction

Disaster risk arises from the interplay of hazards, exposure and vulnerability. This assessment uses the Probabilistic Multi-Hazard Risk Assessment (PMHRA) approach, incorporating probabilistic modelling techniques. Exposure and physical vulnerability models help to quantify potential losses across different hazard scenarios; hazard profiles are developed through both individual hazard analyses and, where relevant, multi-hazard assessments. The latter is particularly important when compound hazards occur frequently enough to influence loss estimates.

Social vulnerability plays a crucial role in interpreting risk outputs by identifying socio-economic factors that can either increase or decrease the potential for harm and loss. It also helps address varying needs during disaster recovery by considering how different social groups might be affected differently.

Various indicators have been utilized to quantify risks associated with different hazards under both current and projected climate and socio-economic conditions. The selection of these indicators is guided by several factors, including their relevance to the country and context, data availability, and alignment with international policies such as the Sendai Framework.

For Malawi, the chosen indicators address the following needs and constraints:
Availability of Homogeneous and Reliable Exposure Data: Indicators are based on consistent and dependable exposure data to ensure accurate risk assessments.
Availability of Homogeneous and Reliable Impact Data: Reliable impact data is necessary for calibrating risk estimation methods and ensuring their accuracy.
Relevance of Exposure Layers and Risk Indicators: Selected indicators must be pertinent to disaster risk management (DRM) and align with the specific needs of the region.
Feasibility of Deriving Reliable Metrics: The chosen indicators should allow for the derivation of credible and actionable metrics.
These criteria ensure that the risk indicators used are effective, relevant, and practical for assessing and managing risks in Malawi.

Table 6 provides an overview of the indicators selected for this assessment, detailing their category (Economic, Population, Built-up Environment), the specific definitions used (such as AAL in both absolute and relative terms, or PML), and the relevant hazards for which each indicator is applicable to. It should be noted that not all indicators are meaningful or computable for every hazard considered in this analysis.

Table 6. Risk indicators developed in the PRA for single and compound hazards.

INDICATORS		Riverine Floods	Flash Floods	Strong Winds	Compound	Droughts	Landslides	Earthquakes
Economic	AAL	●	●	●	●	● *	●	●
	AALR	●	●	●	●	●	●	●
	PML	●	●	●	●	●		
Built-up	AAL Buildings Affected	●	●	●	●		●	●
	AAL Buildings damage							●
People	AAL People Affected	●	●	●	●	●	●	
	AAH							●
	AAHR							●
	PML	●	●	●	●	●		●

* Limited to Agriculture and hydropower production

Risk Indicators compliant with Sendai Framework

The Sendai Framework provides the structure for organizing the risk profile results. Each section of the results in this assessment aligns with specific targets of the Sendai Framework, depending on the available data for each hazard, as outlined in the previous table.

Affected Population: The first section reports the annual average number of people directly affected by disasters of different types. This indicator corresponds to **Sendai Framework Target B**: "Substantially reduce the number of affected people globally by 2030," specifically addressing **B1**: "Number of directly affected people attributed to disasters."

Economic Losses: Several indicators are used to enhance understanding of **Sendai Framework Target C**: "Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030." This includes:
C1: Direct Economic Loss Attributed to Disasters - Computed as a compound index, summing various indicators derived from our fully probabilistic risk methodology. These include:
C2: Direct Agricultural Loss Attributed to Disasters.
C3: Direct Economic Loss to Other Damaged or Destroyed Productive Assets. In this risk profile, C3 is further divided into:
- Productive Assets (e.g., industrial buildings and energy facilities)
- Service Sector (e.g., governmental and service buildings)
C4: Direct Economic Loss in the Housing Sector Attributed to Disasters.
C5: Direct Economic Loss Resulting from Damaged or Destroyed Critical Infrastructure. In this profile, C5 specifically refers to economic losses related to health facilities, education facilities and transportation systems.

Critical Infrastructure: Finally, the results address **Sendai Framework Target D**: "Substantially reduce disaster damage to critical infrastructure and disruption of basic services, including health and educational facilities, by 2030." This is reported by counting affected critical infrastructure, such as health and education facilities, as well as kilometres of transportation network impacted. These sections collectively provide a comprehensive view of the risks associated with different hazards, aligned with the Sendai Framework's objectives.

Riverine Floods

B1 - Number of People Directly Affected by Disasters
Riverine Floods

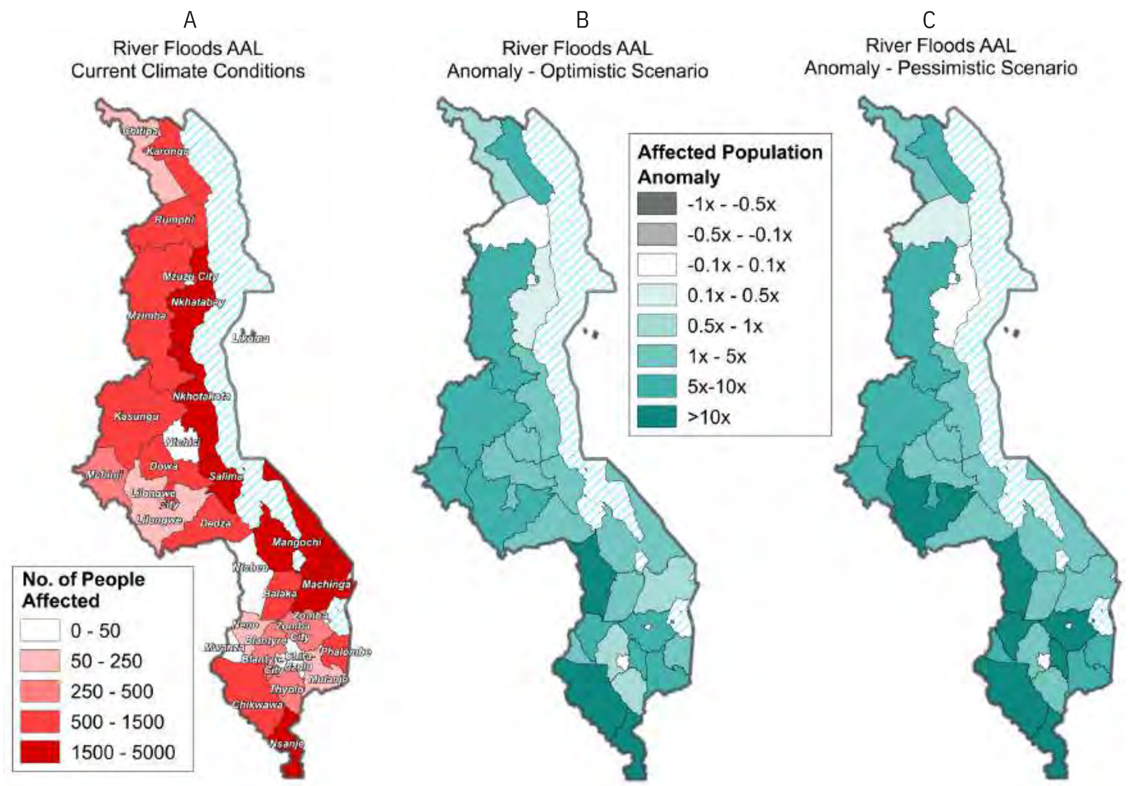


Figure 34. Average annual population affected by riverine floods in current and anomalies in projected climate scenarios.

The maps in Figure 34 show the number of people affected annually by riverine floods across districts in Malawi in current climate and in future climate scenarios.

A: Current Climate Conditions
The colour scale ranges from light red to dark red, indicating the number of people affected:
50–250 people (light red): Areas with the fewest flood-affected individuals.
250–1,500 people (medium red): Moderately affected regions.
1,500–5,000 people (dark red): Areas with the largest population impacted annually.

Insights from the map:

- **Highly Affected Areas**: Districts shaded in dark red represent the most severely affected areas, where between 1,500 and 5,000 people are impacted annually by river floods. These areas likely include low-lying floodplains and areas near major rivers.
- **Moderately Affected Areas**: Districts in medium red shades indicate areas where 500 to 1,500 people are affected annually. These areas might still experience significant flooding but with relatively fewer people at risk.
- **Less Affected Areas**: Light red and pink-shaded areas denote areas with 50 to 500 people affected yearly. These areas may experience occasional flooding but at a lower frequency or severity.
- **White regions** (0–50 people affected): indicate minimal impact from riverine floods.

B: Anomaly in the Optimistic Climate Scenario
This map presents the anomaly in affected population under an optimistic climate scenario, where mitigation measures and climate actions have reduced the severity of climate change trends.

The scale ranges from -1x to +10x:
-1x - -0.5X: A reduction between 100% and 50% in the number of people affected by floods is expected (darker shades).
-0.5x – -0.1x: A reduction between 50% and 10% is expected (lighter shades)
-0.1x - 0.1x: no significant change
0.1x - 0.5x: An increase between 50% and 100% in the number of people affected by floods is expected
1x – 5x: An increase in the affected population of one to 5 times with respect to the current climate.
5x -10x: An increase in the affected population of 5 to 10 times with respect to the current climate.
>10x: variations in the increase of the affected population exceed 10 times as much.

Observations:

- Many areas in southern Malawi experience moderate to high increases in affected populations despite the optimistic scenario.
- Central and northern regions generally experience reduced or minimal changes in flood impacts.

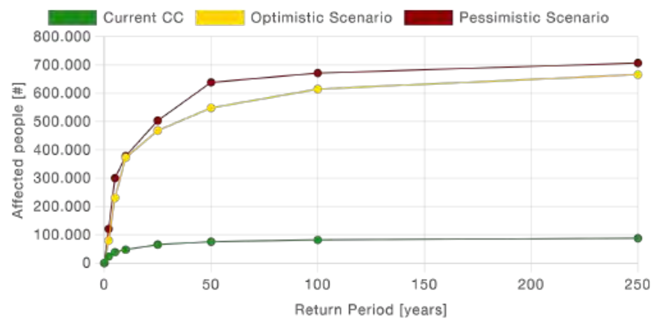


Figure 35. Probable maximum loss curves for population affected by riverine flood under different climate conditions.

C: Anomaly in the Pessimistic Climate Scenario
This map shows the anomaly in the affected population under a pessimistic scenario, where climate change impacts are more severe due to insufficient mitigation efforts and uses the same scale of the map showing the optimistic climate scenario.

Insights from the map:

- Southern districts, particularly Nsanje, Chikwawa, and Phalombe, show significant increases in affected populations, with anomalies ranging from 5x to more than 10x.
- Even in the central Malawi, districts such as Lilongwe and Ntcheu, exhibit notable increases, indicating a widespread intensification of flood impacts.

Key Messages:

Rising Population Vulnerability:
The number of people affected by riverine floods in Malawi is generally high and it is expected to increase significantly under projected climate scenarios, underscoring the growing vulnerability of Malawi's population to climate-induced disasters. This is particularly true in the southern region in the Lower Shire.

District-Level Disparities:
Southern region districts, including Nsanje, Chikwawa, and Phalombe, are disproportionately affected by floods. These areas require prioritized interventions to reduce flood-related impacts on communities. Similar situations are detectable along the districts facing Lake Malawi.

Urgent Need for Adaptive Strategies:
The projected increase in flood-affected populations emphasizes the necessity for immediate implementation of adaptive strategies at the district level to protect the most vulnerable communities.

C1 - Direct Economic Loss Attributed to Disasters
Riverine Floods

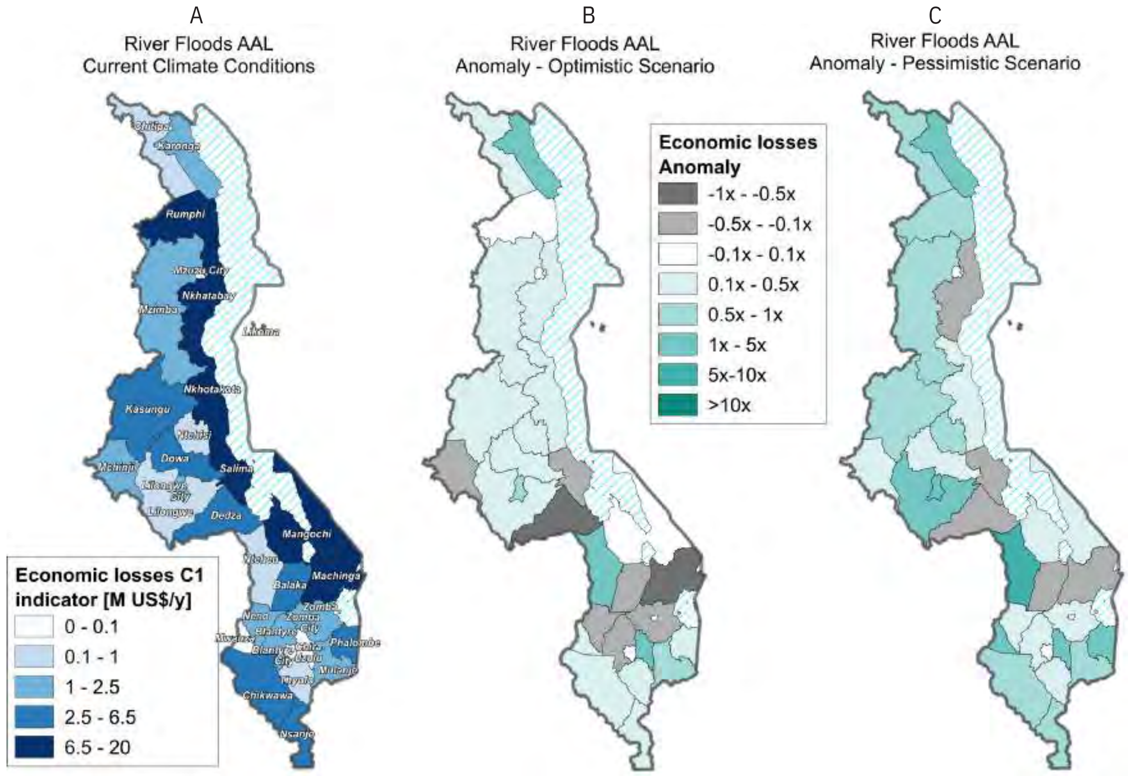


Figure 36. Average annual loss [M US$] linked to riverine floods in current and projected climate scenarios (anomalies).

The maps in the Figure 36 show the average annual direct economic loss in million USD caused by riverine floods across districts in Malawi in current climate and future climate scenarios.

A: Current Climate Conditions
The colour scale ranges from light blue to dark blue, indicating the economic loss accumulated over different asset's categories ranging from 0 to over 20 million USD.

Insights from the map:
- Districts along lake Malawi and some districts in the south along the main course of Shire River exhibit the highest losses deriving from riverine floods.

B: Optimistic Climate Scenario
This map presents the anomaly in the total economic loss due to riverine floods under the optimistic climate scenario, where mitigation measures and climate actions have reduced the severity of climate change trends.
The legend is similar for all anomalies.

Insights from the map:
- Most districts in Malawi especially in the northern and central part of the country exhibit a moderate increase of expected economic losses when climate change conditions are considered.
- Few districts exhibit a tendency to reduce.

C: Pessimistic Climate Scenario
This map shows the anomaly in the total economic loss due to riverine floods under the pessimistic scenario, where climate change impacts are more severe due to insufficient mitigation efforts ('business as usual policy').

Insights from the map:
- The pattern observed for the optimistic climate change scenario is also confirmed for the pessimistic one, but a more extreme increase is predicted.
- The few districts showing a trend in reduction of the losses are in this case showing more moderate anomalies.

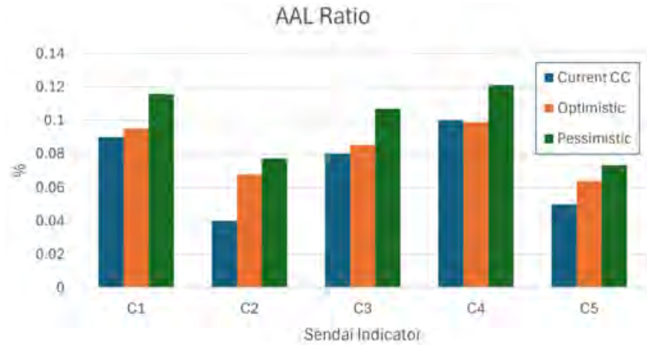


Figure 37. Ratio of average annual loss to the corresponding stock value under riverine floods in current and projected climate conditions; measured against different Sendai indicators.

Current Conditions (A): Southern Malawi is highly vulnerable to riverine floods under existing climate conditions.
Optimistic Scenario (B): While the large part of districts will experience a worsening of economic losses in future, global mitigation measures aimed at containing the temperature trends could slightly reduce the impact of riverine floods in some areas, particularly in central and northern regions.
Pessimistic Scenario (C): Without adequate interventions, the number of people affected by floods will increase significantly, particularly in southern Malawi, where the vulnerability is already high.

Sendai Indicator	Riverine Floods	AAL current CC	AAL optimistic scenario	AAL pessimistic scenario
C1 [M US$]	**Direct economic loss attributed to disasters** (as sum of C2, C3, C4, and C5 in the following)	**127**	**130.5**	**159.4**
C2 [M US$]	Direct agricultural loss attributed to disasters	1.5	2.8	3.2
C3 [M US$]	Direct economic loss to all other damaged or destroyed productive assets attributed to disasters	7.3	7.4	9.3
C4 [M US$]	Direct economic loss in the housing sector attributed to disasters	114	115	140.8
C5 [M US$]	Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters	4.2	5.3	6.1

Key Messages:

The total direct economic loss attributed to disasters is expected to rise significantly under both optimistic and pessimistic climate scenarios, with losses potentially increasing from $127 million to $159.4 million.

The housing sector in Malawi faces the highest annual expected losses due to riverine floods. With projected losses ranging from $114 million under current conditions to $140.8 million in a pessimistic scenario, it is critical to prioritize resilience measures in housing, particularly in flood-prone districts like Blantyre and Lilongwe where there is an already high concentration of exposed values.

Although the direct agricultural losses are smaller in absolute terms, they represent a significant threat to food security, particularly in rural areas heavily dependent on agriculture. The expected increase in losses from $1.5 million to $3.2 million under worsening climate conditions highlights the need for adaptive farming practices and disaster preparedness in districts such as Nsanje and Chikwawa.

Damage to critical infrastructure, including roads and social infrastructure, is expected to increase, with losses potentially rising from $4.2 million to $6.1 million under pessimistic climate scenarios. It is important to note that direct infrastructure losses typically represent only a portion of the total losses, as the interruption of services from these critical infrastructures often leads to additional, compounded economic impacts.

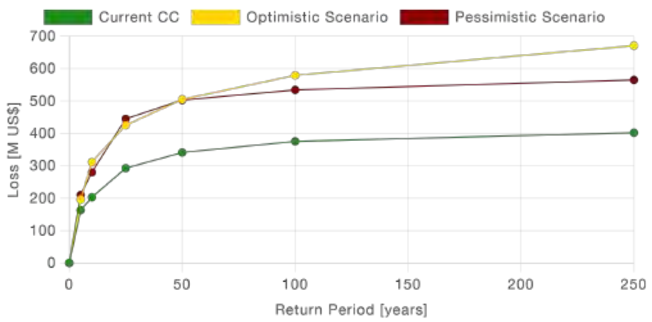


Figure 38. Probable maximum loss curves for economic damages to the built-up area [M US $], linked to riverine floods under different climate conditions.

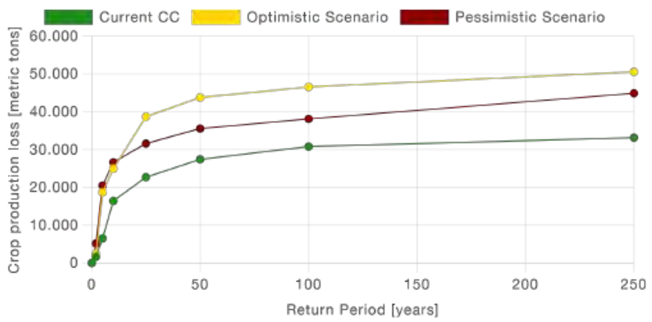


Figure 39. Probable maximum loss curves for damages to the crop production [metric tons], linked to riverine flood under different climate conditions.

Key Messages:

The PML curves provide important information on the frequency of floods and associated economic losses. Even though the average annual losses are of around 115 million USD per year, floods with losses close to 200 million USD are expected to occur very frequently, with a return period of about 10 years (i.e. an event with equal or greater magnitude that is on average experienced every decade). Considering projected climate conditions, the frequency of high-impact floods will increase significantly, and it will be very likely to experience losses of at least 300 million USD. The sudden rise of the PML curve in the very frequent events' domain depicts Malawi as a fragile country that needs to drastically reduce its vulnerability to frequent flooding events.

The figure shows that under different climate conditions, the economic damages to built-up areas due to riverine floods are likely to increase significantly. This trend suggests that as climate conditions worsen, urban and semi-urban areas, which contain a high concentration of built-up infrastructure, are at heightened risk of severe financial losses.

The curves demonstrate a marked difference in potential losses between current and projected scenarios. In future, the expected maximum losses are considerably higher, indicating the need for urgent and proactive urban planning and infrastructure reinforcement to mitigate these risks.

The substantial risks riverine floods pose to crop production in Malawi are evident from the risk figures. As climate conditions change, the maximum potential loss of crop yields is projected to increase, which could have dire consequences for food security and the livelihoods of farmers, particularly in the Southern Region's agricultural districts.

D - Damage to Critical Infrastructures, Including Basic Services

Riverine Floods

Figure 40. Average Annual Proportion of Hospitals and Schools Affected by riverine floods.

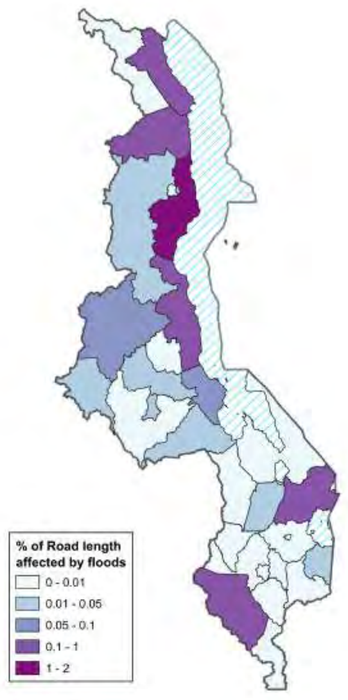


Figure 41. Average Annual Proportion of Roads/Railways affected by riverine floods.

Figure 40 illustrates the average annual percentage of hospitals and schools affected by riverine floods in each district across Malawi. The percentages are expressed as a proportion of the total number of hospitals and schools (buildings) in each district. The map uses a gradient of green shades to represent varying levels of impact:

0–0.01% (lightest yellow-green): Districts with the lowest percentage of hospitals and schools affected by riverine floods.
0.01–0.05% (light green): Areas with slightly higher flood impacts on critical infrastructure.
0.05–0.1% (medium green): Districts where a moderate proportion of hospitals and schools are affected annually.
0.1–0.4% (dark green): Areas with a higher percentage of flood-affected buildings.
0.4–0.6% (darkest green): Districts with the highest proportion of hospitals and schools impacted by riverine floods.

Insights from the maps:

- **Most Affected Districts (Dark Green: 0.4 - 0.6%)**
  Nkhata Bay has the highest proportion of hospitals and schools affected by floods, followed by Salima. This suggests that essential services in these districts experience frequent disruptions, potentially impacting healthcare delivery and education.
- **Moderately Affected Areas (Medium to Light Green: 0.1 - 0.5%)**
  Districts such as Nkhotakota, Rumphi, Karonga, Mulanje, and Mangochi fall into this category, experiencing moderate levels of flood impact on essential services.
- **Less Affected Areas (Yellow: 0 - 0.1%)**
  Most districts, especially in the Phalombe, Mwanza, Neno, Ntcheu, Dedza, Lilongwe, Dowa, Kasungu, and Mzimba, show low or minimal flood impact on hospitals and schools.

Figure 41 illustrates the average annual percentage of road and railway length affected by riverine floods, expressed as a proportion of the total road and railway stock (measured in kilometres) within each district of Malawi. The map uses a gradient of blue to purple shades to indicate the severity of flood impacts on roads:

0–0.01% (lightest blue): Districts with the lowest percentage of roads affected by riverine floods.
0.01–0.05% (light blue): Districts with slightly higher flood impacts on road/railway infrastructure.
0.05–0.1% (medium blue): Areas where moderate percentages of roads/railways are affected annually.
0.1–1% (dark blue): Districts experiencing notable flood impacts on road/railway infrastructure.
1–2% (dark purple): Districts with the highest percentage of road/railway length affected by riverine floods annually.

Figure 41 illustrates the annual proportion of road and railway networks affected by riverine flooding across different districts in Malawi.

Insights from the maps:

- **Most Affected Districts (Dark Purple: 1 - 2%)**
  Nkhata Bay has the highest proportion of roads impacted by floods, followed closely by Salima (includes railway line), Karonga, Rumphi, Nkhotakota, Chikwawa, and Machinga.
  The frequent flood damage in these districts suggests the need for flood-resistant infrastructure and improved drainage systems.
- **Moderately Affected Areas (Medium Purple: 0.1 - 1%)**
  Districts such as Rumphi, Karonga,Khotakota, Chikwawa and Machinga experience moderate flood impacts on roads.
  Although these areas do not face extreme disruption, seasonal flooding can still cause transport challenges, requiring regular maintenance and flood mitigation efforts.
- **Less Affected Areas (Light Purple to Blue: 0 - 0.1%)**
  Most districts, including Ntcheu, Lilongwe, Mwanza, Neno and Blantyre show minimal road and railway disruption from floods.

Key Messages:

Infrastructure Vulnerability:
Hospitals and schools in flood-prone districts are increasingly at risk, which could disrupt essential services.

Transport Disruption:
The proportion of roads affected by floods is projected to rise, which would severely impair transportation and logistics, especially in districts like Zomba and Machinga and along the lake coast in the northern part of the country.

Need for Resilient Infrastructure:
Investing in resilient infrastructure is critical to maintaining essential services and reducing long-term economic losses, particularly in the most affected districts.

Social Vulnerability Assessment
Riverine Floods

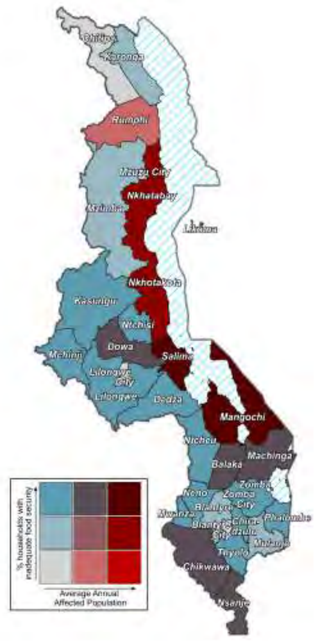


Figure 42. Combined Map of Average Annual Affected Population and Food Security Indicator.

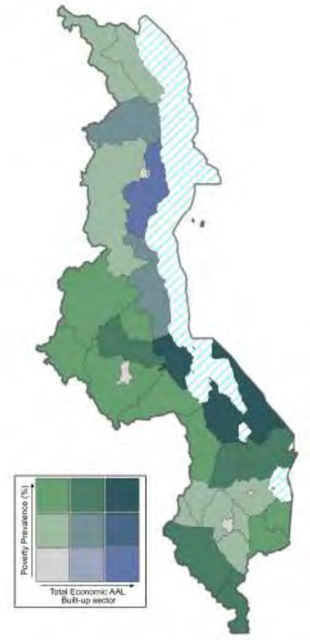


Figure 43. Combined Map of Total Economic AAL in Built-Up Areas and Poverty Prevalence Indicator.

Figure 44. Combined Map of Annual number of Damaged Buildings and Economically Inactive Population.

Figure 42 presents a combined analysis of two critical indicators:
Average Annual Population Affected by Riverine Flooding (AAL) – This represents the total population affected by flooding annually in each district.
Food Security Indicator – This indicates the percentage of households experiencing inadequate food security in the corresponding districts.

The map employs a colour gradient matrix to visually combine these two variables, showing the severity of flood impacts alongside food security challenges. The colours range from light shades (lower values) to dark shades (higher values) for both indicators.

Colour Key:
Light blue to dark blue: Districts with low flood impact but increasing food insecurity.
Light red to dark red: Districts with high flood impact and increasing food insecurity.
Intermediate shades: Districts with a combination of both indicators.

Observations from the map:

- **Southern Malawi:**
  Districts such as Mangochi, Nsanje, and Chikwawa show dark red shading, indicating high flood impact combined with severe food insecurity. These regions are among the most vulnerable, facing both climatic and socio-economic challenges.
  The combined burden suggests these areas require urgent interventions for both flood resilience and food security improvement.
- **Central Malawi:**
  Salima exhibits dark red shading, reflecting high flood impacts coupled with significant food insecurity. Nkhotakota also faces notable challenges but exhibits a lower degree of food insecurity.
  This highlights the need for targeted measures to mitigate flooding and enhance food systems.
- **Northern Malawi:**
  Districts such as Chitipa, Karonga, display blue shades, indicating relatively low flood impacts and better food security. These regions are less vulnerable compared to the rest of the country. Other districts like Nkhatabay and Rumphi are more affected.

Insights from the map:

- The map highlights the intersection of climate vulnerability and food insecurity, emphasising regions where both issues are most acute.
- Flood-prone areas in the south, with already

weakened food systems, are at a higher risk of compounded impacts, including displacement, loss of agricultural productivity, and economic instability.

- This calls for integrated interventions, such as:
  Enhancing flood protection infrastructure (e.g., embankments, drainage systems).
  Promoting climate-resilient agricultural practices to improve food security.
  Developing emergency response systems for both flooding and food crises.

Figure 43 presents a combined analysis of two critical variables:
Total Economic Average Annual Loss (AAL) in Built-Up Areas: This reflects the annual economic loss to riverine floods in each district.
Poverty Prevalence Indicator: This indicates the percentage of the population living below the poverty line in each district.

The map uses a colour gradient matrix to display the intersection of these two indicators. Different shades of green and blue represent varying combinations of economic losses and poverty prevalence:
Green shades indicate areas with lower poverty prevalence but varying levels of economic AAL.
Blue shades represent districts with higher poverty prevalence and varying levels of economic AAL.
Darker shades signify districts with higher values for both indicators, highlighting areas of heightened vulnerability.

Insights from the map:

- **Northern Malawi:**
  Districts such as Chitipa, Karonga, and Rumphi are predominantly shaded in light green to medium green, indicating low economic losses in built-up areas and lower poverty prevalence.
  These districts face less vulnerability in terms of combined economic and poverty-related impacts.
- **Central Malawi:**
  Districts like Nkhotakota and Salima show medium to dark green shading, indicating moderate economic losses in built-up areas combined with low to moderate poverty prevalence.
  This suggests the need for economic resilience measures in these areas to prevent exacerbation of vulnerabilities.
- **Southern Malawi:**
  Districts such as Mangochi, Chikwawa, and Nsanje exhibit dark green to dark blue shades, signifying high poverty prevalence coupled with moderate to high economic losses in built-up areas.
  These districts represent the most vulnerable regions, as high poverty levels intensify the impact of economic losses on communities.

Policy Implications:

- **Urban Resilience Planning:**
  Focus on flood-resilient infrastructure in southern districts to reduce economic losses in built-up areas.
  Prioritise districts with high poverty prevalence, where losses are harder to recover from.
- **Poverty Alleviation:**
  Implement social protection programmes in areas where poverty prevalence intersects with high economic vulnerability to enhance community resilience.
- **Data-Driven Resource Allocation:**
  Use this combined analysis to allocate resources effectively, focusing on districts with the highest combined vulnerabilities.

Figure 44 illustrates the intersection of two critical variables:
Annually Damaged Buildings: This represents the average number of buildings damaged each year due to natural hazards such as riverine floods within each district.
Economically Inactive Population Indicator: This refers to the percentage of the population within a district that has no income, highlighting economic inactivity.

The map uses a colour gradient matrix to display the overlap of these variables:
Brown shades indicate higher numbers of damaged buildings combined with varying levels of economically inactive population.
Purple shades represent districts with lower levels of building damage and economically inactive population.
Darker shades (brown or purple) signify districts with higher values for both indicators, indicating areas with compounded vulnerabilities.

Insights from the map:

- **Northern Malawi:**
  Districts such as Karonga shows moderate building damage and low economic inactivity, while Rumphi combines a moderate risk with higher social vulnerability.
  These districts are less vulnerable to combined structural and economic impacts.
- **Central Malawi:**
  Lilongwe City shows moderate risk combined with high economic inactivity.
  These areas may require moderate interventions to address structural and economic challenges.
- **Southern Malawi:**
  Similar to Lilongwe city Blantyre shows a moderate risk combined with high vulnerability factors.

Policy Implications:

- **Structural Resilience:**
  Focus on enhancing building standards in high-risk districts to reduce annual structural damage caused by natural hazards.
  Invest in disaster-resilient infrastructure in southern regions, particularly in districts with high annual building damage.
- **Economic Empowerment:**
  Implement livelihood diversification programmes in districts with high economic inactivity to improve income levels and reduce vulnerability to disasters.
  Introduce cash-for-work schemes during post-disaster recovery to engage economically inactive populations.
- **Targeted Resource Allocation:**
  Use this combined data to prioritise regions with overlapping vulnerabilities for climate adaptation investments and poverty alleviation efforts.

Key Messages:

Disproportionate Impact on Food-Insecure Populations:
Districts with high food insecurity, such as Chikwawa and Nsanje, show a significant overlap with areas experiencing high annual population impact from riverine floods. This indicates that the most vulnerable populations to flooding are at greater risk of both immediate harm and long-term food insecurity hotspots in this sense.

Exacerbated Vulnerability Among At-Risk Communities:
In areas where food security is already compromised, the additional strain of frequent flooding can lead to a cycle of poverty and increased dependency on external aid, underlining the need for targeted resilience-building efforts in these districts.

Need for Integrated Risk Management:
The stark differences between districts highlight the necessity of integrating flood risk management with food security initiatives, particularly in regions where these two factors intersect, to enhance overall community resilience.

High Economic Losses in Districts with High Poverty Prevalence:
Districts like Mangochi and Salima, which have high poverty prevalence, also experience significant economic losses due to flooding. The combination of poverty and frequent economic losses hinders the ability of these communities to recover and rebuild, perpetuating economic disparities.

Limited Capacity for Recovery in Regions with High Poverty Prevalence:
The correlation between high poverty levels and economic losses from flooding suggests that districts with high poverty prevalence are less resilient and have fewer resources to invest in flood protection and recovery, increasing their long-term vulnerability.

Targeted Interventions Needed:
The pronounced economic impact in poverty-stricken areas calls for targeted interventions that focus on both reducing flood risk and alleviating poverty, to break the cycle of vulnerability and improve resilience in these districts.

High Building Damage in Economically Inactive Areas:
Districts with a higher proportion of economically inactive populations, such as Phalombe and Machinga, also report a high number of buildings damaged annually by floods. This combination indicates that these regions may struggle to finance repairs and recovery, exacerbating their vulnerability.

Diminished resilience:
The high rate of building damage in areas with low economic activity further strains local economies, potentially leading to longer recovery times and higher rates of displacement, as communities may lack the financial means to rebuild.

Resilience Building Through Economic Activation:
Enhancing economic activity and providing support for rebuilding efforts in these districts is crucial for improving resilience, reducing the long-term impacts of flooding, and preventing further economic decline.

Cracked Road in Malawi - Naypong - Fotolia.com

Recommendations
Riverine Floods

Effective flood management and mitigation strategies are essential, especially given the potential impacts of climate change. The stark differences between current conditions and projected scenarios highlight the urgent need to prepare for and adapt to changing climate conditions to protect vulnerable populations. The results provide a clear visual representation of how climate scenarios can dramatically alter flood risks, emphasising the importance of proactive climate adaptation and disaster risk management.

Specific Recommendations

Develop District-Specific Flood Management Plans
Recommendation: Accelerate the development and implementation of district-specific flood management and mitigation strategies, in alignment with the National Disaster Risk Management Policy.
Focus: Prioritise the most vulnerable districts, such as Mangochi, Nsanje, and Chikwawa, tailoring strategies to address their unique geographic and demographic challenges.

Strengthen Early Warning Systems
Recommendation: Enhance early warning systems to provide timely alerts to communities in flood-prone districts, as outlined in the National Resilience Strategy in Malawi.
Focus: Integrate these systems with community-based disaster preparedness programmes to ensure vulnerable populations are well-informed and capable of responding effectively to imminent risks.

Invest in Resilient Infrastructure
Recommendation: Prioritise the construction and reinforcement of resilient infrastructure, including housing, roads, schools, and hospitals, in districts with high flood exposure.
Impact: These investments will mitigate the effects of future floods and ensure the continuity of critical services during disasters, as per the National Resilience Strategy.

Integrate Climate Adaptation into Policy and Planning
Recommendation: Incorporate climate adaptation measures into national and district-level development planning, including the use of projected climate scenario flood hazard maps.
Focus: Ensure policies address future climate risks and prioritise long-term resilience in sectors such as agriculture and housing.

Engage Communities and Build Local Capacity
Recommendation: Actively involve local communities in flood risk management efforts by providing education and resources to enhance disaster preparedness and response capabilities.
Focus: Empower high-risk districts to take proactive measures that safeguard lives and livelihoods.

Strengthen International Cooperation and Support
Recommendation: Build on existing partnerships with international donors to bolster Malawi's capacity to manage flood risks. Leverage global expertise and resources to implement advanced flood mitigation technologies and strategies.
Focus: Promote transboundary cooperation with neighbouring countries to enhance flood management through data sharing and collaborative planning.

Flash Floods

B1 - Number of People Directly Affected by Disasters

Flash Floods

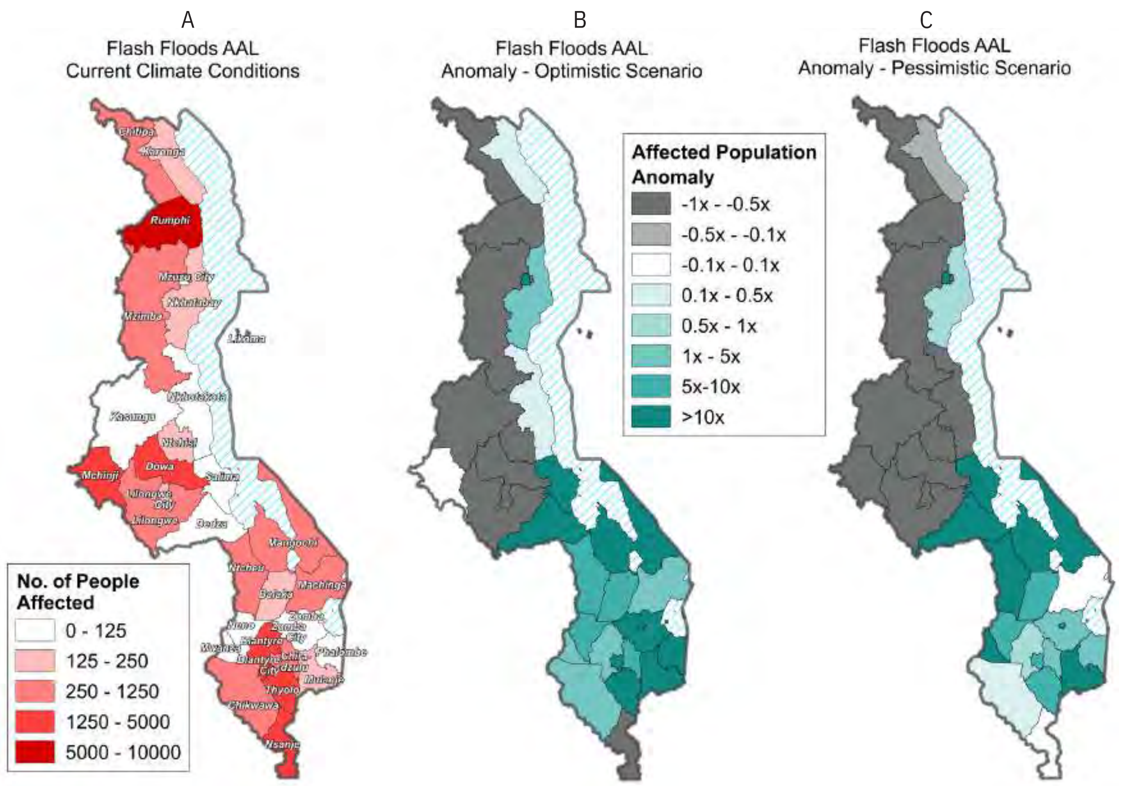


Figure 45. Average Annual Population Affected by Flash Floods in Current and Projected Climate Scenarios.

Figure 45 illustrates the average annual number of people affected by flash floods under current climate conditions and anomalies of the same variable for two projected climate scenarios (optimistic and pessimistic). The maps provide a visual comparison of the impacts across Malawi's districts, highlighting both the existing risks and the potential future changes.

A: Current Climate Conditions
The map shows the average annual number of people affected by flash floods under the current climate.
Colour scale:
Light red: 0–125 people affected.
Medium red: 125–2,500 people affected.
Dark red: 2,500–10,000 people affected.

Insights from the map:

- Southern districts, such as Nsanje, Thyolo and Blantyre, experience the highest impact, primarily due to their low-lying terrain and proximity to rivers.
- In the North, Rumphi represents the hotspot for Flash Floods risk.

B: Optimistic Scenario
The map presents the anomaly in affected populations under an optimistic climate scenario, assuming effective climate mitigation and adaptation measures.
Colour scale:
Grey shades: Reduction in the number of affected people.
Green shades: Increase in the number of affected people.

Insights from the map:

- **Significant Increase in Flood Impact (Dark Green to Teal Shades: >10x Anomaly)**
  The southern and central regions of Malawi, particularly Mangochi, Zomba, Mulanje, Phalombe, Salima and Dedza, show a substantial increase in the number of people affected by flash floods.
- **Moderate Increase in Flood Impact (Light Green Shades: 0.5x - 1x Anomaly)**
  Some districts including Nkhatabay, Chikwawa, Blantyre and Machinga are projected to experience a moderate rise in flood-affected populations, though not as extreme as in the dark green zones.
- **Decreased Flood Impact (Grey Shades: -1x to -0.5x Anomaly)**
  Districts including Chitipa, Rumphi, Mzimba, Kasungu Lilongwe Dowa, Ntchisi and Sanje is projected to see a decline in the number of people affected by flash floods.
- **Minimal Change (White Areas: -0.1x to 0.1x Anomaly)**
  One district shows little to no change in flood impact, meaning that projected climate conditions are not expected to significantly alter the number of people affected by flash floods.

C: Pessimistic Scenario
The map depicts the anomaly in affected populations under a pessimistic climate scenario, assuming limited mitigation efforts and severe climate impacts.
Colour scale:
Grey shades: Reduction in the number of affected people (rare in this scenario).
Green shades: Significant increases in affected populations (ranging from 1x to >10x).

Insights from the map:

- **Significant Increase in Flash Flood Impact (Dark Green to Teal Shades: 1x - >10x Anomaly)**
  The southern and central regions of Malawi show a substantial increase in the number of people affected by flash floods, particularly in districts shaded in dark green and teal.
  Some districts are expected to experience more than a tenfold (10x) increase in flood-affected populations.
- **Moderate Increase in Flood Impact (Light Green to Blue Shades: 0.5x - 1x Anomaly)**
  Some district such as Blantyre, Nkhatabay are projected to see a moderate rise in flood-affected populations.
- **Decreased Flash Flood Impact (Grey Shades: -1x to -0.5x Anomaly)**
  The northern region exhibits a significant decrease in the population affected by flash floods, as indicated by the dark grey shades.
  These areas may experience less frequent or less intense flooding compared to current conditions, potentially due to shifting rainfall patterns or improved natural drainage.
- **Minimal Change (White: -0.1x to 0.1x Anomaly)**
  Karonga district shows little to no change in flood impact, meaning that the projected climate conditions are not expected to significantly alter flash flood exposure for these populations.

Policy Implications:

- **Strengthen Flood Mitigation in Vulnerable Areas:**
  Prioritise districts like Rumphi, Nsanje, Thyolo, Blantyre for investment in flood defences, such as drainage systems and embankments.
- **Implement Early Warning Systems:**
  Ensure communities in high-risk regions receive timely alerts to prepare for flash floods.
- **Promote Climate Adaptation Measures:**
  Integrate flood risk reduction into development planning, particularly in agriculture and infrastructure sectors.
- **Focus on Resilience Building:**
  Provide resources and education to empower communities in high-risk districts to adapt to and recover from flash floods.

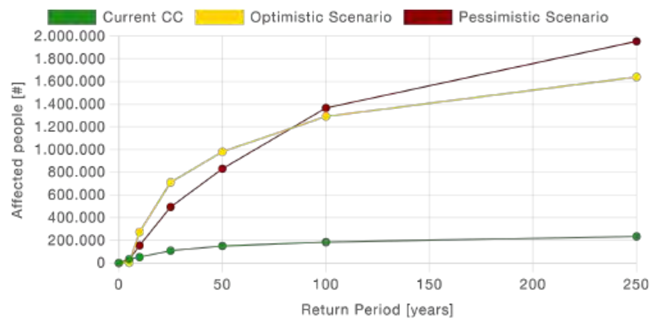


Figure 46. Probable Maximum Loss Curves for Populations Affected by Flash Floods Under Different Climate Conditions.

Key Messages:

Increasing Vulnerability to Flash Floods:
A significant number of people are currently affected by flash floods, with this number projected to rise under projected climate scenarios. Current climate hotspots are visible in Nsanje, Chikwawa and Blantyre as well as in the Rumphi districts. In projected climate conditions, a strong increase in flash flood risk concentrates in the southern districts, which are already experiencing severe impacts.

Geographic Disparities:
The distribution of affected populations shows that certain districts are more severely impacted by flash floods due to their geographical and climatic conditions. Targeted interventions in these high-risk areas are essential to reduce the number of people affected.

Need for Proactive Adaptation:
The increasing number of people affected under the considered climate scenarios underscores the urgent need for proactive adaptation measures to safeguard vulnerable populations and mitigate the adverse effects of flash floods. This is particularly true for high return periods whose severity will be exacerbated by climate.

C1 - Direct Economic Loss Attributed to Disasters
Flash Floods

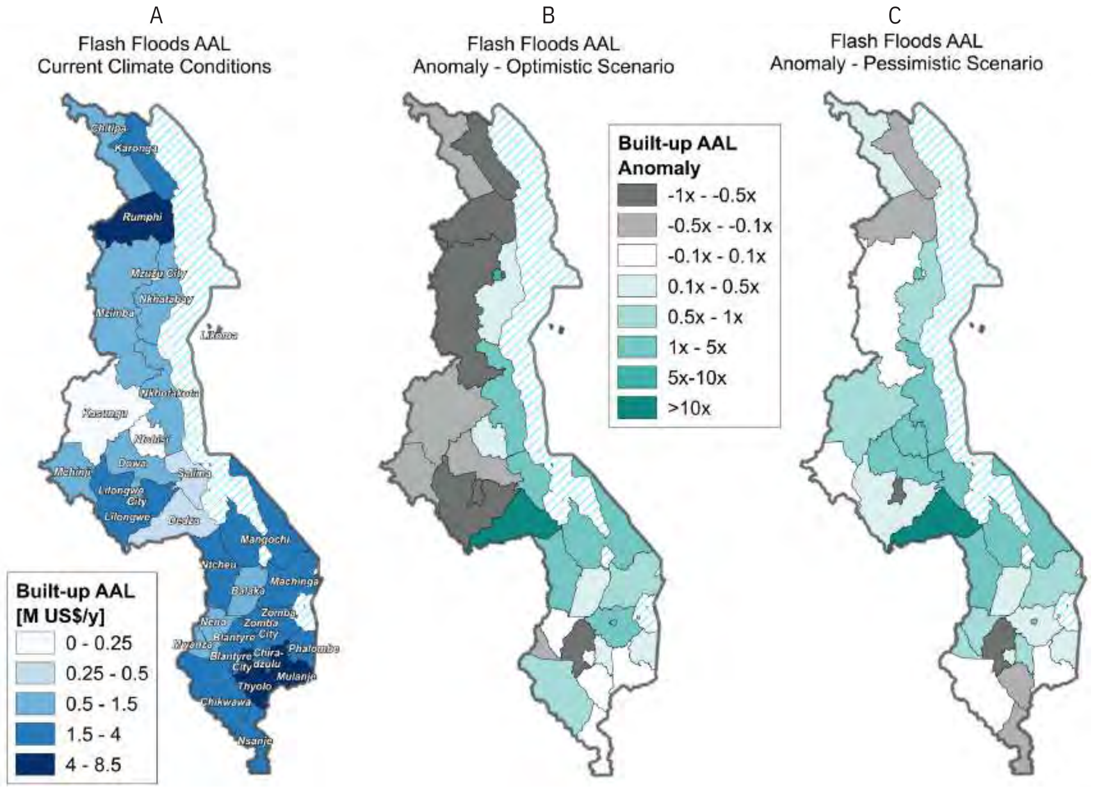


Figure 47. Average Annual Loss to the Built-Up Sector Due to Flash Floods Under Current and Projected Climate Scenarios.

The Figure 47 displays the AAL in the built-up sector caused by flash floods across districts in Malawi.
The map is divided into three panels:

A: Current Climate Conditions
This map shows the AAL to the built-up sector (in million USD/year) under current climate conditions.
Colour scale:
Light blue: Losses of $0–0.25 million per year.
Medium blue: Losses of $0.25–4 million per year.
Dark blue: Losses exceeding $4 million per year.

Insights from the map:
- Southern districts, such as Nsanje, Chikwawa, and Phalombe, experience the highest losses, exceeding $4 million annually.
- Central and northern districts, such as Karonga, Rumphi, and Kasungu, show significantly lower losses, with many under $0.25 million per year.

B: Optimistic Scenario
This map depicts the anomaly in AAL (change compared to current conditions) under an optimistic climate scenario, assuming effective climate mitigation.

Colour scale:
Grey shades: Reduction in AAL, ranging from -1x to -0.1x.
Green shades: Increase in AAL, ranging from 0.1x to >10x.

Insights from the map:
- Many districts in northern and central Malawi show reductions in AAL (grey shades), suggesting that mitigation measures could decrease losses in these regions.
- However, southern districts like Chikwawa and Nsanje still experience slight to moderate increases in AAL, indicating persistent vulnerability even under optimistic conditions.

C: Pessimistic Scenario
This map shows the anomaly in AAL under a pessimistic climate scenario, assuming more severe impacts due to insufficient mitigation efforts.
Colour scale:
Grey shades: Reduction in AAL (rare in this scenario).
Green shades: Significant increases in AAL, ranging from 1x to >10x.

Insights from the map:
- **Significant Increase in Economic Losses (Dark Green: >10x Anomaly)**
  The district particularly Dedza is projected to experience over a tenfold increase in annual economic losses due to flash floods.
- **Moderate Increase in Losses (Light Green to Teal: 1x - 5x Anomaly)**
  Several districts such as Khotakota, Salima, Ntchisi, Dowa, Mangochi, and Ntcheu are projected to experience a moderate rise in flood-related losses.
- **Stable or Minimal Change (White to Light Grey: -0.5x to 0.1x Anomaly)**
  Some districts, particularly Mzimba, Mchinji, Chikwawa, and Mulanje show little to no change in flood-related economic losses.
- **Reduction in Economic Losses (Dark Grey: -1x to -0.5x Anomaly)**
  District such as Lilongwe city is expected to experience a decline in annual flood-related losses.

Key message from all maps:
- **Current Conditions:**
  Southern districts bear the greatest economic burden from flash floods, with high AAL in the built-up sector.
- **Optimistic Scenario:**
  Mitigation efforts can reduce AAL in many districts, particularly in the north and central regions, but some southern districts remain highly vulnerable.
- **Pessimistic Scenario:**
  Without effective mitigation, flash flood impacts on the built-up sector will increase dramatically, especially in southern and some central districts.

Policy Implications:
- **Resilient Infrastructure:**
  Prioritise flood-resilient construction and reinforcement of infrastructure in southern districts to reduce AAL.
- **Climate Mitigation:**
  Implement effective climate adaptation and mitigation strategies, such as improved drainage systems, flood barriers, and sustainable urban planning.
- **Early Warning Systems:**
  Deploy early warning systems in high-risk districts to minimise flood impacts and reduce economic losses.
- **Regional Focus:**
  Allocate resources strategically, targeting southern districts where losses are highest, while maintaining efforts to prevent emerging risks in central regions.

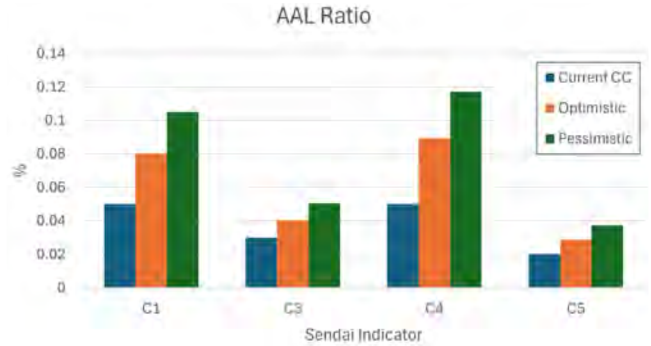


Figure 48. Ratio of Average Annual Loss as a Percentage of Corresponding Stock Value for Different Sendai Indicators Related to Flash Floods Under Current Climate Conditions.

Key Messages:

Rising Economic Costs:
The data shows that the direct economic losses attributed to flash floods are expected to increase significantly, from $60.3 million under current conditions to as much as $96.9 million in pessimistic scenarios. The housing sector is particularly vulnerable, with potential losses of up to $90.1 million.

Sectoral Impact Analysis:
The housing sector is the most affected by economic losses due to flash floods, followed by other productive assets and critical infrastructure. This sectoral impact analysis suggests the need for sector-specific resilience strategies, especially in urbanized districts like Blantyre and Lilongwe.

Infrastructure at Risk:
The increase in economic losses related to critical infrastructure, including roads and public utilities, highlights the need for substantial investments in resilient infrastructure, particularly in flood-prone areas.

Sendai Indicator	Flash Floods	AAL current CC	AAL optimistic scenario	AAL pessimistic scenario
C1 [M US$]	**Direct economic loss attributed to disasters** (as sum of C3, C4, and C5 in the following)	**60.3**	**74.1**	**96.9**
C3 [M US$]	Direct economic loss to all other damaged or destroyed productive assets attributed to disasters	2.5	3.5	4.3
C4 [M US$]	Direct economic loss in the housing sector attributed to disasters	56.3	68.6	90.1
C5 [M US$]	Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters	1.5	2.0	2.5

Key Messages:

Significant Economic Burden from Flash Floods:
The Average Annual Loss (AAL) table highlights the substantial economic burden that flash floods impose on Malawi, with current losses estimated at $60.3 million. This burden is expected to increase dramatically under both optimistic and pessimistic climate scenarios, reaching up to $96.9 million. This underscores the critical need for enhanced flood risk management strategies to mitigate economic impacts.

Housing Sector as the Most Vulnerable:
The housing sector is identified as the most vulnerable, with AAL values increasing from $56.3 million under current climate conditions to $90.1 million in a pessimistic scenario. This highlights the urgent need for targeted interventions in the housing sector, particularly in flood-prone districts, to reduce vulnerability and protect assets.

Escalating Risks to Critical Infrastructure:
The table also reveals that critical infrastructure, including roads and public services, faces increasing risks, with AAL values rising from $1.5 million to $2.5 million in the most severe climate scenarios. Investing in the resilience of these infrastructures is essential to minimize disruption and ensure the continuity of essential services during and after flood events.

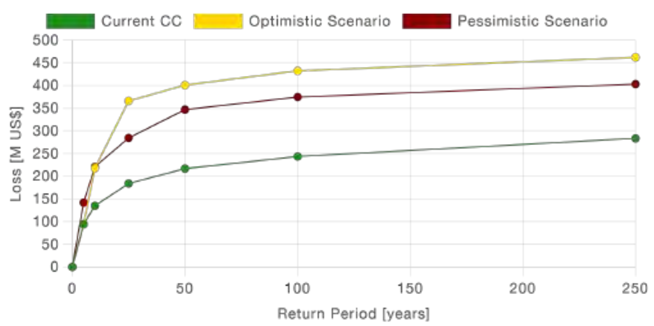


Figure 49. Probable maximum loss curves for economic damages to the built-up area [M US $], linked to flash floods under different climate conditions

The curves indicate a clear upward trend in potential losses, particularly under pessimistic climate scenarios. This suggests that as climate change progresses, urban and semi-urban areas will face increasingly severe economic impacts from flash floods. This underscores the importance of integrating climate risk assessments into urban planning and development policies to mitigate future losses.
Despite an AAL of 60M USD the fast rising of the PML curve predicts possible losses of 100 M USD for a 10-year return period event and losses close to 200 M USD when a return period of 25 Years is considered. Such numbers almost doubled in projected climate conditions.

D - Damage to Critical Infrastructures, Including Basic Services
Flash Floods

Figure 50. Average annual proportion of hospitals affected by flash floods.

Figure 51. Average annual proportion of schools affected by flash floods.

Key Messages:

High Vulnerability of Social Infrastructure:
The figures reveal that hospitals and schools in flood-prone districts are at significant risk of being affected by flash floods. This could lead to the disruption of essential services, particularly in districts Thyolo, Rumphi and Karonga which are hotspots in relative terms.

Disruption of Essential Services:
The potential damage to critical infrastructure such as hospitals and schools poses a severe threat to public health and education. Ensuring the resilience of these facilities is crucial to maintaining service continuity during and after flood events.

Need for Enhanced Protection Measures:
The data emphasizes the need for enhanced protection and resilience measures for critical infrastructure. Strengthening these systems will be key to reducing the long-term impact of flash floods on essential services.

Figures 50 and 51 illustrate the average annual percentage of hospitals and schools respectively affected by riverine floods in each district across Malawi.
The percentages are expressed as a proportion of the total number of hospitals and schools (buildings) in each district. The map uses a gradient of green shades to represent varying levels of impact:

0–0.01% (lightest yellow-green): Districts with the lowest percentage of hospitals and schools affected by riverine floods.
0.01–0.05% (light green): Areas with slightly higher flood impacts on critical infrastructure.
0.05–0.1% (medium green): Districts where a moderate proportion of hospitals and schools are affected annually.
0.1–0.4% (dark green): Areas with a higher percentage of flood-affected buildings.
0.4–0.6% (darkest green): Districts with the highest proportion of hospitals and schools impacted by riverine floods.

Insights from the maps:

- **Most Affected Districts (Dark Green: 0.4 - 0.6%)**
  Rumphi, Karonga and Thyolo have the highest proportion of hospitals and schools affected by flash floods.
  This suggests that essential services in these districts might experience frequent disruptions, potentially impacting healthcare delivery and education.
- **Moderately Affected Areas (Medium to Light Green: 0.1 - 0.5%)**
  Most of the districts in southern Malawi fall into this category, experiencing moderate levels of flood impact on essential services.
- **Less Affected Areas (Yellow: 0 - 0.1%)**
  Most districts in Central Malawi show low or minimal flood impact on hospitals and schools.

Social Vulnerability Assessment
Flash Floods

Figure 52. Combined Map of AAL and Food Security Indicator.

Figure 53. Combined Map of Total Economic AAL in the Built-Up Sector and Poverty Prevalence Indicator.

Figure 54. Combined Map of Annual Damaged Buildings and Economically Inactive Population Indicator.

Figure 52 provides a spatial analysis of the intersection between two critical indicators:
Average Annual Population Affected: This represents the total population impacted by flash floods annually, shown as a district-level cumulate.
Food Security Indicator: This reflects the percentage of households within each district experiencing inadequate food security.

Insights from the map:

- **High Flash Flood Risk (Dark Red Areas)**
  Rumphi is the most severely affected district, experiencing high flood losses.
- **Moderate Flash Flood Risk and Food Insecurity (Brownish-Red Areas)**
  Several districts in northern and central Malawi, including Mzimba, and Blantyre, show a combination of moderate flood exposure and food insecurity.
- **Lower Flash Flood Risk but High Food Insecurity (bue Areas)**
  Districts such as Salima, and Kasungu have higher exposure to flood-related losses but relatively lower food insecurity levels.
- **Moderate Flash Flood Risk combined with High Food Insecurity (Mixed Color Areas)**
  Some districts, Mangochi, Machinga, Ntcheu, Lilongwe, Dedza, Mchinji, Dowa, Chikwawa, Nsanje, have high food insecurity and moderate flood risk.

Policy Implications:

- **Integrated Interventions:**
  Target areas with high food insecurity and AAL, such as southern districts, with holistic strategies combining disaster risk reduction and food security improvements.
- **Strengthen Resilience:**
  Enhance climate-resilient agriculture and promote alternative livelihoods in vulnerable districts.
- **Improve Early Warning and Response:**
  Develop robust systems for early warning and disaster preparedness in areas with high AAL, particularly in southern Malawi.

Figure 53 illustrates the relationship between two key variables across Malawi:
Total Economic Average Annual Loss (AAL) in the Built-Up Sector: This represents the annual economic losses in built-up areas (e.g., urban infrastructure) due to flash floods.
Poverty Prevalence Indicator: This indicates the percentage of the population living below the poverty line in each district.

The map uses a colour gradient matrix to combine these two variables, with different shades of green and blue representing varying levels of economic losses and poverty prevalence:

Green shades: Represent areas with lower poverty prevalence and varying economic losses.
Blue shades: Represent areas with higher poverty prevalence and varying economic losses.
Darker shades: Indicate districts with high values for both indicators, highlighting areas with compounded vulnerabilities.

Insights from the map:

- **High Poverty and High Economic Loss (Dark Green-Blue Areas)**
  Several districts in southern and central Malawi experience both high levels of poverty and significant economic losses due to disasters affecting the built-up sector.
  This suggests that vulnerable populations in these regions are highly exposed to climate risks and economic shocks, making it harder for them to recover from disasters.
- **Moderate Economic Losses with High Poverty (Green-Dominant Areas)**
  Some districts in northern and central regions exhibit high poverty levels but lower economic losses in the built-up sector.
- **High Economic Losses with Lower Poverty (Blue-Dominant Areas)**
  Certain urbanized districts in the south and parts of the central region show higher economic losses in the built-up sector but lower poverty prevalence.
  This implies that while these areas face significant financial damage from disasters, they may have better economic resilience and recovery mechanisms.
- **Lower Economic Loss and Lower Poverty (Lighter Areas)**
  Some districts have both low economic losses and lower poverty prevalence, suggesting better infrastructure resilience and relatively stable socio-economic conditions.

Figure 54 presents a spatial analysis combining annual building damage due to disasters with the percentage of individuals who are economically inactive (no income) across different districts in Malawi. The dual-colour gradient indicates:
Brownish shades represent a high percentage of economically inactive individuals.
Purple shades indicating a high number of annually damaged buildings.
Darker mixed shades (brown + purple) highlighting areas where both factors are significantly high.

Insights from the map:

- **High Building Damage and High Economic Inactivity (Dark Brown-Purple Areas)**
  Some districts in central and southern Malawi experience both high building damage and high levels of economic inactivity.
  These areas are particularly vulnerable to disasters, as the population has limited financial capacity to rebuild homes and recover from damage.
- **Moderate Building Damage with High Economic Inactivity (Brown-Dominant Areas)**
  Certain rural districts exhibit high economic inactivity but lower levels of damaged buildings.
  This suggests that while fewer buildings are at risk, the economic capacity of the population remains low, making it difficult to recover from any potential disasters.
- **High Building Damage with Lower Economic Inactivity (Purple-Dominant Areas)**
  Some urban and peri-urban districts experience significant building damage but lower levels of economic inactivity.
  This suggests that while buildings are frequently damaged, the population has a relatively higher economic ability to recover through income sources or financial support.
- **Lower Risk Areas (Lighter Shades)**
  Some districts have both low building damage and low economic inactivity, indicating better resilience, economic stability, and lower exposure to severe structural damage from disasters.

Key Messages:

Need for Proactive and Inclusive Adaptation:
The projected increase in the number of people affected by flash floods and the significant economic losses call for proactive and inclusive adaptation strategies. These strategies must consider both the physical and socio-economic vulnerabilities of the population, ensuring that the most at-risk communities are prioritized in flood risk management plans. Integrating climate risk assessments into urban planning and development policies is essential to mitigate future losses and protect vulnerable populations.

Socio-Economic Vulnerability and Flash Floods:
The maps combine flash flood risk indicators with socio-economic factors, such as food security, poverty prevalence, and economic inactivity. These combinations provide a clearer picture of the vulnerability landscape. Districts with high poverty rates and low economic activity are more susceptible to the devastating effects of flash floods. The overlay of these socio-economic factors with the risk indicators suggests that the most vulnerable populations are not only the most affected by flash floods but also have the least capacity to recover, amplifying the overall risk. The geographical distribution of flash flood impacts, as illustrated in the maps, reveals stark vulnerability of the most socio-economically vulnerable populations.

Strategic Focus on High-Risk Areas:
The maps highlighting the correlation between economic loss and poverty prevalence underscore the need for robust economic resilience strategies, particularly in urbanized and economically disadvantaged districts. Given the concentration of risk in certain geographical areas, particularly the southern districts, there is a clear need for a strategic focus on these high-risk regions. Tailored interventions that address both the physical risks of flash floods and the socio-economic vulnerabilities of these areas are necessary to reduce the overall risk and enhance community resilience.

Depiction of Flash Floods - DoDMA

Recommendations
Flash Floods

District-Specific Flood Mitigation Strategies
Recommendation: Accelerate the development and implementation of district-specific flood mitigation strategies, focusing on areas most vulnerable to flash flooding, such as highly urbanised regions and lowlands prone to flash flood risks due to low soil permeability and reduced drainage capacity.
Tailored Approach: These strategies should be customised to address the unique geographic and demographic characteristics of each district, ensuring effective reduction of flash flood impacts.

Strengthening Early Warning Systems and Community Preparedness
Early Warning Systems: Expand and enhance early warning systems to deliver timely and accurate alerts to communities, particularly in districts at the highest risk of flash floods.
Community Preparedness: Integrate these systems with robust community preparedness programmes to ensure vulnerable populations can respond swiftly and effectively to flood threats.

Investment in Resilient Infrastructure
Priority: Focus investments on resilient infrastructure, especially in the housing and critical infrastructure sectors.
Objective: Strengthening these areas will help mitigate economic losses and ensure the continuity of essential services amidst increasing flood risks.

Integrating Climate Adaptation into Development Planning
Policy Alignment: Strengthen the integration of climate adaptation strategies and disaster risk reduction into national and district-level development plans.
Focus: Address long-term risks associated with climate change, particularly in sectors and districts most vulnerable to flash floods.
Urban Planning: Include information about design storms, as identified in this study, in urban development plans to account for potential increases in the severity of localised rainfall events.

Promoting Sustainable Land and Water Management Practices
Implementation: Adopt sustainable land and water management practices in flood-prone districts to minimise the risk of flash floods.
Examples:
- Reforestation to improve soil stability and reduce surface runoff.
- Riverbank protection to minimise erosion and maintain natural flow paths.
- Restoration of natural floodplains to absorb excess water during heavy rainfall events.

Strong Winds

B1 - Number of People Directly Affected by Disasters

Strong Winds

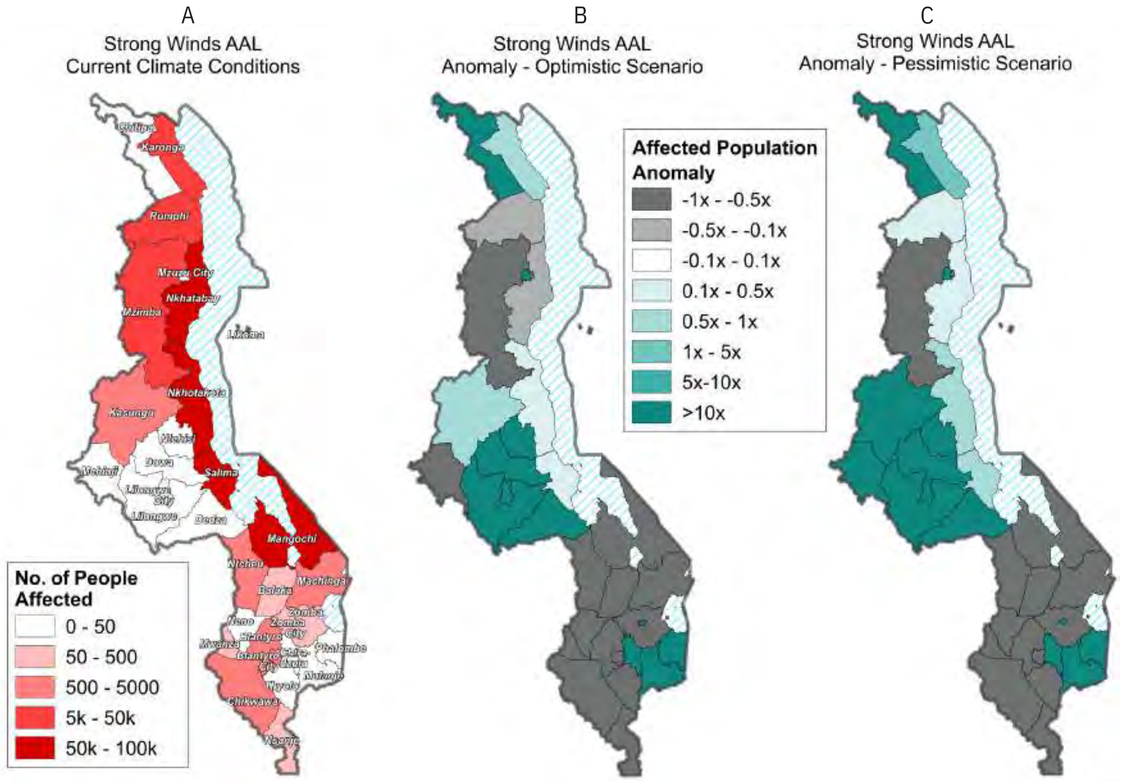


Figure 55. Average Annual Population Affected by Strong Wind Events Under Current and Projected Climate Scenarios.

The Figure 55 illustrates the average annual number of people affected by strong wind events under three different conditions:

A: Current Climate Conditions
This map depicts the average annual number of people affected by strong winds under the current climate.
Colour scale:
Light red: 0–50 people affected.
Medium red: 50–50,000 people affected.
Dark red: 50,000–100,000 people affected.

Insights from the map:

- Districts along the lake Malawi shore experience the highest impacts, with more than 50,000 people affected annually.
- Northern districts, including Karonga and Rumphi, have lower numbers of affected populations, but still significant risk.

B: Optimistic Scenario
This map shows the anomaly in affected populations under the optimistic scenario, assuming effective climate mitigation efforts.
Colour scale:
Grey shades: Reductions in the number of affected people (e.g., -1x to -0.1x).
Green shades: Increases in the number of affected people (e.g., 0.1x to >10x).

Insights from the map:

- **Significant Increase in Wind Impact (Dark Green: >10x Anomaly)**
  Several districts in southern Malawi and parts of the central region are projected to experience a more than tenfold increase in population affected by strong winds. This suggests that climate change could intensify windstorms in these regions, leading to increased risks of property damage, infrastructure failure, and livelihood disruptions.
- **Moderate Increase in Wind Impact (Teal to Light Green: 1x - 10x Anomaly)**
  Some districts in central and eastern Malawi show a moderate rise in population affected by strong winds, indicating a growing need for wind-resistant infrastructure and preparedness measures.
  These areas may experience more frequent or intense wind events, but the impact will not be as severe as in high-risk zones.
- **Minimal Change in Wind Exposure (White and Light Grey: -0.1x to 0.1x Anomaly)**
  Certain districts in northern Malawi and parts of the central region exhibit little to no change in the population affected by strong winds.
  This suggests that windstorm risks in these areas may remain relatively stable under future climate conditions.
- **Decreased Wind Impact (Dark Grey: -0.5x to -1x Anomaly)**
  Some northern and western districts are projected to experience a decline in wind-related impacts, possibly due to shifting weather patterns or improved resilience measures.
  While this is a positive trend, continued monitoring and preparedness are necessary to ensure that these areas remain protected.

C: Pessimistic Scenario
This map shows the anomaly in affected populations under the pessimistic scenario, assuming effective climate mitigation efforts.
Colour scale:
Grey shades: Reductions in the number of affected people (e.g., -1x to -0.1x).
Green shades: Increases in the number of affected people (e.g., 0.1x to >10x).

Insights from the map:

- **Significant Increase in Wind Impact (Dark Green: >10x Anomaly)**
  Chiradzulu, Thyolo, Mulanje, Lilongwe, Dedza, Lilongwe City, Dowa, Ntchisi, Mzuzu City, and Chitipa are projected to experience a more than tenfold increase in affected populations due to strong winds.
- **Moderate Increase in Wind Impact (Light Green: 0.5x - 1x Anomaly)**
  Kasungu, and Karonga will experience a moderate rise in wind-affected populations.
- **Stable or Minimal Change (Light Grey: -0.5x to -0.1x Anomaly)**
  Rumphi and Nkhatabay show little to no change in windstorm impacts, suggesting that strong wind events may not intensify significantly in these areas.
- **Decreased Wind Impact (Dark Grey: -1x to -0.5x Anomaly)**
  Some areas, particularly Mzimba, Mchinji, Ntcheu, Balaka, Mangochi, Machinga, Zomba, Blantyre, Blantyre City, Chikwawa, Neno, Mwanza Nsanje and Thyolo are projected to experience a reduction in strong wind impacts.

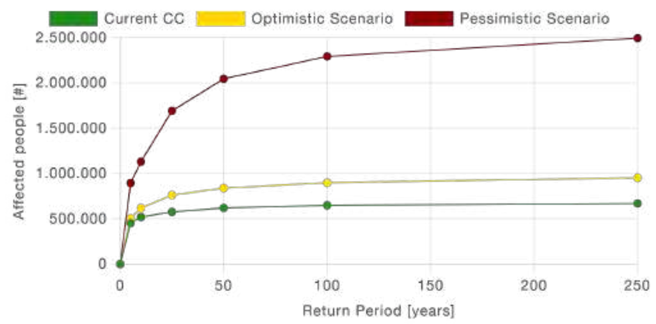


Figure 56. Probable Maximum Loss Curves for Populations Affected by Strong Winds Under Different Climate Conditions.

Key Messages:

Rising Impact of Strong Winds on Populations:
Data shows a significant and increasing number of people affected by strong wind events in Malawi. The districts along the Lake Malawi shore are the most affected. Under projected climate scenarios, this number is expected to rise, indicating that more communities, particularly in central Malawi, will face the direct impacts of strong winds.

Increasing Vulnerability with Climate Change:
As climate conditions worsen, the population's vulnerability to strong winds is expected to increase, especially in the central region, a region with high population density. This trend underscores the need for comprehensive disaster risk reduction and climate adaptation strategies.

C1 - Direct Economic Loss Attributed to Disasters
Strong Winds

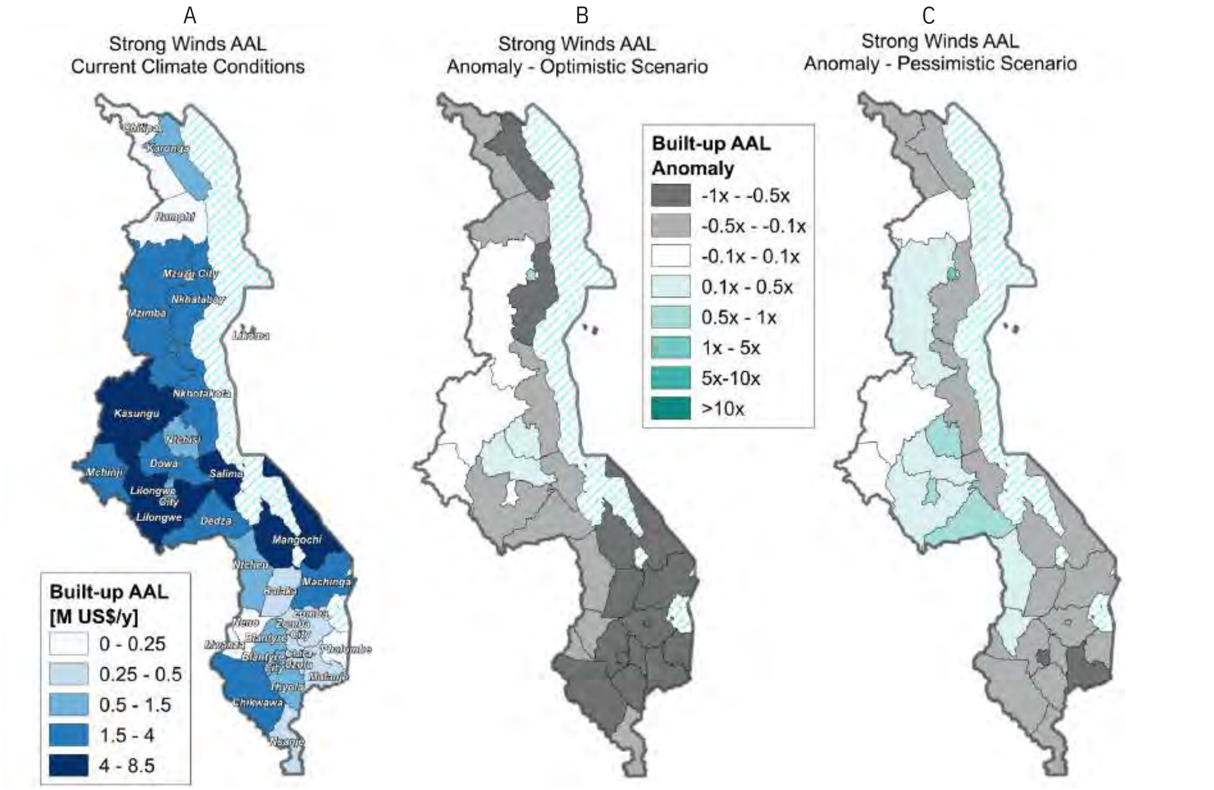


Figure 57. Average Annual Loss to the Built-Up Sector Due to Strong Wind Events in Current Climate and Projected Scenarios.

Figure 57 illustrates the estimated financial losses to the built-up sector (urban infrastructure, buildings, and economic assets) caused by strong wind events under current climate conditions and future climate scenarios across Malawi.

A: Current Climate Conditions
The colour-coded scale represents the total economic loss in millions of US dollars per year (M US$/y), with darker shades indicating higher financial damage.

Insights from the map

- **High Economic Loss Areas (Dark Blue: 4 - 8.5 M US$/y)**
  Lilongwe, Kasungu, Salima, and Mangochi experience the highest annual economic losses due to strong winds.
- **Moderate Economic Loss Areas (Medium Blue: 1.5 - 4 M US$/y)**
  Dowa, Salima, Dedza, and Machinga also show considerable financial losses, indicating that these regions are moderately affected by strong wind events.
- **Lower Economic Loss Areas (Light Blue: 0.25 - 0.5 M US$/y)**
  Most central and northern districts, including Karonga, Ntchisi, Blantyre, Thyolo, and Ntcheu, fall within this category.
- **Minimal Loss Areas (White: 0 - 0.25 M US$/y)**
  Chitipa, Rumphi, Neno, Mwanza, and Phalombe have minimal financial losses from strong winds, possibly due to lower infrastructure exposure and sparser populations.

B: Anomaly in the Optimistic Scenario
This map shows the anomaly in total economic loss under the optimistic scenario.
Colour scale:
Grey shades: represent reductions in the total economic loss.
Green shades: represent increases in the total economic loss).

Insights from the map

- **Significant Increase in Economic Losses (Dark Green: >10x Anomaly)**
  No districts are expected to see a more than tenfold increase in wind-related damages, even under an optimistic climate scenario.
- **Moderate Increase in Economic Losses (Light Green: 0.5x to -1x Anomaly)**
  Some districts including Chitipa, Rumphi, Khotakota, Salima, Lilongwe, Dedza, Ntcheu, Neno, Mwanza, and Nsanje are projected to experience a moderate rise in financial losses, indicating that wind-related risks may still pose economic challenges.
- **Stable or Minimal Change (White: -0.1x to 0.1x Anomaly)**
  Mzimba, Kasungu, Mchinji, and Lilongwe City exhibit little to no change in built-up sector losses, indicating that wind-related economic impacts may remain stable in these areas.
- **Decrease in Economic Losses (Dark Grey: -1 to -0.5x Anomaly)**
  Karonga, Nkhatabay, Mangochi, Machinga, Balaka, Zomba, Phalombe, Chiradzuru, Blantyre City, Blantyre, Tholo, Mulanje, and Chikwawa are expected to experience a decline in wind-related financial losses.

C: Anomaly in the Pessimistic Scenario
This map shows the anomaly in total economic loss under the pessimistic scenario.
Colour scale:
Grey shades: represent reductions in the total economic loss.
Green shades: represent increases in the total economic loss.

Insights from the map

- **Significant Increase in Economic Losses (Dark Green: >10x Anomaly)**
  No district are projected to experience more than a tenfold increase in wind-related financial losses
- **Moderate Increase in Economic Losses (Light Green: 0.1x to 0.5x Anomaly)**
  Mzimba, Dowa, Lilongwe, Ntcheu and Neno are expected to see a moderate increase in financial losses, requiring reinforced infrastructure and improved disaster preparedness.
  This implies that strong winds will become a more frequent and severe hazard, even in areas currently at moderate risk.
- **Stable or Minimal Change (White and Light Grey: -0.1x to 0.1x Anomaly)**
  Certain districts such as Rumphi, Kasungu and Mchinji show little to no change in economic losses, suggesting that wind-related impacts in these areas may remain relatively stable.
- **Moderate Decrease in Economic Losses (Light Dark Gray: 0.5x to -0.5x)**
  Chitipa, Karonga, Nkhatabay, Khotakota, Salima, Mangochi, Machinga, Balaka, Zomba, Phalombe, Chiradzuru, Thyolo, Neno, Nsanje and Mulanje are projected to experience a moderate decline in economic losses
- **Decrease in Economic Losses (Dark Grey: -1x to -0.5x Anomaly)**
  Blantyre City and Thyolo are projected to experience a decline in economic losses, likely due to changing weather patterns, improved resilience measures, or natural geographical protection from strong winds.

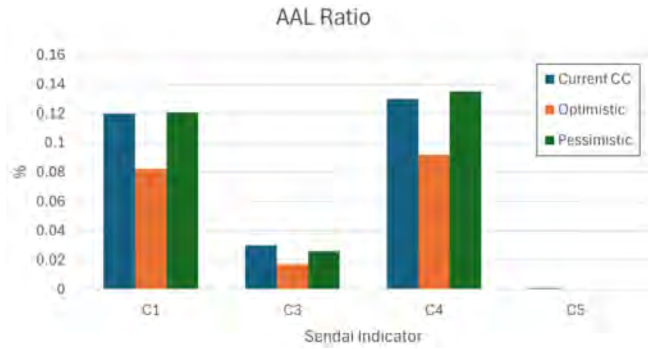


Figure 58. Ratio of Average Annual Loss for Different Sendai Indicators Related to Strong Winds in Current Climate Conditions and climate change projections.

Key Messages:

High Economic Costs from Strong Winds:
The AAL table reveals that strong winds already cause significant economic losses, with the housing sector bearing the brunt. Current losses are estimated at $153.7 million, potentially rising to $157.2 million in pessimistic scenarios. This highlights the need for increased investment in resilient housing.

Disproportionate Impact on Housing Sector:
The housing sector is by far the most affected by economic losses due to strong winds, indicating a critical need for strengthening building codes and implementing wind-resistant construction practices in vulnerable districts.

Minimal Impact on Critical Infrastructure:
Despite the high overall economic losses, the impact on critical infrastructure is relatively low. However, this does not diminish the importance of ensuring that essential services and infrastructure are resilient to wind-related disasters.

Sendai Indicator	Strong Winds	AAL current CC	AAL optimistic scenario	AAL pessimistic scenario
C1 [M US$]	**Direct economic loss attributed to disasters** (as sum of C3, C4, and C5 in the following)	**153.7**	**107**	**157.2**
C3 [M US$]	Direct economic loss to all other damaged or destroyed productive assets attributed to disasters	2.3	1.5	2.2
C4 [M US$]	Direct economic loss in the housing sector attributed to disasters	151.4	105.5	155
C5 [M US$]	Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters	<0.01	<0.01	<0.01

Key Messages:

Significant Financial Exposure:
The AAL table reveals a substantial financial exposure to strong winds, with losses concentrated heavily in the housing sector. The projected increase in these losses under pessimistic scenarios underscores the importance of addressing the vulnerabilities in this sector to reduce overall economic risks.

Potential for Improved Resilience:
The relatively modest increases in losses for other productive assets and critical infrastructure suggest that there is potential to mitigate risks effectively through targeted investments in resilience. Strengthening these areas can help contain economic losses even as climate conditions worsen.

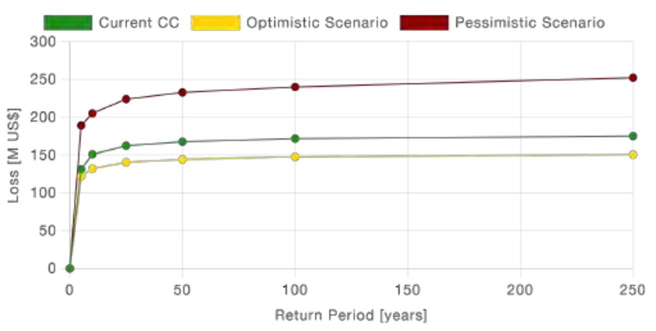


Figure 59. . Probable maximum loss curves for economic damages to the built-up area [M US $], linked to strong winds under different climate conditions.

District-Level Implications:
Given the concentration of losses in certain districts, especially those with high housing density, district-level interventions are essential. This includes both preventative measures and post-disaster recovery plans tailored to the specific needs of each district.

High Sensitivity to Climate Scenarios:
The PML curve shows that economic damages to built-up areas due to strong winds are sensitive to different climate scenarios. Under the pessimistic climate scenario, the PML curve indicates a sharp increase in potential losses, reflecting the heightened risk that climate change poses to urban and semi-urban areas.

Implications for Urban Planning:
The steep rise in potential losses under pessimistic scenarios underscores the urgent need for incorporating wind resilience into urban planning and building regulations. This includes ensuring that new developments are constructed with materials and designs capable of withstanding stronger winds.

Focus on High-Risk Areas:
The most affected districts, likely those with high-density built-up areas, should be the focus of resilience-building efforts. This could involve retrofitting existing buildings and enhancing community preparedness to reduce the potential economic impact of future wind events.

D - Damage to Critical Infrastructures, Including Basic Services
Strong Winds

Figure 60. Average Annual Hospitals Affected by Strong Winds in current climate.

Figure 61. Average Annual Schools Affected by Strong Winds in current climate.

Figure 60 illustrates the proportion of hospitals affected by strong winds annually under current climate conditions across Malawi. The colour-coded scale categorizes districts based on the percentage of hospitals impacted by strong wind events, with darker shades indicating a higher percentage of affected hospitals.

Insights from the map

- **Most Affected Areas (Dark Green: 0.01 - 0.02%**
  Salima has the highest proportion of hospitals affected by strong winds, suggesting higher wind exposure, weaker infrastructure, or frequent storm events in the district.
- **Moderately Affected Areas (Light Green: 0.001 - 0.01%)**
  Nkhatabay shows moderate hospital exposure to strong winds, meaning that some healthcare facilities may experience periodic wind-related damage or service disruptions.
- **Low to Minimal Impact Areas (Yellow: 0 - 0.001%)**
  The majority of districts have low or negligible hospital exposure to strong winds, indicating either limited wind intensity or resilient healthcare infrastructure.

The Figure 61 illustrates the average annual percentage of schools affected by strong winds across districts in Malawi. The percentages are calculated relative to the total number of school buildings (stock) in each district, providing insight into the vulnerability of educational infrastructure to strong wind events.The colour-coded scale categorizes districts based on the percentage of schools impacted by strong wind events, with darker shades indicating a higher percentage of affected hospitals.

Insights from the map:

- **Most Affected Areas (Dark Green: 0.01 - 0.02%)**
  Nkhatabay has the highest proportion of schools affected by strong winds, suggesting greater exposure to wind events, infrastructure vulnerability, or frequent storm activity in this district.
- **Moderately Affected Areas (Light Green: 0.001 - 0.01%)**
  Salima also shows moderate school exposure to strong winds, indicating that some educational facilities may experience periodic wind-related damage or operational interruptions.
- **Low to Minimal Impact Areas (Yellow: 0 - 0.001%)**
  The majority of districts across the country show low or negligible school exposure to strong winds, suggesting either.
  However, even in low-risk areas, occasional extreme wind events could still pose a threat, especially if buildings are poorly maintained.

Key Messages:

Risks to Essential Services:
The data indicates that hospitals and schools in Nkhata Bay and Salima districts are at risk from strong winds, although the percentage of affected infrastructure is relatively low. Ensuring the resilience of these critical facilities is vital to maintaining public health and education services during wind events.

Geographic Focus on Vulnerable Districts:
Districts with higher exposure to strong winds, such as Salima and Nkhata Bay, should be prioritized for infrastructure upgrades to prevent service disruptions and protect critical community assets.

Proactive Infrastructure Strengthening:
The relatively low current impact on infrastructure offers an opportunity to proactively strengthen these systems before more severe climate conditions take hold. This includes reinforcing buildings and ensuring that new constructions are built to withstand strong winds.

Depiction of impact of strong winds - DoDMA

Social Vulnerability Assessment
Strong Winds

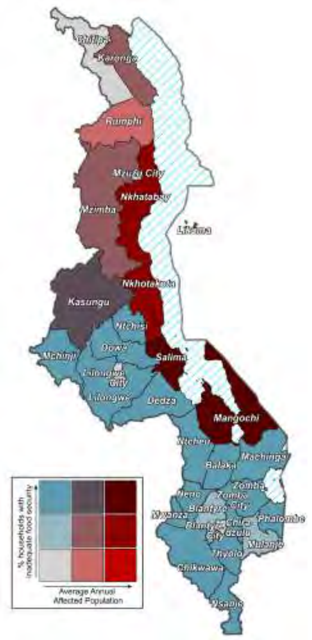


Figure62. Combined Map of AAL and Food Security Indicator.

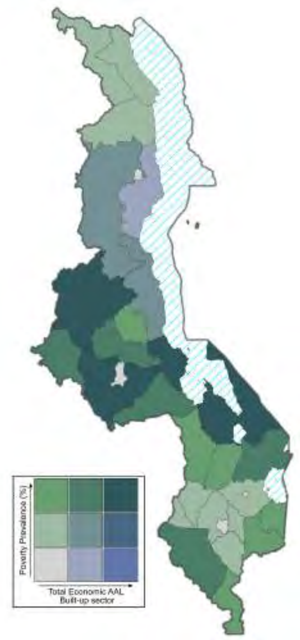


Figure 63. Combined Map of Total Economic AAL in the Built-Up Sector and Poverty Prevalence Indicator.

Figure 64. Combined Map of Annual Damaged Buildings and Economically Inactive Population.

Figure 62 provides a spatial analysis of the intersection between two critical indicators:
Average Annual Population Affected: This represents the total population impacted by Strong Winds annually, shown as a district-level cumulate.
Food Security Indicator: This reflects the percentage of households within each district experiencing inadequate food security.

Insights from the map:

- **High Strong Wind Risk and High Food Insecurity(Dark Red Areas)**
  Salima and Mangochi are the most severely affected districts, experiencing high losses and high food insecurity percentages.
- **High to Strong Wind Risk and moderate Food Insecurity (Brownish-Red Areas)**
  Nkhatabay and Nkhotakota, show a combination of high risk and moderate food insecurity.
- **Lower Flood Risk but High Food Insecurity (bue Areas)**
  Large parts of central and southern Malawi show a low level of risk but a high food insecurity level.

Policy Implications:

- **Integrated Interventions:**
  Target areas with high food insecurity and risk with holistic strategies combining disaster risk reduction and food security improvements.
- **Strengthen Resilience:**
  Enhance climate-resilient agriculture and promote alternative livelihoods in vulnerable districts.
- **Improve Early Warning and Response:**
  Develop robust systems for early warning and disaster preparedness in areas with high AAL, particularly along the lake shore districts in Malawi.

Figure 63 presents a spatial analysis that overlays Total Economic Average Annual Loss (AAL) in the built-up sector with poverty prevalence across different districts in Malawi. The dual-colour gradient categorizes districts based on:
Shades of green indicating higher poverty prevalence (% of the population living in poverty).
Shades of blue indicating higher economic losses in the built-up sector (AAL).
Darker mixed shades (green + blue) representing areas where both high poverty and high economic losses overlap.

Insights from the map

- **High Poverty and High Economic Loss (Dark Green-Blue Areas)**
  Mangochi, Kasungu, Lilongwe, Salima districts experience both high poverty rates and significant economic losses due to disasters affecting the built-up sector.
- **Moderate Economic Losses with High Poverty (Green-Dominant Areas)**
  Mchinji, Dowa, Dedza, Phalombe,Mulanje, Nsanje, Machinga, exhibit high poverty rates but lower economic losses in the built-up sector.
- **High Economic Losses with Lower Poverty (Blue-Dominant Areas)**
  Nkhatabay shows higher economic losses in the built-up sector but lower poverty prevalence.
- **Lower Economic Loss and medium Poverty (Lighter Green)**
  Chitipa, Karonga, Rumphi, Mwanza, Neno, Blantyre, Zomba, Chiradzuru, and Thyolo, have both low economic losses and medium poverty prevalence.

Figure 64 presents a combined analysis of two critical indicators across districts in Malawi:
Annual Damaged Buildings: The number of buildings damaged on average each year by strong winds in each district.
Economically Inactive Population Indicator: The percentage of the population in each district with no income, representing economic inactivity and financial vulnerability.

The map uses a colour gradient matrix to visualise the overlap of these two indicators:
Brown shades: Indicate higher percentages of damaged buildings and varying levels of economic inactivity.
Purple shades: Indicate lower percentages of damaged buildings and varying levels of economic inactivity.
Mixed darker shades: Represent districts with high values for both indicators, highlighting compounded vulnerabilities.

Insights from the map:

- **Northern Malawi:**
  Districts such as Mzimba and Nkatabay show combinations of the two factors while the other districts are included in the lower classs for both indicators considered.
- **Central Malawi:**
  Districts like Salima, Lilongwe and Kasungu exhibit high levels of damaged buildings and low economic inactivity.
  These districts face some vulnerability but are less impacted compared to other regions.
- **Southern Malawi:**
  Mangochi shows high risk but low inactivity such inactivity is more visible in the areas around Blantyre but combined with a low level of risk

Policy Implications:

- **Improve Resilient Infrastructure:**
  Invest in climate-resilient building designs in high-risk districts to reduce annual building damage. Strengthen disaster mitigation infrastructure, such as drainage systems and flood defences, in districts with high vulnerability.
- **Boost Economic Empowerment:**
  Develop employment and income-generation programmes for economically inactive populations, especially in districts with high building damage rates.
- **Integrate Risk Reduction and Economic Development:**
  Address the overlapping vulnerabilities by combining disaster risk management efforts with socio-economic development programmes.

Recommendations
Strong Winds

Key Messages:

Rising Impact of Strong Winds on Vulnerable Populations:
Strong winds already affect a significant number of people in Malawi, particularly in districts along the shores of Lake Malawi, such as Salima and Nkhata Bay. The data shows that under projected climate scenarios, the number of people affected by strong winds is expected to increase, especially in central Malawi. This highlights the growing vulnerability of these communities, many of which are characterized by limited infrastructure and high population density. As climate conditions worsen, the need for robust disaster risk reduction strategies becomes increasingly urgent.

Socio-Economic Vulnerability and Strong Winds:
The combined maps that overlay strong wind risk indicators with socio-economic factors, such as food security, poverty prevalence, and economic inactivity, provide a nuanced understanding of the vulnerability landscape. Districts with high poverty rates and low economic activity are severely affected by strong winds, both in terms of population impact and economic loss especially along the southern shore of lake Malawi. This suggests that the most economically disadvantaged populations are also the most at risk, with limited capacity to recover from wind-related disasters. Addressing these socio-economic vulnerabilities is essential for reducing overall disaster risk.

Urgent Need for Climate-Resilient Urban Planning:
The projected increase in economic losses and population impact due to strong winds underscores the importance of integrating climate resilience into urban planning and development policies. This includes ensuring that new developments are constructed with materials and designs capable of withstanding stronger winds, especially in urban and semi-urban areas that are most vulnerable to these events.

District-Specific Risk Mitigation Strategies:
Develop and implement targeted risk mitigation strategies for districts most vulnerable to strong winds, and other high-risk areas. These strategies should include both structural measures, such as strengthening buildings, and non-structural measures, such as improving early warning systems and community preparedness.

Investment in Resilient Housing and Infrastructure:
Prioritize investments in making the housing sector more resilient to strong winds, given its significant contribution to overall economic losses. This includes revising building codes, providing incentives for wind-resistant construction, and retrofitting existing structures in vulnerable areas.

Strengthening of Critical Infrastructure:
Although the impact on critical infrastructure is currently low, proactive measures should be taken to ensure that hospitals, schools, and other essential services can withstand strong winds. This will help maintain service continuity and protect public safety during and after wind events.

Integrating Climate Adaptation into Development Planning:
Ensure that climate adaptation measures are integrated into national and district-level development plans, with a focus on reducing the vulnerability of the most affected sectors and regions. This includes both long-term planning and immediate action to address existing vulnerabilities.

International Collaboration and Support:
Engage with international partners to secure funding, technical assistance, and best practices for improving wind resilience in Malawi. Collaboration can help accelerate the implementation of necessary measures and provide access to advanced technologies and approaches.

Public Awareness and Education:
Increase public awareness and education about the risks of strong winds and the importance of resilience measures. This includes community-level training on emergency preparedness and the dissemination of information on how to protect homes and assets from wind damage.

Compound Fast Onset Weather-related Hazards*

B1 - Number of People Directly Affected by Disasters

Compound Fast Onset Weather-related Hazards

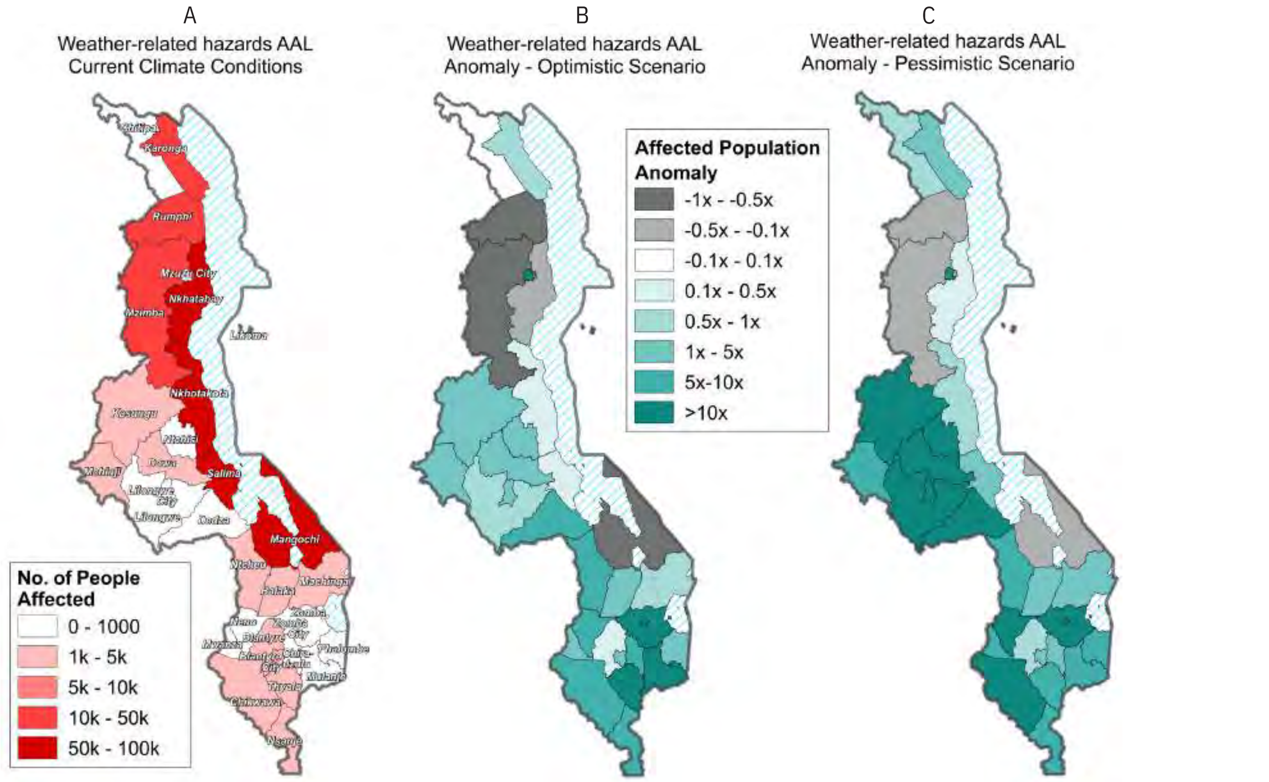


Figure 65. Average Annual Population Affected by Combined Weather-Related Hazards Under Current and Projected Climate Conditions.

Figure 65 presents a spatial analysis of the annual population affected by fast-onset weather-related hazards under current climate conditions and future climate scenarios across Malawi.

A: Current Climate Conditions
The map uses a colour-coded scale with darker red shades representing higher exposure levels.

Insights from the map:

- **Severely Affected Areas (Dark Red: 50,000 - 100,000 People Affected Annually)**
  Mangochi, Nkhatabay, Nkhotakota, and Salima have the highest number of people affected by weather-related hazards annually.
- **Highly Affected Areas (Red: 10,000 - 50,000 People Affected Annually)**
  Karonga, Rumphi and Mzimba experience substantial climate-related impacts, affecting tens of thousands of residents annually.
- **Moderately Affected Areas (Light Red: 1,000 - 5,000 People Affected Annually)**
  Several districts, including Machinga, Ntcheu, Balaka, Chikwawa, Nsanje, Thyolo, Dowa, Mchinji, and Kasungu fall into this category.
- **Lower Impact Areas (Pink to White: 0 - 1,000 People Affected Annually)**
  Chitipa, Ntchisi, Lilongwe, Dedza, Neno, Mwanza, Zomba, Phalombe, Mulanje, and Chiradzuru have fewer people affected by extreme weather events, possibly due to lower exposure to hazards or better resilience mechanisms.

B: Anomaly in the Optimistic Scenario
This panel represents the anomaly in affected populations compared to current conditions, assuming successful climate mitigation efforts.
Colour scale:
Grey shades: Reductions in the number of affected people (ranging from -1x to -0.1x).
Green shades: Increases in the number of affected people (ranging from 0.1x to >10x).

* A synthesized representation of the compound effects of all considered weather-related hazards that present high correlation and possible compound effects i.e Strong Winds, Flash Floods and Riverine Floods is shown. This is presented in terms of aggregated B1 (people affected) and C1 (direct economic loss) indicators.

Insights from the map:

- **Significant Increase in Climate Impact (Dark Green: >10x Anomaly)**
  Districts, including Thyolo, Mulanje, Mzuzu City, and Zomba, are projected to experience a more than tenfold increase in the population affected by weather-related hazards.
- **Increase in Climate Impact (Green: 5x - 10x Anomaly)**
  Dedza, Ntcheu, Neno, Chikwawa, Nsanje, are projected to see increases in climate-related exposure.
- **Moderate Increase in Climate Impact (Teal Light Green 0.5x to 1x)**
  Karonga, Lilongwe Machinga and Neno are projected to moderate to high increases in climate-related exposure.
- **Stable or Minimal Change in Climate Impact (Light Grey: -0.1x to 0.1x Anomaly)**
  Nkhotakota, and Salima show little to no projected change in the population affected by weather-related disasters.
- **Reduction in Climate Impact (Dark Grey: -1x to -0.5x Anomaly)**
  Rumphi, Mzimba, Mangochi are expected to experience a decline in climate-related hazard impacts.

C: Anomaly in the Pessimistic Scenario
This panel depicts the anomaly in affected populations under a pessimistic scenario.

Insights from the map:

- **Significant Increase in Climate Impact (Dark Green: >10x Anomaly)**
  Districts, including Chikwawa, Zomba, Neno and Dedza, Lilongwe, Lilongwe City, Dowa, Ntchsi, Kasungu and Mzuzu city are projected to experience a more than tenfold increase in the population affected by weather-related hazards.
- **Moderate Increase in Climate Impact (Light Green: 0.5x - 10x Anomaly)**
  Nsanje, Blantyre, Thyolo, Mulanje, Ntcheu, Mchinji and Salima are projected to see moderate to high increases in climate-related exposure.
  Stable or Minimal Change in Climate Impact (Light Grey: -0.5x to -0.1x Anomaly)
  Mzimba, Rumphi, and Mangochi show little to no projected change in the population affected by weather-related disasters.

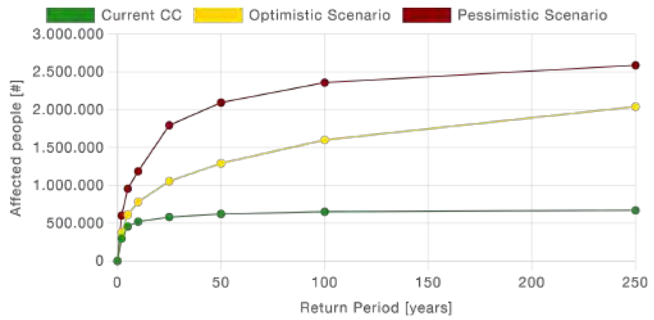


Figure 66. Probable Maximum Loss (PML) Curves for Population Affected by Weather-Related Hazards Under Different Climate Conditions.

Key Messages:

High Population Vulnerability to Compound Hazards:
The analysis shows a significant number of people are affected annually by the combination of riverine floods, flash floods, and strong winds. The areas most impacted are those with high population densities and limited infrastructure resilience, particularly in southern and central Malawi. The pattern is dominated by wind that impacts many people in the south and along the shore of Lake Malawi.

Geographical Disparities in Impact:
The geographical distribution map highlights that the most affected districts are in regions prone to multiple hazards, such as Salima, Blantyre, and Chikwawa. These areas require targeted interventions to reduce the vulnerability of populations to compound weather-related events.

Escalating Risks Under Climate Change:
The probable maximum loss (PML) curves indicate a sharp increase in the number of people affected under projected climate scenarios. This underscores the critical need for adaptive strategies that address the compounded risks of multiple hazards, especially in districts already facing high impacts. This is true already for very frequent events where the number of people impacted doubles already for frequencies below 10-year return periods, but exacerbates for rare events (e.g., for 50-year Return Period the number of impacted people rises from 500 thousand in present climate to 2 million when the pessimistic scenario is considered).

C1 - Direct Economic Loss Attributed to Disasters
Compound Fast Onset Weather-related Hazards

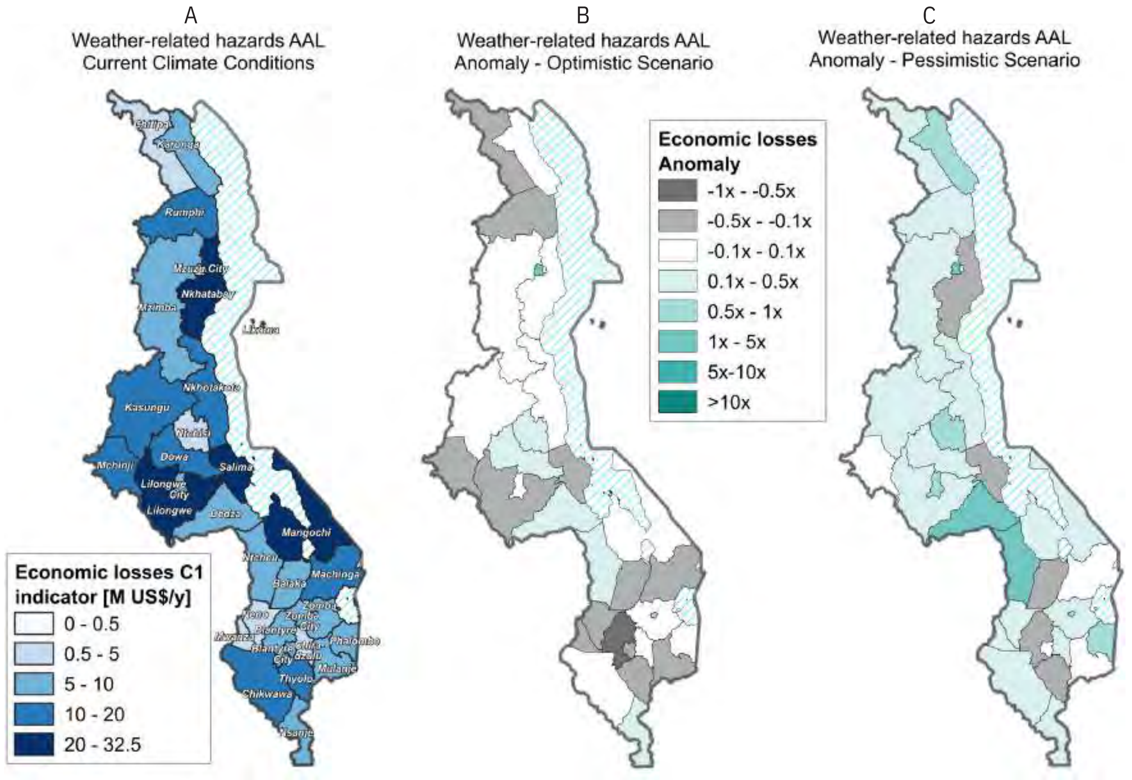


Figure 67. Average Annual Loss Due to Combined Riverine, Flash Floods, and Strong Winds in Current Climate Conditions and Projected Scenarios.

Figure 67 presents a spatial analysis of the economic losses caused by weather-related hazards, including riverine floods, flash floods, and strong winds, across Malawi under current climate conditions and future climate scenarios.

A: Current Conditions
The colour-coded scale represents the total economic loss in millions of US dollars per year (M US$/y), with darker shades indicating higher financial losses.

Insights from the map:

- **High Economic Loss Areas (Dark Blue: 20 - 32.5 M US$/y)**
  Mangochi, Salima, Lilongwe and Nkhatabay City experience the highest annual economic losses due to climate hazards.
- **Moderate to High Economic Loss Areas (Medium Blue: 10 - 20 M US$/y)**
  Chikwawa, Thyolo, Rumphi, Nkhotakota, Kasungu, Mchinji, Dowa, and Machinga also show significant financial losses, indicating that these regions are moderately exposed to climate-related damages but still at high risk.
- **Moderate Economic Loss Areas (Light Blue: 5 - 10 M US$/y)**
  Nsanje, Ntcheu, Balaka, Blantyre, Zomba, Mulanje, Phalombe and Karonga fall within this category, experiencing moderate but consistent losses from floods and windstorms.
- **Lower Economic Loss Areas (White to Light Grey: 0.5 - 5 M US$/y)**
  Chitipa, Neno, Mwanza, and Chiradzulu, likely due to lower infrastructure density or reduced exposure to extreme weather events.

B: Anomaly in the Optimistic Scenario
This map shows the anomaly in total economic loss under the optimistic scenario.
Grey shades represent reductions in the total economic loss.
Green shades represent increases in the total economic loss.

Insight from the map:

- **Moderate Increase in Economic Losses (Teal to Light Green: 0.1x to -0.5x Anomaly)**
  Ntcheu, Dowa, Dedza, Ntcheu and Zomba City show moderate increases in economic losses, indicating that climate-related hazards such as floods and strong winds will continue to impact infrastructure and livelihoods.
- **Stable or Minimal Change in Economic Losses (White and Light Grey: -0.1x to 0.1x Anomaly)**
  Karonga, Mzimba, Nkhatabay, Khotakota, Kasungu, Lilongwe City, Mangochi, Chikwawa, Chiradzulu, and Mulanje show little to no projected change in economic losses, meaning that climate risks may remain stable under this scenario.
- **Reduction in Economic Losses (Dark Grey: -0.5x to -1x Anomaly)**
  Chitipa, Rumphi, Mchinji, Lilongwe Salima, Balaka, Machinga, Neno, Mwanza, Blantyre City, Thyolo, and Mulanje are expected to experience a decline in economic losses.

C: Anomaly in the Pessimistic Scenario
This map shows the anomaly in total economic loss under the pessimistic scenario.
Grey shades represent reductions in the total economic loss.
Green shades represent increases in the total economic loss.

- **Increase in Economic Losses (Green: 1x to 5x Anomaly)**
  Dedza and Ntcheu are projected to increase in economic losses due to more severe and frequent floods, storms, and strong winds.
- **Moderate Increase in Economic Losses (Light Green: 0.5x - 1x Anomaly)**
  Karonga, Mzuzu City, Ntchisi, Lilongwe City and Phalombe are expected to see moderate increases in economic losses, meaning that climate-related hazards will still pose a serious risk even in less extreme areas.
- **Stable or Minimal Change in Economic Losses (Light Grey: -0.1x to 0.1x Anomaly)**
  Nkhatabay, Salima, Balaka, Blantyre and Thyolo show little to no projected change in economic losses, suggesting that certain areas may not experience significant shifts in climate hazard exposure.

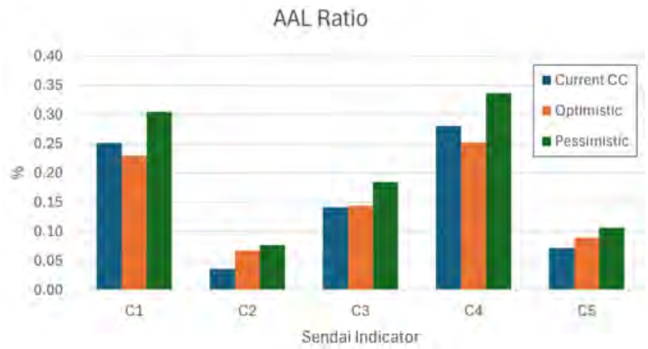


Figure 68. Ratio of Average Annual Loss) Relative to Stock Value for Different Sendai Indicators Due to Combined fast-onset Weather Hazards.

Key Messages:

Substantial Economic Losses from Compound Hazards:
The aggregated economic losses due to the combined effects of riverine floods, flash floods, and strong winds are considerable, with current annual losses estimated at $341.2 million. The housing sector is the most vulnerable, contributing the largest share of these losses.

Regional Economic Disparities:
The economic impact is not evenly distributed, with southern regions such as Nsanje and Chikwawa, as well as urban areas like Blantyre, facing the highest economic losses. Salima and Mangochi are leading the risk figures in the case of compound events. These regions are also characterized by high poverty levels, which exacerbate the economic impact of these hazards.

Climate Projections Worsen Economic Outlook:
Under pessimistic climate scenarios, annual economic losses could rise to $413.4 million, with the housing sector particularly at risk. The maps indicate that these losses are likely to be most severe in districts that are already economically disadvantaged, highlighting the need for urgent investment in resilience-building measures.

Sendai Indicator	Compound Fast Onset Weather-related Hazards	AAL current CC	AAL optimistic scenario	AAL pessimistic scenario
C1 **[M US$]**	**Direct economic loss attributed to disasters** (as sum of C2, C3, C4, and C5 in the following)	**341.2**	**311.4**	**413.4**
C2 [M US$]	Direct agricultural loss attributed to disasters*	1.5	2.8	3.2
C3 [M US$]	Direct economic loss to all other damaged or destroyed productive assets attributed to disasters	12.1	12.3	15.8
C4 [M US$]	Direct economic loss in the housing sector attributed to disasters	321.7	289.1	385.8
C5 [M US$]	Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters**	5.8	7.2	8.6

* C2 is only computed for Riverine Floods; ** C5 considers Hospitals, Schools and Government buildings as critical infrastructure; additionally, damages to roads have been considered but only for the case of Riverine Floods.

Key Messages:

Significant Financial Exposure Across Multiple Sectors:
The Table reveals a substantial financial exposure to compound hazards, with total direct economic losses currently estimated at $341.2 million annually. These losses are spread across multiple sectors, with the housing sector being the most impacted, followed by losses to productive assets and critical infrastructure. The wide distribution of economic losses underscores the need for a comprehensive approach to disaster risk reduction that addresses vulnerabilities across various sectors.

Vulnerability of Critical Infrastructure:
Although the direct economic losses to critical infrastructure are relatively lower compared to the housing sector it is worth noting that this considers only direct economic physical impact. If indirect impact would be considered the share of risk for the critical infrastructures would rise in some cases in order of magnitude. Therefore, the projected rise in losses to critical infrastructure, including hospitals, schools, and roads, highlights the need for targeted investments in resilient infrastructure to ensure the continuity of essential services during and after compound weather-related events.

Need for Enhanced Sector-Specific Resilience Strategies:
The varying levels of economic impact across different sectors suggest that sector-specific resilience strategies are essential. For instance, strengthening building codes and construction practices in the housing sector, alongside targeted interventions to protect critical infrastructure, can significantly mitigate the overall economic risks posed by compound hazards.

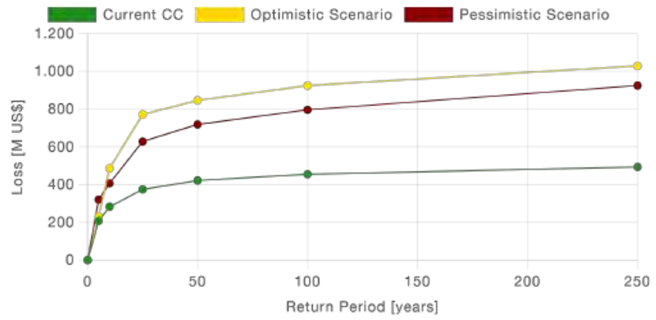


Figure 69. Probable maximum loss curves for economic damages to the built-up area [M US $], linked to strong winds under different climate conditions.

Key Messages:

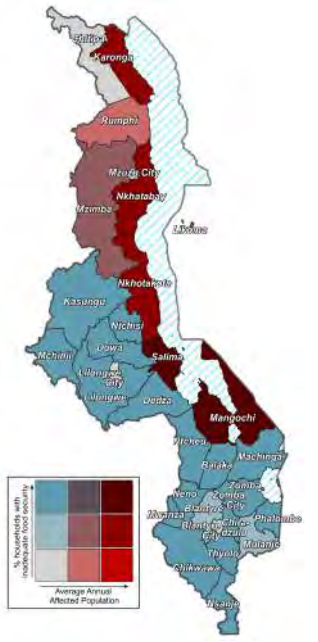
High Sensitivity to Climate Change:
The Probable Maximum Loss (PML) curve for economic damages to built-up due to compound hazards shows a steep increase in potential losses under pessimistic climate scenarios. This highlights the extreme sensitivity of urban and semi-urban areas to worsening climate conditions, emphasizing the urgent need for climate-resilient urban planning and building practices.

Climate change projected to increase losses:
The PML curve analysis indicates that already for very frequent events (below 10-year return periods) losses are projected to double. This tendency exacerbates for rare events above the 50-year Return Period.

Urgent Need for Long-Term Investment in Resilience:
The steep rise in potential losses illustrated by the PML curve underlines the importance of long-term investment in resilience-building measures. This includes retrofitting existing buildings, enhancing early warning systems, and implementing strict land-use policies to minimize future economic impacts of compound hazards, particularly in the most vulnerable districts.

Flooding in Malawi - Arjan van de Merwe - UNDP

Social Vulnerability Assessment
Compound Fast Onset Weather-related Hazards



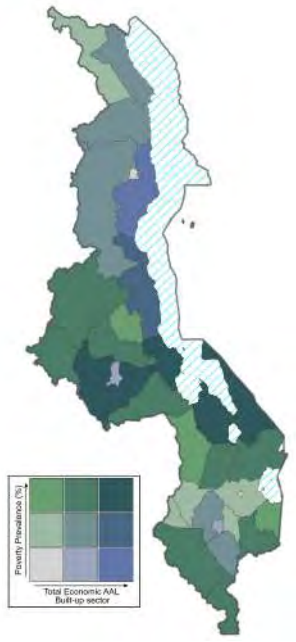


Figure 70. Combined Map of Average Annual Population Affected (AAL) and Food Security Indicator.

Figure 71. Combined Map of Total Economic AAL in the Built-Up Sector and Poverty Prevalence Indicator.

Figure 72. Combined Map of Average Number of Buildings Damaged Annually and Economically Inactive Population.

Figure 70 presents a spatial analysis combining the average annual population affected by climate-related hazards (AAL) with food security indicators across Malawi.

The map uses a dual-colour gradient, where:
Shades of red indicate higher levels of food insecurity (% of households with inadequate food security).
Shades of blue indicate a higher number of people affected annually by climate-related disasters.
Darker shades in both red and blue highlight areas where both high climate-related exposure and food insecurity overlap.

Insight from the map:

- **High Climate Exposure and High Food Insecurity (Dark Red Areas)**
  Mangochi and Salima are among the districts experiencing both high levels of food insecurity and high numbers of people affected by climate-related disasters.
- **High Food Insecurity with Some Climate Impact (Brownish-Red Areas)**
  Nkhatabay, Nkhotakota, Karonga exhibit high food insecurity while also experiencing climate-related impacts.
- **Higher Food Insecurity with Lower Climate Exposure (Blue-Dominant Areas)**
  Districts such as Dowa, Ntchisi, and Kasungu, Chikwawa, Machinga, show lowe exposure to climate hazards but relatively high food insecurity levels.
- **Lower Climate Exposure and Low Food Insecurity (Lighter Areas)**
  Chitipa has relatively lower climate hazard exposure and food insecurity levels, suggesting better overall resilience to environmental and economic stresses.

Figure 71 presents a spatial analysis that overlays Total Economic Average Annual Loss (AAL) in the built-up sector with poverty prevalence across districts in Malawi.
The dual-colour gradient categorizes districts based on:
Shades of green indicating higher poverty prevalence (% of the population living in poverty).
Shades of blue indicating higher economic losses in the built-up sector (AAL).
Darker mixed shades (green + blue) representing areas where both high poverty and high economic losses overlap.

Insights from the map:

- **High Poverty and High Economic Loss (Dark Green-Blue Areas)**
  Mangochi, Lilongwe, and Salima experience both high poverty rates and significant economic losses due to disasters affecting the built-up sector.
- **Moderate Economic Losses with High Poverty (Green-Dominant Areas)**
  Kasungu, Mchinji, Dowa, Dedza, Balaka, Machinga, Mulanje, Chikwawa and Nsanje exhibit high poverty rates but lower economic losses in the built-up sector.
- **High Economic Losses with Lower Poverty (Blue-Dominant Areas)**
  Nkhatabay, and Nkhotakota show higher economic losses in the built-up sector but lower poverty prevalence.
  This implies that while these areas face significant financial damage from disasters, they may have stronger economic resilience and better recovery mechanisms.
- **Lower Economic Loss and Lower Poverty (Lighter Areas)**
  Mzuzu City, Lilongwe City and Blantyre City have both low economic losses and lower poverty prevalence, suggesting better overall resilience and stable socio-economic conditions.

Figure 72 presents a spatial analysis that overlays the average number of buildings damaged annually due to climate-related hazards with the proportion of the economically inactive population (individuals with no income) across districts in Malawi.
The dual-colour gradient categorizes districts based on:
Shades of brown indicating a higher percentage of individuals with no income (economically inactive population).
Shades of purple indicating a higher number of buildings damaged annually.
Darker mixed shades (brown + purple) representing areas where both high economic inactivity and frequent building damage overlap.

Insights from the map:

- **High Economic Inactivity and High Building Damage (Dark Brown-Purple Areas)**
  Mzuzu City, Lilongwe City, Blantyre City and Zomba City experience both high rates of economic inactivity and frequent building damage.
- **Moderate Economic Inactivity with High Building Damage (Purple-Dominant Areas)**
  Nkhatabay, Nkhotakota, Salima, Mangochi, Machinga, and Lilongwe have frequent building damage but lower levels of economic inactivity, suggesting that while infrastructure is at risk, there may be financial resources available to support recovery efforts.
- **High Economic Inactivity with Lower Building Damage (Brown-Dominant Areas)**
  Blantyre, Chiradzulu, Thyolo, Mzuzu City, Lilongwe City, Blantyre City and Zomba City struggle with high unemployment and economic inactivity but experience relatively lower building damage.
- **Lower Economic Inactivity and Low Building Damage (Lighter Areas)**
  Dedza, Ntcheu, Neno, Mwanza, Zomba, Mulanje and Phalombe have relatively lower economic inactivity and fewer buildings damaged annually, suggesting greater overall resilience.

Key Messages:

Intersecting Vulnerabilities Exacerbate Impact:
The combined maps reveal that districts with high poverty rates, food insecurity, and a high proportion of economically inactive populations are more severely affected by compound weather-related hazards.
These socio-economic vulnerabilities intensify the impact, making recovery more challenging for affected communities.

Targeting High-Risk Populations:
The maps show that the most socio-economically vulnerable populations are concentrated in specific districts, particularly in the southern and central regions. These areas should be prioritized for targeted interventions that address both physical risks from hazards and underlying socio-economic vulnerabilities.

Need for Integrated Risk Management:
The analysis underscores the importance of integrating socio-economic factors into risk management strategies. Addressing the compounded risks of multiple hazards requires a holistic approach that includes enhancing social safety nets, improving infrastructure resilience, and fostering community preparedness, particularly in the most vulnerable regions.

Recommendations
Compound Fast Onset Weather-related Hazards

Implementing Strengthen Multi-Hazard Risk Management Frameworks:
Integration of Multi-Hazard Approaches: Implementing comprehensive disaster risk management (DRM) frameworks along the lines of the official strategy designed by Malawi and considering the compound effects of multiple weather-related hazards such as riverine and flash floods as well as strong winds is a key step to be undertaken to minimise the current risk figure highlighted by this study. This includes integrating risk assessments (such as the one developed for this study), early warning systems, and response plans that are tailored to address the interconnected nature of these hazards.
Sector-Specific Resilience Strategies: Prioritize the development of sector-specific resilience strategies, particularly in the housing sector and critical infrastructure. Strengthen building codes and promote the adoption of wind- and flood-resistant construction practices in vulnerable areas.

Enhance Urban and Regional Planning for Climate Resilience:
Climate-Resilient Urban Planning: Incorporate climate projections into urban and regional planning processes, focusing on enhancing the resilience of built-up areas, particularly in high-risk urban and semi-urban districts. This includes enforcing land-use policies that limit development in high-risk zones and promoting the use of climate-resilient materials and designs in new constructions.
Targeted Infrastructure Investments: Prioritize investments in resilient infrastructure, particularly in districts identified as hotspots for compound hazards. Ensure that critical infrastructure such as hospitals, schools, and roads are designed and maintained to withstand the projected increase in extreme weather events.

Focus on Vulnerable Populations and Geographies:
Geographically Targeted Interventions: Direct resources and efforts towards the most vulnerable districts, particularly those along Lake Malawi and in southern and central Malawi, which are disproportionately affected by compound hazards. Tailored interventions should address both physical risks and underlying socio-economic vulnerabilities, such as poverty and food insecurity.
Community-Based Disaster Preparedness: Strengthen community-based disaster preparedness and response mechanisms, particularly in high-risk areas. This includes improving early warning systems, conducting regular community drills, simulation exercises, and promoting education and awareness programs to enhance local resilience.

Increase Investment in Adaptive and Preventative Measures:
Long-Term Resilience Investments: Allocate long-term investments towards adaptive infrastructure and preventative measures that can reduce the impact of compound weather-related events. This includes retrofitting existing structures, reinforcing critical infrastructure, and implementing nature-based solutions such as reforestation and wetland restoration to mitigate flood risks.
Enhanced Social Safety Nets: Expand and strengthen social safety nets to protect the most vulnerable populations from the socio-economic impacts of compound hazards. This could include improving access to emergency funds, insurance schemes, and livelihood support programs that help communities recover more quickly after disasters.

Strengthen Data Collection and Monitoring:
Improved Hazard and Vulnerability Data: Enhance data collection and monitoring systems to better track the frequency, intensity, and impacts of compound weather-related events. This will enable a critical update of the existing risk assessments. Efforts should focus on developing more detailed hazard maps and vulnerability assessments that can guide local-level decision-making. Priority should be given to districts identified in this assessment as having the highest risk in conjunction with socio-economic vulnerability factors.
Regular Review and Update of Risk Assessments: Conduct regular reviews and updates of risk assessments to incorporate new data, emerging trends, and advances in climate science. This ensures that risk management strategies remain relevant and effective in the face of changing climate conditions.

Promote Regional and International Collaboration:
Cross-Border Cooperation: Strengthen regional collaboration with neighbouring countries to address transboundary risks associated with compound weather-related events (e.g. in the case of cyclones). This includes sharing data, coordinating response efforts, and jointly developing strategies to mitigate shared risks.
Leverage International Support: Engage with international donors and organizations to secure technical and financial support for implementing comprehensive disaster risk reduction and climate adaptation programs in Malawi.

Droughts
B1 - Number of People Directly Affected by Disasters
Droughts

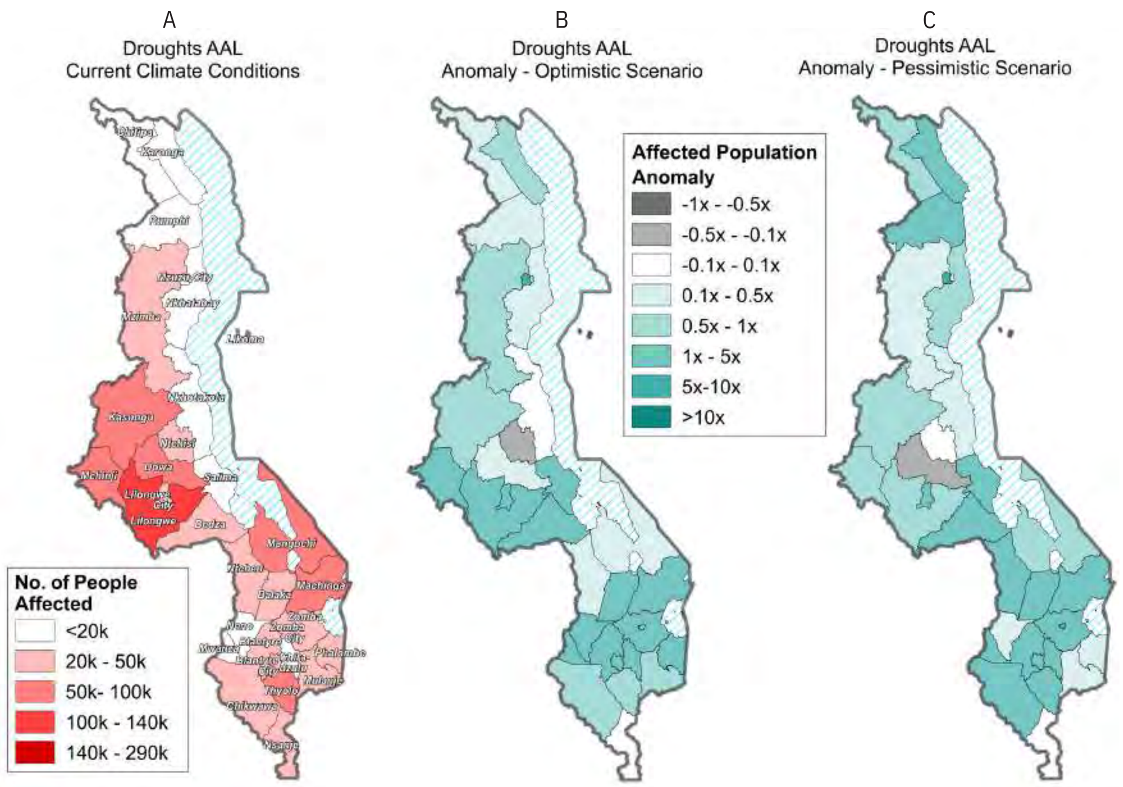


Figure 73. Average Annual Population Affected by Droughts Under Current and anomalies in Projected Climate Conditions.

Figure 73 presents a spatial analysis of the average annual population affected by droughts in Malawi under current climate conditions and future climate scenarios.

A: Current climate conditions
The colour-coded scale categorizes districts based on the number of people impacted annually by drought events:
Dark red indicating the highest number of affected individuals (140k - 290k people annually).
Lighter red and pink shades representing moderate to high drought exposure.
White areas showing districts with fewer than 20,000 people affected annually.

Insights from the map:
- **Highly Affected Area (Dark Red: 100,000 - 240,000 People Affected Annually)**
  Lilongwe is the most affected by droughts. It is vulnerable to prolonged dry spells, which significantly impact water availability, crop yields, and food security.
- **High Affected Areas (Red: 50,000 - 100,000 People Affected Annually)**
  Kasungu, Mchinji, Dowa, Mangochi, Machinga, and Thyolo districts experience substantial drought-related impacts.
- **Moderately Affected Areas (Light Red to Pink: 20,000 - 50,000 People Affected Annually)**
  Districts including Mzimba, Ntchisi, Dedza, Ntcheu, Phalombe, Nsanje experience moderate drought exposure.
- **Lower Impact Areas (White: <20,000 People Affected Annually)**
  Some districts, including Karonga, Rumphi, Nkhatabay, Salima, Neno and Mwanza have lower populations affected by droughts annually.

B: Anomaly in the Optimistic Scenario
Figure 73 presents a spatial analysis of projected changes in the annual population affected by droughts across Malawi under an optimistic climate scenario.
The colour-coded scale categorizes districts based on how the affected population is expected to change, with:
Dark green indicating districts where the population affected by droughts is projected to increase significantly (>10x anomaly).
Teal and light green shades representing moderate increases in affected populations.
Grey shades showing areas where the number of affected people is expected to decrease or remain stable.

Insights from the map:

- **Increase in Drought-Affected Population (Dark Green: 1x to 5x Anomaly)**
  Mchinji, Lilongwe, Salima, Dedza, Neno, Mwanza, Balaka Machinga, Zomba, Chiradzulu and Phalombe are projected to experience a more than tenfold increase in the number of people affected by droughts.
- **Moderate Increase in Drought-Affected Population (Teal to Light Green: 0.01x to 0.1x Anomaly)**
  Chitipa, Rumphi, Dowa, Mangochi, Ntcheu and Nkhatbay show moderate increases in drought exposure.
  These areas will likely experience more frequent or prolonged dry spells, leading to increased water stress and agricultural losses.
- **Stable or Minimal Change in Drought-Affected Population (White and Light Grey: -0.5x to -0.1x Anomaly)**
  Ntchisi show little to no projected change in drought-affected populations.
  This suggests that drought conditions may remain stable due to natural resilience factors or ongoing adaptation efforts.

C: Anomaly in the Pessimistic Scenario
This map shows the anomaly in affected populations under the pessimistic scenario.
The colour-coded scale categorizes districts based on how the affected population is expected to change, with:
Grey shades: Reductions in the number of affected people.
Green shades: Increases in the number of affected people.

Insights from the map:

- **Increase in Drought-Affected Population (Dark Green: 1x to 5x Anomaly)**
  Mzuzu City, Lilongwe City, Salima, Ntcheu, Zomba, Blantyre, Blantyre City, Mwanza, Chikwawa, Thyolo, Zomba, Machinga, Cjiradzulu, Rumphi and Karonga are projected to experience a more than tenfold increase in the number of people affected by droughts.
- **Moderate Increase in Drought-Affected Population (Light Green: 0.5x - 1x Anomaly)**
  Chitipa, Nkhatabay, Kasungu, Mchinji, and Lilongwe show moderate increases in drought exposure, with southern and central regions particularly affected.
- **Stable or Minimal Change in Drought-Affected Population (Light Grey: -0.5x to -0.1x Anomaly**
  Dowa shows little to no projected change in drought-affected populations.

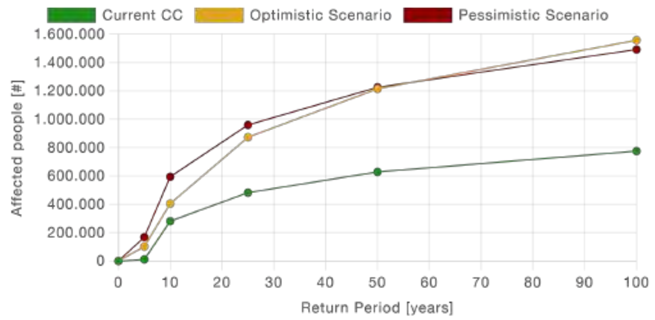


Figure 74. Probable Maximum Loss Curves for Population Affected by Droughts Under Different Climate Conditions.

Key Messages:

Significant Population Impact:
The drought conditions, both under current climate scenarios and future projections, continue to affect a substantial portion of Malawi's population annually. Particularly vulnerable districts include Lilongwe, Machinga and Thyolo, that are the most affected in absolute terms. In Balaka, Chikwawa, and Nsanje the highest percentages of affected people relative to district population are observed. In projected climate conditions an increased number of affected people is predicted especially in the southern part of Malawi.

Increased Risk Under Pessimistic Scenarios:
The pessimistic climate scenario projects a noticeable increase in the number of affected individuals, underscoring the urgent need for adaptive measures to mitigate the impact on the most vulnerable populations. When the PML curve is considered, consistently almost a doubling of the people affected for all return periods considered is observed, i.e. both for frequent and more rare drought events.

Need for Targeted Interventions:
With certain districts more severely affected, it is critical to prioritize these areas for disaster risk reduction strategies and social protection programs to reduce vulnerability and enhance resilience.

C2 - Direct Agricultural Loss Attributed to Disasters
Droughts

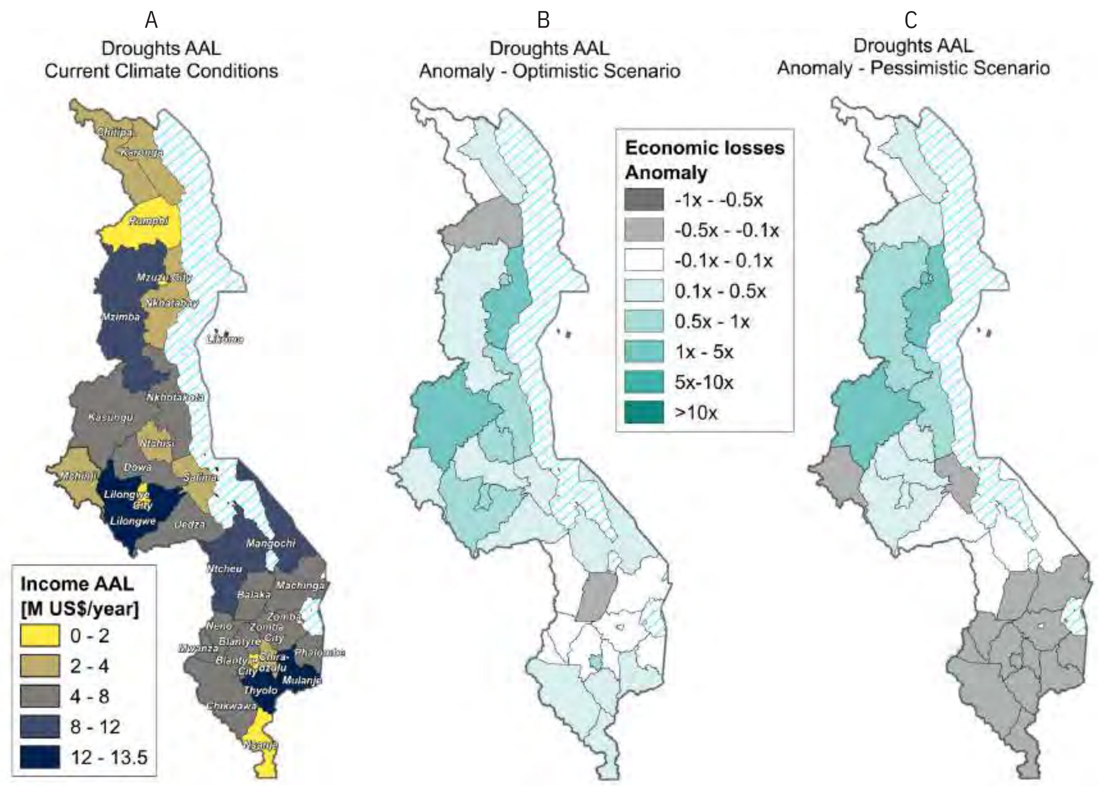


Figure 75. Average Annual Loss of Income Due to Droughts Under Current and anomalies in Projected Climate Conditions.

Figure 75 presents a spatial analysis of the estimated income loss per year due to droughts across Malawi under current climate conditions and future climate scenarios.

A: Current Climate Conditions
The first panel presents a spatial analysis of estimated income loss due to droughts across Malawi. Darker red shades depicts larger losses.

Insights from the map:

- **Severely Affected Areas (Dark Blue: 12 - 13.5 Million US$/Year)**
  Lilongwe, Thyolo, Mulanje, are the most affected by drought-induced income losses.
- **High Income Loss Areas (Dark Grey and Brown: 8 - 12 Million US$/Year)**
  Mangochi, Ntcheu, and Mzimba experience high income losses.
- **Moderate Income Loss Areas (Dark Grey and Brown: 4 - 8 Million US$/Year)**
  Dedza, Dowa, Kasungu, Nkhotakota, Machinga, Balaka, Zomba, Phalombe, Chikwawa, Neno, Blantyre, Mwanza, and Nenoexperience moderate income losses.
- **Low Income Loss Areas (Light Grey Yellow: 2-4 Million US$/Year)**
  Chitipa, Karonga, Nkhatabay, Mchinji, Ntchis, Salima and Chiradzulu experience low income losses due to drought.
- **Lower Income Loss Areas (Yellow: 0 - 2 Million US$/Year)**
  Rumphi, Lilongwe City and Nsanje experience lower income losses due to drought.

B: Anomaly in the Optimistic Scenario
The second panel presents a spatial analysis of projected changes in annual income losses due to droughts across Malawi under an optimistic climate scenario. The colour-coded scale categorizes districts based on how economic losses are expected to change, with:
Dark green indicating districts where income losses due to droughts are projected to increase significantly (>10x anomaly).
Teal and light green shades representing moderate increases in economic losses.
Grey shades showing areas where losses are expected to decrease or remain stable.

Insights from the map:

- **Increase in Income Losses (Dark Green: 1x to 5x Anomaly)**
  Nkhatabay, Kasungu and Blantyre City are projected to experience a more than tenfold increase in drought-related income losses.
- **Moderate Increase in Income Losses (Teal to Light Green: 0.5x - 1x Anomaly)**
  Nkhotakota, Lilongwe, Lilongwe City, and Blantyre City show moderate increases in economic losses due to droughts.
- **Stable or Minimal Change in Income Losses (White Light Grey: -0.1x to -0.1x Anomaly)**
  Ntcheu, Neno, Mwanza, Blantyre, Chiradzulu, Zomba, and Phalombe show little to no projected change in income losses due to droughts.
- **Reduction in Income Losses (Grey: -0.5x to -1x Anomaly)**
  Rumphi and Balaka are projected to experience a decline in drought-induced economic losses.

C: Anomaly in the Pessimistic Scenario
This map shows the anomaly in annual income losses under the pessimistic scenario.
Grey shades represent reductions in the total economic loss, while green shades represent increases in the total economic loss.

Insights from the map:

- **Increase in Income Losses (Green: 1x to 0.5x Anomaly)**
  Nkhatabay, Mzuzu City, and Kasungu show a more than tenfold increase in projected drought-induced income losses.
- **Moderate Increase in Income Losses (Light Green: 0.5x - 1x Anomaly)**
  Mzimba, and Nkhotakota show moderate increases in income losses due to worsening drought conditions.
- **Stable or Minimal Change in Income Losses (White and Light Grey: -0.1x to 0.1x Anomaly)**
  Dedza, Ntcheu, Mangochi and Zomba City show little to no projected change in income losses due to droughts.
- **Reduction in Income Losses (Grey: -0.5x to -1x Anomaly)**
  Mchinji, Salima, Balaka, Machinga, Mwanza, Neno, Zomba, Mulanje, Chiradzulu, Chikwawa, Nsanje, Thyolo, Phalombe show a reduction in projected income losses, which could indicate either economic shifts away from agriculture or successful climate adaptation measures.

Figure 76 shows the contribution of the different crops considered in the analysis to the Average Annual Loss of Income due to Droughts Under Current and Projected Climate Conditions. The largest income losses are determined by few crops at national level.

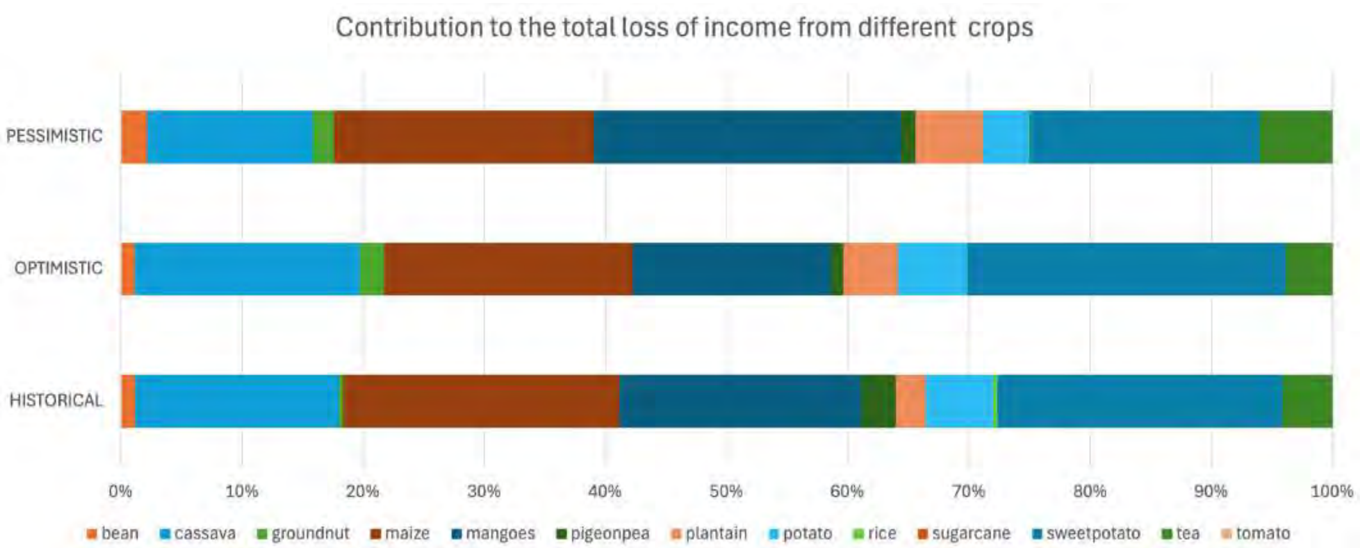


Figure 76. Contribution of Different Crops to the Average Annual Loss of Income Due to Droughts Under Current and Projected Climate Conditions.

Key Messages:

Agricultural Sector at High Risk:
The droughts result in significant agricultural losses, with average annual losses reaching up to $46.4 million under the pessimistic climate scenario chosen in this study. This emphasizes the critical need for agricultural resilience-building strategies, especially in drought-prone districts like Machinga and Mangochi and in general, the southern part of Malawi that is currently exposed to the higher losses in the agricultural sector. In projected climate conditions, the pattern of risk intensifies in the central region of Malawi due to the dominant contribution of Maize, Cassava and Sweet Potato to the overall loss among the crops considered in the study (i.e. food crops contributing at least to the 85% of the national GVP and are important for food security).

Vulnerable Crop Varieties:
Specific crops such as maize are more vulnerable to drought impacts, contributing substantially to the economic losses. Diversifying crops and investing in drought-resistant varieties can mitigate these risks.

Impact on Food Security:
The substantial agricultural losses directly threaten food security in Malawi, particularly in regions heavily dependent on subsistence farming. This could lead to increased food insecurity if adaptive measures are not implemented.

Sendai Indicator	Droughts	AAL current CC (min - max)	AAL optimistic scenario (min - max)	AAL pessimistic scenario (min - max)
C2 [M US$]	Direct agricultural loss attributed to disasters	158.2 (139.5 - 169.8)	204.6 (174.6 - 219.2)	161.6 (154.1 - 192.7)

Key Messages:

At national level the direct loss to agriculture is estimated to be around 39 M USD per year on average, considering the variability of market prices this estimate can range from 34 to 44 M USD. This average annual loss increases to 55 M USD when a pessimistic climate scenario is considered. This loss born by one sector alone and a sector with strategic importance for Malawi calls for immediate attention both in current climate conditions and considering possible exacerbations connected to climate change.

Implications for Food Security
Droughts

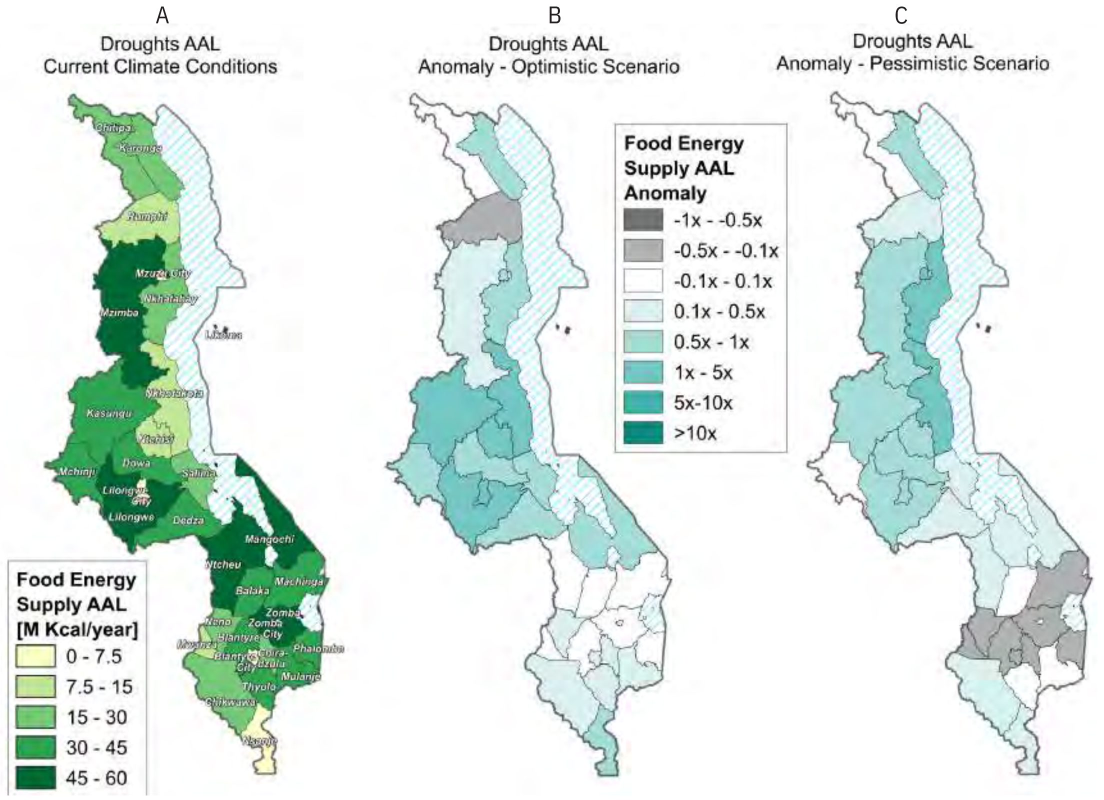


Figure77. Average Annual Loss of Food Energy Supply Due to Droughts Under Current and anomalies in Projected Climate Conditions.

Figure 77 presents a spatial analysis of the estimated food energy loss (measured in million kilocalories per year) due to droughts across Malawi under current climate conditions and future climate scenarios.

A: Current Climate Conditions
The colour-coded scale categorizes districts based on the level of food energy supply lost annually, with:
Dark green representing the highest food energy losses (45 - 60 million kcal/year).
Medium green indicating moderate food energy losses (15 - 45 million kcal/year).
Light green to yellow representing lower losses (0 - 15 million kcal/year).

Insights from the map:

- **Severely Affected Areas (Dark Green: 45 - 60 Million Kcal/Year Lost)**
  Mzimba, Lilongwe, Ntcheu, Mangochi, and Zomba are experiencing the highest levels of food energy loss due to droughts.
- **Moderate Food Energy Loss Areas (Medium Green: 15 - 30 Million Kcal/Year Lost)**
  Kasungu, and Machinga, Mchinji, Dowa, Dedza, Balaka, Machinga, Blantyre, Phalombe, Mulanje, and Thyolo show moderate food energy losses.
- **Slightly Lower Impact Areas (Light Green to Yellow: 7.5 – 15 Million Kcal/Year Lost)**
  Chitipa, Karonga, Nkhatabay, Salima, Neno, Chikwawa, and Chiradzulu have lower food energy losses.
- **Lower Impact Areas (Lighter Green to Yellow: 0 – 7.5 Million Kcal/Year Lost)**
  Mzuzu, Lilongwe, Blantyre, Zomba Cities and Nsanje have relatively lower food energy losses.

B: Anomaly in the Optimistic Scenario
The colour-coded scale categorizes districts based on how food energy losses are expected to change, with:
Dark green representing districts where food energy supply losses are projected to increase significantly (>10x anomaly).
Teal and light green shades representing moderate increases in food energy supply losses.
Grey shades showing areas where food energy losses are expected to decrease or remain stable.

Insights from the map:

- **Increase in Food Energy Losses (Teal to Light Green: 1x - 5x Anomaly)**
  Kasungu, Nkhotakota, Kasungu, Ntchisi, Lilongwe, and Nsanje districts show increases in food energy losses.
- **Moderate Increase in Food Energy Losses (Teal to Light Green: 0.5x - 1x Anomaly)**
  Nkhatabay, Mchinji, Dowa, Dedza, Mangochi, Karonga, and Nsanje moderate increase in food energy losses.
- **Stable or Minimal Change in Food Energy Losses (White and Light Grey: -0.1x to 0.1x Anomaly)**
  Chitipa, Ntcheu, Balaka, Machinga, Zomba, Phalombe, Blantyre and Mwanza show little to no projected change in food energy losses due to droughts.
- **Reduction in Food Energy Losses (Grey: -0.1x to -0.5x Anomaly)**
  Rumphi is projected to experience a decrease in drought-induced food energy losses.

Key Messages:

Severe Threat to Food Security:
Droughts cause a significant reduction in food energy supply, particularly in districts like Blantyre and Lilongwe. This reduction threatens the nutritional status of the population, highlighting the need for robust food security interventions.

Rising Energy Deficits:
Under pessimistic climate projections, the loss of food energy supply is projected to increase, exacerbating existing food security challenges and potentially leading to malnutrition and increased poverty levels.

Need for Sustainable Agricultural Practices:
To combat the loss of food energy supply, promoting sustainable agricultural practices and improving irrigation systems in highly affected districts can help stabilize food production and ensure a more resilient food supply.

C: Anomaly in the Pessimistic Scenario
Similarly to panel B, the colour-coded scale categorizes districts based on how food energy losses are expected to change in a pessimistic climate scenario.

Insights from the map:

- **Increase in Food Energy Losses (Green: 1x to 5x Anomaly)**
  Nkhatabay, and Nkhotakota are projected to experience a more than tenfold increase in food energy losses, highlighting extreme drought vulnerability.
- **Minimal Increase in Food Energy Losses (Lighter Green: 0.1x to 0.5x Anomaly)**
  Rumphi, Salima, Dedza, Ntcheu, Mangochi, Chikwawa and Nsanje show minimal increase in food energy losses
- **Moderate Increase in Food Energy Losses (Green: 0.5x - 1x** Anomaly)
  Mzimba, Kasungu, Lilongwe, Ntchisi, Dowa and Karonga show moderate increases in food energy losses.
- **Stable or Minimal Change in Food Energy Losses (Grey: -0.5x to -0.1x Anomaly)**
  Neno, Mwanza, Blantyre, Chiradzulu, Machinga, Zomba, and Phalombe show little to no projected change in food energy losses.

Depiction of a food insecure household that benifitted from a relief aid programme - DoDMA

Social Vulnerability Assessment
Droughts

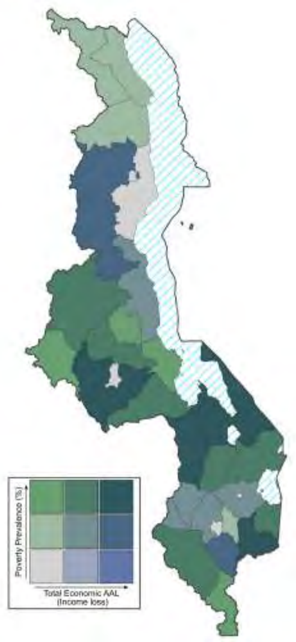


Figure 78. Combined Map of Average Energy Supply Loss AAL in Agriculture and the Food Security Indicator.

Figure 79. Combined Map of Total Economic AAL on Agriculture and the Poverty Prevalence Indicator.

Figure 80. Combined Map of Average Total Working Days Lost in Agriculture and Economically Inactive Population Indicator.

Figure 78 presents a spatial analysis of the relationship between food energy supply loss (measured in million kilocalories per year) and food insecurity levels across Malawi. The color-coded scale categorizes districts based on the combined impact of drought-induced food supply loss and the percentage of households experiencing inadequate food security.
Dark red areas represent regions with the highest food energy losses and high levels of food insecurity.
Medium red to brown shades indicate districts with moderate losses and food insecurity.
Blue and grey shades represent districts with lower food energy supply losses but varying levels of food insecurity.

Insight from the maps:

- **Severely Affected Areas (Dark Red: High Food Energy Loss & High Food Insecurity)**
  Mangochi, Dedza, Ntcheu, Lilongwe and Zomba are the most affected regions, experiencing both significant food energy supply loss and high levels of food insecurity.
- **Moderately Affected Areas (Medium Red to Brown: Moderate Food Energy Loss & Food Insecurity)**
  Mzimba shows moderate food energy losses combined with high levels of food insecurity.
- **Lower Impact Areas (Blue and Grey: Low Food Energy Loss & Varying Food Insecurity)**
  Kasungu, Mchinji, Dowa, Balaka, Machinga, Phalombe, Thyolo and Chikwawa exhibit relatively lower food energy supply losses, suggesting better climate resilience or irrigation access.
- **Lowest Impact Areas (Light Grey: Low Food Energy Loss & Varying Food Insecurity)**
  Rumphi, Mzuzu City, Lilongwe City and Blantyre show lowest food energy losses.

Figure 79 presents a spatial analysis of the relationship between total economic losses in agriculture (measured as Average Annual Loss - AAL in income) and poverty prevalence across Malawi. The color-coded scale categorizes districts based on the combined impact of agricultural income loss and poverty rates, with:
Darker green areas representing districts with both high economic losses in agriculture and high poverty prevalence.
Lighter green areas showing moderate agricultural income loss but with varying levels of poverty.
Blue shades indicating districts with lower agricultural losses but varying levels of poverty.

Insight from the maps:

- **High Agricultural Income Loss and High Poverty (Dark Green Areas)**
  Ntcheu, Balaka, Mangochi, Mulanje, and Lilongwe experience both high agricultural losses and high poverty levels, suggesting a strong dependency on rain-fed agriculture and exposure to climate risks.
- **Moderate Agricultural Income Loss with Varying Poverty Levels (Medium Green Areas)**
  Chitipa, Karonga, Rumphi, and Chiradzulu show moderate agricultural losses but still exhibit high poverty rates.
- **Lower Agricultural Loss with High Poverty (Blue and Light Green Areas)**
  Mzimba and Thyolo show relatively lower agricultural income loss but still experience high poverty rates.

Figure 80 presents a spatial analysis of the relationship between the total number of working days lost in agriculture (due to climate hazards) and the percentage of economically inactive individuals across Malawi.
The color-coded scale categorizes districts based on the combined impact of labor loss in agriculture and economic inactivity, with:
Darker purple and brown areas indicating regions with both high working days lost and a high percentage of economically inactive individuals.
Lighter purple and beige areas representing districts with moderate or lower working days lost but varying levels of economic inactivity.

Insights from the map:

- **High Agricultural Labor Loss and High Economic Inactivity (Dark Purple and Brown Areas)**
  Mzimba, Blantyre and Thyolo experience high levels of working days lost and economic inactivity.
- **Moderate Working Days Lost with Varying Economic Inactivity (Medium Purple and Beige Areas)**
  Dowa, Lilongwe, Dedza, Ntcheu, Balaka, Mangochi, Blantyre, Mulanje, and Phalombe exhibit moderate labour loss in agriculture but still face high levels of economic inactivity.
- **Lower Agricultural Labor Loss with Moderate or High Economic Inactivity (Light Purple and Beige Areas)**
  Chitipa, Karonga, Nkhatabay, Nkhotakota, Kasungu, Mchinji, Neno, Mwanza and Chikwawa experience relatively fewer lost working days in agriculture but still face economic inactivity challenges.

Key Messages:

Disproportionate Impact on Vulnerable Populations:
The combined analysis of social vulnerability and disaster risk shows that districts in central and southern Malawi, with high poverty prevalence, are disproportionately affected by droughts. This is particularly true for rural areas where this combination creates the largest impacts. This calls for tailored social protection measures in these areas. The combination of these factors impacts the food security of those areas as well as threatens the economic stability of families.

Importance of Integrated Risk Management:
The findings highlight the necessity of integrating social vulnerability data with physical risk assessments to develop more effective and equitable disaster risk management strategies, ensuring that the most vulnerable populations are adequately protected and supported.

Secondary Effects on Local Economy and Food Security:
Loss of seasonal labour opportunities significantly increases the risk of long-term economic impacts, particularly in districts already struggling with a high proportion of inactive populations. Hotspots for these challenges include Mzimba, Thyolo, and Blantyre, where the local economy and food security are particularly vulnerable.

Recommendations
Droughts

Encourage the Enhance Agricultural Resilience
Promote Drought-Resistant Crops: Encourage the adoption of drought-resistant and early-maturing crop varieties, especially in highly vulnerable districts, to mitigate the risk of crop failure.
Diversify Agricultural Practices: Support crop diversification strategies to reduce dependency on a few vulnerable crops like maize and groundnuts. This can help stabilize food production and reduce economic losses.
Improve Irrigation Systems: Invest in the development and maintenance of efficient irrigation systems, particularly in drought-prone areas, to ensure a more reliable water supply for agriculture.

Strengthen Food Security Initiatives
Develop Food Storage and Distribution Systems: Establish and strengthen food storage facilities and distribution networks to manage food supply during droughts, ensuring that affected populations, particularly in districts like Blantyre and Lilongwe, have access to sufficient food resources.
Implement Nutrition Programs: Expand nutrition programs targeting the most vulnerable populations, especially children and the elderly, to prevent malnutrition during periods of reduced food availability due to droughts.
Promote Sustainable Land Use: Encourage sustainable land management practices to prevent soil degradation and maintain agricultural productivity, which is crucial for food security during drought conditions. This might include upscaling livestock farming through livestock subsidy programs.

Enhance Social Protection and Support Mechanisms
Expand Social Protection Schemes: Strengthen and expand social protection programs targeting the most vulnerable populations in districts with high poverty levels.
Develop Community-Based Resilience Programs: Foster community-based initiatives that build local capacity to respond to droughts, including water conservation techniques, community gardens, and collective food storage systems.
Improve Access to Financial Services: Provide access to financial services such as crop insurance and microcredit to help farmers and vulnerable households manage the financial risks associated with droughts.

Invest in Infrastructure and Early Warning Systems
Strengthen Critical Infrastructure: Prioritize investments in the resilience of critical infrastructure, such as health facilities, educational institutions, and transportation networks, to ensure they remain operational during droughts and can support recovery efforts.
Develop and Disseminate Early Warning Systems: Enhance drought monitoring and early warning systems to provide timely information to farmers and communities, enabling them to take pre-emptive actions to minimize losses.
Integrate Climate Adaptation into Planning: Incorporate climate adaptation strategies into regional and national planning processes to ensure that infrastructure development is resilient to future drought risks.
Climate Change adaptation investments: Re-establish Carbon Tax Fund to contribute to mitigation efforts of climate-change related hazards.

Promote Integrated Water Resource Management
Improve Water Resource Management: Implement integrated water resource management (IWRM) strategies to optimize the use of water resources across sectors, ensuring that agricultural, domestic, and industrial water needs are met even during drought periods.
Enhance Rainwater Harvesting: Promote rainwater harvesting techniques at both the household and community levels to capture and store water during the rainy season, reducing dependence on unreliable water sources during droughts.
Protect and Restore Ecosystems: Support the protection and restoration of natural ecosystems, such as wetlands and forests, that play a crucial role in maintaining the water cycle and mitigating the impacts of droughts.

Increase Awareness and Education
Conduct Public Awareness Campaigns: Launch public awareness campaigns to educate communities about drought risks, water conservation practices, and the importance of sustainable agriculture to enhance resilience.
Incorporate Drought Resilience in Education: Integrate topics on climate change, drought resilience, and disaster risk reduction into school curricula to build a culture of preparedness among the younger population.
Increase capacity to access targeted funding: Build capacity for accessing local and international climate change financing including the Climate Change Adaptation Fund and Green Climate Fund.

Landslides
B1 - Number of People Directly Affected by Disasters - Landslides

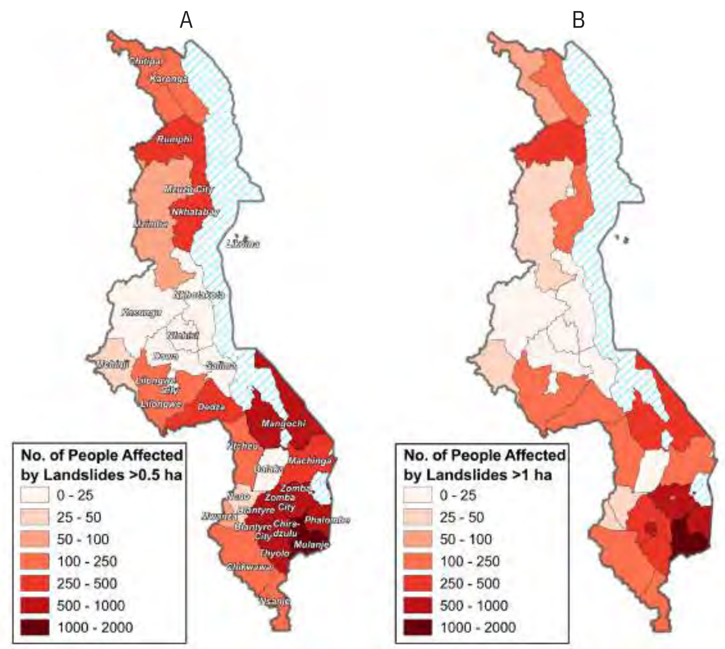


Figure 82. Average Annual Population Affected by Landslides Larger Than 0.5 ha (A) and 1 ha (B).

Key Messages:

High Human Impact in Vulnerable Areas:
Landslides pose a significant threat to populations in hilly and mountainous regions of Malawi, particularly in districts like Phalombe and Mulanje, where the terrain increases susceptibility to landslide events.

Spatial Variation in Vulnerability:
The impact of landslides on populations varies significantly across districts, with rural areas typically facing higher risks due to less robust infrastructure and limited access to emergency services.

Importance of Early Warning Systems:
The significant number of people affected annually highlights the critical need for effective early warning systems and community preparedness initiatives, especially in high-risk areas.

Figure 90 illustrates the average annual population affected by landslides exceeding 0.5 hectare (panel A) and 1 hectare (panel B) across Malawi. The colour gradient represents the severity of impact, with darker shades of red indicating districts with a higher number of affected people per year.

Panel A, Insights from the map:
- **Higher-Impact Areas (Dark Red: 1000 – 2000 People Affected Annually)**
  Mulanje, with over 1000 people impacted annually for smaller landslides
- **High Impact Areas (Red: 500 – 1000 People Affected Annually)**
  Mangochi, Phalombe, Zomba, Blantyre, Blantyre city and Thyolo show high people affected by landslides greater than 0.5 ha.
- **Low-Impact Areas (Orange: 250 - 500 People Affected annually)**
  Dedza, Nkhatabay and Rumpi experience landslide impacts affecting about 250-500 people
- **Lower Impact Areas (Light Orange: 25-50 people Affected annually)**
  Lilongwe, Ntcheu, Chickwawa and Nsanje show lower impacted people by landslides of greater than 0.5 ha.
- **Lowest Impact Area (Cream Orange: 0 – 25 people Affected annually)**
  Other Central Malawi Districts show low risk

Panel B, Insights from the map:
- **Higher-Impact Areas (Dark Red: 1000 – 2000 People Affected Annually)**
  Phalombe is the hotspot when larger landslides are considered
- **High Impact Areas (Red: 500 – 1000 People Affected Annually)**
  Zumba, Ntcheu and Nkhotakota show high people affected by landslides greater than 1 ha.
- **Low-Impact Areas (Orange: 250 - 500 People Affected annually)**
  lower risk, affecting about 250-500 people, is distributed in several districts from Nrth to southern Malawi
- **Lowest Impact Area (Cream Orange: 0 – 25 people Affected annually)**
  Low impacted disctrics by landslides greater than 1 ha are mainly found in Central Malawi.

C1 - Direct Economic Loss Attributed to Disasters

Landslides

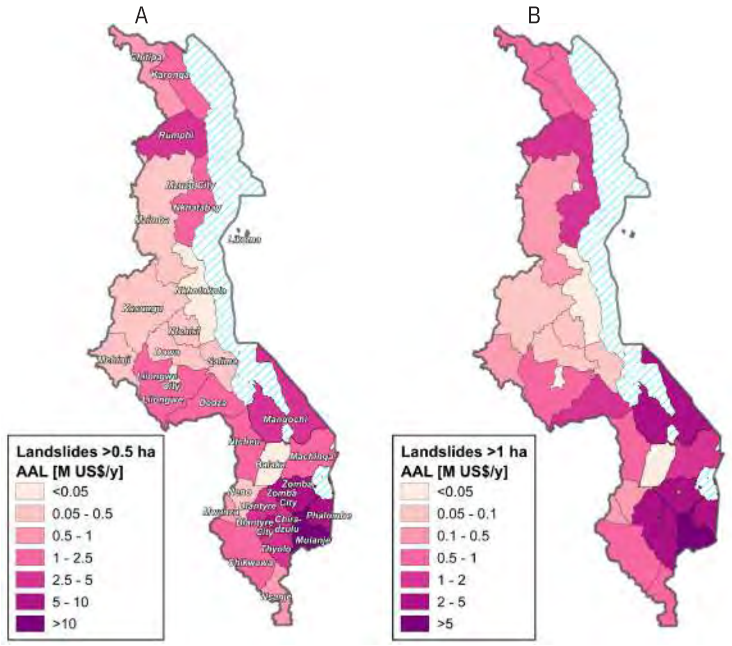


Figure 82. Built-Up Sector Average Annual Losses (AAL) Due to Landslides Larger Than 0.5 ha and Larger Than 1 ha.

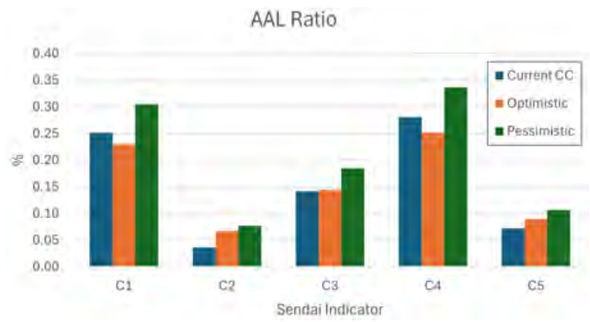


Figure 83. Ratio of average annual loss with respect to the corresponding stock value for different Sendai indicators in connection to strong landslides (>0.5 ha and >1ha, respectively).

Key Messages:

Substantial Economic Losses in Affected Districts: Landslides result in considerable economic losses, with the housing sector bearing the brunt of these impacts, particularly in districts like Blantyre, Phalombe and Mulanje.

Figure 91 (A) illustrates the estimated financial losses in the built-up sector due to landslides exceeding 0.5 hectares across Malawi. The colour gradient represents different levels of economic losses in millions of US dollars per year (M US$/y), with darker shades indicating higher financial damages.

Insights from the map:

- **Highest Economic Loss Areas (Dark Purple: >5 M US$/y)**
  Mulanje experiences the highest financial losses due to landslides.
- **High Economic Loss Areas (Purple: 2 – 5 M US$/y)**
  Thyolo, Blantyre, Blantyre City, Zomba, Phalombe, and Mangochi faces high annual financial losses from landslides.
- **Low Economic Loss Areas (Light Pink: 0.5 - 1 M US$/y)**
  Machinga, Dedza, Rumphi, Nkhatabay experience relatively low financial losses, likely due to flatter terrain and fewer landslide events.
- **Less Economic Loss Areas (Lighter Pink: 0.1 – 0.5 M US$/y)**
  Mzimba, Mchinji, Neno, Mwanza, Lilongwe have less economic annual financial loss and landslide events greater than 1.
- **Marginal Economic Loss Areas (<0.05 M US$/y)**
  Nkhotakota, Lilongwe City, Balaka and Mzuzu City show marginal economic loss from landslides of greater than 1 ha annually.

Figure 91 (B) illustrates the estimated financial losses in the built-up sector due to landslides 1 hectare across Malawi. The colour gradient represents different levels of economic losses in millions of US dollars per year (M US$/y), with darker shades indicating higher financial damages.

Insights from the map:

- **Highest Economic Loss Areas (Dark Purple: >5 M US$/y)**
  Mulanje experiences the highest financial losses due to landslides.
- **High Economic Loss Areas (Purple: 2 – 5 M US$/y)**
  Thyolo, Blantyre, Blantyre City, Zomba, Phalombe, and Mangochi faces high annual financial losses from landslides.
- **Low Economic Loss Areas (Light Pink: 0.5 - 1 M US$/y)**
  Machinga, Dedza, Rumphi, Nkhatabay experience relatively low financial losses, likely due to flatter terrain and fewer landslide events.
- **Less Economic Loss Areas (Lighter Pink: 0.1 – 0.5 M US$/y)**
  Mzimba, Mchinji, Neno, Mwanza, Lilongwe have less economic annual financial loss and landslide events greater than 1.
- **Marginal Economic Loss Areas (<0.05 M US$/y)**
  Nkhotakota, Lilongwe City, Balaka and Mzuzu City show marginal economic loss from landslides of greater than 1 ha annually.

Sendai Indicator	Landslides	AAL >0.5 ha	AAL >1 ha
C1 [M US$]	**Direct economic loss attributed to disasters** (as sum of C3, C4, and C5 in the following)	**65.1**	**41.1**
C3 [M US$]	Direct economic loss to all other damaged or destroyed productive assets attributed to disasters	5.4	3.4
C4 [M US$]	Direct economic loss in the housing sector attributed to disasters	58.2	36.7
C5 [M US$]	Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters	1.6	1.0

Key Messages:

Disproportionate Impact on Housing Sector:
Most economic losses are concentrated in the housing sector, indicating the urgent need for improving building standards and implementing landslide-resistant construction practices.

Critical Infrastructure at Risk:
While economic losses to critical infrastructure such as roads and healthcare facilities are smaller in absolute terms, their impact on community resilience and recovery is significant, requiring targeted protection and retrofitting efforts.

Landslides in Malawi - Amos Gumulira AFP - Getty Images

D - Damage to Critical Infrastructures, Including Basic Services
Landslides

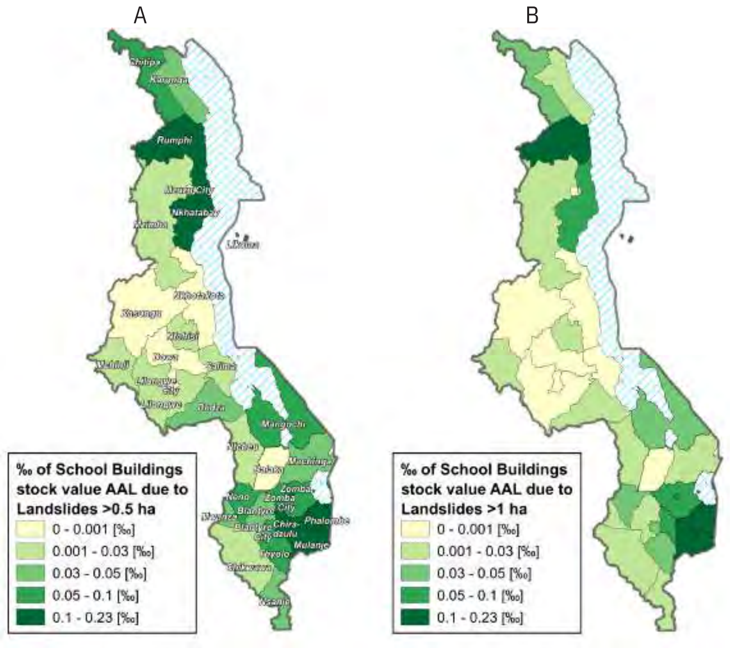


Figure 84. Annual Percentage of School Building Stock Affected by Landslides.

Key Messages:

Critical Infrastructure Highly Vulnerable:
Landslides severely impact critical infrastructure, particularly hospitals and schools in affected districts. This poses a threat to essential services during and after disasters.

Focus on Health Facilities:
Health facilities are particularly at risk, with landslides potentially disrupting medical services in districts with high landslide susceptibility. This necessitates prioritizing these facilities in risk mitigation strategies.

Need for Infrastructure Resilience:
The consistent threat to essential infrastructure highlights the need for resilient construction practices and strategic location planning to minimize the impact of landslides on critical services.

Figure 84 (A) presents the estimated annual percentage loss of school building stock value due to landslides exceeding 0.5 hectares across Malawi. The colour gradient represents different levels of economic vulnerability, with darker shades indicating higher losses in school infrastructure.

Insights from the map:

- **High-Risk Districts (Dark Green: 0.1 - 0.23‰**
  Rumphi, Nkhatabay, Mulanje, and Phalombe experience the highest annual percentage losses of school building stock due to landslides.
- **Moderate-Risk Districts (Medium Green: 0.05 - 0.1‰)**
  Chitipa, Neno, Mangochi, Zomba, and Thyolo show moderate risks of school building damage.
- **Low Risk Districts (Light Green: 0.03 – 0.05‰)**
  Dedza, Karonga, Machinga, Neno, Blantyre, and Nsanje face relatively lower risks due to flatter terrain and fewer landslide-prone areas.
- **Lower-Risk Districts (Light Yellow: 0 -001‰)**
  Kasungu, Nkhotakota, Dowa and Balaka show lower risk of school buildings stock value due to landslides

Figure 84 (B) illustrates the estimated annual percentage loss of school building stock value due to landslides larger than 1 hectare across Malawi. The colour gradient indicates the extent of infrastructure vulnerability, with darker shades representing higher losses.

Insights from the map:

- **High-Risk Districts (Dark Green: 0.1 - 0.23‰)**
  Rumphi, Phalombe and Mulanje school buildings stock value AAL due to landslides are at high risk.
- **Moderate High-Risk Districts (Medium Green: 0.05 - 0.1‰)**
  Districts such as Zomba, Chiradzulu and Nkhatabay exhibit moderate high risk school infrastructure vulnerability.
- **Low-Risk Districts (Light Green to Yellow: <0.05‰)**
  Karonga, Mzimba, Ntchisi, Mchinji, Dedza, Ntcheu Machinga, Mwanza, Chikwawa and Nsanje show low risk of school buildings stock value due to landslides greater than 1 ha.
- **Lower-Risk Districts (Yellow Green: 0.001 – 0.03 ‰)**
  Mzuzu City, Kasungu, Nkhotakota, Dowa, Lilongwe, Lilongwe City, Salima and Balaka experience minimal annual school stock losses due to landslides.

Recommendations
Landslides

National Level Recommendations

Improving Input Data and Updating Information
Develop a National Landslide Inventory: Invest in creating a comprehensive national landslide inventory to improve risk assessment and enhance decision-making.
Update and Standardize Data: Regularly update datasets and standardize data collection methods to ensure accuracy and consistency in landslide risk assessments.

Enhancing Public Awareness
National Awareness Campaigns: Launch nationwide campaigns to educate the public about landslide risks, early warning signs, and appropriate response measures.
Use of Media and Educational Programs: Utilize national media platforms and educational programs to disseminate information on landslide preparedness and response.

Strengthening Disaster Risk Management Framework
Institutional Strengthening: Enhance the capacity of disaster risk management institutions to better address landslide hazards, including the integration of landslide risk into national planning and policy frameworks.
Allocate Resources for Landslide Mitigation: Ensure that sufficient resources are allocated for landslide mitigation, including funding for critical infrastructure protection and community-based risk reduction programs.

District Level Recommendations

Improving Input Data and Updating Information
Localized Data Collection: Focus on collecting detailed landslide data at the district level, especially in high-risk areas, to improve local risk assessments and decision-making.
Adaptation to Climate Change: Continuously adapt risk assessments and mitigation strategies to reflect the impacts of climate change on landslide frequency and severity.

Improving Understanding of Landslide Hazard and Risk
District-Level Risk Maps: Develop and utilize detailed district-level landslide risk maps to identify high-risk areas and guide land use planning and infrastructure development.
Sub-District Analysis: Conduct sub-district analyses to pinpoint specific areas of heightened vulnerability, allowing for more targeted mitigation efforts.

Improving Public Awareness
Community Education Programs: Implement community education programs in high-risk districts to raise awareness about landslide risks and promote safe practices.
Engage Local Leaders: Work with local leaders to disseminate information and foster community engagement in landslide risk reduction activities.

Improving Decision-Making Processes
Land-Use Planning and Zoning: Integrate landslide risk into land-use planning and zoning decisions to prevent the development of high-risk areas and reduce exposure.
Infrastructure Planning: Prioritize landslide-resistant infrastructure in development plans, especially in districts with a history of landslide events.

Early Warning and Emergency Preparedness
Develop Early Warning Systems: Establish and maintain early warning systems tailored to landslide risks, ensuring timely alerts to communities at risk.
Emergency Preparedness Drills and simulation exercises: Conduct regular emergency preparedness drills in high-risk districts as well as simulation exercises at a community level to ensure community readiness and effective response during landslide events.

Earthquakes

B1 - Number of People Directly Affected by Disasters - Earthquakes

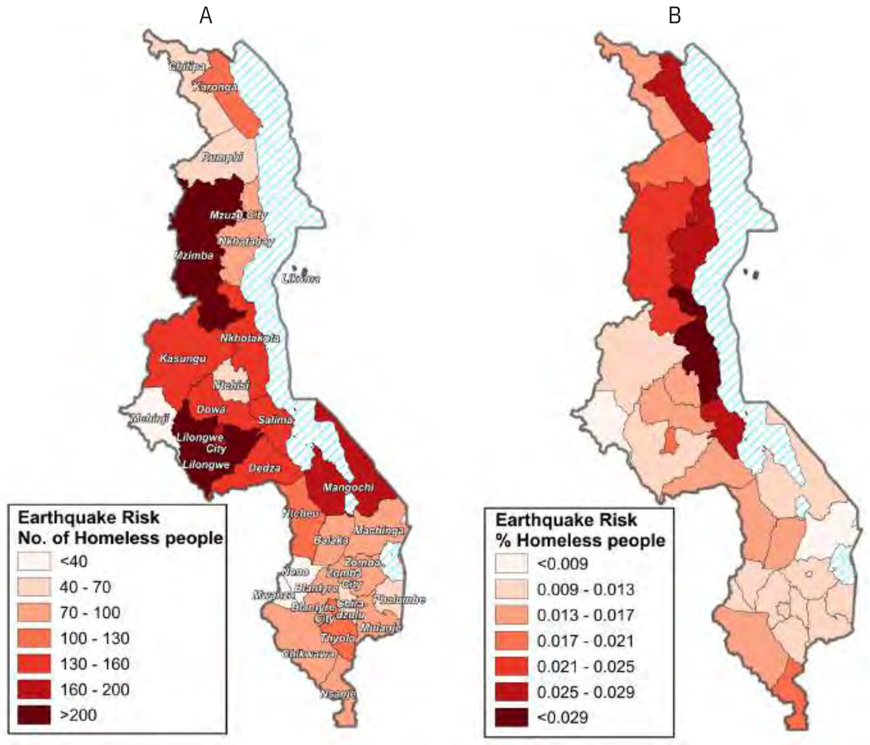


Figure 85. Average Annual Homeless Population Due to Earthquakes in Absolute (A) and Relative Terms (B).

Figure 85 presents a spatial analysis of the estimated number of people left homeless annually due to earthquake events across Malawi. The color-coded scale categorizes districts based on the severity of homelessness risk due to seismic activity, with:
Dark red areas representing districts with the highest number of homeless individuals (>200 annually).
Medium red and orange shades indicating moderate levels of earthquake-induced homelessness.
Lighter shades showing areas with lower homelessness risks due to earthquakes.

Insights from the maps:

- **Severely Affected Areas (>200 Homeless Annually, Dark Red)**
  Mzimba, and Lilongwe experience the highest levels of earthquake-induced homelessness.
- **High Affected Areas (130–160 Homeless Annually, Medium Red Shades)**
  Mangochi exhibit moderate high homelessness risk due to earthquakes.
- **Moderately High Affected Areas (100–130 Homeless Annually, Medium Red Shades)**
  Kasungu, Nkhotakota, Dowa, Salima and Dedza experience moderately high homeless risk due to earthquakes.

Key Messages:

Widespread Homelessness Risk:
Earthquakes pose a significant threat to housing in Malawi, with a high number of people potentially becoming homeless with districts like Mzimba, Lilongwe (rural) and Lilongwe city expected to register significant numbers of residents left homeless due to buildings' extensive or complete damage.

Variable Impact Across Districts:
The impact of earthquakes on homelessness varies significantly across different districts, with urban areas generally seeing higher absolute numbers but rural areas experiencing higher relative impacts, making targeted interventions crucial.

Maximum Loss Scenarios Highlight Vulnerability:
Probable maximum loss curve indicates a potential for a sharp increase in homelessness during major seismic events, underscoring the need for pre-emptive measures such as retrofitting and public education.

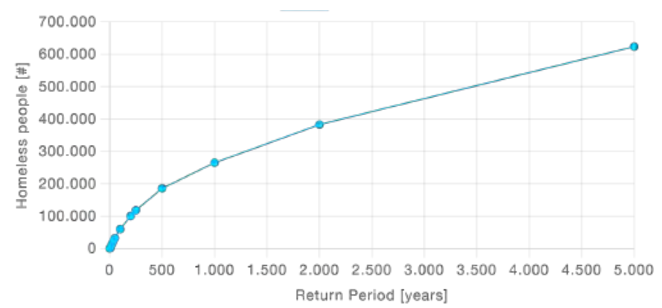


Figure 86. Probable Maximum Loss Curves for Homeless Population Due to Earthquakes.

- **Lower Impact Areas (40-70 Homeless Annually, Light Orange and Beige Shades)**
  Chitipa, Rumphi, Ntchisi and Phalombe experience relatively lower levels of earthquake-induced homelessness.

C1 - Direct Economic Loss Attributed to Disasters
Earthquakes

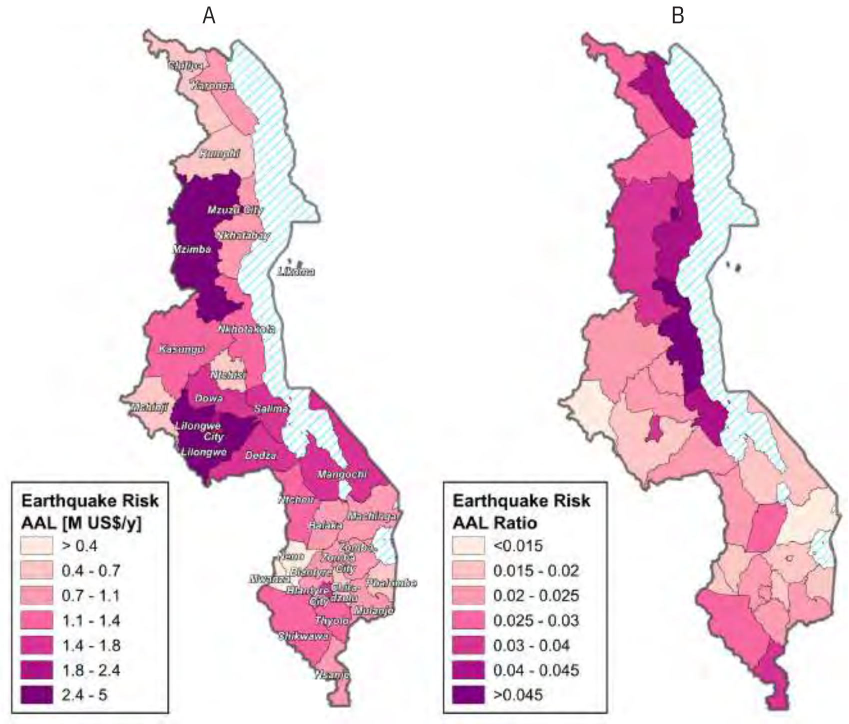


Figure 87. Average Annual Loss (AAL) Due to Earthquakes in Absolute and Relative Terms.

Key Messages:

Significant Economic Losses:
Earthquakes contribute to substantial economic losses, with the housing sector bearing the majority of the financial burden, particularly in districts with dense populations like Lilongwe, Blantyre and Mzimba.

Figure 87 (A) presents the estimated economic losses per year due to earthquake events across Malawi, expressed in millions of US dollars per year (M US$/y).

Insights from the map

- **High Economic Loss Areas (Dark Purple: 2.4 -5M US$/y)**
  Mzimba and Lilongwe experience the highest annual economic losses due to earthquakes.
- **Moderately Affected Areas (Medium Pink and Purple: 1.4M–1.8M US$/y)**
  Dowa, Salima, Mangochi, Blantyre Dedza, and Mangochi, experience moderate financial losses from earthquakes.
- **Low Economic Loss Areas (Light Pink: 0.7M – 1.1M US$/y)**
  Nsanje, Chikwawa, Balaka, Machinga, Zomba, Chiradzulu, Thyolo, and Ntcheu show low annual economic losses.
- **Lower Economic Loss Areas (Light Pink: 0.4M – 0,7M US$/y)**
  Chitipa, Rumphi, Karonga, Mchinji, Ntchisi, Neno, Mwanza, Chradzulu show low annual economic losses. and Phalombe.

Figure 87 (B) presents the relative economic loss to earthquake hazards across Malawi, using the AAL Ratio, which represents the proportion of total economic output (GDP or asset value) lost annually due to seismic activity.

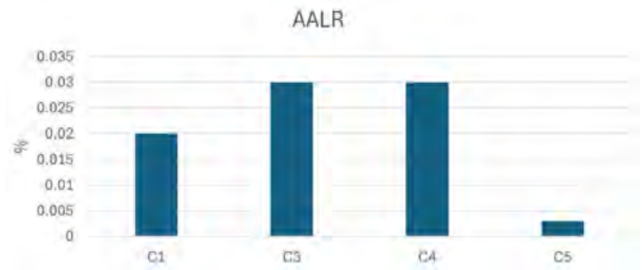


Figure 88. Ratio of Average Annual Loss for Different Sendai Indicators in Relation to Earthquakes.

insights from the map:

- **High-Risk Districts (Dark Purple: >0.045 AAL Ratio)**
  Nkhotakota, exhibit the highest relative economic burden from earthquake damage.
- **Moderate-Risk Areas (Medium Purple and Pink: 0.04–0.045 AAL Ratio)**
  Karonga, Nkhatabay, Salima, and Nsanje experience moderate levels of economic vulnerability to earthquakes.
- **Low-Risk Districts (Light Pink: 0.025-0.03 AAL Ratio)**
  Chitipa, Lilongwe, Balaka, Chikwawa and Rumphi have the low AAL ratios.
- **Lower-Risk Districts (Light Pink: 0.025-0.03 AAL Ratio)**
  Lilongwe. Mangochi, Zomba, Phalombe, Neno, Mwanza, Lilongwe have lower AAL ratio.

Sendai Indicator	Earthquakes	AAL Current Climate
C1 **[M US$]**	**Direct economic loss attributed to disasters** (as sum of C3, C4, and C5 in the following)	**32.1**
C3 [M US$]	Direct economic loss to all other damaged or destroyed productive assets attributed to disasters	2.6
C4 [M US$]	Direct economic loss in the housing sector attributed to disasters	29.3
C5 [M US$]	Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters	0.2

Key Messages:

Housing Sector Most Affected:
Most of the economic losses are concentrated in the housing sector, accounting for $29.3 million annually, which highlights the critical need for enhancing building standards and retrofitting existing structures.

Critical Infrastructure at Risk:
While the overall economic impact on critical infrastructure is lower compared to other sectors, even minimal damage to essential services like hospitals and schools can have outsized effects on community resilience and recovery.

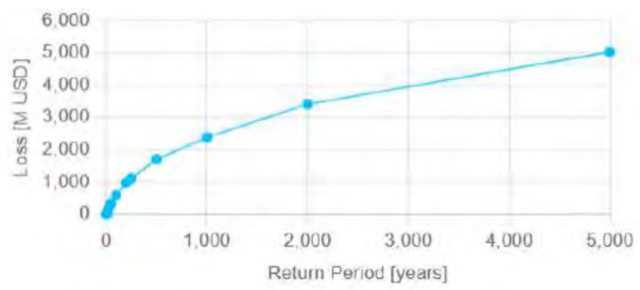


Figure 89. Probable maximum loss curves for economic damages to the built-up area [M US $], linked to earthquakes.

Key Messages:

The PML curves provide important information on the frequency of earthquakes and associated economic losses. Even though the average annual losses are of around 32 million USD per year, Earthquakes with losses close to 150 million USD are expected to occur with a return period of about 100 years (i.e. an event with equal or greater magnitude that is on average experienced every century).

D - Damage to Critical Infrastructures, Including Basic Services

Earthquakes

Figure 90. Average Annual Economic Damages to Hospitals and Schools Due to Earthquakes.

Key Messages:

Essential Services at Risk:
Earthquakes threaten critical infrastructure, particularly schools and hospitals, which are vital for post-disaster recovery. Districts like Karonga and Mzimba are especially vulnerable due to their seismic activity.

Transport Networks Vulnerable:
The disruption of transportation networks, including roads and railways, can severely impede disaster response and recovery efforts, highlighting the need for strengthening these infrastructures against seismic risks.

Prioritization of Retrofitting Needed:
The protection of critical infrastructure should be prioritized in risk mitigation plans, with a focus on retrofitting essential services to ensure their functionality during and after seismic events.

Figure 90 presents the estimated economic losses (in thousands of US dollars per year) incurred by hospitals and schools across Malawi due to earthquake hazards. The colour gradient represents the varying levels of financial damage, with darker green shades indicating higher economic losses.

Insights from the map:

- **High-Risk Areas (Dark Green: 10 – 15.2k US$/year)**
  Karonga, Mzimba, Mzuzu City, Lilongwe, Nkhatabay, Nkhotakota and Dedza experience the highest annual financial losses to schools and hospitals due to earthquake impacts.
- **Moderate Economic Losses (Green: 5 – 10k US$/year)**
  Rumphi, Kasungu, Ntchisi, Dowa, Salima, Ntcheu, Balaka, Mangochi, Zomba, Chikwawa, Nsanje, Mulanje, and Thyolo fall within this category.
- **Lower Economic Losses (Light Green: 1 – 2.5k US$/year)**
  Chitipa, Mchinji, and Neno see relatively lower annual losses.

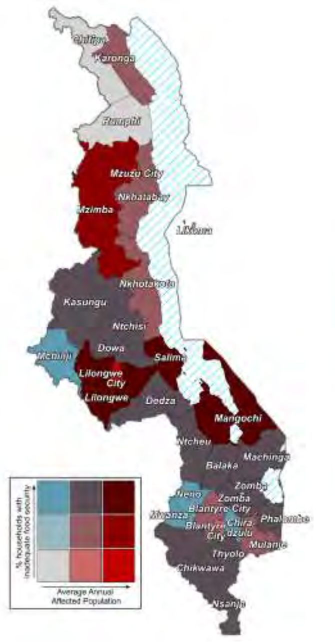
Key Messages referred to Social Vulnerability assessment: (Figures 91 - 92 - 93)

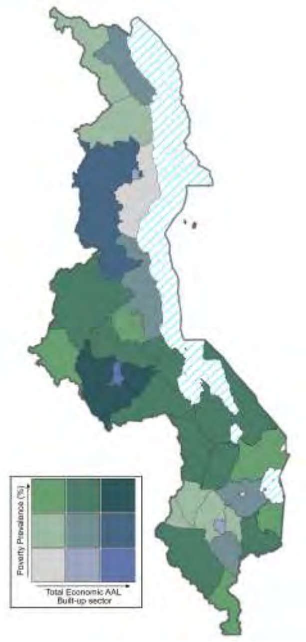
High Vulnerability in Poverty-Stricken Areas:
Social vulnerability is highest in districts with high poverty rates and low economic activity, such as rural Lilongwe and Mangochi, where the population is less resilient to earthquake impacts. People made homeless in food insecure districts such as Machinga and Chikwawa are likely to suffer secondary effects of the earthquake disasters.

Economic Disparities Amplify Risk:
The combined impact of economic loss and social vulnerability is most severe in regions where poverty prevalence is high, necessitating targeted risk reduction strategies that consider socio-economic disparities. This is particularly problematic in Central Malawi that concentrates high poverty rates and high potential economic losses.

Critical Infrastructure and Social Vulnerability Correlation:
There is a strong correlation between the vulnerability of critical infrastructure and social vulnerability, indicating that improvements in infrastructure could have a significant positive impact on overall community resilience.

Social Vulnerability Assessment
Earthquakes





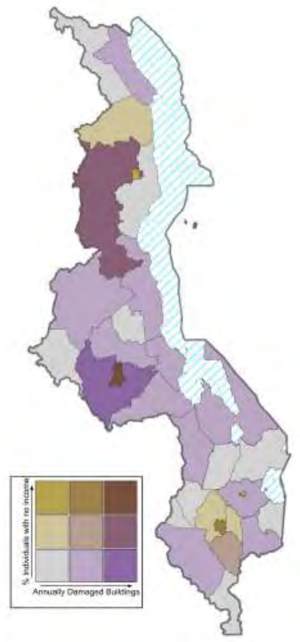


Figure 91. Combined Map of Average Annual Population Affected (AAL) and Food Security Indicator.

Figure 92. Combined Map of Total Economic Average Annual Loss (AAL) on Built-Up Sector and Poverty Prevalence Indicator.

Figure 93. Combined Map of Annually Damaged Buildings and Economically Inactive Population Indicator.

Figure 91 illustrates the relationship between the annual population affected by disasters (AAL) and food security levels across different districts in Malawi.
The map integrates two key indicators:
The average annual affected population (AAL) due to disasters, represented on the horizontal axis of the legend.
The percentage of households experiencing inadequate food security, shown on the vertical axis of the legend.

Insights from the map:

- **High Disaster Impact and Severe Food Insecurity (Dark Red and Maroon):**
  Lilongwe, Salima and Mangochi experience both a high population affected by disasters and high levels of food insecurity.
- **Slightly High Disaster Impact and Severe Food Insecurity (Red-Maroon Areas)**
  Mzimba and Lilongwe experience both slightly high population affected by disasters and high levels of food insecurity.
- **Moderate Disaster Impact with Severe Food Insecurity:**
  Kasungu, Ntchisi, Dowa, Dedza, Ntcheu, Balaka, Machinga, Zomba, Phalombe, Thyolo, Chikwawa and Nsanje experience moderate levels of disaster-affected populations, but food insecurity remains high.
- **Lower Disaster Impact and High Food insecurity (Blue Areas):**
  Mchinji, Mwanza, Neno and Chiradzulu exhibit relatively lower levels of disaster impact and food insecurity.
- **Low Disaster Impact and Better Food Security (Grey Areas):**
  Chitipa and Rumphi show low households with inadequate food security and low average annual affected population.

Figure 92 presents a combined analysis of economic losses in the built-up sector and poverty prevalence across districts in Malawi.
The map integrates two critical indicators:
Total Economic Average Annual Loss (AAL) in the Built-Up Sector, represented on the horizontal axis of the legend. This includes financial damages to urban infrastructure, buildings, and public facilities caused by earthquakes.
Poverty Prevalence, displayed on the vertical axis of the legend, indicating the percentage of people living below the poverty line in each district.

Insights from the map:

- **High Economic Loss and High Poverty Levels (Dark Bule-Green):**
  Lilongwe district experiences both high poverty prevalence and high economic losses in the built-up sector.
- **Moderate Economic Loss with High Poverty (Green):**
  Mchinji, Nchisi, Machinga, Phalonbe and Nsanje exhibit moderate to low financial losses but high poverty rates.
- **High Economic Loss with Low Poverty (Blue):**
  Lilongwe city shows high annually damaged buildings but low individual with no income.
- **Low Economic loss and low povert rate (Light Grey):**
  Nkhatabay, has low economic losses with low povery incidence.

Figure 93 illustrates the intersection of two key factors across districts in Malawi:
Number of Buildings Damaged Annually:
Reflects the number of buildings annually affected by earthquakes on average.
Economically Inactive Population Indicator:
Represents the percentage of the population without a steady income, highlighting socio-economic vulnerabilities.

The map uses a colour gradient matrix to showcase the relationship between these two indicators, providing a spatial understanding of compounded risks across Malawi.

Key Components:
Colour Gradient Matrix:
Light shades: Districts with fewer annually damaged buildings and a low proportion of economically inactive populations.
Medium shades: Districts with moderate values for either or both indicators.
Dark shades: Districts with a high number of damaged buildings and a significant proportion of economically inactive populations.
District-Level Representation:
Each district is shaded based on the interaction between annual building damage and economic inactivity, highlighting areas with the most significant compounded risks.

Insights from the map:

- **High Damage and High Economic inactivity (Dark Brown):**
  Mzimba and Lilongwe City experience both high poverty prevalence and high economic losses in the built-up sector.
- **Low Damage Loss with Moderate to High Economic inactivity (Yellow Gold):**
  Rumphi, Mzuzu City, Blantyre and Chiradzulu exhibit moderate financial losses but high poverty rates.
- **High damage with Low Economic inactivity (Dark Purple):**
  Lilongwe shows high annually damaged buildings but low individual with no income.
- **Medium annual damaged buildings with low individuals with no income (Light Purple):**
  Karonga, Kasungu, Nkhotakota, Dowa, Salima, Dedza, Ntcheu, Mangochi, Zomba, Mulanje and Chikwawa experience minimal financial losses in the built-up sector.
- **Low individuals with no income and low annual damaged building (Light Grey):**
  Nsanje, Neno, Mwanza, Phalombe, Machinga, Balaka, Ntchisi, Nkhatabay, Chitipa and Mchinji have low individuals with no income and low annual damaged building.

Policy Implications:

- **Focus on High-Risk Districts:**
  Prioritise interventions where both annual building damage and economic inactivity are high.
- **Strengthen Building Resilience:**
  Promote disaster-resistant construction and retrofitting of buildings in high-risk districts to minimise damage and losses.
- **Boost Economic Opportunities:**
  Implement programmes to generate income and economic activity in districts with high economic inactivity, particularly in disaster-prone areas.
- **Integrate Disaster and Socio-Economic Policies:**
  Link disaster risk reduction strategies with poverty alleviation programmes to address both structural and socio-economic vulnerabilities.
- **Community Engagement:**
  Involve local communities in resilience-building efforts, focusing on training for disaster preparedness and alternative income generation.

Recommendations
Earthquakes

Enhance Building Resilience
Promote and Implement Retrofitting: Prioritize the retrofitting of buildings in high-risk districts like Nkhotakota, focusing on the most vulnerable structures, particularly housing and critical infrastructure like schools and hospitals.
Develop Cost-Effective Retrofitting Solutions: Invest in cost-effective retrofitting techniques that are easy to implement, such as wall plates, ring beams, and buttresses, using locally available materials and expertise.
Enforce Building Codes: Strengthen the enforcement of building codes to ensure that new constructions are more resilient to seismic activity, particularly in urban areas. Strengthening the understanding of building codes/ guidelines at the district level.

Strengthen Critical Infrastructure
Focus on Health and Education Facilities: Allocate resources to the retrofitting and reinforcement of hospitals and schools, ensuring they remain operational during and after seismic events.
Improve Transport Networks: Enhance the resilience of transportation networks, including roads and railways, to ensure that disaster response and recovery efforts are not hindered by infrastructure damage.
Implement Regular Assessments: Conduct regular seismic risk assessments of critical infrastructure to identify vulnerabilities and prioritize upgrades.

Increase Public Awareness and Preparedness
Launch Seismic Awareness Campaigns: Implement public education campaigns to raise awareness about earthquake risks and preparedness, starting with schools and extending to communities in high-risk areas.
Develop Community-Based Disaster Plans: Encourage the development of community-based disaster preparedness plans that include evacuation routes, emergency supplies, and communication strategies.
Provide Earthquake Drills and Training: Conduct regular earthquake drills and training for both the general public and emergency response teams to ensure readiness in the event of a seismic event.

Integrate Social Vulnerability into Risk Reduction
Target Vulnerable Populations: Design risk reduction strategies that specifically address the needs of the most socially vulnerable populations, including the poor and economically inactive in the most vulnerable districts according to the analysis.
Enhance Social Protection Mechanisms: Strengthen social protection mechanisms, to support vulnerable households in the aftermath of an earthquake.
Promote Livelihood Diversification: Encourage livelihood diversification in high-risk areas to reduce dependency on vulnerable economic sectors and increase overall community resilience.

Multi-hazard Risk Assessment

B1 - Number of People Directly Affected by Disasters
Multi-hazard Risk Assessment

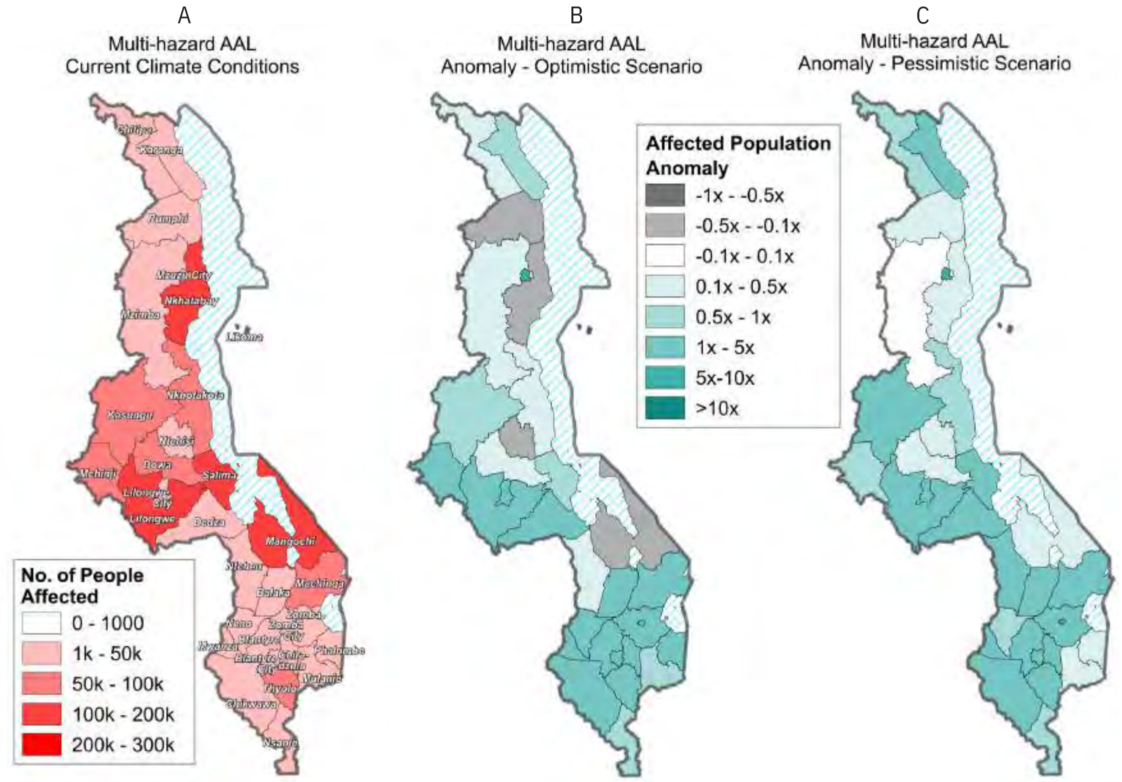


Figure 94. Average Annual Population Affected in a Multi-Hazard Context (A) Current Climate, (B) Optimistic Climate Scenario, (C) Pessimistic Climate Scenario.

Figure 94 (A) presents the estimated annual population affected by multiple hazards (including floods, droughts, strong winds, earthquakes, and landslides) under current climate conditions across Malawi. The colour gradient represents the number of people impacted annually, with darker shades indicating higher exposure levels.

Insights from the map:

- **High-Risk Districts (Dark Red: 200k - 300k People Affected Annually)**
  Mangochi, Lilongwe, Nkhatabay and Salima are the most heavily affected districts, experiencing the highest number of people impacted by multiple hazards annually.
- **Low to Medium-Risk Districts (Pink to Light Red: 1k - 50k People Affected Annually)**
  Kasungu, Nkhotakota, Mchinji, Dowa, Machinga and Thyolo show low population exposure to hazards.
- **Least Affected Areas (White: 1k – 50k People Affected Annually)**
  Karonga, Chitipa, Rumphi, Mzimba, Dedza, Ntcheu, Neno, Balaka, Mwanza, Neno, Blantyre, Chikwawa, Mulanje, Phalombe, Zomba, Chiradzulu, Mzuzu City, Lilongwe City, Blantyre City and Nsanje have relatively low multi-hazard impact, likely due to lower population density or reduced exposure to extreme weather events.

Figure 94 (B) illustrates the projected changes in the average annual population affected by multiple hazards (multi-hazard AAL) under an optimistic climate scenario in Malawi. The colour gradient represents anomalies in affected population, with darker shades of blue indicating increased exposure, while grey shades indicate a reduction in hazard impact compared to the baseline (current climate conditions).

Insights from the map:

- **Increase in Affected Population (Dark Green: 1x - 5x Increase)**
  Mchinji, Lilongwe, Lilongwe City, Dedza, Balaka, Machinga, Neno, Mwanza, Blantyre, Blantyre City, Phalombe, Chikwawa, Chiradzulu, Thyolo, and Zomba are projected to experience a significant increase in the number of people affected by multiple hazards, including floods, droughts, landslides, and strong winds.

- **Moderate to High Increases (0.1x – 0.5x Increase)**
  Mzimba, Nkhotakota, Chitipa, Ntcheu and Dowa show moderate increases in hazard impact.
- **Slightly Reduced Impacts (White: -0.1x to 0.1x Change)**
  Some districts, particularly in Central Malawi, show minimal changes in projected exposure, suggesting that hazards may remain at similar levels to the present climate scenario.
- **Reduction in Hazard Impacts (Grey Shades: -10.5 to -0.1x Decrease)**
  Rumphi, Nkhatabay, Ntchisi and Mangochi show a reduction in the projected number of people affected, possibly due to less severe climate impacts, improved resilience measures, or reduced hazard frequency in these regions.

Figure 94 (C) presents anomalies in the average annual population affected by multiple hazards (multi-hazard AAL) under a pessimistic climate scenario in Malawi. The color gradient represents changes in affected populations, where:
Dark blue and green shades indicate a significant increase in hazard exposure (>10x rise).
Lighter shades of blue suggest moderate increases (1x - 10x rise).
Grey shades indicate a reduction in hazard exposure compared to current conditions.

Insights from the map:

- **Drastic Increase in Hazard Exposure (5x – 10xIncrease)**
  Karonga, Mzuzu City, Kasungu, Lilongwe, Lilongwe City, Salima, Dedza, Ntcheu, Balaka, Machinga, Zomba, Zomba City, Blantyre, Blantyre City, Mwanza, Chikwawa, Thyolo, and Chiradzulu exhibit substantial increases in hazard exposure.
- **Moderate Increases in Affected Population (1x - 10x Increase)**
  Mchinji, Neno, Nsanje, and Chitipa show notable increases in multi-hazard exposure, indicating that more people will be vulnerable to climate-related disasters.
- **Slightly Reduced Impacts (-0.1x to 0.1x Change)**
  Mzimba, Dowa, Ntchisi, Mangochi, Mulanje and Phalombe indicate relatively stable hazard exposure, possibly due to existing resilience measures or unchanged hazard frequencies.

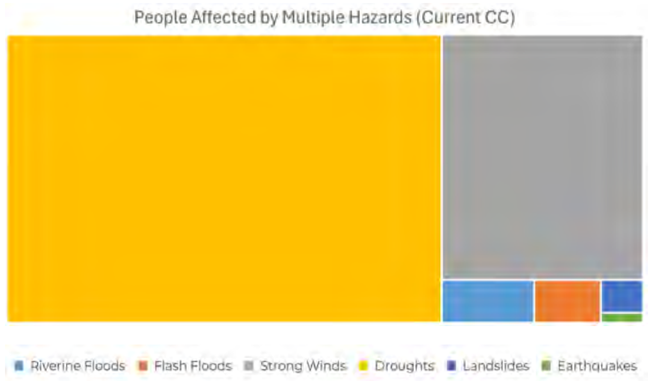


Figure 95. Proportion of Affected population (AAL) for different hazards.

Key Messages:

High Vulnerability to Multi-Hazard Events:
The figure shows that the southern and central regions of Malawi have the highest number of people annually affected on average by multiple hazards, particularly in districts like Blantyre, Mangochi, and Lilongwe. Droughts and Strong Winds are the most impactful, followed by riverine floods and landslides. The vulnerability is amplified in these densely populated areas, highlighting the need for targeted risk reduction and resilience measures.

Geographical Concentration of Risk:
The southern and central regions, especially districts such as Chikwawa, Salima, and Mangochi, have the highest exposure to multiple hazards. The current climate scenario map highlights a significant concentration of affected populations in these areas, calling for focused and localized disaster management strategies.

Escalating Risk Under Climate Change:
Under both optimistic and pessimistic climate scenarios, the affected population is projected to increase significantly in southern districts such as Chikwawa and Nsanje. The pessimistic scenario indicates up to a tenfold increase in affected populations, underscoring the urgency for adaptive measures, especially in high-risk areas.

C1 - Direct Economic Loss Attributed to Disasters
Multi-hazard Risk Assessment

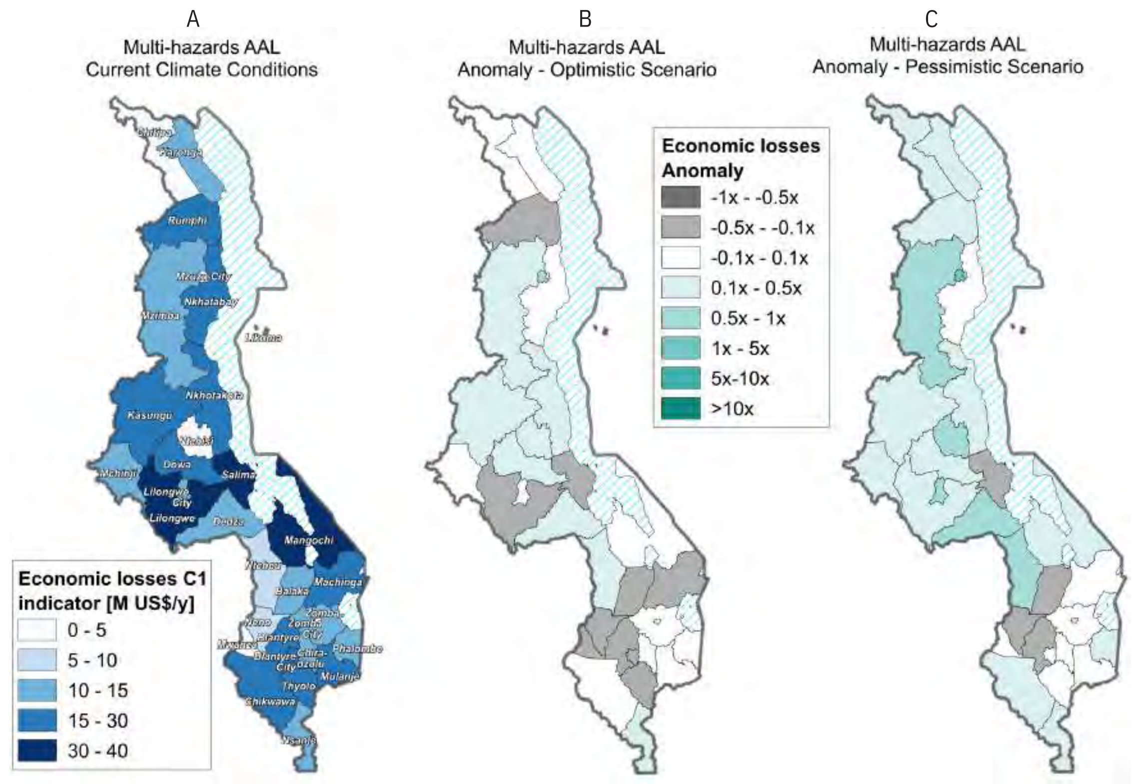


Figure96. Average Annual Economic Losses Derived from Multiple Hazards in Current and Projected Climate Scenarios.

Figure 96 (A) presents the estimated average annual economic losses (AAL) due to multiple hazards (such as floods, droughts, strong winds, and landslides) under current climate conditions in Malawi.
The economic losses are expressed in millions of US dollars per year (M US$/y), with a colour gradient representing the severity of financial losses across districts.

Insights from the map:

- **High Economic Loss Areas (Dark Blue: 30 - 40 M US$/y)**
  Mangochi, Lilongwe and Salima experience the highest annual economic losses due to multiple hazards.
- **Moderate Economic Loss Areas (Medium Blue: 15 -30 M US$/y)**
  Nkhotakota, Nkhatabay, Rumphi, Kasungu, Nkhotakota, Dowa, Machinga, Blantyre, Blantyre City, Chikwawa, Thyolo, and Mulanje experience moderate economic losses, likely due to flood risks, strong winds, and localized landslides.
- **Lower Economic Loss Areas (Light Blue: 10- 15 M US$/y)**
  Mzimba, Mchinji, Dedza, Zomba, Chiradzulu, Nsanje and Phalombe experience relatively lower annual losses.
- **Minimal Loss Areas (White: 0 - 5 M US$/y)**
  Chitipa, Ntchisi, and Mwanza where economic losses remain below 5 million US$ per year.

Figure 96 (B) presents the expected changes in average annual economic losses (AAL) due to multiple hazards (such as floods, droughts, strong winds, landslides, and earthquakes) under an optimistic climate scenario for Malawi. The figure represents the economic losses anomaly, which highlights the projected increase or decrease in losses compared to the current climate conditions.

Insights from the map:

- **Increase in Economic Losses (Areas: -1x to -0.5x)**
  Mzimba, Kasungu, Nkhotakota, Ntchisi, Dowa, Dedza, Ntcheu and Nsanje indicating possible increase of losses due to extreme weather events under an optimistic scenario.

- **Areas of Uncertainty (White Areas: -0.1x to -0.1x)**
  Karonga, Chitipa, Nkhatabay, Mchinji, Lilongwe City, Mangochi, Chikwawa, Zomba, Mulanje and Phalombe no projected change in economic losses.
- **Reduction in Economic Losses (Gray Areas: -0.5x to -0.1x)**
  Rumphi, Lilongwe, Salima, Balaka, Machinga, Neno, Mwanza, Blantyre, Blantyre City and Thyolo show a decline in projected losses, indicating possible reduced impacts of extreme weather events under an optimistic scenario.

Figure 96 (C) presents the projected changes in average annual economic losses (AAL) due to multiple hazards (floods, droughts, strong winds, landslides, and earthquakes) under a pessimistic climate scenario for Malawi. The economic losses anomaly indicates how losses increase or decrease relative to the current climate conditions.

Insights from the map:

- **Increase in Economic Losses (0.5x - 1x)**
  Mzimba, Ntchisi, Lilongwe City, Dedza and Ntcheu experience notable increases in economic losses.
- **Moderate Economic Loss Growth in Most Areas (Light Blue Areas: 0.1x – 0.5x)**
  Many districts, Chitipa, Karonga, Rumphi, Kasungu, Mchinji, Lilongwe, Dowa, Nkhotakota, Mangochi, Chikwawa, Nsanje and Phalombe will experience a slight to moderate increase in economic losses, indicating progressive climate-induced damages.
- **Some Areas with Minimal Change or Slight** Reductions (Gray Areas: -1x to -0.1x)
  A few districts, like Salima, Balaka, Neno, and Blantyre will have minimal reduction in economic losses.

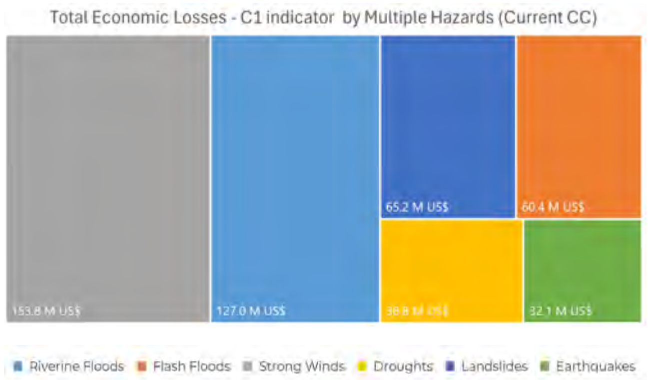


Figure 97. Overall economic loss (AAL) for different hazards.

Key Messages:

Substantial Economic Impact of Multi-Hazards:
Multi-hazard events result in substantial economic impacts, particularly affecting the housing sector. Annual losses are projected to increase under more extreme climate scenarios, with wind and riverine floods being the primary contributors, followed by landslides and flash floods.

Sectoral and Regional Disparities in Economic Loss:
Economic losses are concentrated in the housing sector, especially in areas like Lilongwe, Mangochi and Salima which bear the largest share of losses in absolute terms. Sector-specific mitigation is needed to address the unique vulnerabilities across regions.

Projected Increase in Economic Losses:
Under pessimistic climate scenarios, total economic losses could rise to $557 million annually, with the housing sector contributing the largest share. The largest changes are concentrated in Central and Northern Malawi. This projection underscores the need for significant investments in disaster-resilient housing and infrastructure to mitigate future economic damages.

Multi-hazard Risk Assessment

Sendai Indicator	Multi-hazard Risk Assessment	AAL value	OPT[1]	PES[2]
C1 **[M US$]**	**Direct economic loss attributed to disasters** (as sum of C2, C3, C4, and C5 in the following)	**596.6**	**613.2**	**672.2**
C2 [M US$]	Direct agricultural loss attributed to disasters*	159.7	207.3	164.7
C3 [M US$]	Direct economic loss to all other damaged or destroyed productive assets attributed to disasters	20.1	20.3	23.8
C4 [M US$]	Direct economic loss in the housing sector attributed to disasters	409.2	376.5	473.2
C5 [M US$]	Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters	7.6	9.0	10.4

* Losses due to landslides with areas >5 ha are considered for both Current climate conditions and projected climate conditions, meanwhile Earthquake AAL are considered the same in projected scenarios

[1] C2 is only computed for Riverine Floods and Droughts;
[2] C5 considers Hospitals, Schools and Government buildings as critical infrastructure; additionally, damages to roads have been considered but only for the case of Riverine Floods.

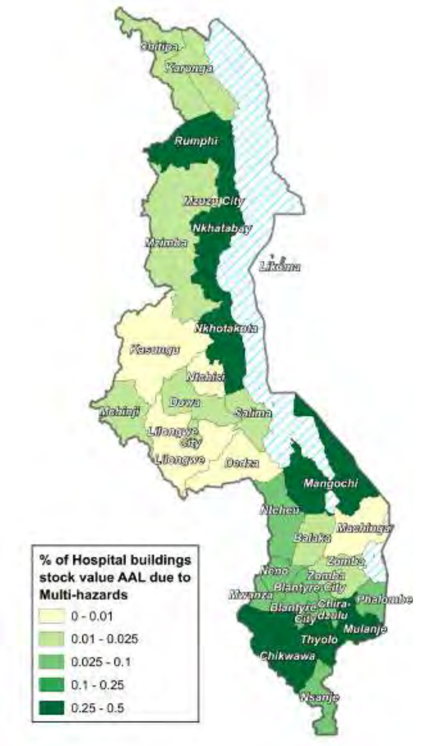
Key Messages:

Critical Exposure Across Multiple Sectors:
The Table shows a broad distribution of economic losses across various sectors, with the housing sector being the most vulnerable. The total annual loss under current conditions is already high at $477.2 million, highlighting the critical need for comprehensive risk reduction across all sectors.

Growing Risks to Agricultural and Critical Infrastructure:
The agricultural sector and critical infrastructure, including hospitals and schools, are increasingly at risk, with projected losses expected to rise under more extreme climate scenarios. This points to the necessity for targeted interventions that enhance the resilience of these essential sectors.

Need for Adaptive Sectoral Planning:
The varying levels of risk across different sectors suggest that a one-size-fits-all approach to disaster risk management is insufficient. Adaptive planning that considers the specific vulnerabilities and needs of each sector, particularly housing, agriculture, and critical infrastructure, is essential for effective risk mitigation.

D - Damage to Critical Infrastructures, Including Basic Services
Multi-hazard Risk Assessment



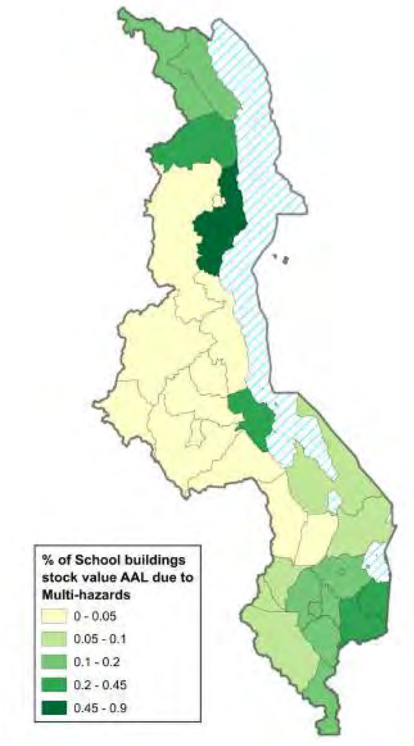


Figure 98. Average Annual Healthcare Buildings Affected by Multi-Hazards.

Figure 99. Average Annual Schools Affected by Multi-Hazards.

Figure 98 illustrates the average annual loss (AAL) of hospital building stock value in Malawi due to multiple hazards, including floods, droughts, strong winds, landslides, and earthquakes.
The map highlights areas where healthcare infrastructure is at risk, quantified as a percentage of total hospital building stock value affected annually.

Insights from the maps:

- **High-Risk Areas (Dark Green: 0.25% - 0.5%)**
  Rumphi, Nkhotakota, Mangochi, Thyolo, Mulanje, Thyolo, and Chikwawa show high levels of hospital building stock affected annually.
- **Moderate to Low-Risk Areas (Light Green to Yellow: 0.01% - 0.25%)**
  Neno, Mwanza, Blantyre, Chiradzulu, Phalombe, and Ntcheu fall in the moderate risk category, with a small fraction of hospital building stock affected annually.
- **Lower Risk area (0.01 – 0.025%)**
  Chitipa, Karonga, Mzimba, Mchinji, Dowa, Salima, Balaka, and Zomba experience lower risk of hospital buildings stock value Aal due to multi-hazards.
- **Minimal Risk Areas (Pale Yellow: 0 - 0.01%)**
  Kasungu, Ntchisi, Lilongwe and Machinga experience minimal impact on healthcare buildings.

Figure 99 presents the percentage of education building stock value affected annually (AAL) due to multiple hazards in Malawi. The multi-hazards considered in the analysis likely include floods, droughts, strong winds, landslides, and earthquakes, which have varying impacts on school infrastructure.

Insights from the map:

- **High-Risk Areas (Dark Green: 0.45% - 0.9%)**
  Nkhatabay faces the highest annual percentage loss in school buildings due to multiple hazards.
- **Moderate High Risk Areas (Light to Medium Green: 0.2% - 0.45%)**
  Schools in Thyolo, Phalombe, Salima and Rumphi are at moderate risk, experiencing some level of building damage every year.
- **Low Risk Areas (Green: 0.1 – 0.2)**
  Chitipa, Karonga, Zomba, Blantyre, Chiradzulu, Thyolo and Nsanje exhibit low risk of schools building stock value due to multi-hazards.
- **Moderate Low-Risk Areas (Green: 0.05% - 0.1%)**
  Mangochi, Machinga, Neno, Mwanza and Chikwawa show relatively low risk levels.

Key Messages:

Vulnerability of Essential Services to Multi-Hazard Events:
Schools and hospitals are increasingly susceptible to multiple hazards, especially in flood- and wind-prone regions, causing significant disruptions to education, healthcare, and transportation, particularly in rural areas.

Disparities in Infrastructure Resilience:
The vulnerability of infrastructure is not uniform, with districts in southern Malawi and along Lake Malawi facing higher risks due to older, less resilient infrastructure. Upgrading these assets is crucial to enhance resilience.

Projected Increase in Infrastructure Damage Under Climate Change:
Even if the figures refer to present climate conditions the study indicates a potential rise in the frequency and severity of extreme weather events, leading to increased damage to critical infrastructures under climate change projections. This trend emphasizes the urgency of strengthening infrastructure resilience, particularly in high-risk districts, to ensure the continuity of essential services during and after disaster events.

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Social Vulnerability Assessment
Multi-hazard Risk Assessment

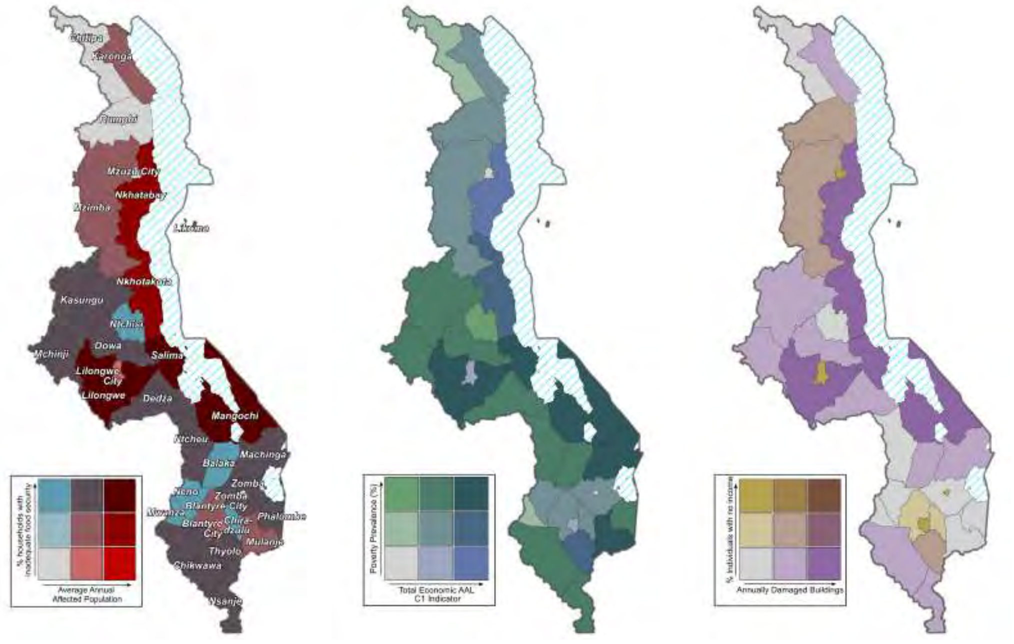


Figure 100. Combined Map of Average Total Population Affected Annually (AAL) with a Food Security Indicator.

Figure 101. Combined Map of Total Economic AAL on Built-Up Sector and Poverty Prevalence Indicator.

Figure 102. Combined Map of Annually Damaged Buildings with an Economically Inactive Population Indicator.

Figure 100 integrates multi-hazard exposure (AAL) with household food security across Malawi. It provides insights into the relationship between disaster vulnerability and food insecurity, helping to identify areas requiring urgent interventions.

Insights from the map:

- **High Multi-Hazard Risk & Severe Food Insecurity (Dark Brown Areas)**
  Districts such as Mangochi, Lilongwe, and Salima are at high risk due to frequent exposure to hazards (e.g., floods, droughts, strong winds).
  These districts show a high percentage of households experiencing food insecurity, indicating that disasters directly contribute to food shortages.
- **High Multi-Hazard Risk & moderate Food Insecurity (Dark Red Areas)**
  Districts such as Nkhatabay and Nkhotakota, are at high risk due to frequent exposure to hazards (e.g., floods, droughts, strong winds).
  These districts show moderate high percentage of households experiencing food insecurity, indicating that disasters directly contribute to food shortages.
- **Low Hazard Risk & High Food Insecurity (Blue Areas)**
  Chiradzulu, Neno, Mwanza, Balaka and Ntchisi have High food insecurity and low average annual affected population.
- **Moderate Hazard Risk & High Food Insecurity (Brown)**
  Ntchisi, Dowa, Zomba, Thyolo, Chikwawa, Nsanje Mchinji, Kasungu, Dowa, Phalombe, and Machinga have high food insecurity and moderate average annual affected population.
- **Low Hazard Risk & Lower Food Insecurity (Grey Areas)**
  Chitipa and Karonga show lower hazard exposure and relatively better food security.

Figure 101 presents a combined assessment of total economic losses (AAL) in the built-up sector and poverty prevalence across districts in Malawi. The AAL (Average Annual Loss) is derived from multiple hazards such as floods, strong winds, droughts, and earthquakes, while the poverty prevalence indicator reflects socio-economic vulnerability.

Insights from the map:

- **High Economic Losses & High Poverty (Dark Green Areas)**
  Mulanje, Machinga, Mangochi, Salima and Lilongwe experience both high economic losses and high poverty prevalence.
- **Moderate Economic Losses & Moderate Poverty (Mid-Green & Mid-Blue Areas)**
  Kasungu, Mchinji, Dowa, Dedza, Ntcheu, Balaka, Chikwawa, Nsanje and Phalombe experience moderate hazard-related economic losses but still face high poverty rates.
- **Low Economic Losses & Low Poverty (Light Green & Light Blue Areas)**
  Neno, Blantyre, Chiradzulu, Mzimba, Karonga and Zomba in show moderate economic losses and moderate lower poverty levels.

The Figure 102 combines the average annual number of buildings damaged by multi-hazards (excluding landslides) with the economically inactive population indicator (percentage of the population with no income). The visualisation provides insights into districts where physical vulnerability to hazard-induced damages intersects with economic inactivity, highlighting areas with compounded socio-economic challenges.

Insights from map:

- **High Building Damage & High Economic Inactivity (Brown Areas)**
  Blantyre City, Mzuzu City and Lilongwe City have both high levels of building damage and a high individual with no income which are the most vulnerable.
- **Moderate Building Damage & Moderate Economic Inactivity (Mid-Brown)**
  Blantyre, Chiradzulu, Mzimba and Rumphi experience moderate levels of both building damage and economic inactivity.
- **Low Building Damage & Low Economic Inactivity (Purple Areas)**
  Lilongwe, Nkhatabay, Nkhotakota, Salima and Mangochi are the vulnerable, as they have lower exposure to hazards and a higher percentage of the individual without income.
- **Lower Building Damage & Lower Economic Inactivity (Light Purple Areas)**
  Karonga, Kasungu, Mchinji, Dowa, Dedza, Balaka, Machinga, Chikwawa and Nsanje are the vulnerable, as they have lower exposure to hazards and a higher percentage of the individual without income.
- **Lowest Building Damage & Low Economic Inactivity (Grey)**
  Chitipa as well as some district in the south present a low level of risk combined with a low level of economic inactivity.

Key Messages:

Socio-economic Vulnerabilities Amplify Risk:
The analysis of risk figures in relation to socio-economic vulnerability factors shows that there are areas with high poverty rates, food insecurity, and economic inactivity that are also severely impacted by natural hazards. This is the case of Central and Southern Malawi Districts and specifically Lilongwe, Salima, Mangochi, Nsanje, Thyolo and Chikwawa. These intersecting vulnerabilities amplify the long-term effects of Natural hazards by acting on fragile communities and enhancing secondary effects, making recovery more difficult and increasing the long-term impact on affected communities.

Geographical Hotspots of Vulnerability:
The maps highlight specific geographical hotspots where socio-economic vulnerabilities and natural hazard risks converge. These areas require focused interventions that address both the physical risks of natural hazards and the socio-economic conditions that exacerbate their impact.

Need for Integrated Risk Reduction Strategies:
The relationship between socio-economic vulnerability and hazard risk underscores the need for integrated risk reduction strategies that combine disaster risk management with socio-economic development. Enhancing social safety nets, improving access to education and healthcare, and fostering economic opportunities are crucial to building resilience in the most vulnerable communities.

Recommendations
Multi-hazard Risk Assessment

Develop and Implement Multi-Hazard Risk Management Frameworks:
Establish comprehensive multi-hazard risk management frameworks that integrate risk assessments, early warning systems, and disaster response plans tailored to the compound nature of natural hazards in Malawi. These frameworks should prioritize high-risk regions, particularly in southern and central Malawi, where the intersection of multiple hazards poses the greatest threat.

Strengthen Resilience in Key Sectors and Infrastructure:
Focus on enhancing the resilience of the housing sector and critical infrastructure, which are most vulnerable to multi-hazard impacts. This includes updating building codes, promoting the use of climate-resilient materials, and investing in the retrofitting of existing structures. Special attention should be given to agricultural resilience, as this sector is critical for food security and livelihoods in rural areas.

Enhance Planning at each level for Climate Resilience:
Incorporate climate projections into urban planning processes at all levels from regional to local, ensuring that new developments are designed to withstand the compounded effects of multiple hazards. Prioritize investments in resilient infrastructure in high-density urban areas, where potential losses are most concentrated.

Target Vulnerable Populations with Tailored Interventions:
Direct resources and efforts towards the most vulnerable populations, particularly those in regions with high poverty rates and low economic activity. Tailored interventions should address both the physical risks posed by natural hazards and the underlying socio-economic vulnerabilities that exacerbate their impact.

Invest in Long-Term Resilience and Adaptation Measures:
Allocate significant long-term investments towards resilience and adaptation measures that can mitigate the impact of future disasters caused by natural hazards. This includes enhancing early warning systems, improving community preparedness, and fostering sustainable land-use practices that reduce vulnerability to floods, droughts, and strong winds. This does not mean that short-term and medium-term investments should be overlooked, on the contrary they should be synergised with the long-term ones to ensure a comprehensive approach.

Promote Data-Driven Decision Making and Regular Updates to Risk Assessments:
Improve data collection and monitoring systems to better understand the risks posed by multiple hazards. Regularly update risk assessments to reflect new data and emerging trends, ensuring that risk management strategies remain relevant and effective in the face of changing climate conditions. In this context continuous capacity building should be provided especially at district and local level, as well as investments in hardware and software enabling the continuous improvements of tools and studies.


Earthquake hit Malawi - DoDMA

Table 7. Data sources for the Study

DATA TYPE / USE	DATASET	REFERENCE
HAZARD ASSESSMENT **Further details on the results concerning hazard assessment can be found in the technical report "Hazard Scenarios for the Comprehensive Multi- Hazard Risk Assessment of Malawi"**		
CLIMATE ANALYSIS **(feeding hydrological modelling, flash flood hazard assessment, strong wind hazard assessment, drought hazard assessment)**		
Climate data - reanalysis	W5E5 Meteo Dataset	https://dataservices.gfz-potsdam.de/pik/showshort. php?id=escidoc:4855898
Climate data – climate projections	ISIMIP3b dataset (SSP126/ IPSL-CM6A-LR and SSP585/ IPSL-CM6A-LR scenarios)	https://www.isimip.org/about/#simulation-rounds
Digital Surface Model	FAB-DEM (Forest And Buildings removed Copernicus 30m Digital Elevation Model)	https://doi.org/10.1088/1748-9326/ac5c18
HYDROLOGICAL MODELLING (feeding riverine hazard assessment, drought hazard assessment, landslides hazard assessment)		
Flow observations	GRDC (Global Runoff Data Centre) Dataset	https://www.bafg.de/GRDC/EN/01_GRDC/grdc_node. html;jsessionid=96480E84291DE6F4B46D9B623F072E98.live21304
Discharge and level observations from ground stations (Shire basin)	Department of Water Resources (DWR) of Malawi	Internal repository
Digital Elevation Map	MERIT-Hydro database	Yamazaki, D., Ikeshima, D., Sosa, J., Bates, P. D., Allen, G. H., and Pavelsky, T. M.: MERIT Hydro: A High-Resolution Global Hydrography Map Based on Latest Topography Dataset, Water Resources Research, 55, 5053–5073, https://doi.org/10.1029/2019WR024873, 2019.
Soil texture map	SoilGrids Sand Content - SoilGrids Clay Content	Hengl, T., Jesus, J. M. de, Heuvelink, G. B. M., Gonzalez, M. R., Kilibarda, M., Blagotić, A., Shangguan, W., Wright, M. N., Geng, X., Bauer-Marschallinger, B., Guevara, M. A., Vargas, R., MacMillan, R. A., Batjes, N. H., Leenaars, J. G. B., Ribeiro, E., Wheeler, I., Mantel, S., and Kempen, B.: SoilGrids250m: Global gridded soil information based on machine learning, PLOS ONE, 12, e0169748, https://doi.org/10.1371/journal.pone.0169748, 2017.
Lake characteristics	HydroLAKES v1.0 database	Messager, M. L., Lehner, B., Grill, G., Nedeva, I., and Schmitt, O.: Estimating the volume and age of water stored in global lakes using a geo-statistical approach, Nat Commun, 7, 13603, https://doi.org/10.1038/ncomms13603, 2016.
Dam characteristics	Global Reservoir and Dam Database (GRanD v1.3)	Lehner, B., Liermann, C. R., Revenga, C., Vörösmarty, C., Fekete, B., Crouzet, P., Döll, P., Endejan, M., Frenken, K., Magome, J., Nilsson, C., Robertson, J. C., Rödel, R., Sindorf, N., and Wisser, D.: High- resolution mapping of the world's reservoirs and dams for sustainable river-flow management, Frontiers in Ecology and the Environment, 9, 494–502, https://doi.org/10.1890/100125, 2011.
Land use and vegetation coverage	Obtained from ESA-CCI C3S Global Land Cover	Buchhorn, M.; Lesiv, M.; Tsendbazar, N.-E.; Herold, M.; Bertels, L.; Smets, B. Copernicus Global Land Cover Layers—Collection 2. Remote Sens. 2020, 12, 1044. https://doi.org/10.3390/rs12061044
River width and depth	Obtained from global database	Andreadis, K. M., Schumann, G. J.-P., and Pavelsky, T.: A simple global river bankfull width and depth database, Water Resources Research, 49, 7164–7168, https://doi.org/10.1002/wrcr.20440, 2013.
Soil Moisture and Evapotranspiration	GLEAM dataset	https://www.gleam.eu/
RIVERINE HAZARD		
Satellite data for hazard map validation	Global Surface Water dataset, Landsat observations	Pekel, JF., Cottam, A., Gorelick, N. et al. High-resolution mapping of global surface water and its long-term changes. Nature, 540, 418–422 (2016). https://doi.org/10.1038/nature20584
Satellite data for hazard map validation	Copernicus Global Flood Monitoring System	Seewald, M., Riffler, M., Ralser, S., Innerbichler, F., Dulleck, B., Leitner, A., Gruber, C., Schleicher, C., Ziselsberger, M., Mccormick, N. and Salamon, P., Global Flood Monitoring, EUR 31425 EN, Publications Office of the European Union, 2023, ISBN 978-92-76-99709-2, doi:10.2760/362585, JRC131351.
DROUGHT HAZARD AND RISK		
Daily rainfall and temperature records (22 stations – 1982-2022)	National Aeronautics and Space Administration (NASA)	https://power.larc.nasa.gov/data- access-viewer/
Monthly Rainfall Records from Ground stations (1988 – 2022)	Department of Climate Change and Meteorological Services	Internal repository
Monthly Temperature Records from Ground stations (1991 – 2022)	Department of Climate Change and Meteorological Services	Internal repository
LANDSLIDES		
DTM – SRTM (30m resolution)		https://search.as f.alaska.edu/#/
Landuse	GlobCover2009	http://due.esrin. esa.int/page_globcover.php
Soil, Soil Texture, Landform	© ESA 2010 and UCLouvain	https://data.isric.org/geonetwork/srv/eng/catalog. search?uuid=60803da0-a15f-4cc5-9cb5-172fa2460af3#/search?any=malawi
Precipitation	ISRIC, Africa SoilGrids	https://www.wo rldclim.org/data /index.html
Structural Map of Malawi 1:1.000.000 resolution	WorldClim, Global climate and weather data	Internal Repository
Geological Map of Malawi 1:1.000.000 resolution	Department of Geological Survey of Malawi	Internal Repository
Geohazard Map of Malawi 1:1.000.000 resolution	Department of Geological Survey of Malawi	Internal Repository
EARTHQUAKES		
Earthquake catalogue	SSA-GEM	Poggi V, Durrheim R, Mavonga Tuluka G, Weatherill G, Gee R, Pagani M, Nyblade A, Delvaux D (2017) Assessing seismic hazard of the East African Rift: a pilot study from GEM and AfricaArray. Bull Earthq Eng 15(11):4499–4529
Seismic Source characterization	Seismic source characterization for the East African Rie System (EARS)	Poggi V, Durrheim R, Mavonga Tuluka G, Weatherill G, Gee R, Pagani M, Nyblade A, Delvaux D (2017) Assessing seismic hazard of the East African Rift: a pilot study from GEM and AfricaArray. Bull Earthq Eng 15(11):4499–4529
PAST EVENTS		
Disaster events dataset (2000 to 2024)	EM-DAT database	https://www.emdat.be/
Disaster events dataset (1989 to 2018)	Desinventar	https://www.desinventar.net/DesInventar/profiletab. jsp?countrycode=mwi&continue=y
EXPOSURE **Further details on the results concerning exposure modelling can be found in the technical report "Exposure Models and Vulnerability Profiles for the Comprehensive Multi-Hazard Risk Assessment of Malawi"**		
Full reference to data and information used for exposure assessment is reported in a dedicated table within the corresponding section, p. 47.		
VULNERABILITY **Further details on the results concerning vulnerability assessment can be found in the technical report "Exposure Models and Vulnerability Profiles for the Comprehensive Multi-Hazard Risk Assessment of Malawi"**		
Full reference to data and information used for vulnerability assessment is reported in a dedicated table (Table 4) within the corresponding section, pp. 52-53.		

District Level Risk Atlases

Organization of the District Atlases

The following sections provide a concise overview of the various elements contributing to the multi-risk assessment of each district in Malawi.

The content is structured to include:

District Overview:
A brief description of each district's geographical location, including any relevant geographical features that may influence risk assessments. This includes the district's size and its role within the broader context of Malawi, providing a basis for understanding its specific vulnerabilities and risks.

Stock Analysis:
The economic stock indicators include the value of the built environment, the number of schools and healthcare facilities, and key agricultural crops within each district.

Social Vulnerability Trends:
An analysis of the district's social vulnerability parameters in comparison to the national average. These parameters are weighted according to the population of each district, offering insights into how social factors may exacerbate or mitigate risks.

Key Risk Messages
A summary of the primary risk findings for each district, highlighting the predominant risks, the influence of climate change, and the district's relative exposure to economic losses and population impacts. These findings are compared against national averages, which are represented by dashed lines in the accompanying figures.

Following the textual descriptions, tables are provided to detail the population, social vulnerability, and economic assets of each district. Social vulnerability is expressed in terms of poverty prevalence, food insecurity, and the percentage of inactive population. These figures are presented both for the individual district and for the nation as a whole, enabling easy comparison.

The results of the single and multi-risk evaluations are presented in both tabular and graphical formats:

Tables:

- The tables outline the average annual losses (AAL) and the average annualized loss ratio (AALR) in economic terms for the built environment across all sectors.
- AAL and AALR specific to road damage caused by riverine floods.
- AAL and AALR associated with crop damage resulting from riverine floods and drought.
- The average annual number of people affected and the corresponding ratios. For earthquakes, this metric reflects the average annual number of homeless people (AAH) and the corresponding average annualized homeless ratio (AAHR).

Graphs:

- The graphs depict the distribution of two key risk indicators: economic losses and population affected, segmented by the hazards considered. These visualizations identify the most significant hazards for each district and indicator.
- In addition, the graphs include Probable Maximum Loss (PML) curves for different risk indicators, providing insight into the potential future impacts of various hazards under different scenarios. The modelling approach adopted for the landslide assessment did not allow the PML to be defined for this hazard.
- Because of its particular nature, Landslide risk has been evaluated with a methodology that does not allow the computation of a PML curve in a format comparable to the one used for the other hazard; the results for landslides are therefore reported only in terms of AAL.

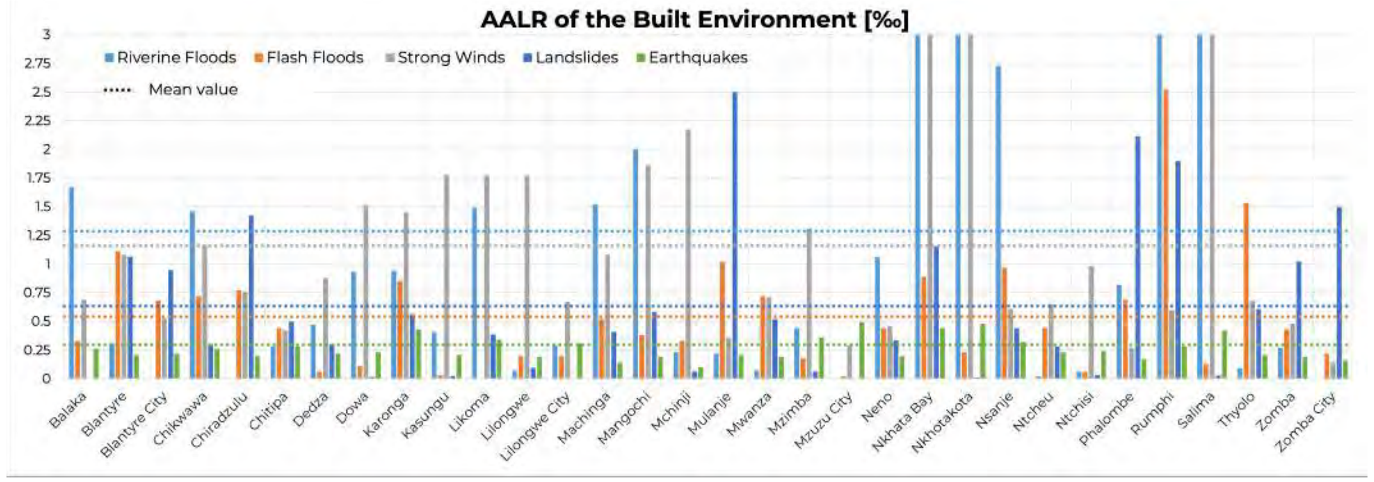


Figure 103. Histograms of the AALR for each district and the mean value for the different hazards, in linear scale.

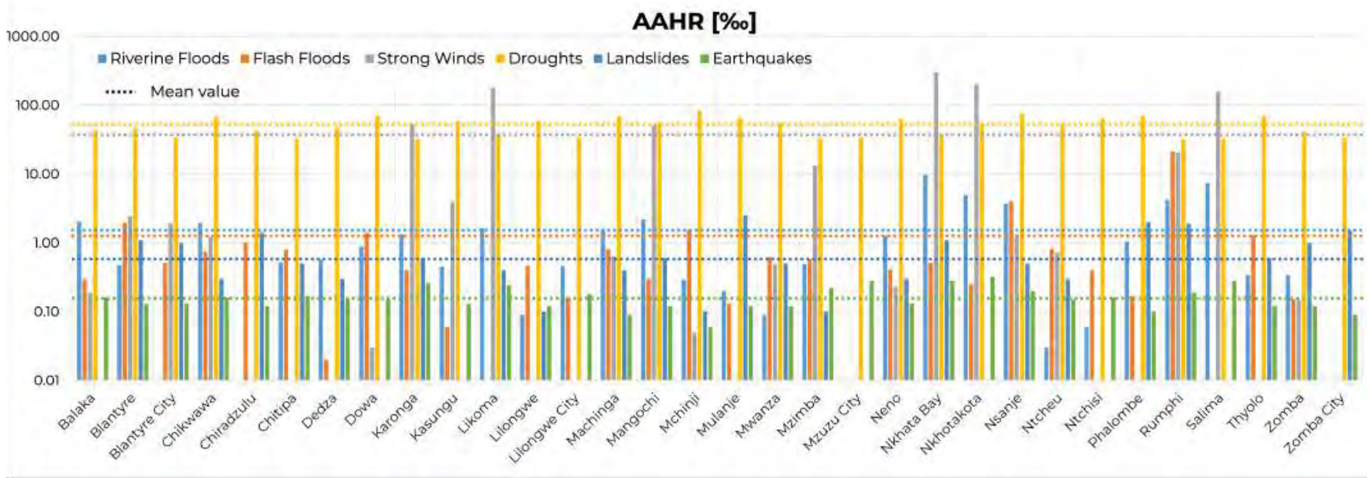


Figure 104. Histograms of the AAHR for each district and the mean value for the different hazards, in logarithmic scale.

Figure 103 (AALR Histogram):
This figure effectively visualizes the economic impact of various hazards across Malawi's districts. The linear scale highlights districts that are particularly at risk, with higher-than-average economic losses. The inclusion of national averages as dashed lines provides a benchmark, making it easier to identify outliers. Districts that consistently exceed the national average for multiple hazards should be prioritized for targeted risk reduction and resilience-building efforts.

Figure 104 (AAHR Histogram):
The logarithmic scale used in this figure is crucial for comparing the relative impact of different hazards on populations. This approach allows for a more nuanced analysis, especially for hazards like wind and drought, which may have significantly different scales of impact. By identifying districts where the population is disproportionately affected, the figure helps to pinpoint areas where social and infrastructural resilience needs to be strengthened. The comparison against the national average further contextualizes these findings, making it clear which districts are most in need of intervention.

BALAKA

Balaka is a district in the Southern Region of Malawi, covering an area of 2,140 km². The district is home to the town of Nkaya, an important urban centre that serves as the junction point for the country's road and rail systems.
Social vulnerability parameters related to poverty and food insecurity are higher than the national average, while the inactive population is lower. Risk evaluation indicates that floods pose the highest risk to the built environment, while drought is affects the population the most. Both flood and drought risks are significantly influenced by climate change projections. The ratio of average annual economic losses due to flooding is higher than the national average, while the average annual number of people affected by drought is lower than the national average, despite the high indicator for drought.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**520 884**	21 500 000 (NSO, 2024)
Ratio on total population (%)	2.42	-
Poverty Prevalence (%)	**63**	51*
Food Insecurity (%)	**72**	64*
Inactive Population (%)	**5**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**3347**	131 953
Ratio on total value (%)	2.54	-
Schools and Hospitals	**198 - 14**	6410 - 671
Ratio on total value (%)	3.09 – 2.09	-
Most important Crops	**Mazie, Cow peas, Groundnuts, Beans, Sweet Potato**	Cassava, Maize, Sweet Potato, Groundnuts

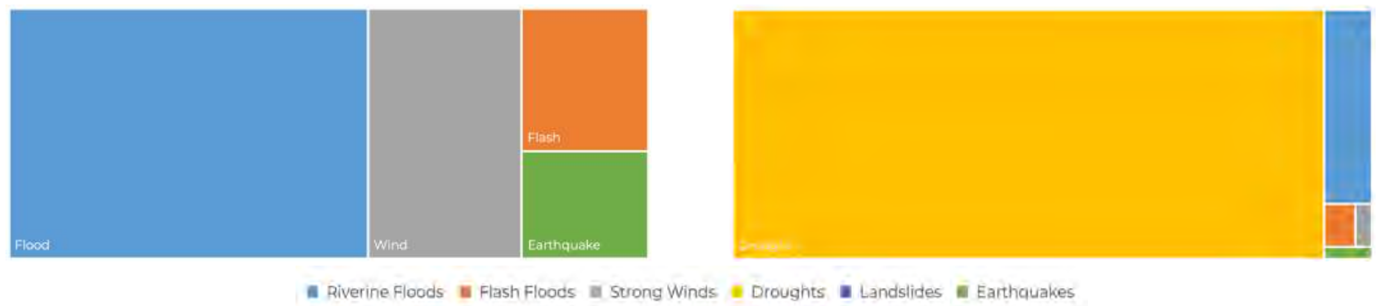
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**10.148**	**-**	**-**	**-**	**-**	**-**	**23 310**	**-**
Riverine Floods	5.725	1.67	0.79	0.22	0.01	-	1359	2.03
Flash Floods	1.152	0.33	-	-	-	-	198	0.29
Strong Winds	2.452	0.69	-	-	-	-	104	0.19
Compound	9.281	-	-	-	-	-	1661	-
Droughts	-	-	-	-	5.709	-	21 565	44
Landslides	0.001	0.0003	-	-	-	-	0.193	0
Earthquakes	0.866	0.26	-	-	-	-	84	0.16

RISK RESULTS – Average Annual Losses CHARTS

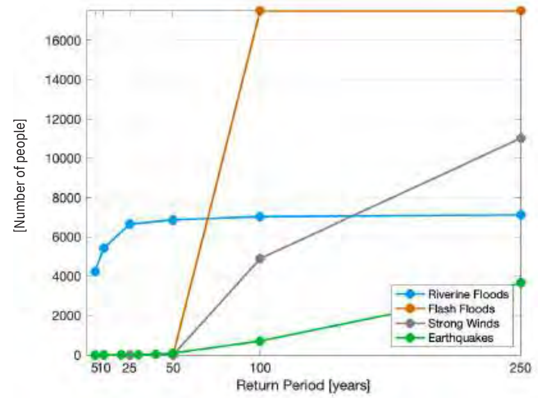
Economic Built - UP

Population

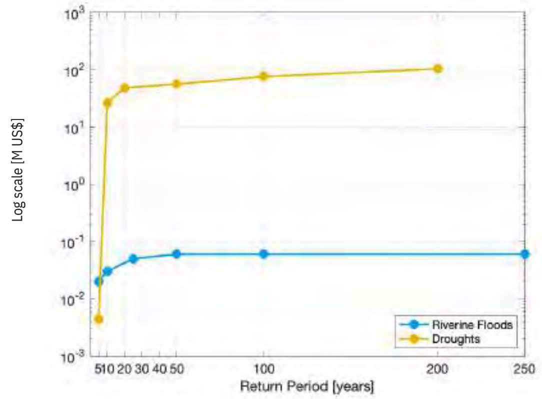


RISK RESULTS – Probable Maximum Losses CURVES

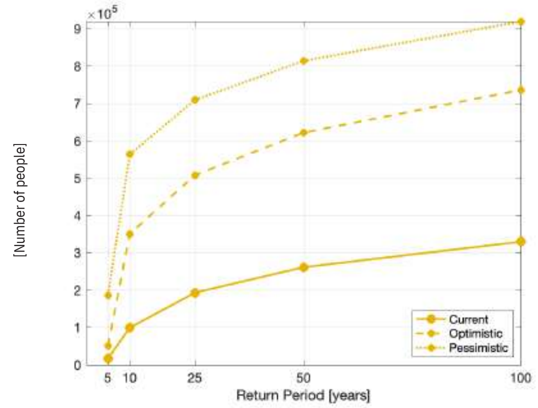
Fast-onset Weather related and Earthquakes - Affected Population



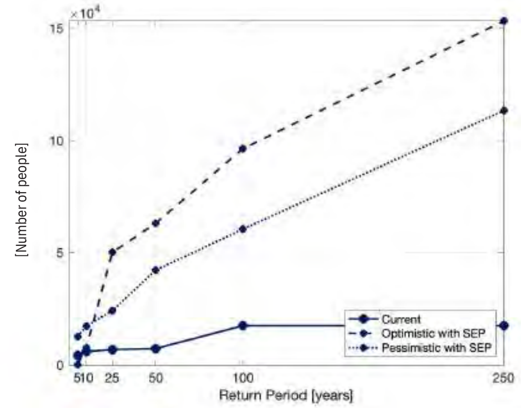
Weather related - Economic Loss



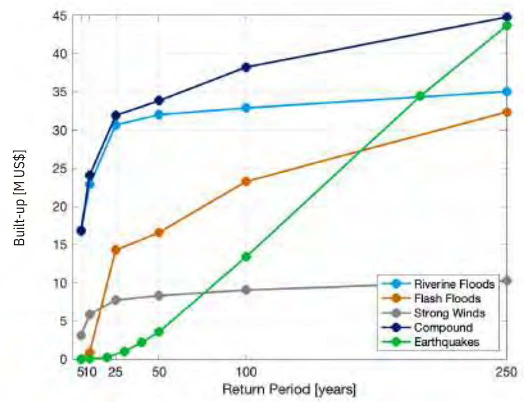
Droughts Projections - Affected Population



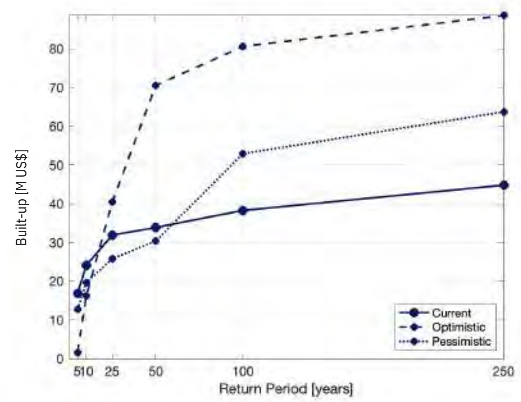
Compound Projections - Affected Population

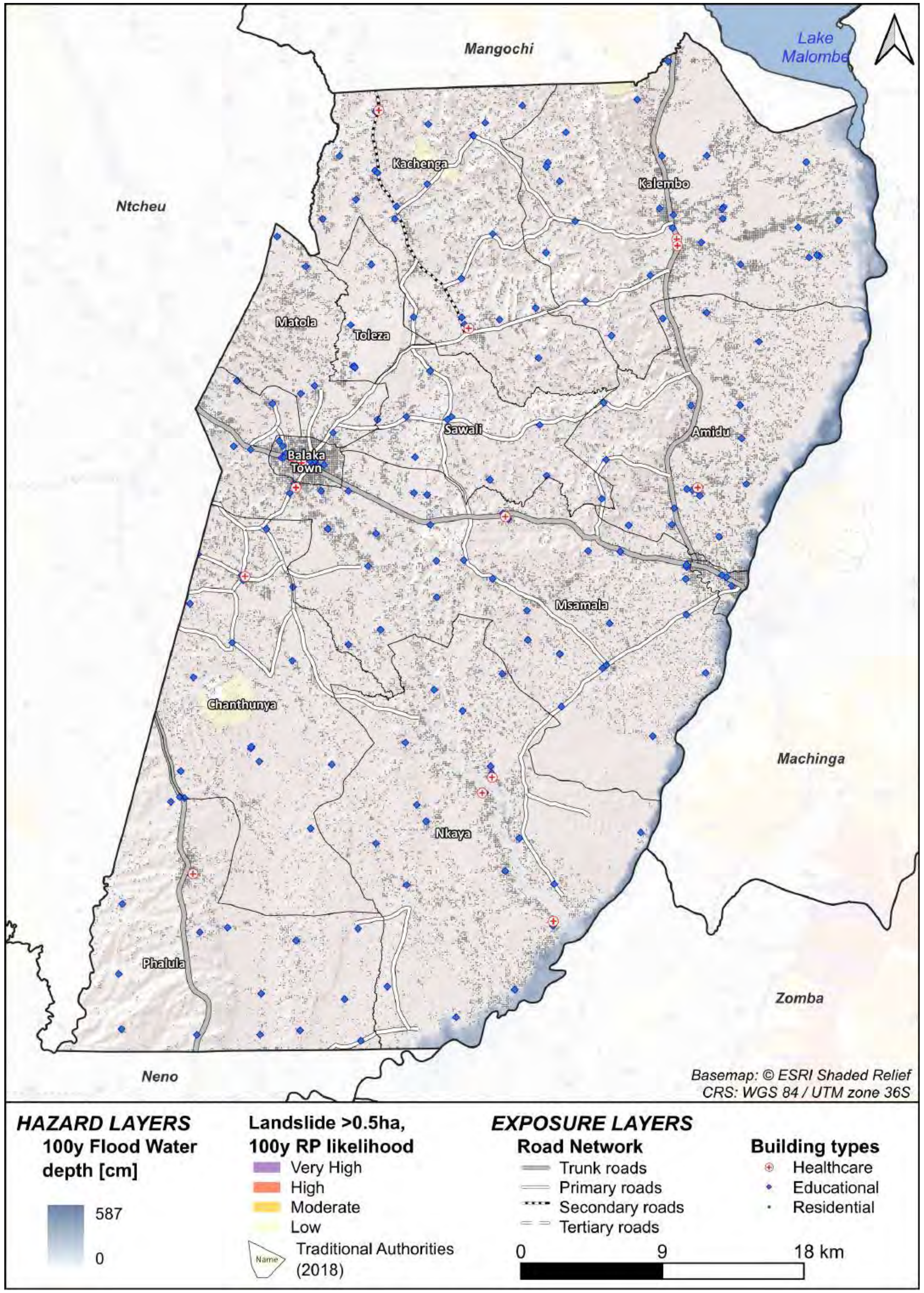


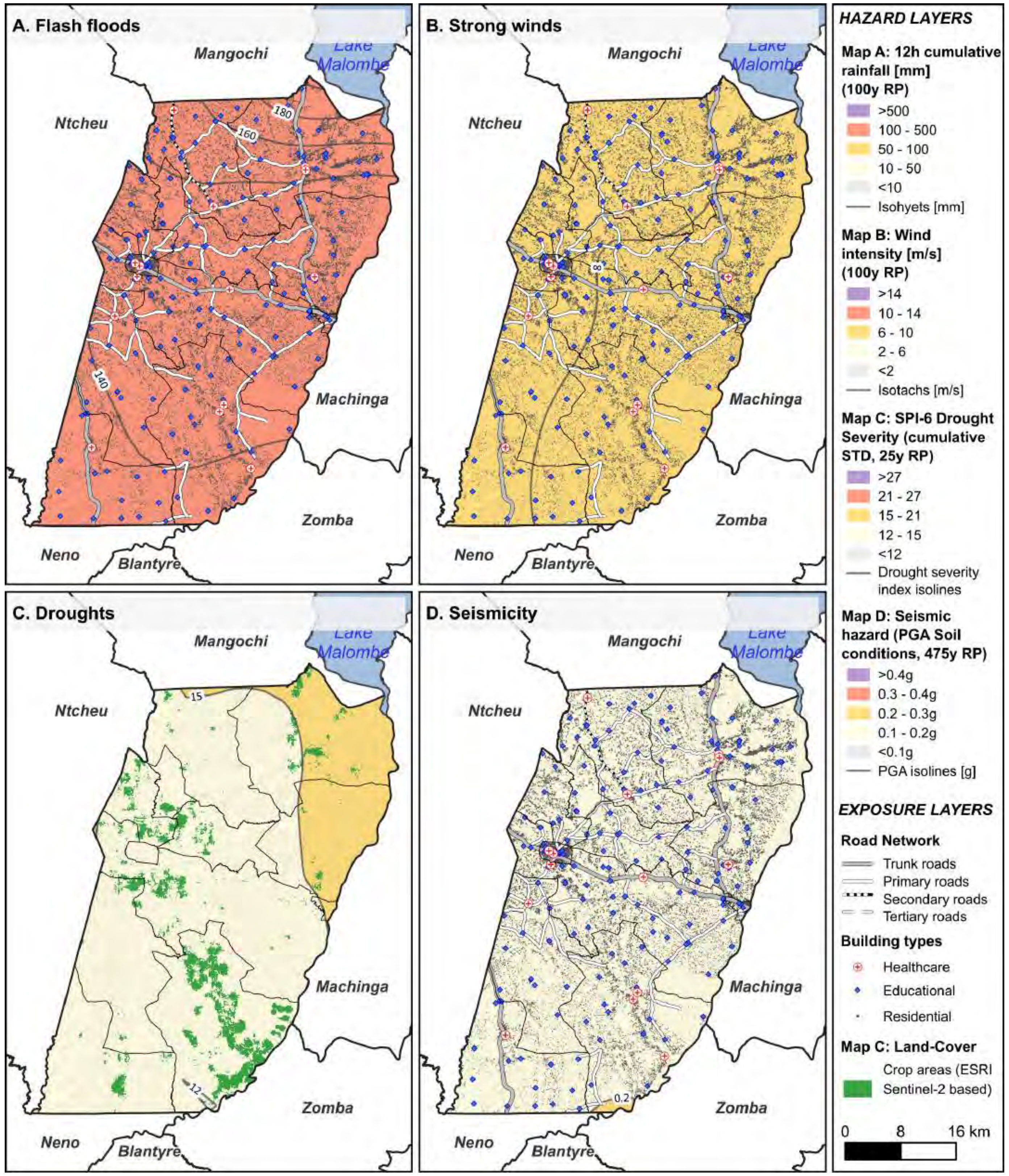
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

BLANTYRE

Blantyre is a district in the Southern Region of Malawi, covering an area of 2,012 km². Social vulnerability parameters related to poverty and food insecurity are lower than the national average, while the inactive population is higher. Drought is the most critical hazard affecting the population, with its severity increasingly influenced by climate change projections. Meanwhile, flash floods, strong winds, and landslides pose equally serious threats to the built environment. The ratio of average annual economic losses due to flash floods and landslides is higher than the national average, while the losses due to strong winds are in line with the national average. The average number of people affected annually by drought aligns with the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**533 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	2.48	-
Poverty Prevalence (%)	**44**	51*
Food Insecurity (%)	**59**	64*
Inactive Population (%)	**13**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**3457**	131 953
Ratio on total value (%)	2.62	-
Schools and Hospitals	**201 – 17**	6410 - 671
Ratio on total value (%)	3.14 – 2.53	-
Most important Crops	**Maize, Pigeon peas, Groundnuts, Sorghum, Cassava, Sweet potatoes**	Cassava, Maize, Sweet Potato, Groundnuts

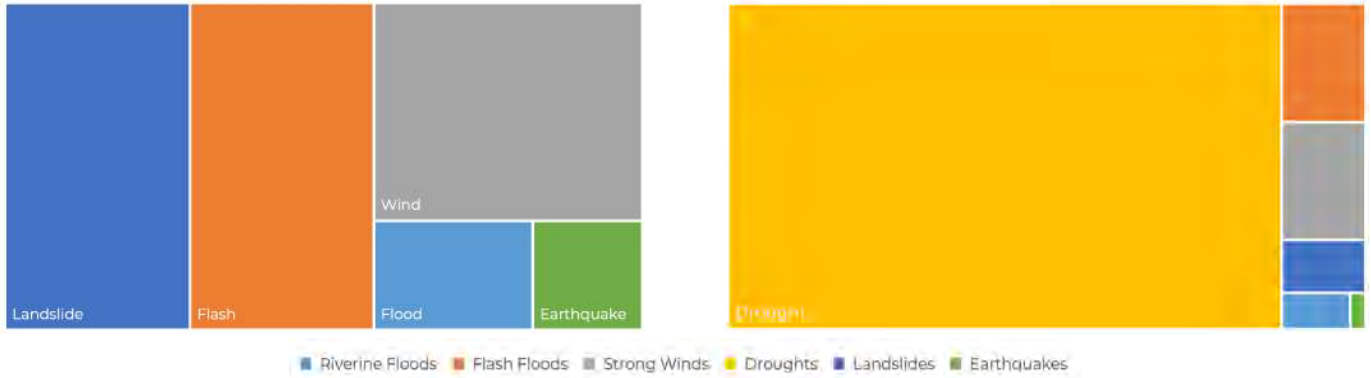
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**12.393**	-	-	-	-	-	**26 328**	-
Riverine Floods	1.038	0.31	0.0004	0.0002	0	-	314	0.47
Flash Floods	3.598	1.11	-	-	-	-	1267	1.95
Strong Winds	3.502	1.081	-	-	-	-	1245	2.44
Compound	8.061	-	-	-	-	-	2809	-
Droughts	-	-	-	-	7.699	-	22 884	47
Landslides	3.617	1.064	-	-	-	-	564	1.1
Earthquakes	0.715	0.21	-	-	-	-	71	0.13

RISK RESULTS – Average Annual Losses CHARTS

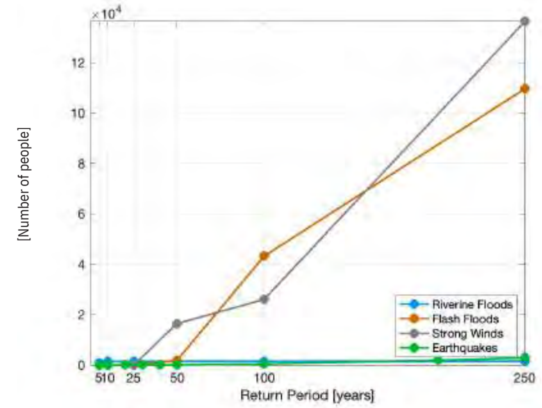
Economic Built - UP

Population

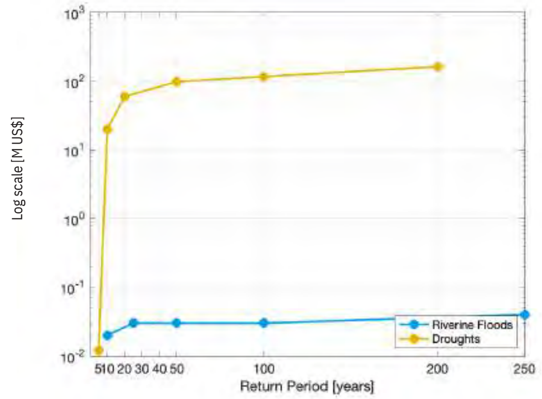


RISK RESULTS – Probable Maximum Losses CURVES

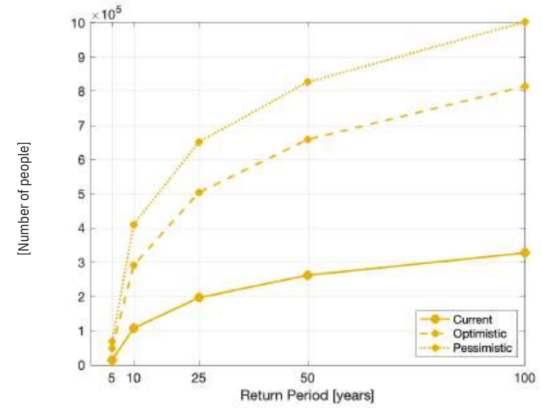
Fast-onset Weather related and Earthquakes - Affected Population



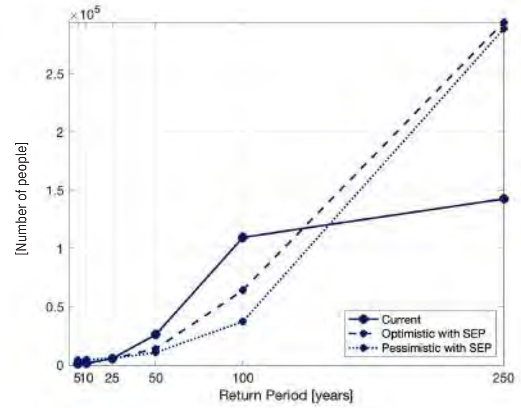
Weather related - Economic Loss



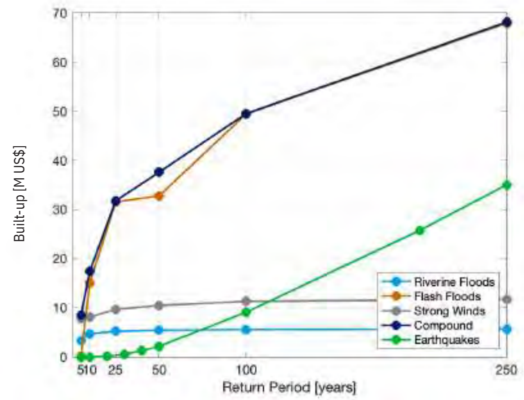
Droughts Projections - Affected Population



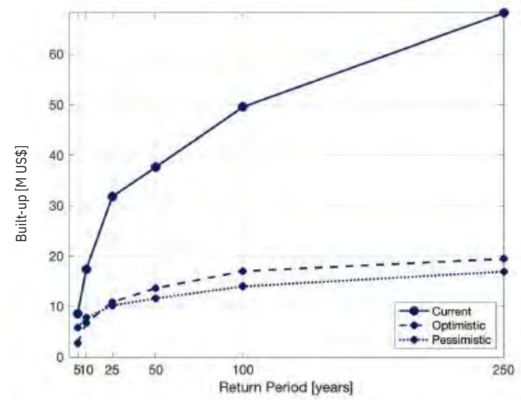
Compound Projections - Affected Population

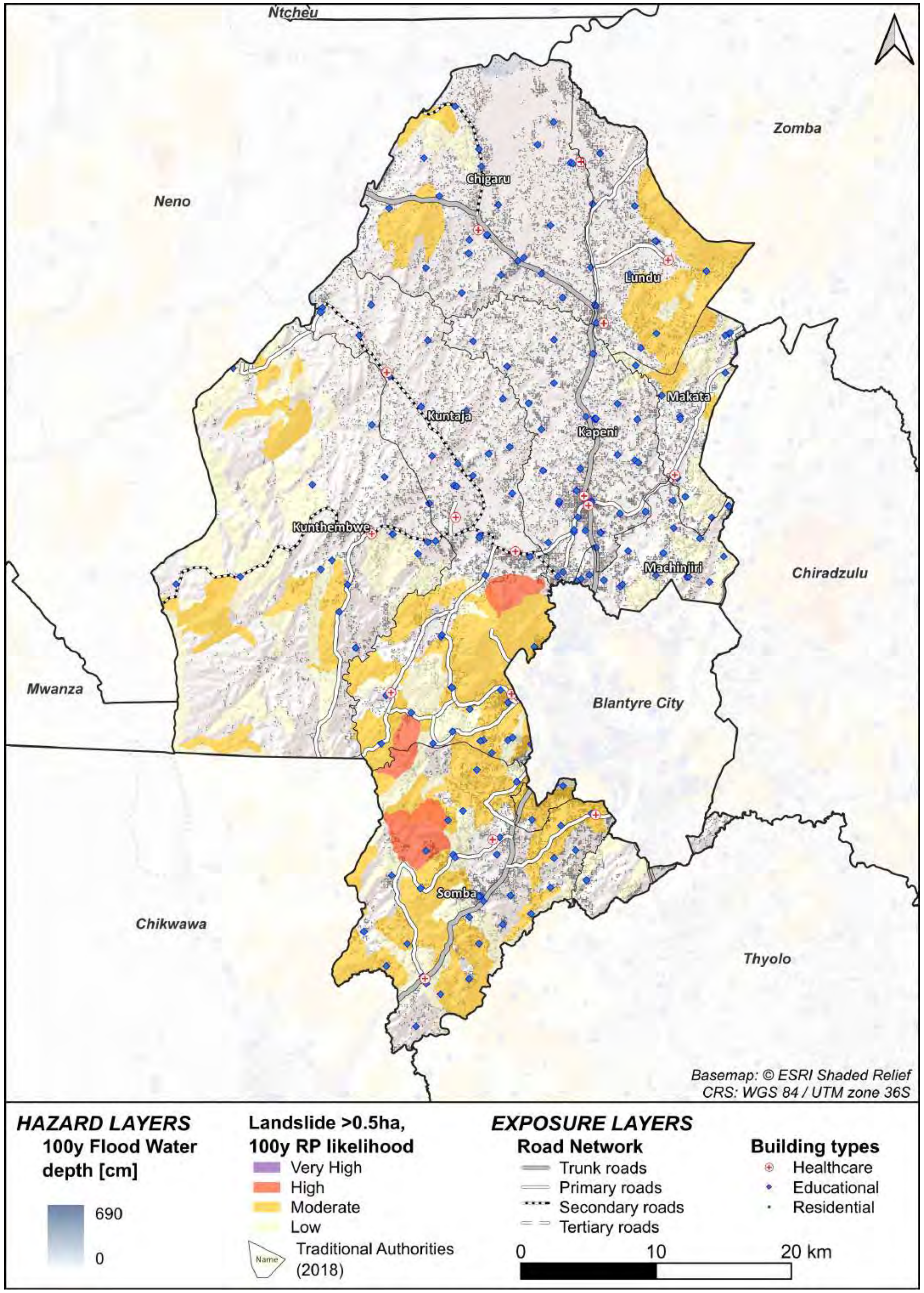


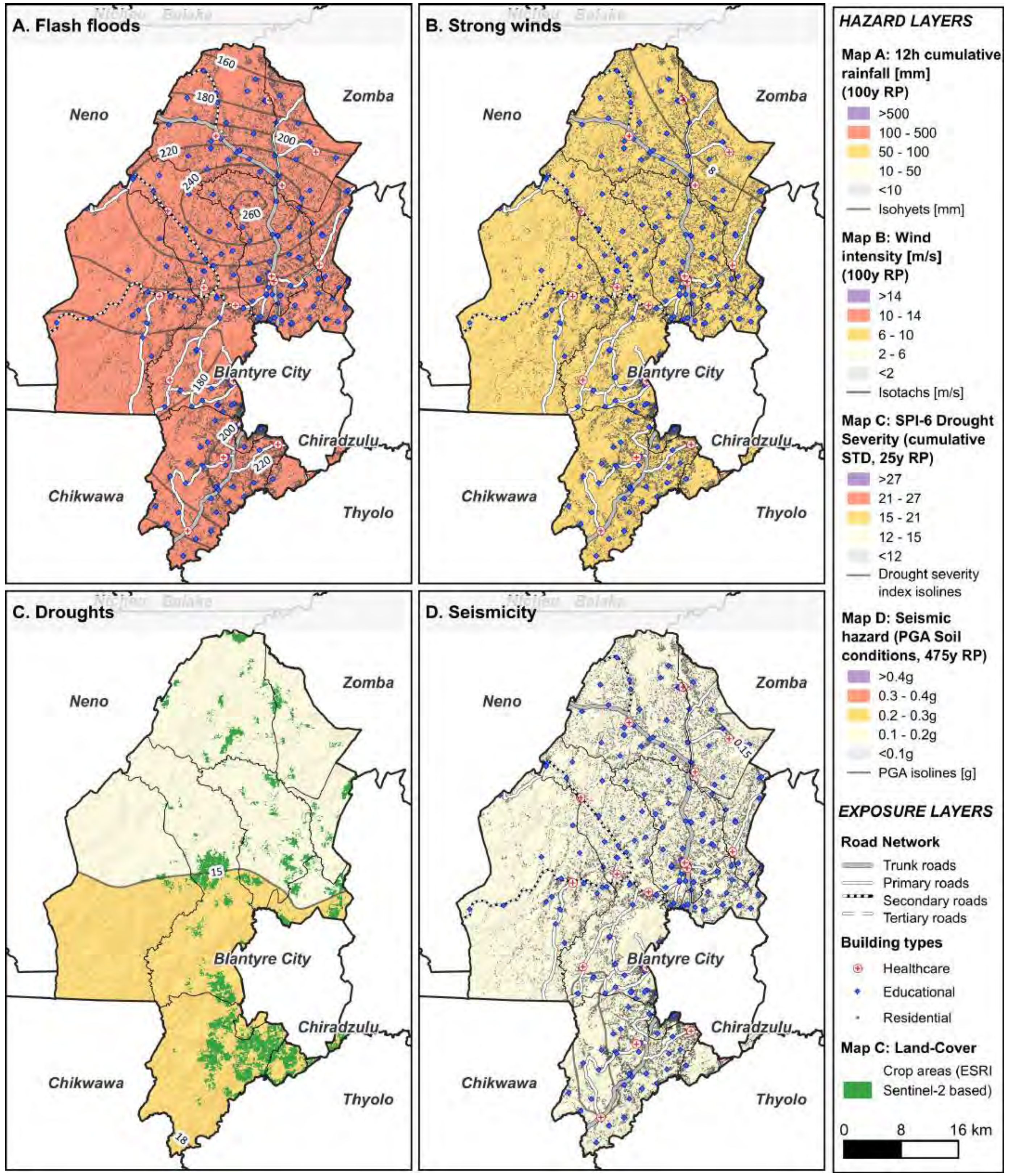
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

BLANTYRE CITY

Blantyre City is the oldest urban centre in Malawi and serves as the hub for communication, industrial, commercial activities, and cooperation in the country. As a district, social vulnerability parameters related to poverty and food insecurity are lower than the national average, while the inactive population is higher. Landslides, flash floods, and strong winds are the hazards that pose the greatest risks to the built environment, in that order. Drought is the predominant hazard affecting the population, and it is significantly influenced by climate change projections, with little difference observed between pessimistic and optimistic scenarios. The ratio of average annual economic losses due to flash floods and landslides is higher than the national average, while the losses from strong winds are similar to the national average. Annually, the average number of people affected by drought is lower than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**918 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	4.27	-
Poverty Prevalence (%)	**15**	51*
Food Insecurity (%)	**35**	64*
Inactive Population (%)	**25**	9*

* National value as weighted mean on population

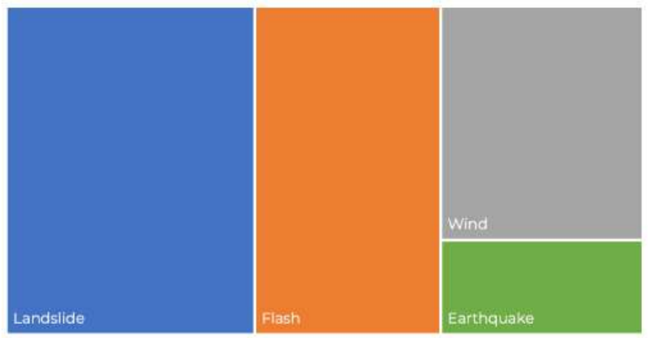
STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**6644**	131 953
Ratio on total value (%)	5.04	-
Schools and Hospitals	**163 - 18**	6410 - 671
Ratio on total value (%)	2.54 – 2.68	-
Most important Crops	**Maize, Groundnuts**	Cassava, Maize, Sweet Potato, Groundnuts

RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**15.913**	-	-	-	-	-	**35 244**	
Riverine Floods	0	0	0	0	0	0	0	0
Flash Floods	4.649	0.68	-	-	-	-	578	0.51
Strong Winds	3.602	0.523	-	-	-	-	1843	1.94
Compound	8.251	-	-	-	-	-	2421	-
Droughts	-	-	-	-	0.053	-	31 828	34
Landslides	6.207	0.948	-	-	-	-	878	1
Earthquakes	1.455	0.22	-	-	-	-	117	0.13

RISK RESULTS – Average Annual Losses CHARTS

Economic Built - UP

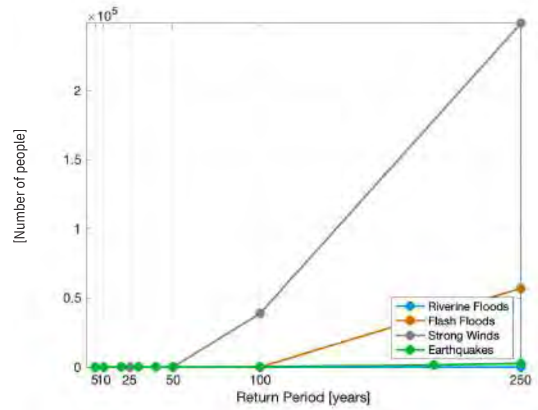


Population

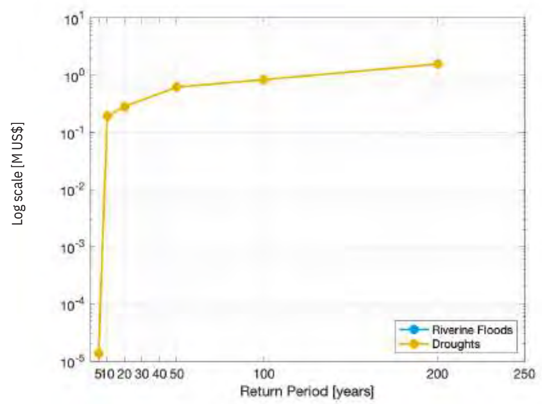
Riverine Floods ■ Flash Floods ■ Strong Winds ■ Droughts ■ Landslides ■ Earthquakes

RISK RESULTS – Probable Maximum Losses CURVES

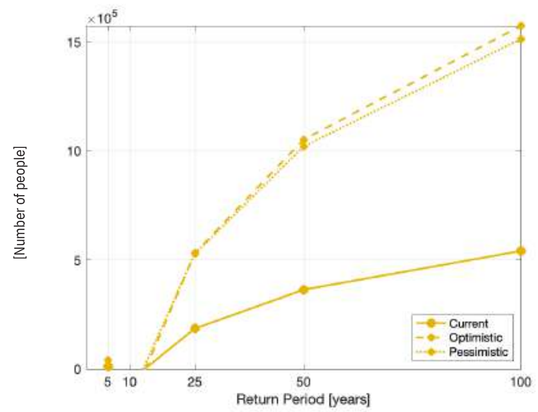
Fast-onset Weather related and Earthquakes - Affected Population



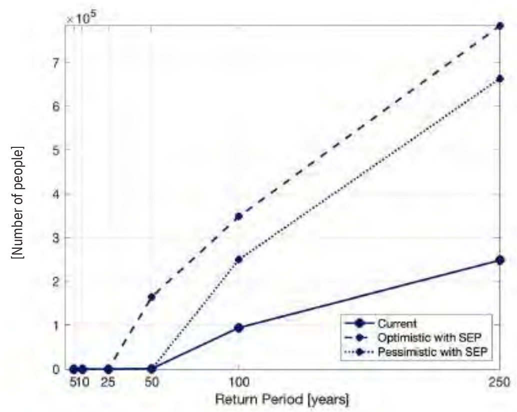
Weather related - Economic Loss



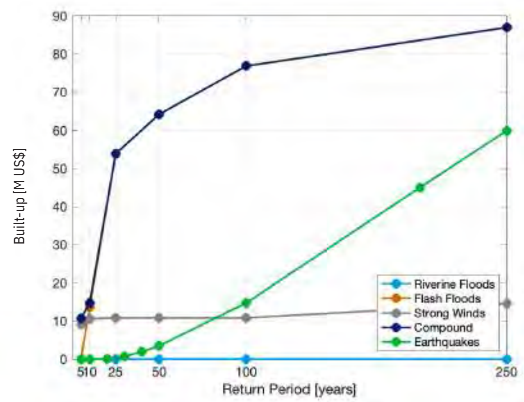
Droughts Projections - Affected Population



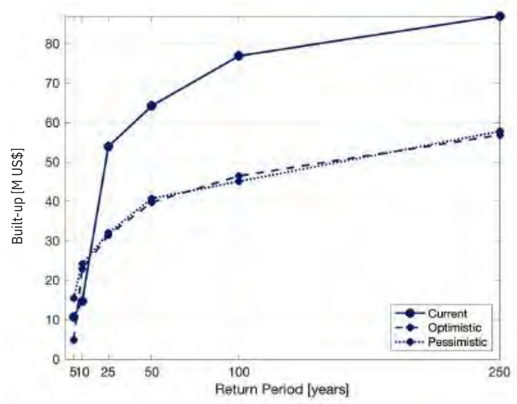
Compound Projections - Affected Population

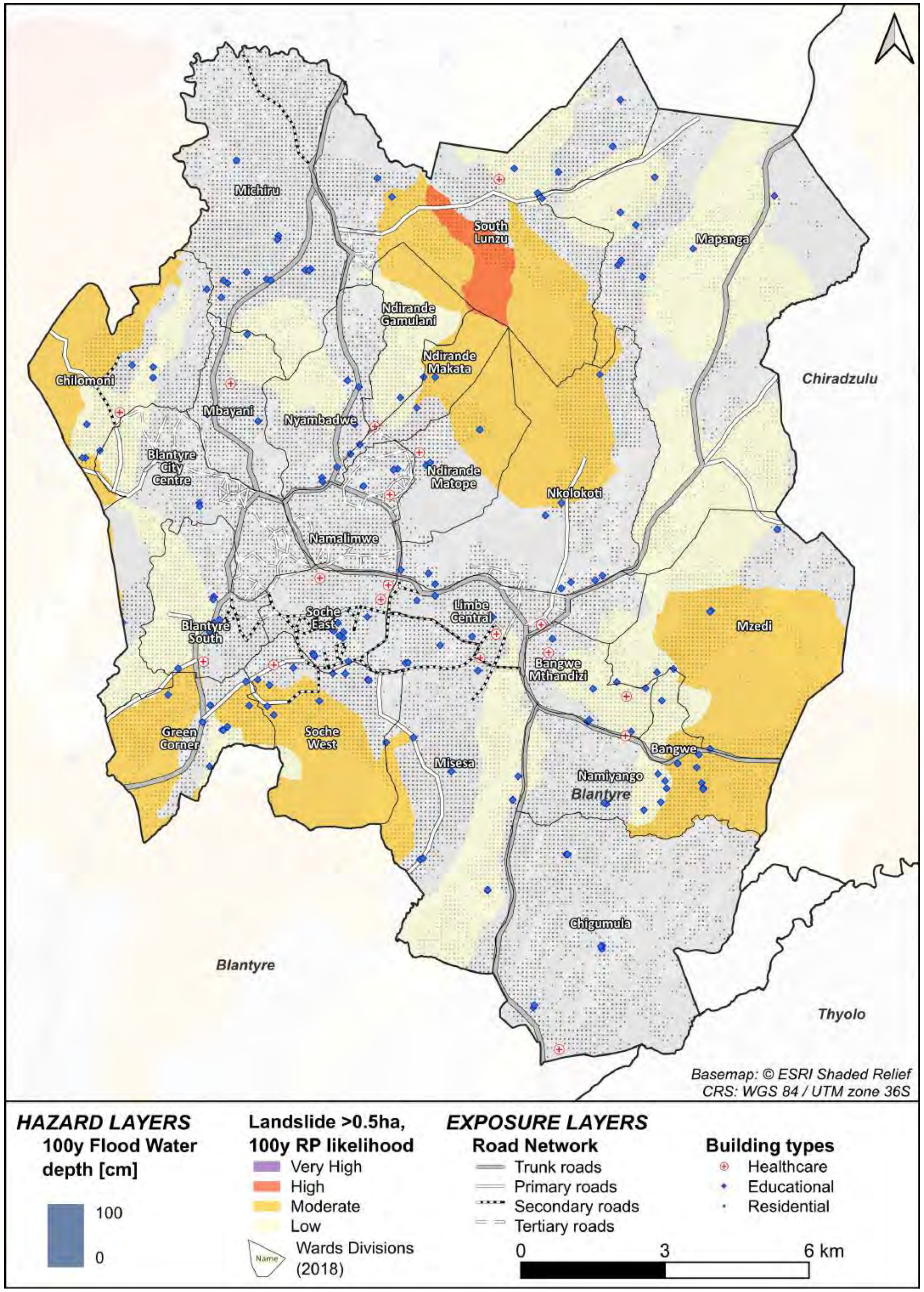


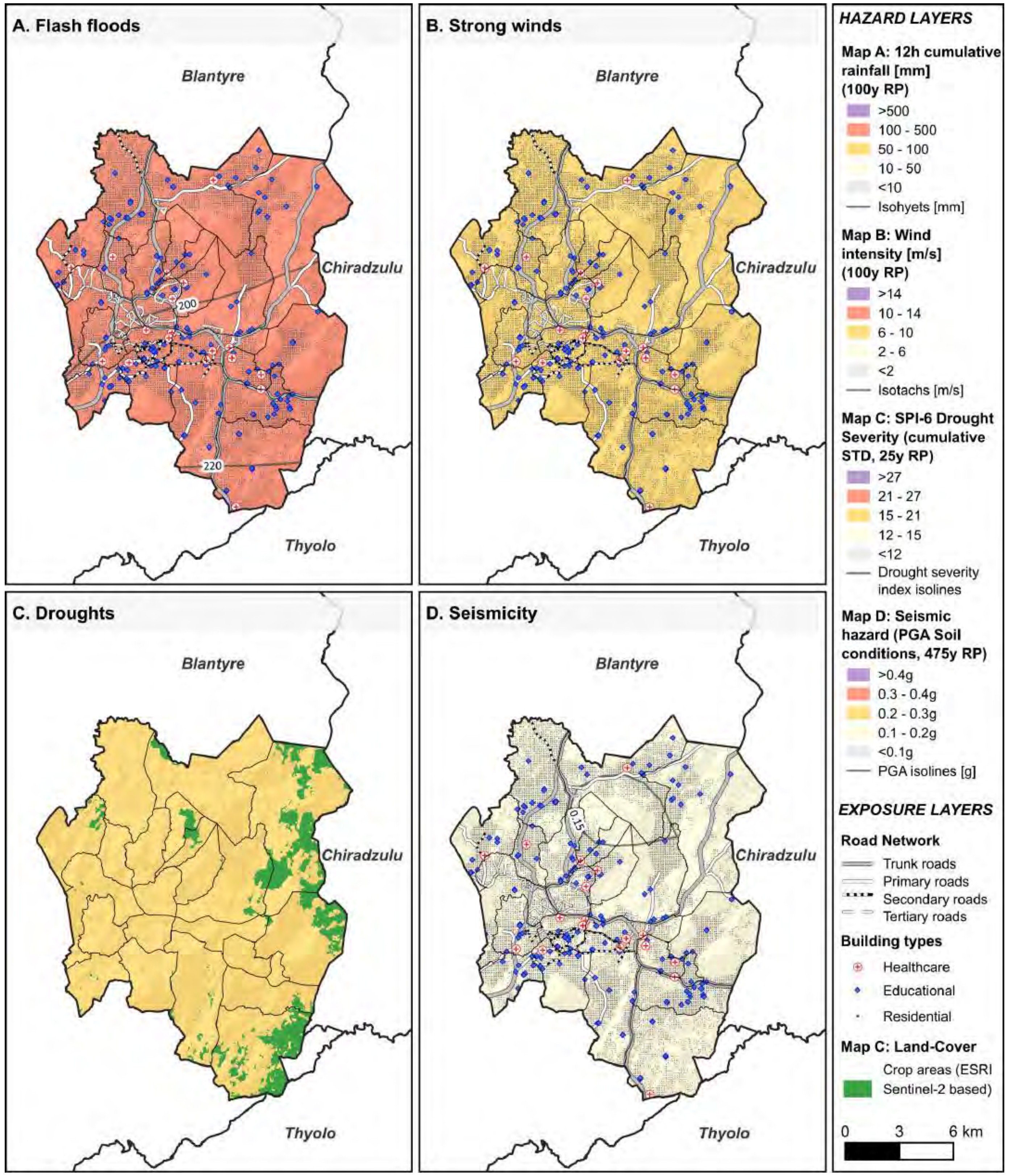
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

CHIKWAWA

Chikwawa is a district in the Southern Region of Malawi. The district covers an area of 4755 km².
Social vulnerability parameters on poverty and food insecurity are higher than the national average, while the inactive population is slightly lower. The risk evaluation identifies riverine floods as the greatest threat to the built environment in the district. Other major hazards in Chikwawa include strong winds and flash floods. Drought is predominant for the affected people. The weather related and drought risks are showing a significant increase when climate change is considered. The ratio of the average annual economic losses due to flood and the other weather-related hazards are greater than the national average, as well as the average annual people affected due to drought.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**616 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	2.87	-
Poverty Prevalence (%)	**61**	51*
Food Insecurity (%)	**78**	64*
Inactive Population (%)	**8**	9*

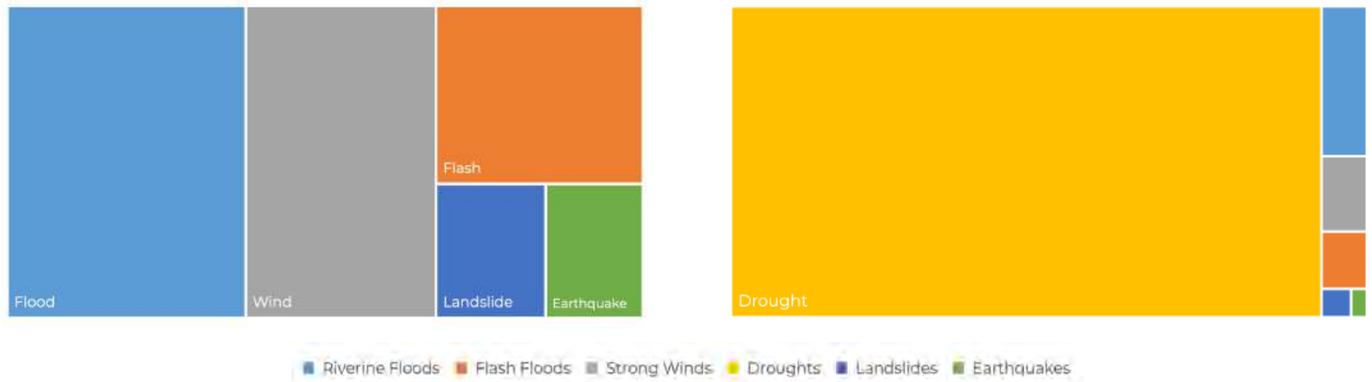
* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**4352**	131 953
Ratio on total value (%)	3.30	-
Schools and Hospitals	**199 – 23**	6410 - 671
Ratio on total value (%)	3.10 – 3.43	-
Most important Crops	**Maize, Sorghum, Pigeon peas, Groundnuts**	Cassava, Maize, Sweet Potato, Groundnuts

RISK RESULTS – Average Annual Losses TABLE

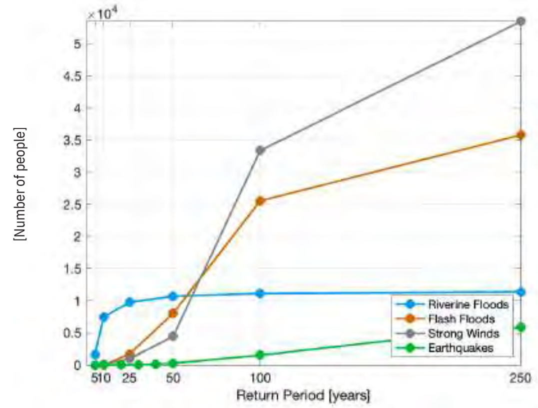
HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**16.845**	-	-	-	-	-	**43 692**	-
Riverine Floods	6.345	1.46	3.447	1.11	0.01	-	1500	1.95
Flash Floods	3.143	0.72	-	-	-	-	571	0.74
Strong Winds	5.066	1.164	-	-	-	-	753	1.22
Compound	14.482	-	-	-	-	-	2799	-
Droughts	-	-	-	-	4.45	-	40 609	68
Landslides	1.251	0.298	-	-	-	-	185	0.3
Earthquakes	1.112	0.26	-	-	-	-	99	0.16

RISK RESULTS – Average Annual Losses CHARTS

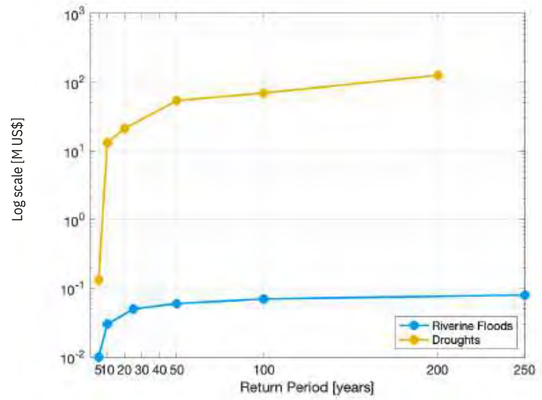


RISK RESULTS – Probable Maximum Losses CURVES

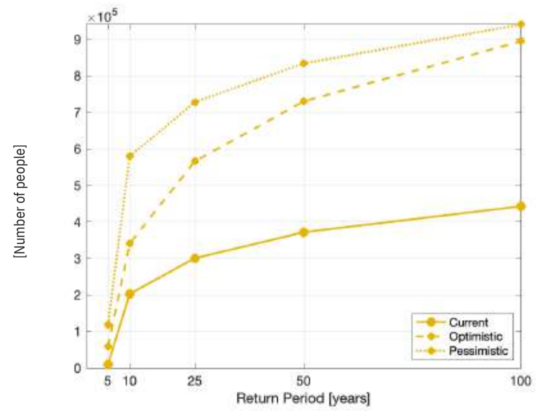
Fast-onset Weather related and Earthquakes - Affected Population



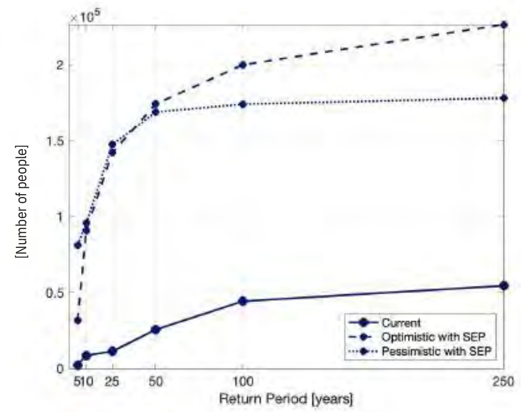
Weather related - Economic Loss



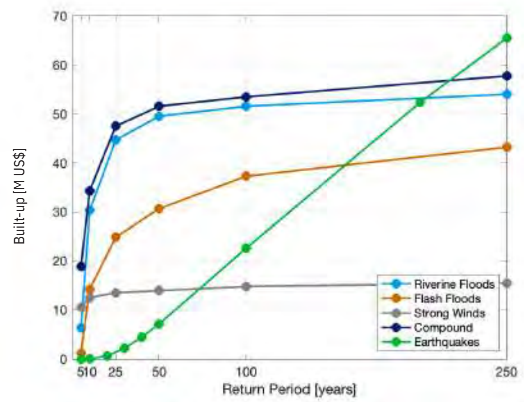
Droughts Projections - Affected Population



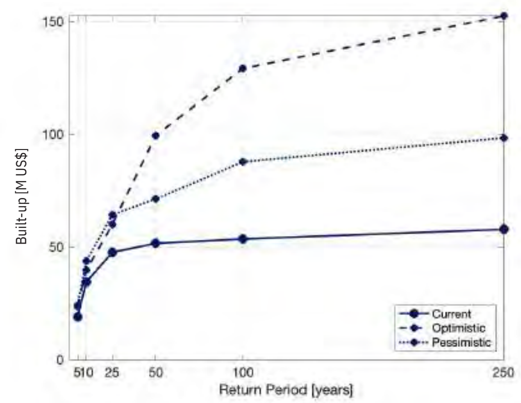
Compound Projections - Affected Population

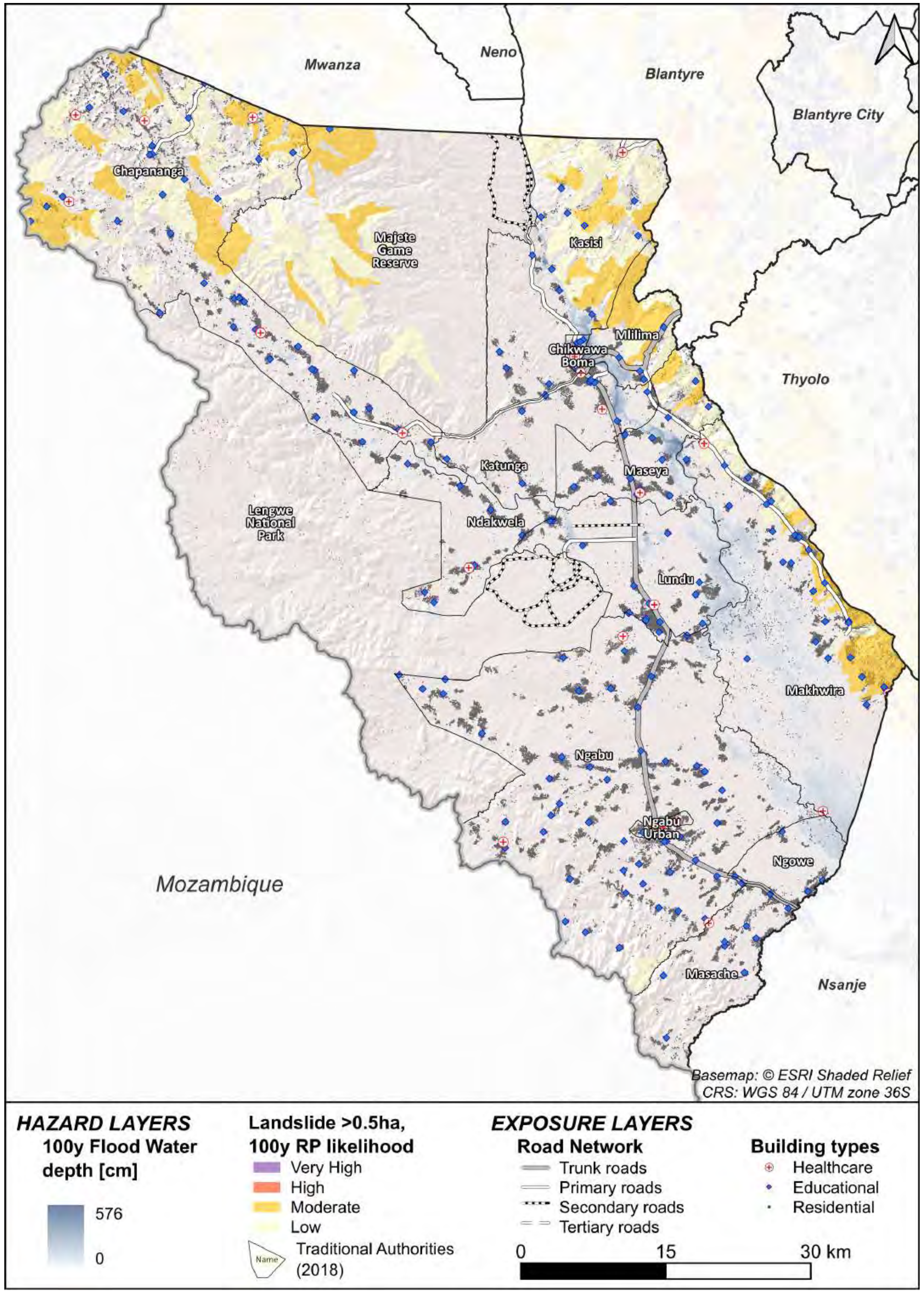


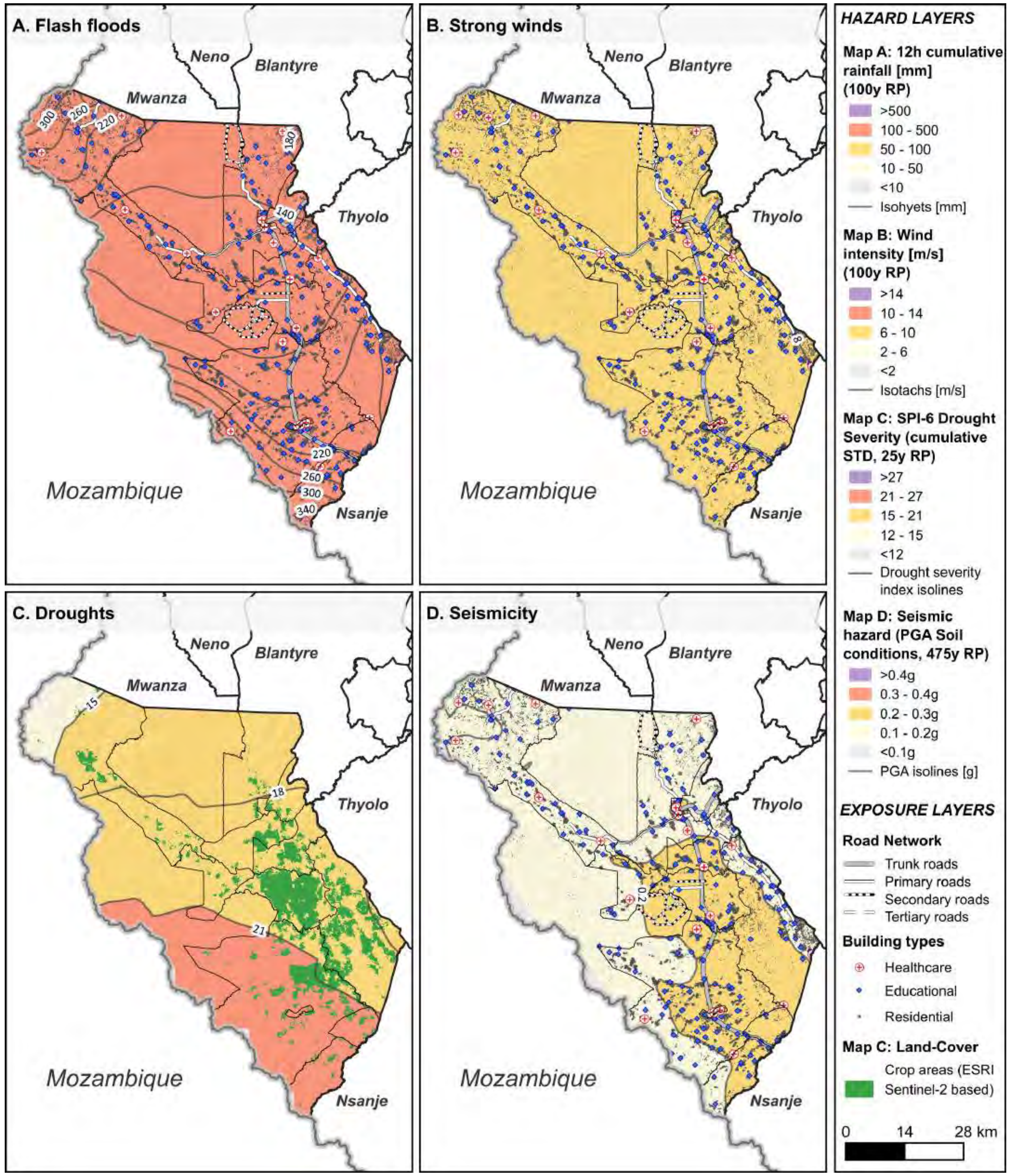
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

CHIRADZULU

Chiradzulu is a district in the Southern Region of Malawi. The district covers an area of 767 km² and lies at the eastern base of the Chiradzulu Mountain.
Social vulnerability parameters for food insecurity and the inactive population are higher than the national average, while poverty prevalence is lower. Results indicate that landslides pose the greatest threat to the built environment, followed by flash floods and strong winds in the district. However, drought is the predominant hazard affecting the population, and it is significantly influenced by climate change projections. The ratio of the average annual economic losses due to landslides is twice the national average. The annual number of people affected by drought is lower than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**400 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	1.86	-
Poverty Prevalence (%)	**38**	51*
Food Insecurity (%)	**70**	64*
Inactive Population (%)	**10**	9*

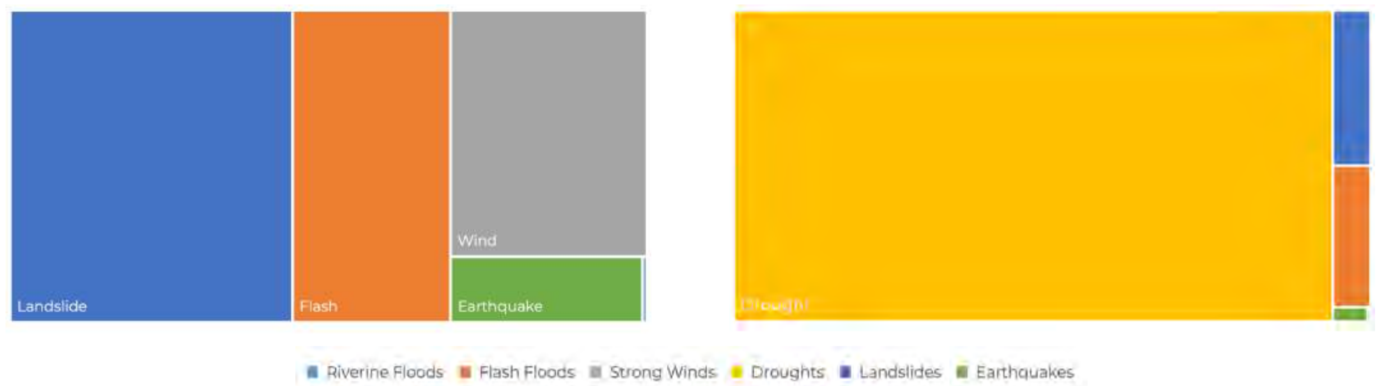
* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**2898**	131 953
Ratio on total value (%)	2.20	-
Schools and Hospitals	**113 - 13**	6410 - 671
Ratio on total value (%)	1.76 – 1.94	-
Most important Crops	**Maize, Sorghum, Pigeon peas, Beans, Cassava**	Cassava, Maize, Sweet Potato, Groundnuts

RISK RESULTS – Average Annual Losses TABLE

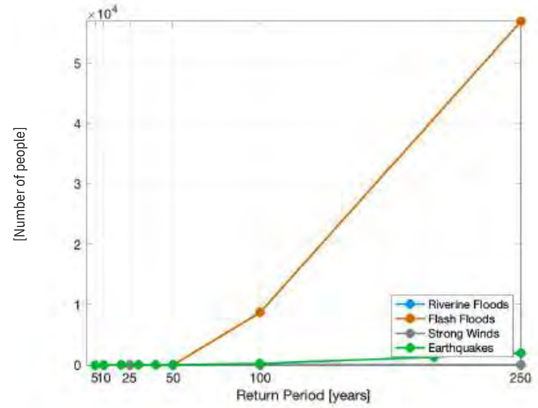
HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**8.925**	-	-	-	-	-	**19 201**	-
Riverine Floods	0.013	0.005	0.000002	0.0000009	0	-	4	0.01
Flash Floods	2.216	0.77	-	-	-	-	522	1.03
Strong Winds	2.172	0.756	-	-	-	-	0	0
Compound	4.396	-	-	-	-	-	526	-
Droughts	-	-	-	-	3.712	-	18 055	43
Landslides	3.961	1.424	-	-	-	-	572	1.4
Earthquakes	0.568	0.2	-	-	-	-	48	0.12

RISK RESULTS – Average Annual Losses CHARTS

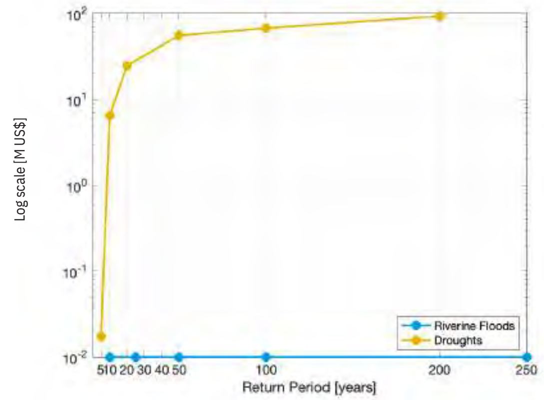


RISK RESULTS – Probable Maximum Losses CURVES

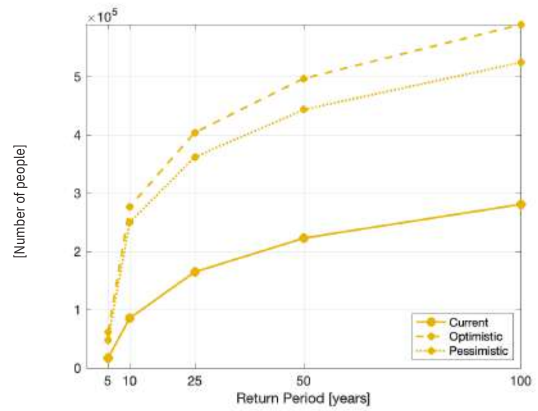
Fast-onset Weather related and Earthquakes - Affected Population



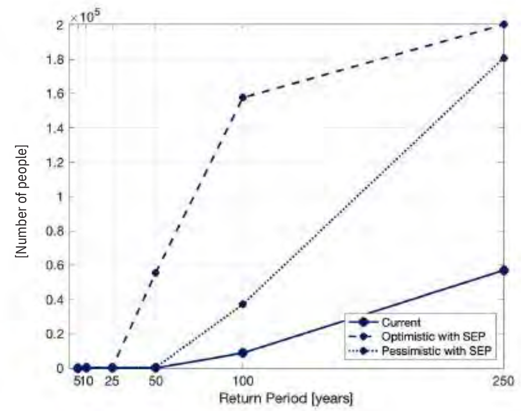
Weather related - Economic Loss



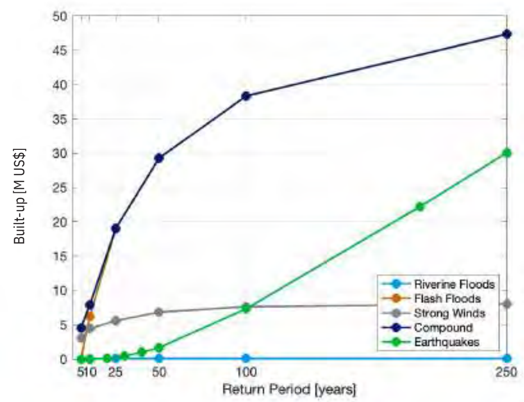
Droughts Projections - Affected Population



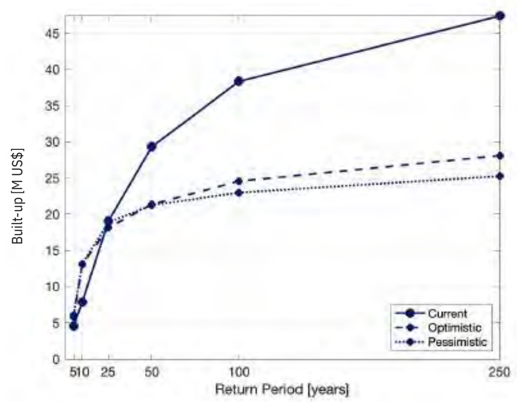
Compound Projections - Affected Population

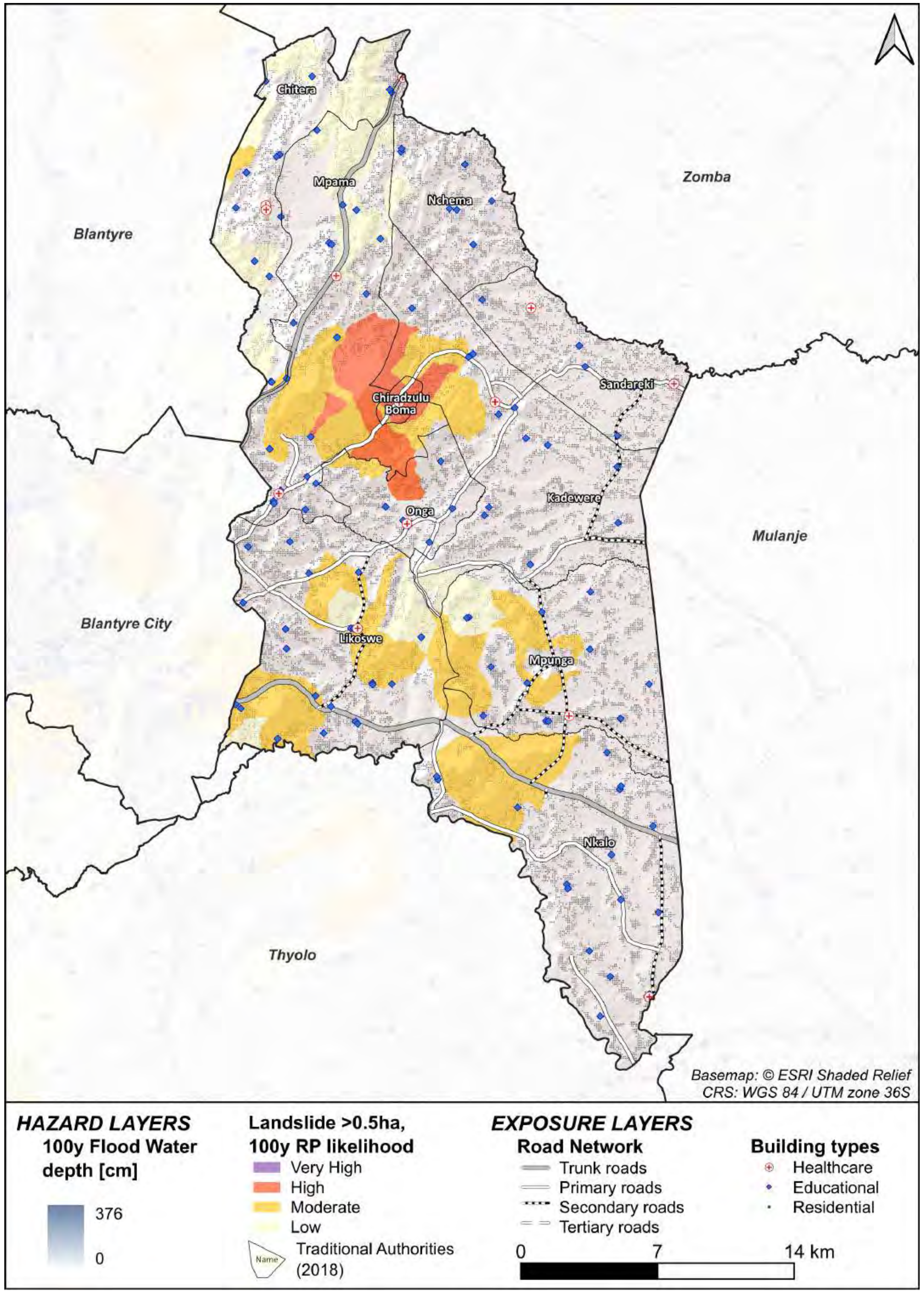


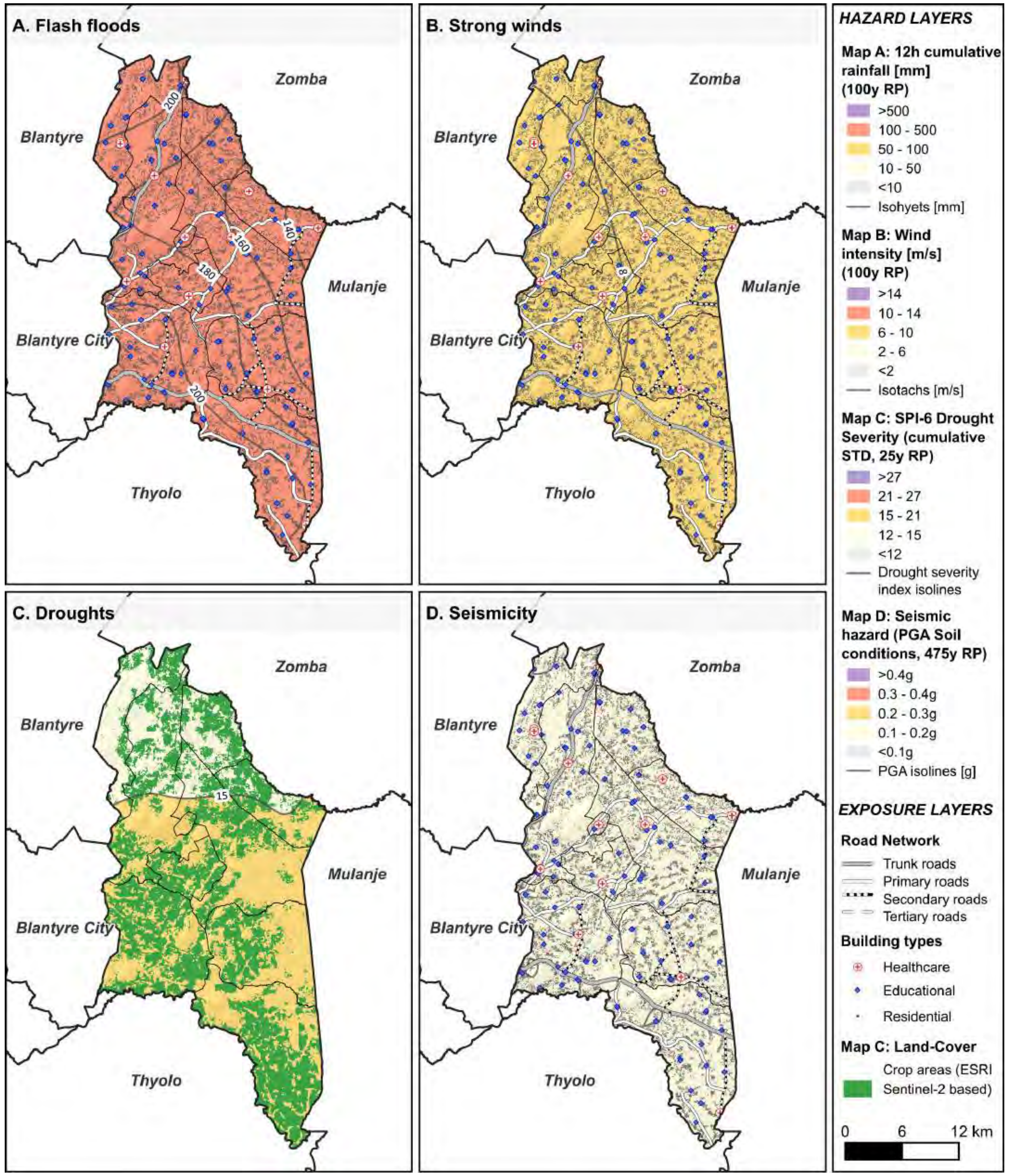
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

CHITIPA

Chitipa is located in the north-western part of Malawi and covers an area of 4,288 km².
The district borders Tanzania and Zambia.
All social vulnerability parameters in Chitipa are lower than the national average. In Chitipa, landslides are the greatest threat to the built environment, while drought is the predominant hazard affecting the population, particularly those reliant on rainfed agriculture. However, climate projections do not show a significant impact on losses due to drought, and other weather-related hazards are expected to decrease.
All values related to the average annual economic losses and the number of people affected are lower than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**279 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	1.30	-
Poverty Prevalence (%)	**39**	51*
Food Insecurity (%)	**30**	64*
Inactive Population (%)	**6**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**1837**	131 953
Ratio on total value (%)	1.39	-
Schools and Hospitals	**198 - 8**	6410 - 671
Ratio on total value (%)	3.09 – 1.19	-
Most important Crops	**Maize, Beans, Groundnuts, Sweet Potato**	Cassava, Maize, Sweet Potato, Groundnuts

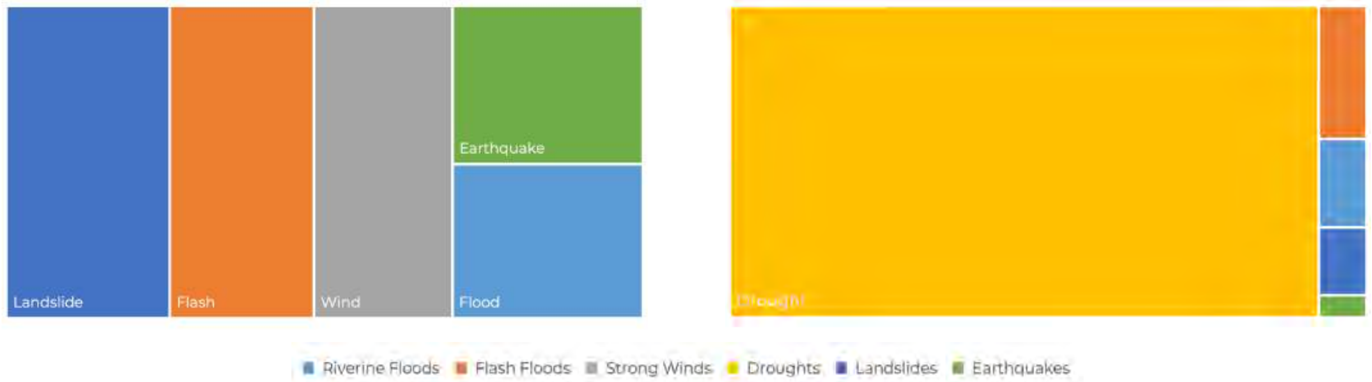
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**3.339**	**-**	**-**	**-**	**-**	**-**	**8831**	**-**
Riverine Floods	0.495	0.28	0	0	0	-	189	0.52
Flash Floods	0.76	0.44	-	-	-	-	285	0.8
Strong Winds	0.729	0.42	-	-	-	-	0	0
Compound	1.966	-	-	-	-	-	469	-
Droughts	-	-	-	-	3.848	-	8170	33
Landslides	0.863	0.499	-	-	-	-	145	0.5
Earthquakes	0.51	0.28	-	-	-	-	47	0.17

RISK RESULTS – Average Annual Losses CHARTS

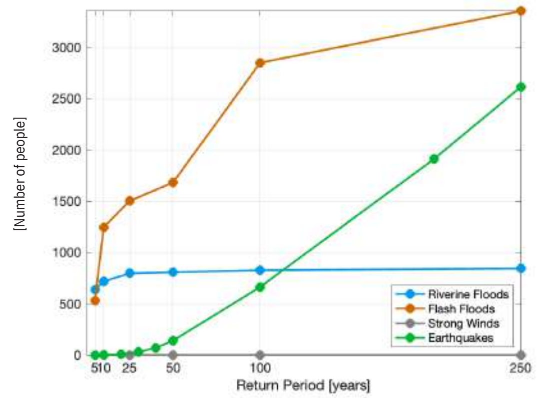
Economic Built - UP

Population

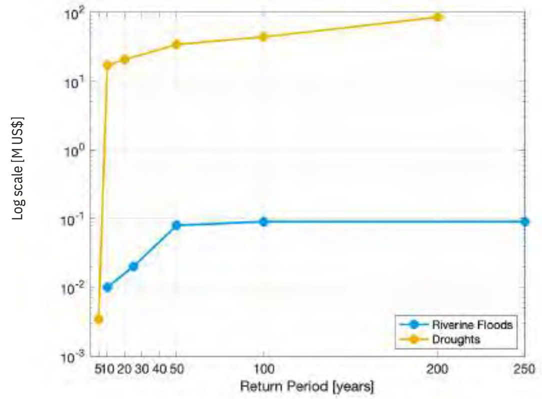


RISK RESULTS – Probable Maximum Losses CURVES

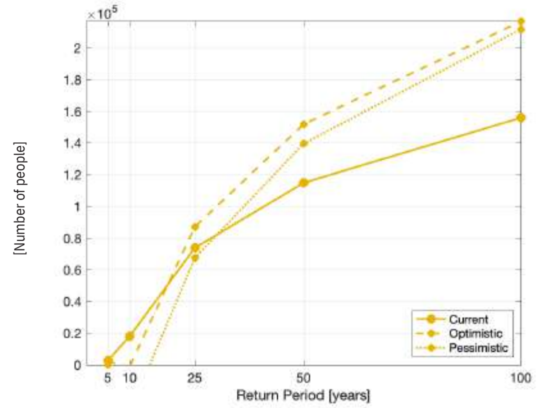
Fast-onset Weather related and Earthquakes - Affected Population



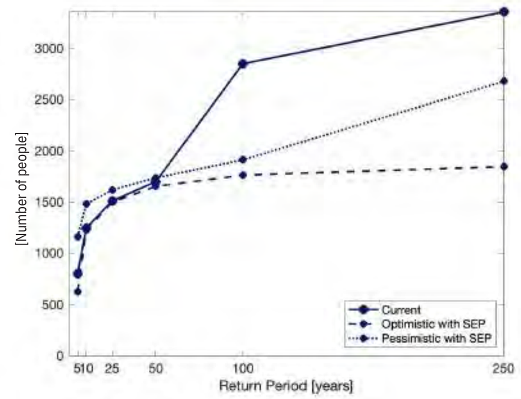
Weather related - Economic Loss



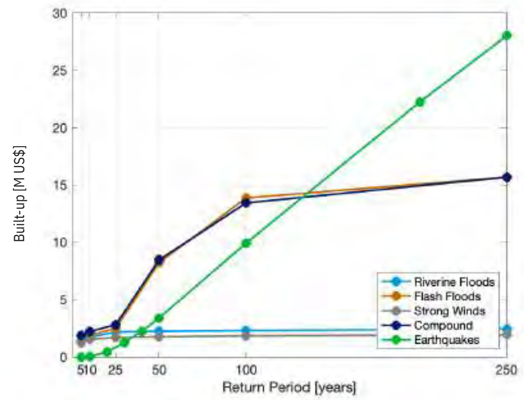
Droughts Projections - Affected Population



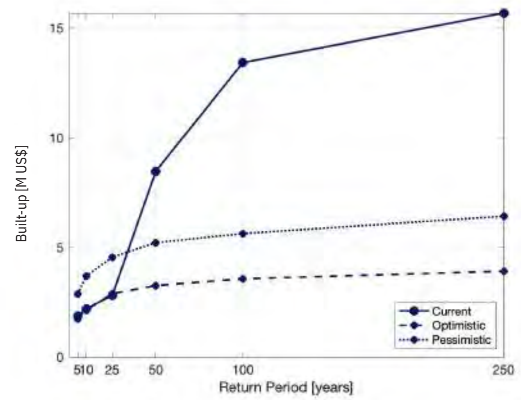
Compound Projections - Affected Population

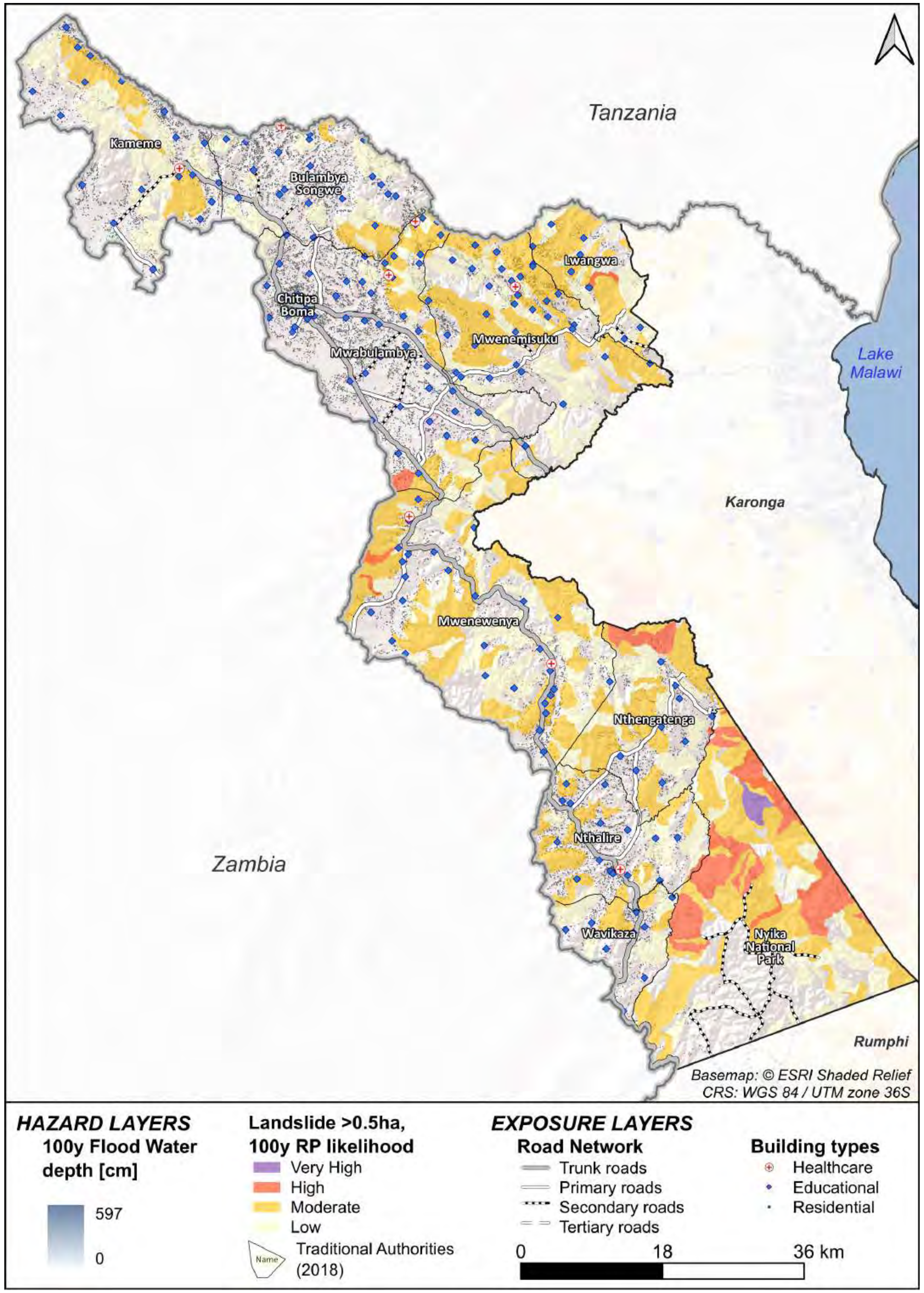


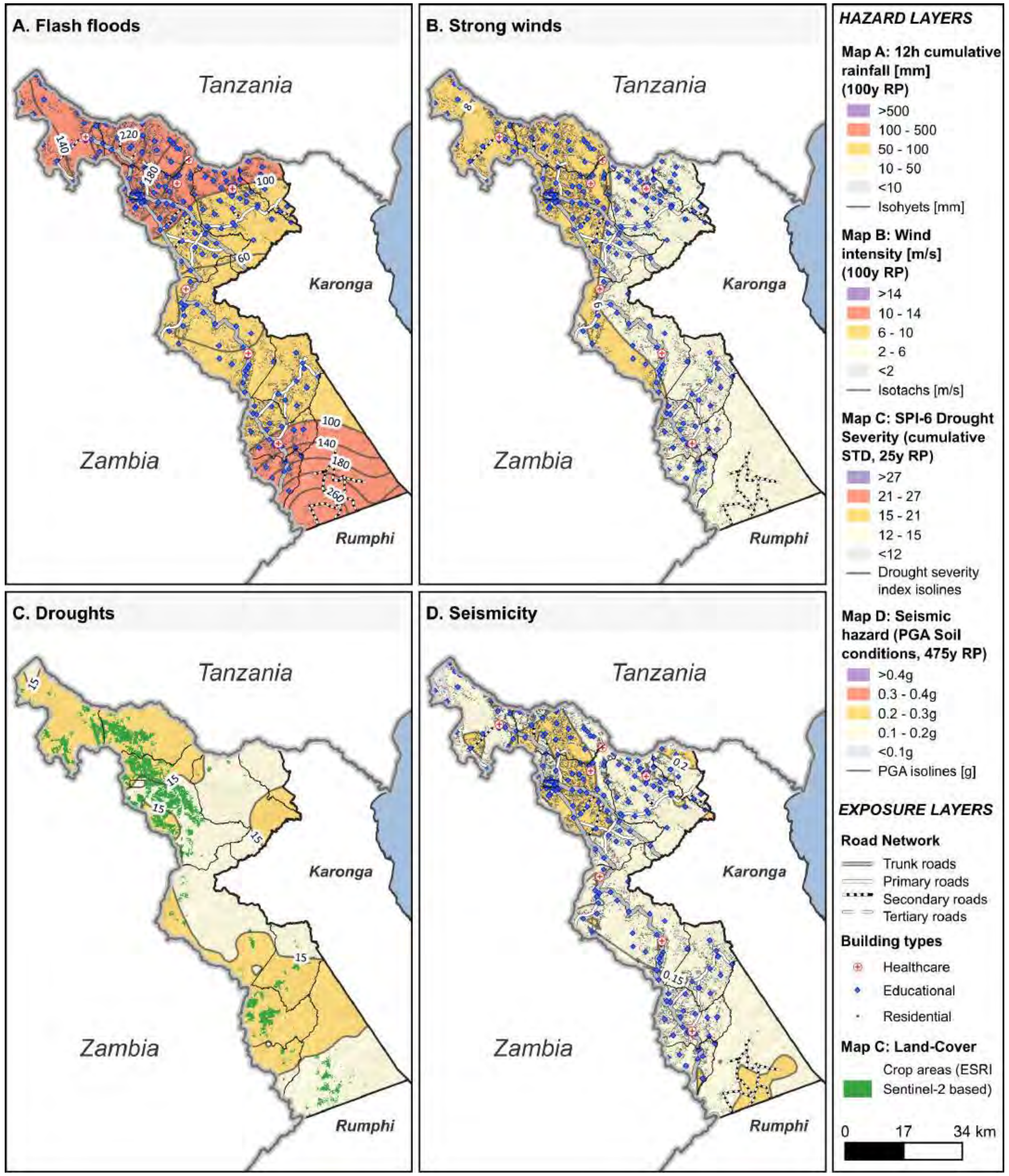
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

DEDZA

Dedza is a district in the Central Region of Malawi, covering an area of 3,754 km². It is one of the highest places in Malawi, situated at an altitude of 1,590 meters, surrounded by a beautiful landscape of forests and highlands.
Social vulnerability parameters, such as poverty prevalence and food insecurity, are higher than the national average, while the inactive population is lower.
The risk evaluation identifies strong winds and floods as the most significant hazards to the built environment. Drought is the predominant hazard affecting the population and is heavily influenced by climate change, regardless of whether the scenario is optimistic or pessimistic. The weather-related hazards show the impact of climate projections for both scenarios. The average annual economic losses and the number of people affected are lower than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**914 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	4.25	-
Poverty Prevalence (%)	**62**	51*
Food Insecurity (%)	**72**	64*
Inactive Population (%)	**4**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**6570**	131 953
Ratio on total value (%)	1.39	-
Schools and Hospitals	**280 – 35**	6410 - 671
Ratio on total value (%)	4.37 – 5.22	-
Most important Crops	**Maize, Beans, Groundnuts, Sweet potato, Potato**	Cassava, Maize, Sweet Potato, Groundnuts

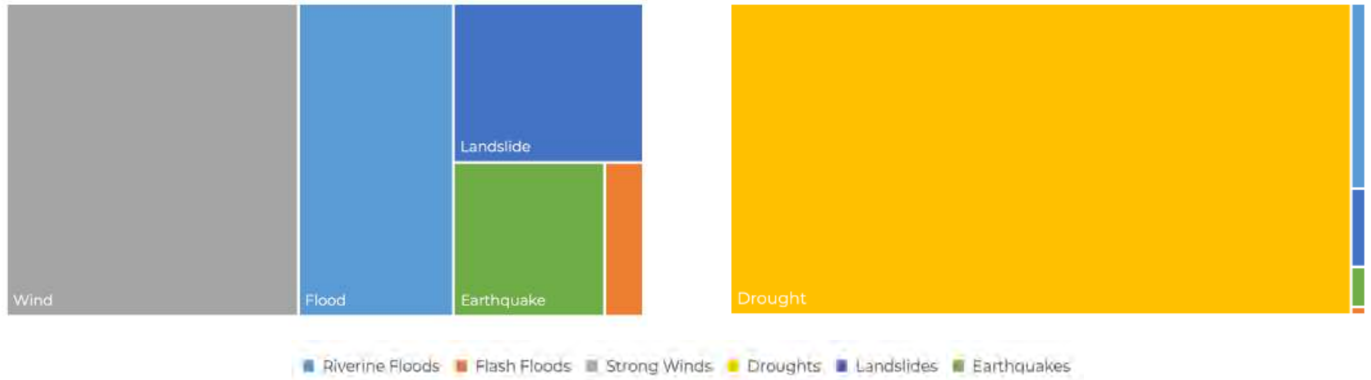
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**12.543**	**-**	**-**	**-**	**-**	**-**	**46 886**	**-**
Riverine Floods	3.06	0.47	0.867	0.21	0.01	-	644	0.57
Flash Floods	0.375	0.06	-	-	-	-	27	0.02
Strong Winds	5.757	0.88	-	-	-	-	0	0
Compound	9.175	-	-	-	-	-	668	-
Droughts	-	-	-	-	5.527	-	45 808	48
Landslides	1.903	0.299	-	-	-	-	271	0.3
Earthquakes	1.465	0.22	-	-	-	-	139	0.15

RISK RESULTS – Average Annual Losses CHARTS

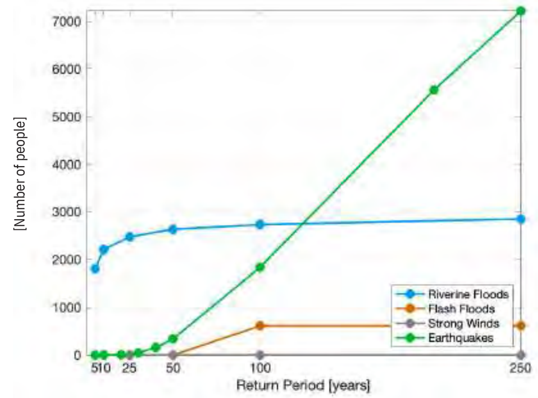
Economic Built - UP

Population

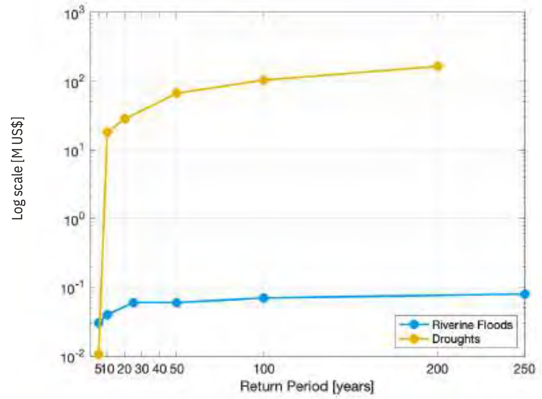


RISK RESULTS – Probable Maximum Losses CURVES

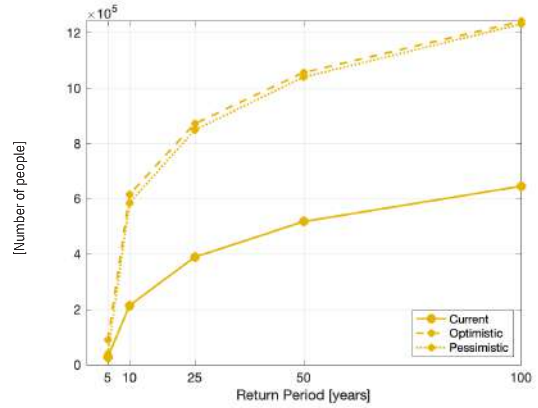
Fast-onset Weather related and Earthquakes - Affected Population



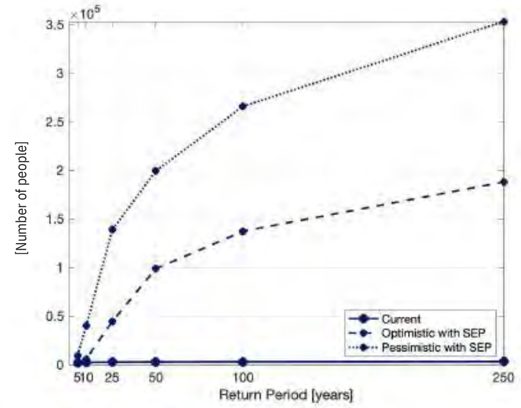
Weather related - Economic Loss



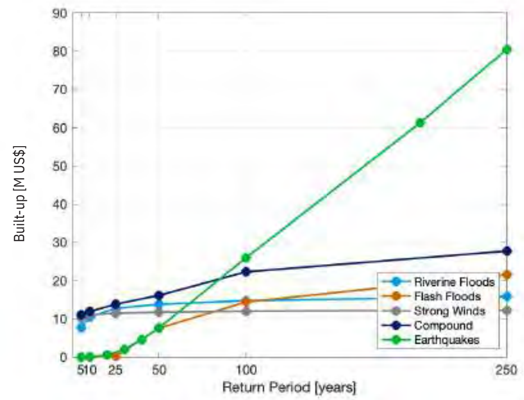
Droughts Projections - Affected Population



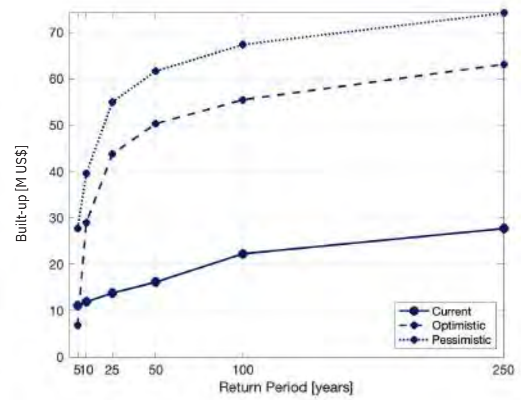
Compound Projections - Affected Population

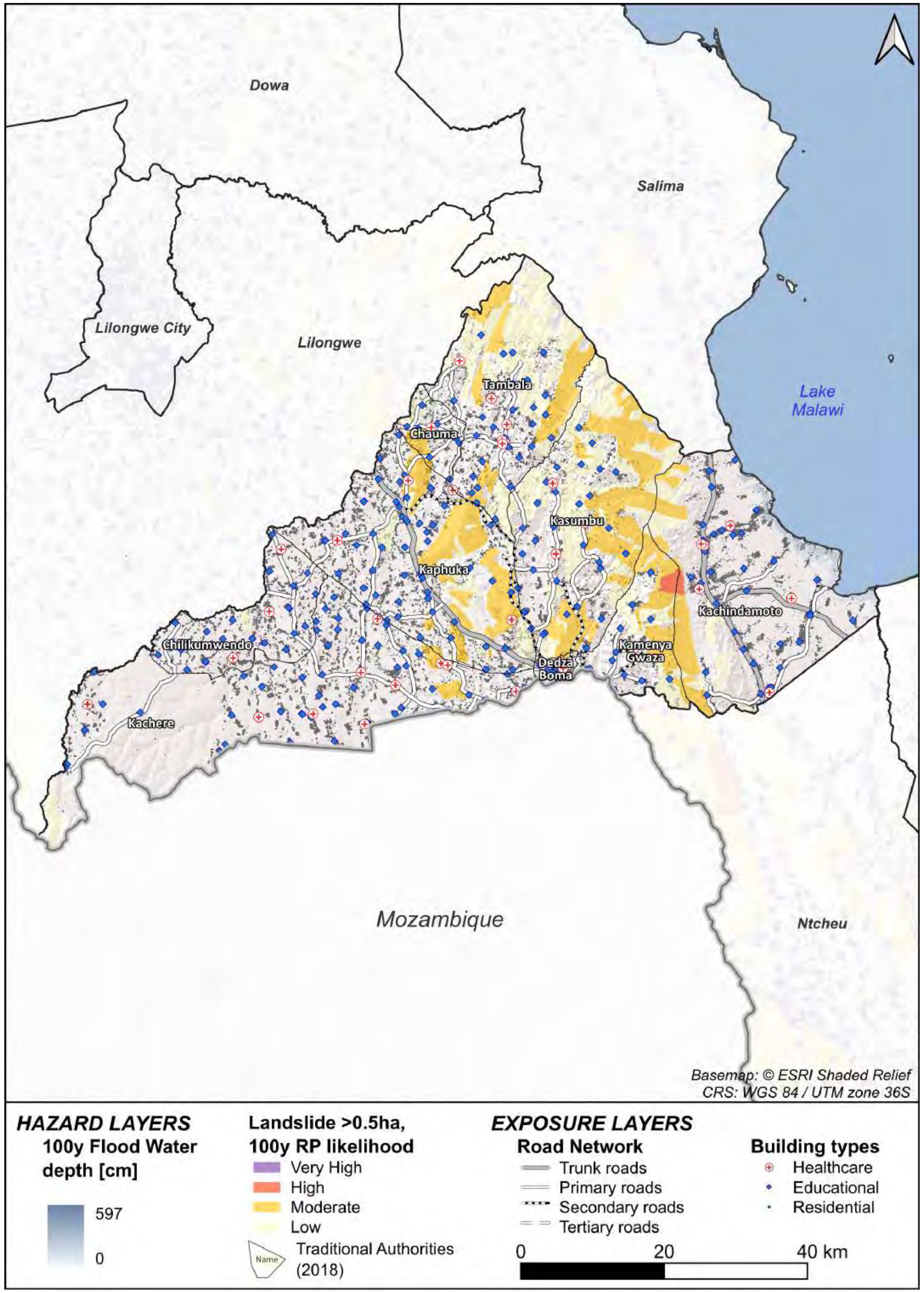


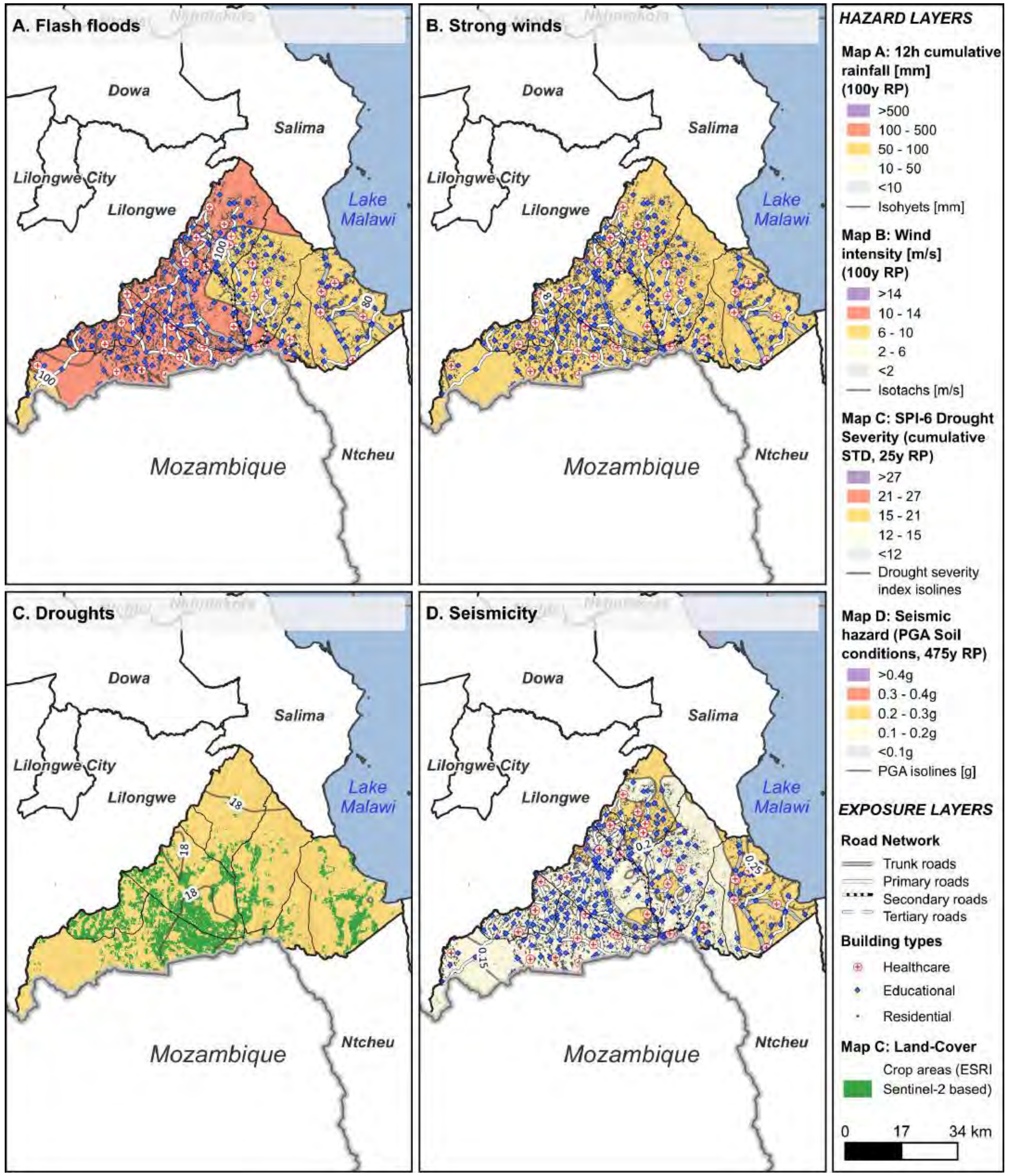
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

DOWA

Dowa is a district located in the Central Region of Malawi, covering an area of 3,041 km². It is an agricultural district and hosts a permanent refugee camp.
Social vulnerability parameters such as poverty prevalence are above the national average, whereas the inactive population is below it. The food insecurity level is average. The built environment in the district faces major hazards, with strong winds and floods posing the most critical threats. Drought is the critical hazard for the affected population. While weather-related risks and drought are influenced by climate change projections, the impact is particularly significant in the pessimistic scenario. The ratio of average annual economic losses due to strong winds and the average number of people affected by drought is higher than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**871 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	4.05	-
Poverty Prevalence (%)	**65**	51*
Food Insecurity (%)	**64**	64*
Inactive Population (%)	**6**	9*

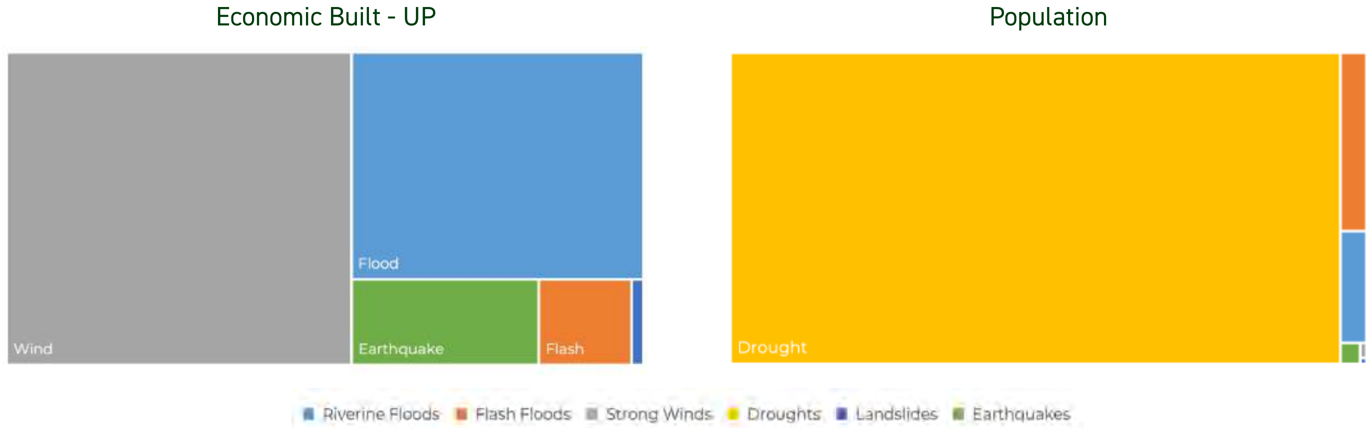
* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**6288**	131 953
Ratio on total value (%)	4.77	-
Schools and Hospitals	**264 – 22**	6410 - 671
Ratio on total value (%)	4.12 – 3.28	-
Most important Crops	**Maize, Groundnuts, Beans, Sweet Potato, Soybeans, Cassava**	Cassava, Maize, Sweet Potato, Groundnuts

RISK RESULTS – Average Annual Losses TABLE

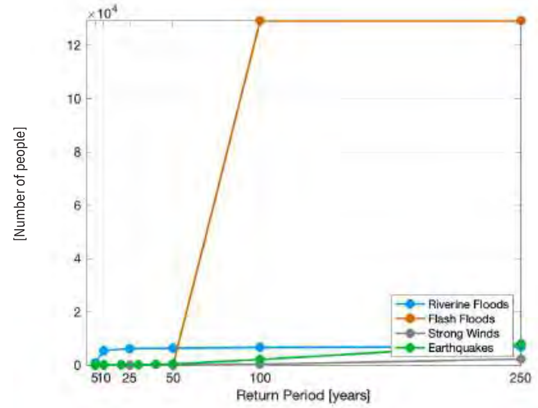
HAZARDS	ECONOMIC LOSS Built-up (M US$)	ECONOMIC LOSS (‰)	ECONOMIC LOSS Roads (M US$)	ECONOMIC LOSS (‰)	AGRICULTURE LOSS Production (M US$)	AGRICULTURE LOSS (‰)	AFFECTED POPULATION (Units)	AFFECTED POPULATION (‰)
Multi-Risk	**17.729**	-	-	-	-	-	**65 226**	-
Riverine Floods	5.913	0.933	2.053	0.32	0.01	-	951	0.88
Flash Floods	0.708	0.11	-	-	-	-	1517	1.39
Strong Winds	9.604	1.515	-	-	-	-	31	0.03
Compound	16.208	-	-	-	-	-	2496	-
Droughts	-	-	-	-	6.605	-	62 584	71
Landslides	0.091	0.015	-	-	-	-	12	0
Earthquakes	1.43	0.23	-	-	-	-	134	0.15

RISK RESULTS – Average Annual Losses CHARTS

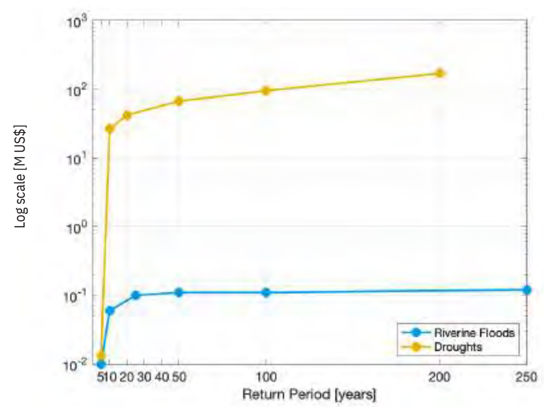


RISK RESULTS – Probable Maximum Losses CURVES

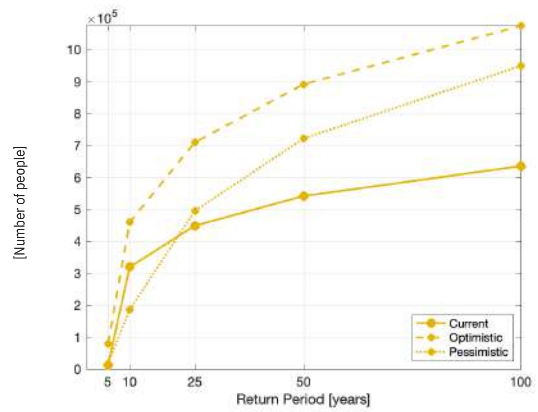
Fast-onset Weather related and Earthquakes - Affected Population



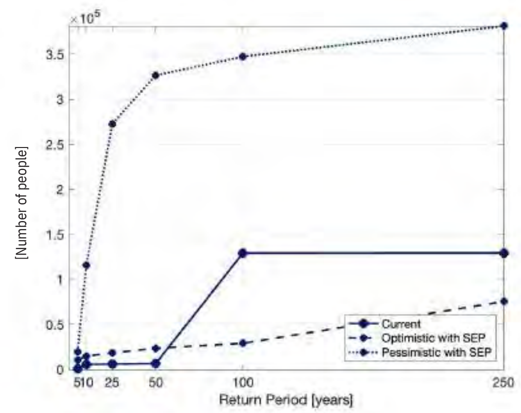
Weather related - Economic Loss



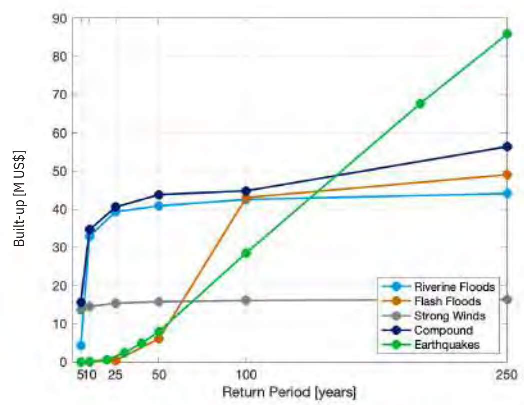
Droughts Projections - Affected Population



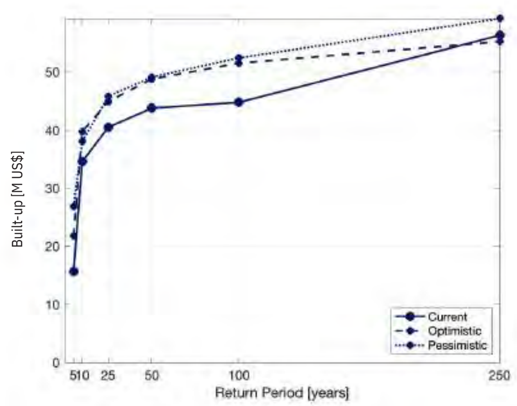
Compound Projections - Affected Population

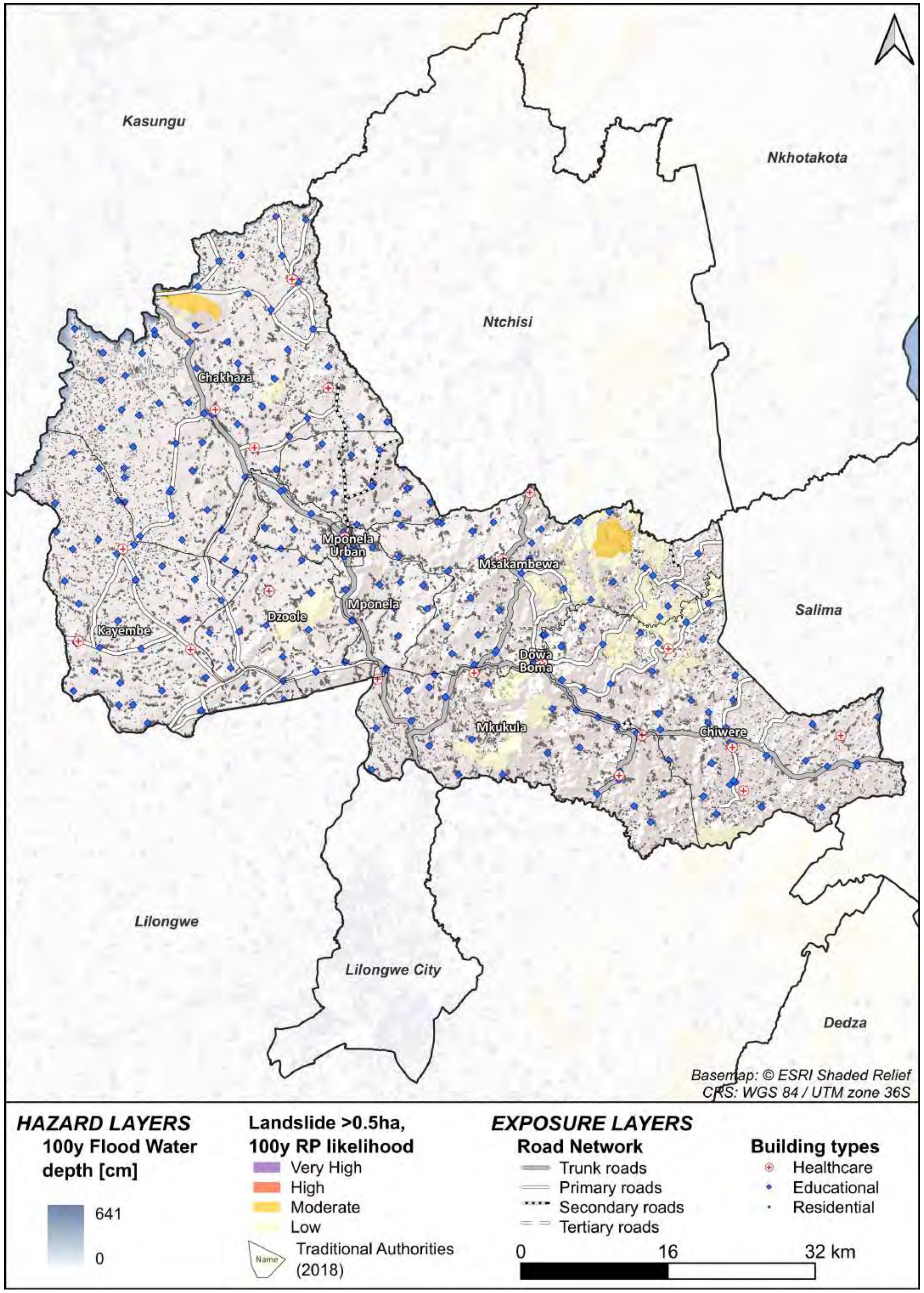


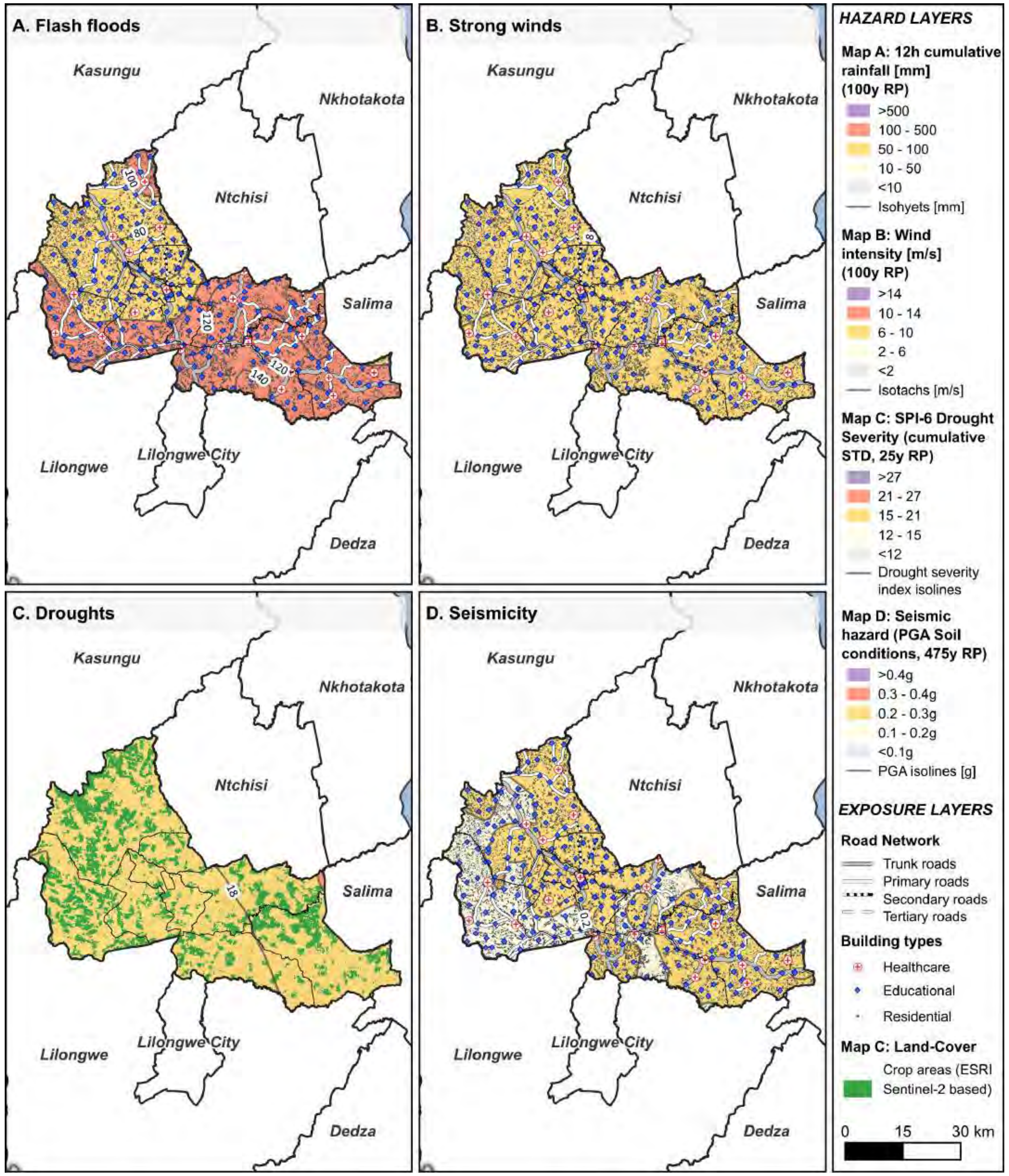
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

KARONGA

Karonga district is one of the largest districts in the far north of Malawi, covering an area of 3,355 km².
All social vulnerability parameters are generally better, with values lower than the national average.
The major hazards to the built environment in the district are strong winds and floods. Additionally, strong winds are a major hazard for the population, followed by drought. Both compound fast-onset weather-related risks and drought risks are significantly impacted by climate change projections. The ratio of average annual economic losses and the average annual number of people affected by strong winds are both higher than the national average. Karonga is the third most affected district in Malawi in terms of economic losses to the transportation system.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**402 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	1.87	-
Poverty Prevalence (%)	**41**	51*
Food Insecurity (%)	**47**	64*
Inactive Population (%)	**7**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**2336**	131 953
Ratio on total value (%)	1.77	-
Schools and Hospitals	**198 – 20**	6410 - 671
Ratio on total value (%)	3.09 – 2.98	-
Most important Crops	**Maize, Cassava, Rice, Beans**	Cassava, Maize, Sweet Potato, Groundnuts

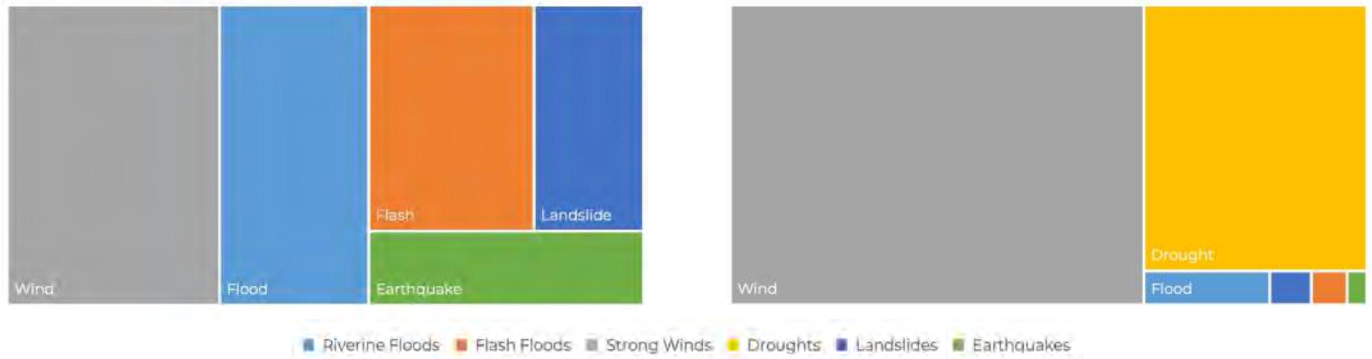
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**9.386**	**-**	**-**	**-**	**-**	**-**	**30 649**	**-**
Riverine Floods	2.199	0.94	15.583	2.23	0.02	-	686	1.33
Flash Floods	1.837	0.85	-	-	-	-	195	0.4
Strong Winds	3.133	1.45	-	-	-	-	19 919	53.11
Compound	7.168	-	-	-	-	-	20 806	-
Droughts	-	-	-	-	3.724	-	9512	32
Landslides	1.22	0.562	-	-	-	-	225	0.6
Earthquakes	0.998	0.43	-	-	-	-	106	0.26

RISK RESULTS – Average Annual Losses CHARTS

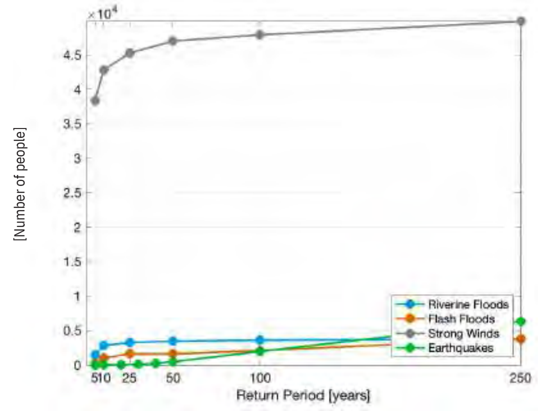
Economic Built - UP

Population

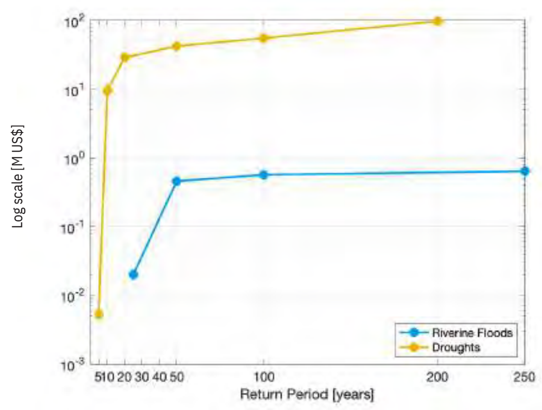


RISK RESULTS – Probable Maximum Losses CURVES

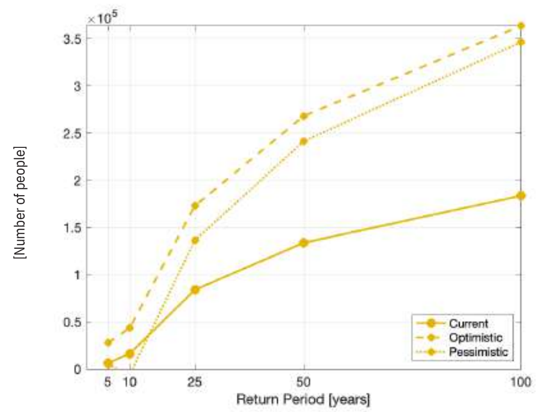
Fast-onset Weather related and Earthquakes - Affected Population



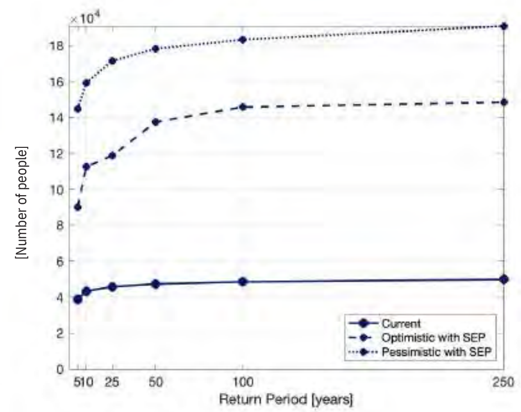
Weather related - Economic Loss



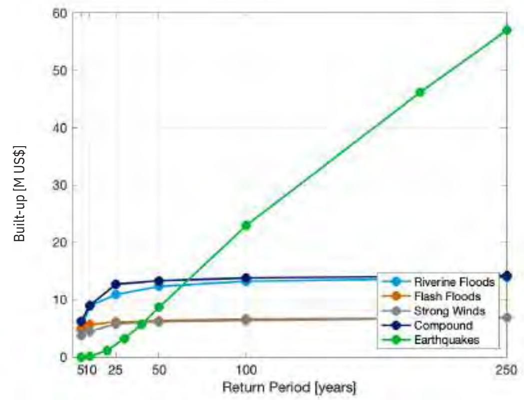
Droughts Projections - Affected Population



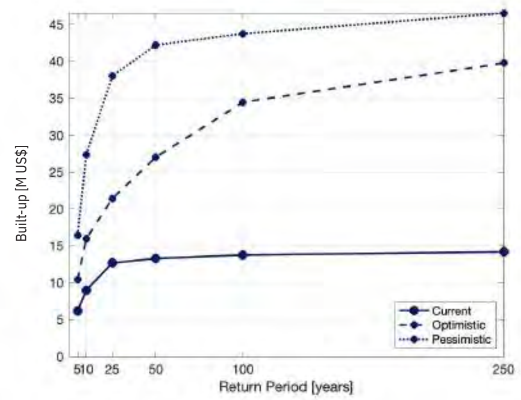
Compound Projections - Affected Population

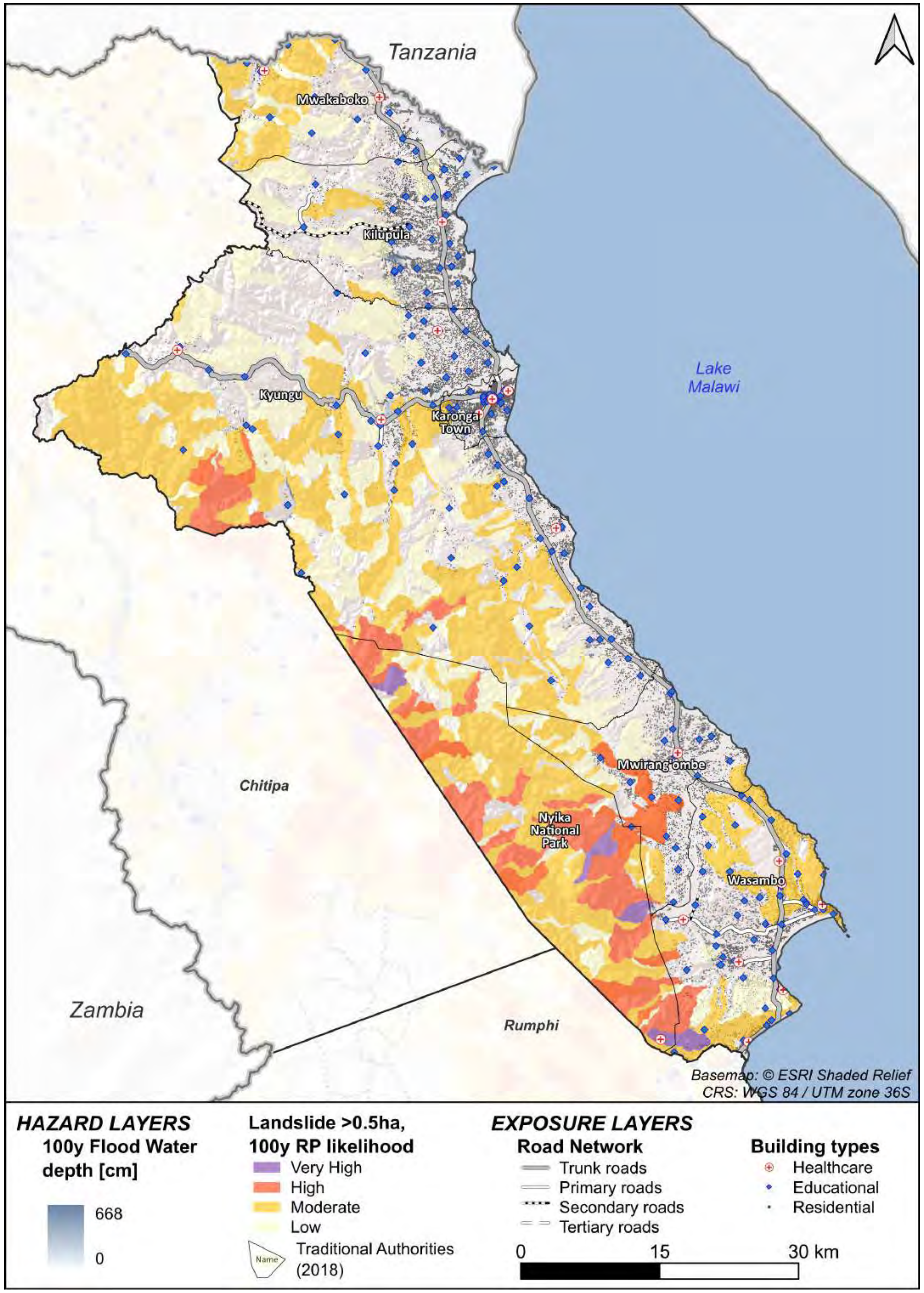


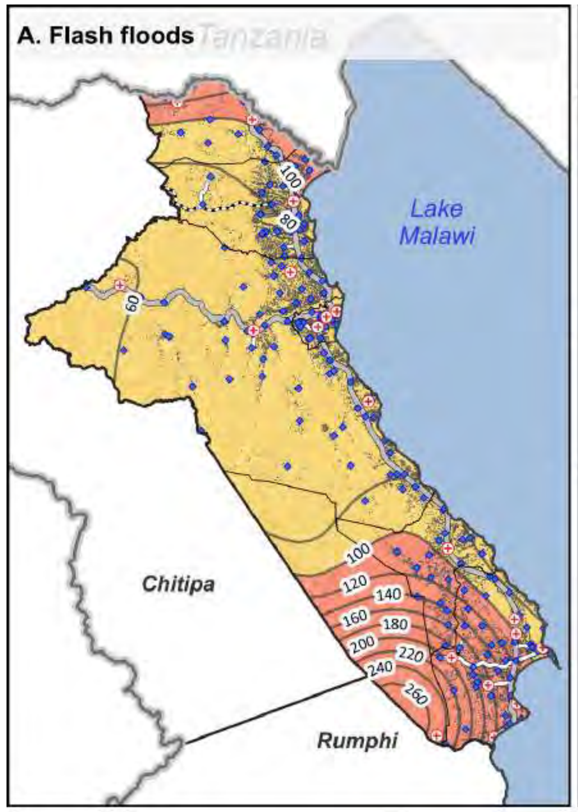
Fast-onset Weather related and Earthquakes - Economic Loss

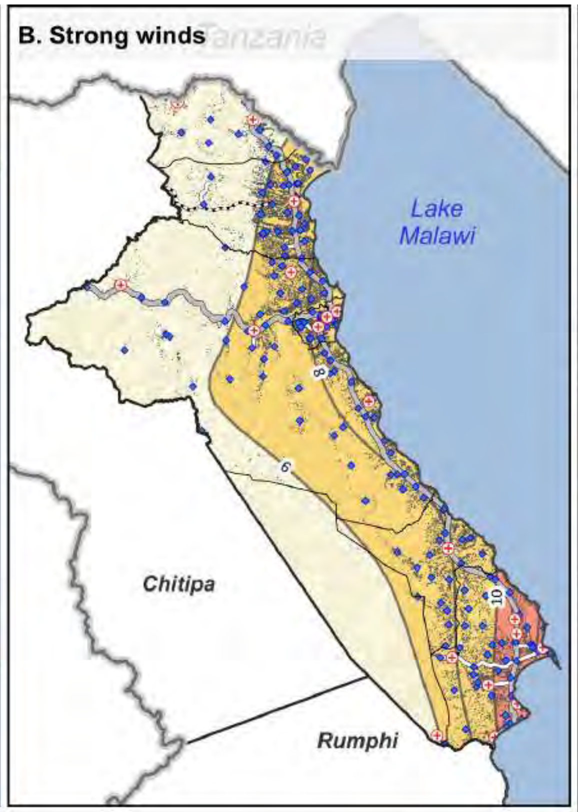


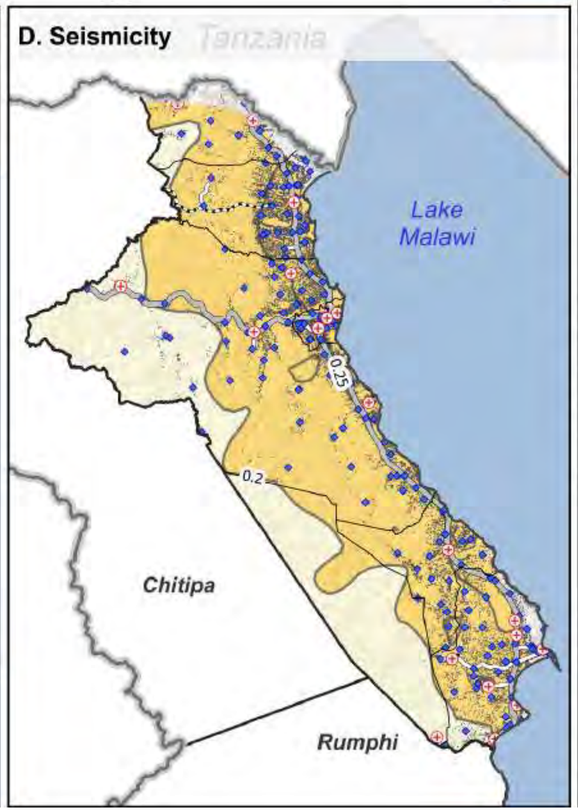
Compound Projections - Economic Loss

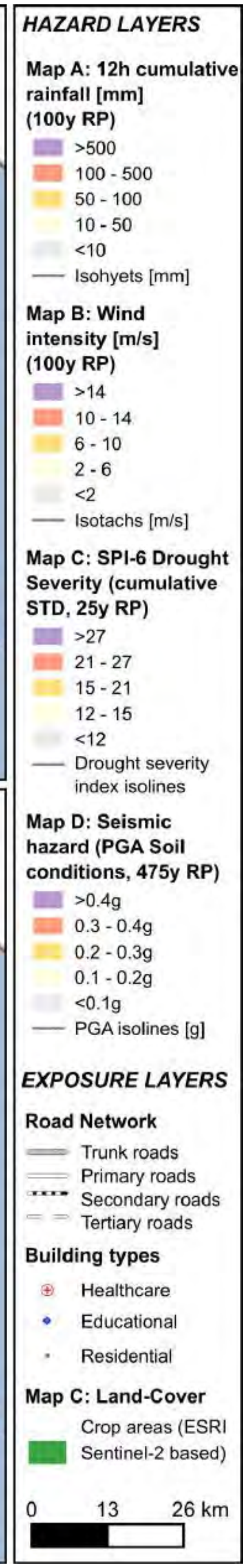












CRS: WGS 84 / UTM zone 36S

KASUNGU

Kasungu is a district in the Central Region of Malawi, covering an area of 7,878 km². It is the sixth-largest urban centre in Malawi.
Social vulnerability parameters related to poverty and food insecurity are higher than the national average, while the inactive population is lower. The key hazards in the risk to the built environment are strong winds, while drought is the primary threat to the population. Both fast-onset weather-related hazards and drought risks are compounded by climate change projections. Drought shows minimal differences between the optimistic and pessimistic scenarios, while strong winds are significantly more impactful in the pessimistic scenario. The ratio of average annual economic losses due to strong winds and the number of people affected by drought are both higher than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**981 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	4.56	-
Poverty Prevalence (%)	**67**	51*
Food Insecurity (%)	**66**	64*
Inactive Population (%)	**8**	9*

* National value as weighted mean on population

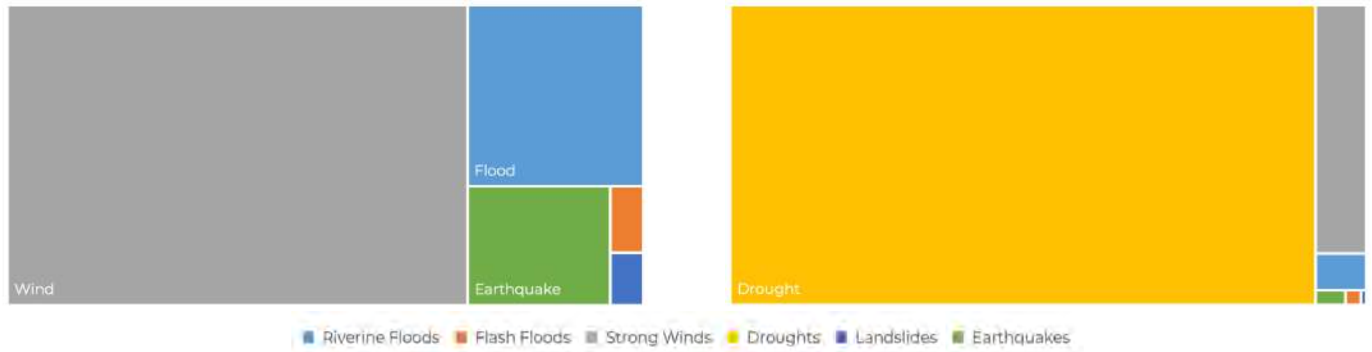
STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**6333**	131 953
Ratio on total value (%)	4.80	-
Schools and Hospitals	**393 – 31**	6410 - 671
Ratio on total value (%)	6.13 – 4.62	-
Most important Crops	**Maize, Groundnuts, Beans, Cassava, Sweet Potato**	Cassava, Maize, Sweet Potato, Groundnuts

RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**15.297**	-	-	-	-	-	**57 023**	-
Riverine Floods	2.558	0.41	5.447	0.69	0.03	-	554	0.45
Flash Floods	0.176	0.03	-	-	-	-	69	0.06
Strong Winds	11.073	1.779	-	-	-	-	3762	3.89
Compound	13.798	-	-	-	-	-	4383	-
Droughts	-	-	-	-	4.807	-	52 486	58
Landslides	0.14	0.023	-	-	-	-	23	0
Earthquakes	1.359	0.21	-	-	-	-	131	0.13

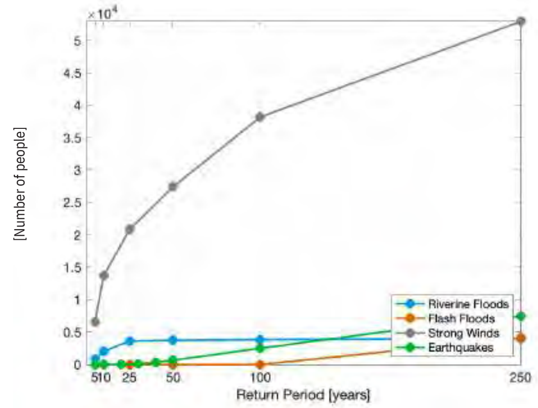
RISK RESULTS – Average Annual Losses CHARTS

Economic Built - UP | Population

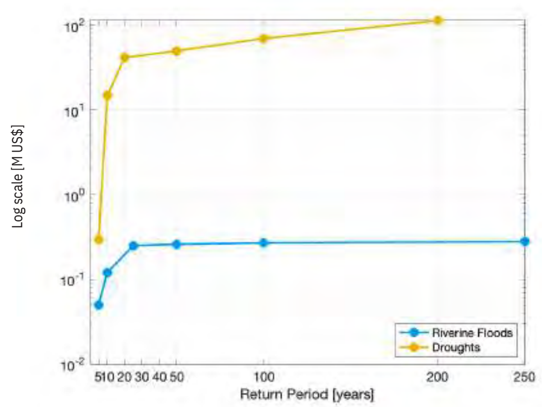


RISK RESULTS – Probable Maximum Losses CURVES

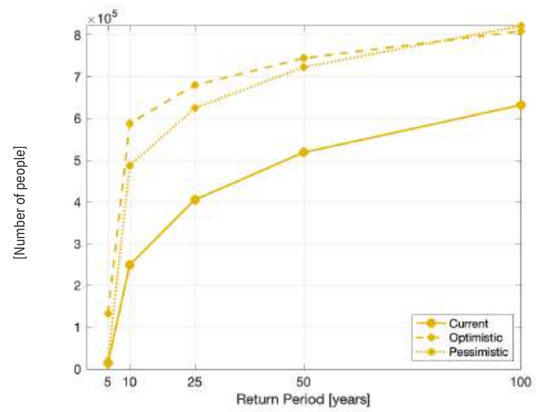
Fast-onset Weather related and Earthquakes - Affected Population



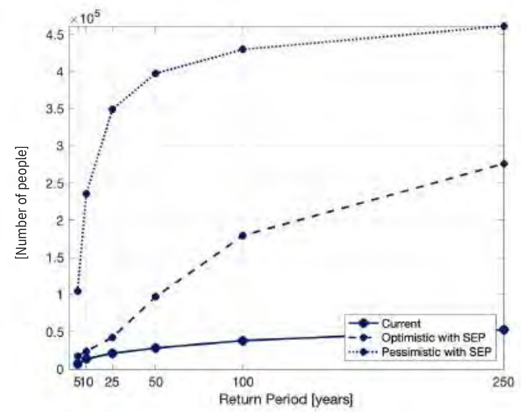
Weather related - Economic Loss



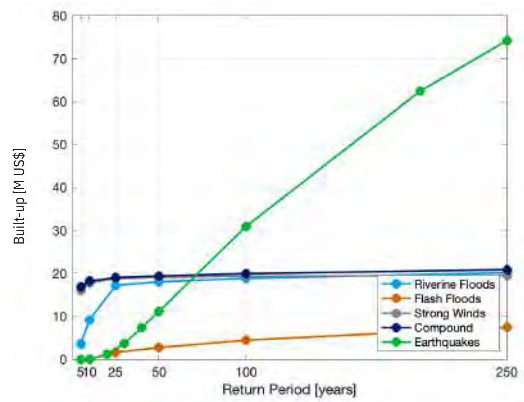
Droughts Projections - Affected Population



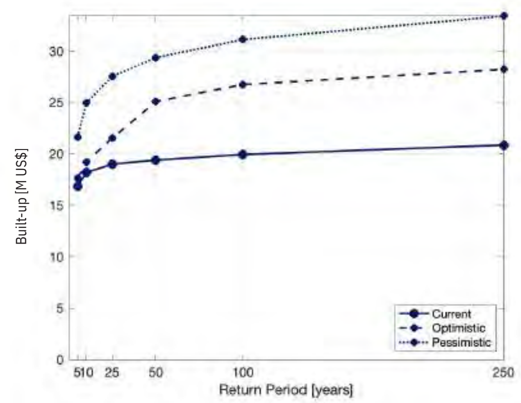
Compound Projections - Affected Population

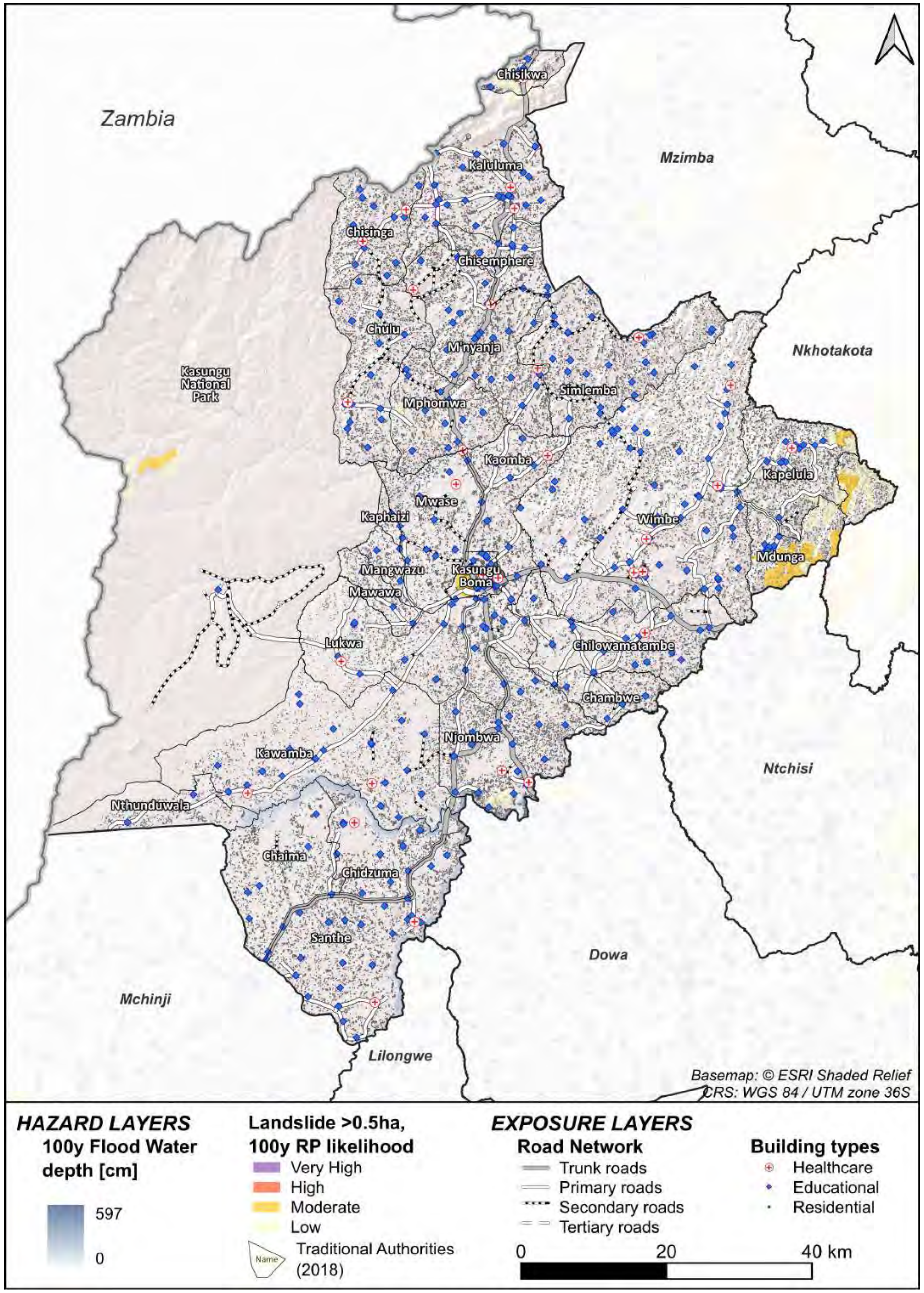


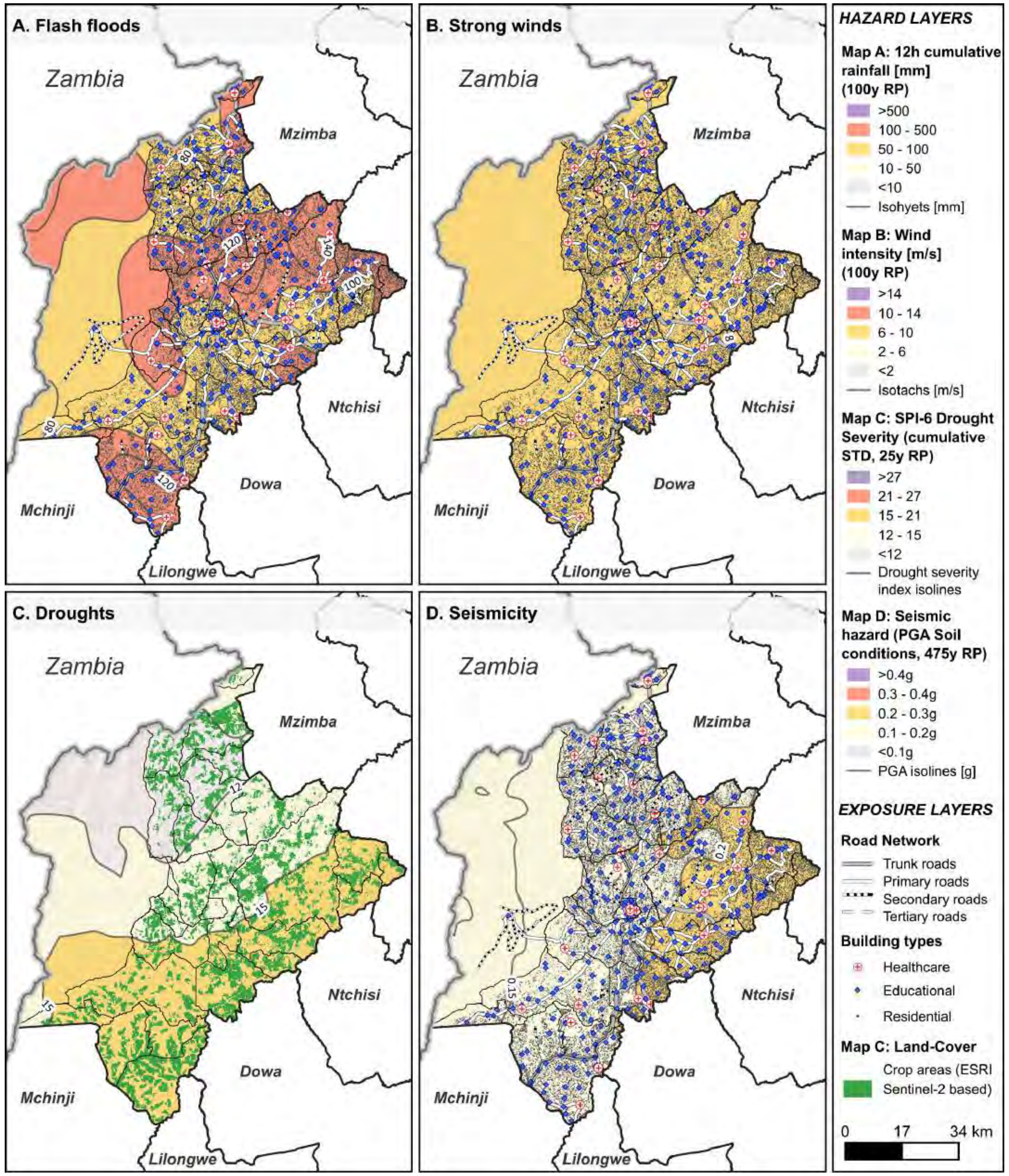
Fast-onset Weather related and Earthquakes - Economic Loss



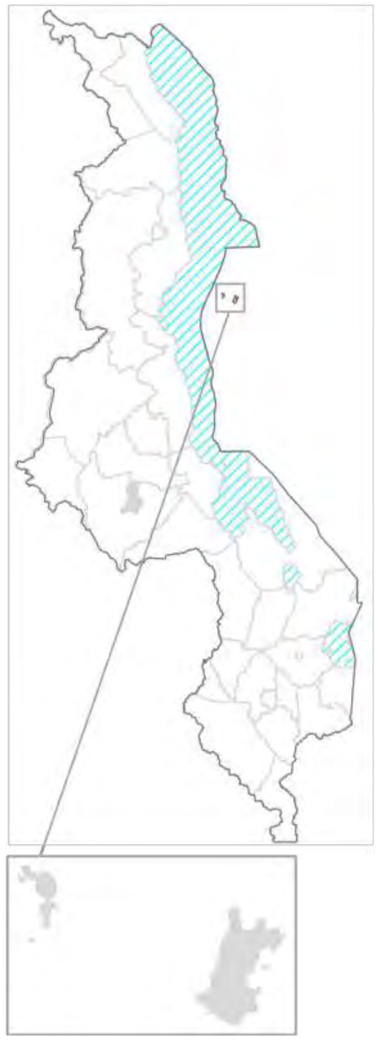
Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S



LIKOMA

Likoma is a district in the Northern Region of Malawi. It is the smallest district in terms of size (20 km²) and population, yet it has the highest population density. The district consists of two main islands, Likoma and Chizumulu.
All social vulnerability parameters in Likoma are lower than the national average. Strong winds and floods pose the most significant risk to the built environment. Strong winds are also the primary hazard affecting the population. The fast-onset weather-related risks are not significantly impacted by climate change projections. The average annual economic losses due to strong winds and floods are higher than the national average. Additionally, the average annual number of people affected by strong winds is more than four times the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**16 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	0.07	-
Poverty Prevalence (%)	**26**	51*
Food Insecurity (%)	**46**	64*
Inactive Population (%)	**7**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**83**	131 953
Ratio on total value (%)	0.06	-
Schools and Hospitals	**14 – 2**	6410 - 671
Ratio on total value (%)	0.22 – 0.30	-
Most important Crops	**Maize, Cassava, Cow peas**	Cassava, Maize, Sweet Potato, Groundnuts

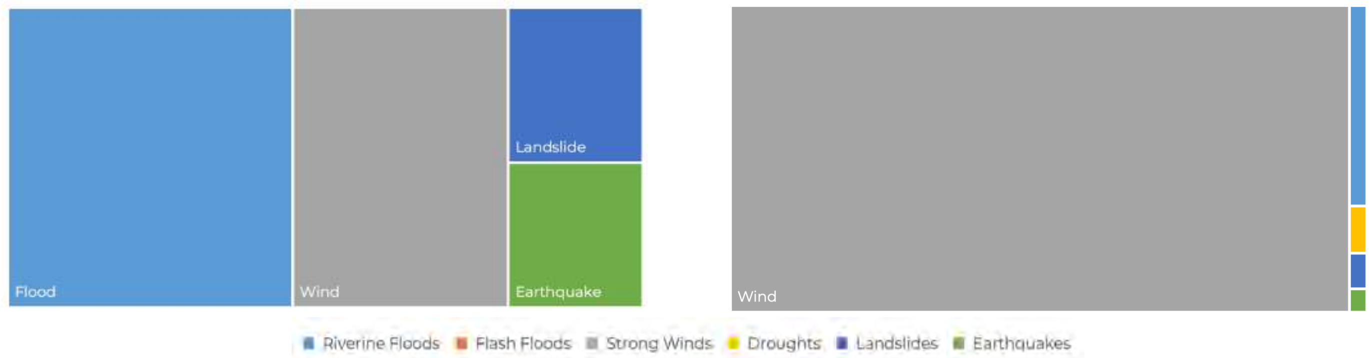
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**0.274**	-	-	-	-	-	**1912**	-
Riverine Floods	0.123	1.49	0	0	0	0	34	1.62
Flash Floods	0	0	-	-	-	-	0	0
Strong Winds	0.093	1.772	-	-	-	-	1860	181.79
Compound	0.216	-	-	-	-	-	1894	-
Droughts	-	-	-	-	0	-	8	38
Landslides	0.03	0.385	-	-	-	-	6	0.4
Earthquakes	0.028	0.34	-	-	-	-	4	0.24

RISK RESULTS – Average Annual Losses CHARTS

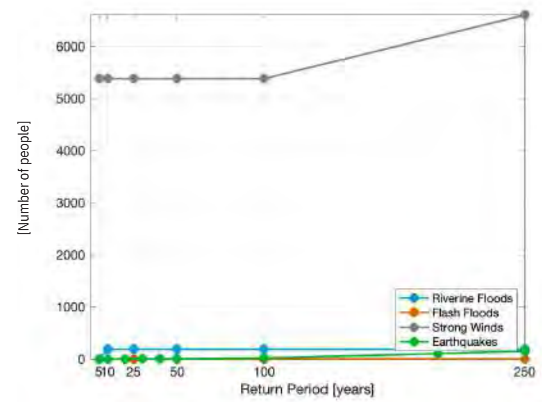
Economic Built - UP

Population

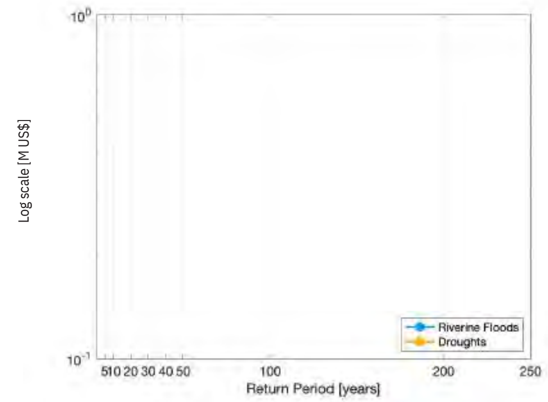


RISK RESULTS – Probable Maximum Losses CURVES

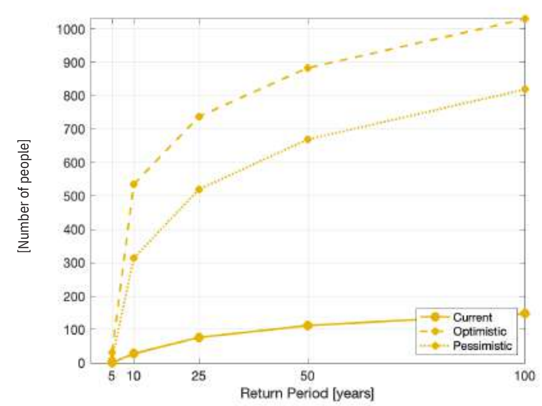
Fast-onset Weather related and Earthquakes - Affected Population



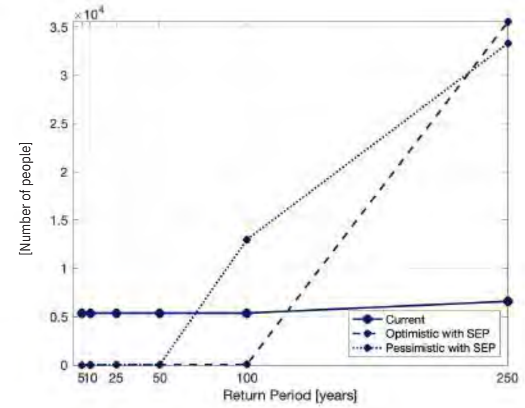
Weather related - Economic Loss



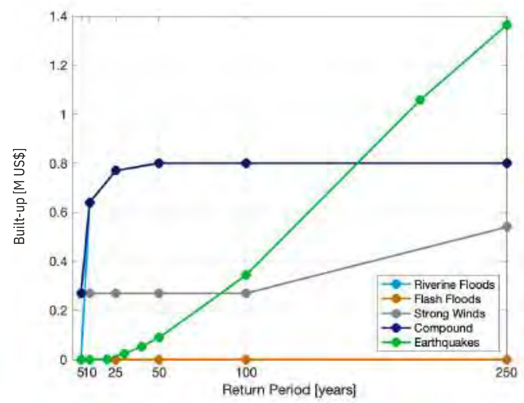
Droughts Projections - Affected Population



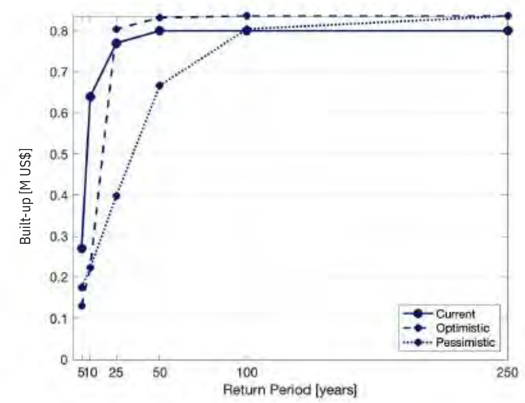
Compound Projections - Affected Population

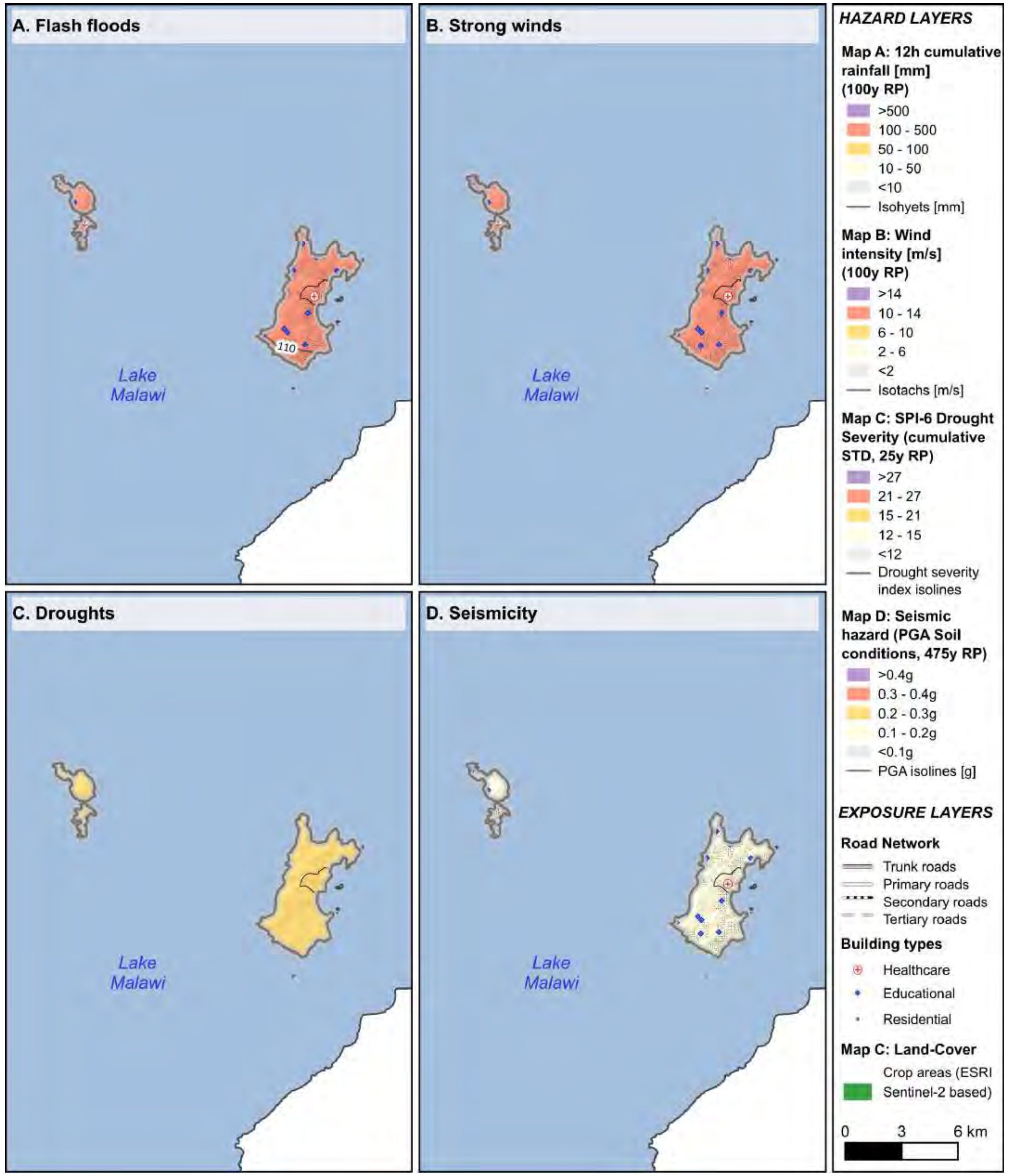


Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss





CRS: WGS 84 / UTM zone 36S

LILONGWE

Lilongwe is a district in the Central Region of Malawi covering an area of 6159 km2 located 1050 metres above sea level.
Social vulnerability parameters on poverty prevalence and food insecurity are higher than the national average, while the inactive population is lower.
Strong winds pose the greatest risk to the built environment, followed by flash floods, floods, and earthquakes. Meanwhile, drought affects the population the most.
According to climate projections, weather-related hazards lead to increased losses in the pessimistic scenario, whereas drought is similarly impacted in both scenarios. The ratio of the annual average economic losses due to strong winds is higher than the national average whilst the annual average of people affected by drought is slightly higher than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**1 836 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	8.54	-
Poverty Prevalence (%)	**64**	51*
Food Insecurity (%)	**74**	64*
Inactive Population (%)	**6**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**12 832**	131 953
Ratio on total value (%)	9.72	-
Schools and Hospitals	**397 – 43**	6410 - 671
Ratio on total value (%)	6.19 – 6.41	-
Most important Crops	**Maize, Groundnuts, Beans, Sweet Potato, Cassava**	Cassava, Maize, Sweet Potato, Groundnuts

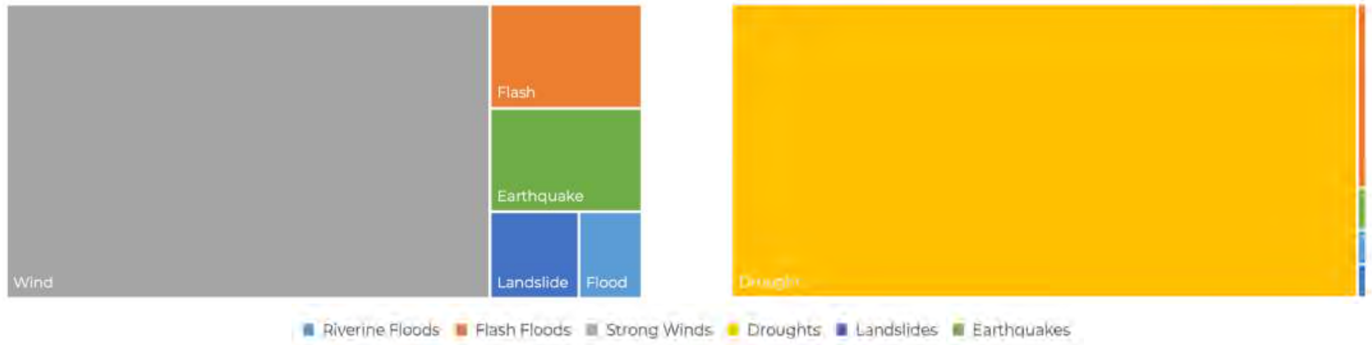
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**28.925**	-	-	-	-	-	**113237**	-
Riverine Floods	0.845	0.07	0.059	0.02	0	-	189	0.09
Flash Floods	2.462	0.2	-	-	-	-	999	0.46
Strong Winds	22.161	1.77	-	-	-	-	0	0
Compound	25.281	-	-	-	-	-	1150	-
Droughts	-	-	-	-	12.981	-	111683	58
Landslides	1.198	0.095	-	-	-	-	178	0.1
Earthquakes	2.446	0.19	-	-	-	-	226	0.12

RISK RESULTS – Average Annual Losses CHARTS

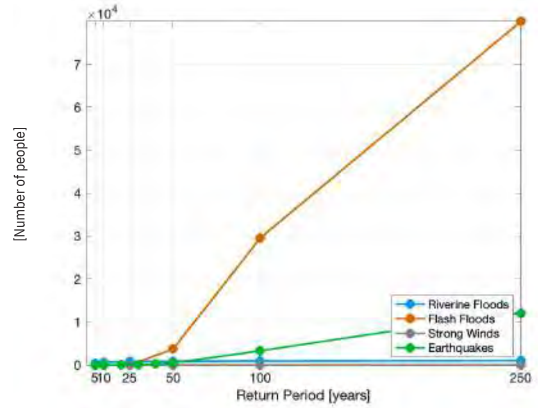
Economic Built - UP

Population

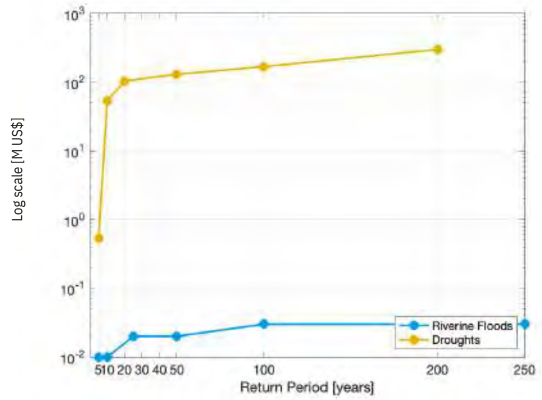


RISK RESULTS – Probable Maximum Losses CURVES

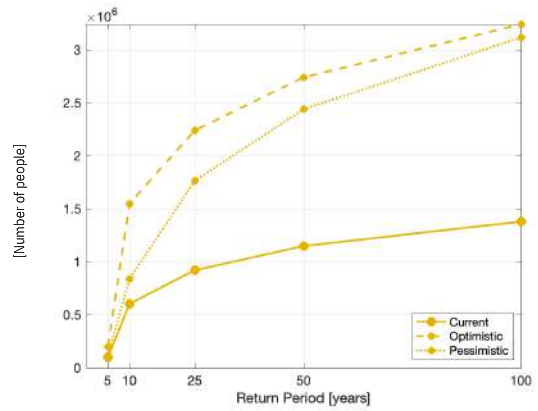
Fast-onset Weather related and Earthquakes - Affected Population



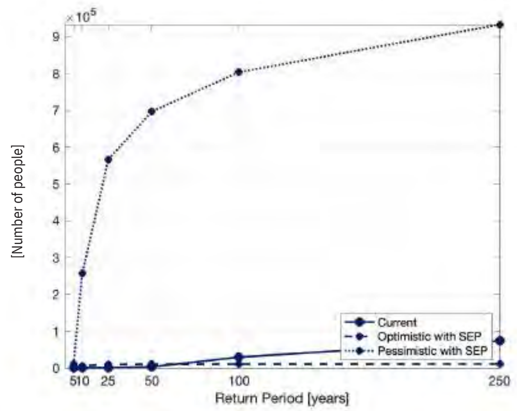
Weather related - Economic Loss



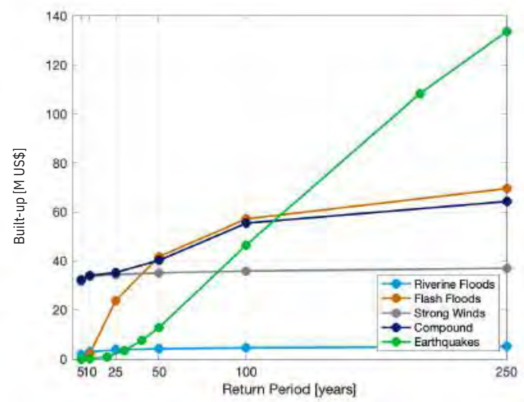
Droughts Projections - Affected Population



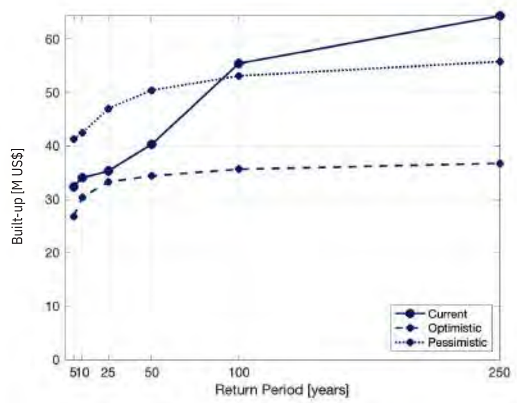
Compound Projections - Affected Population

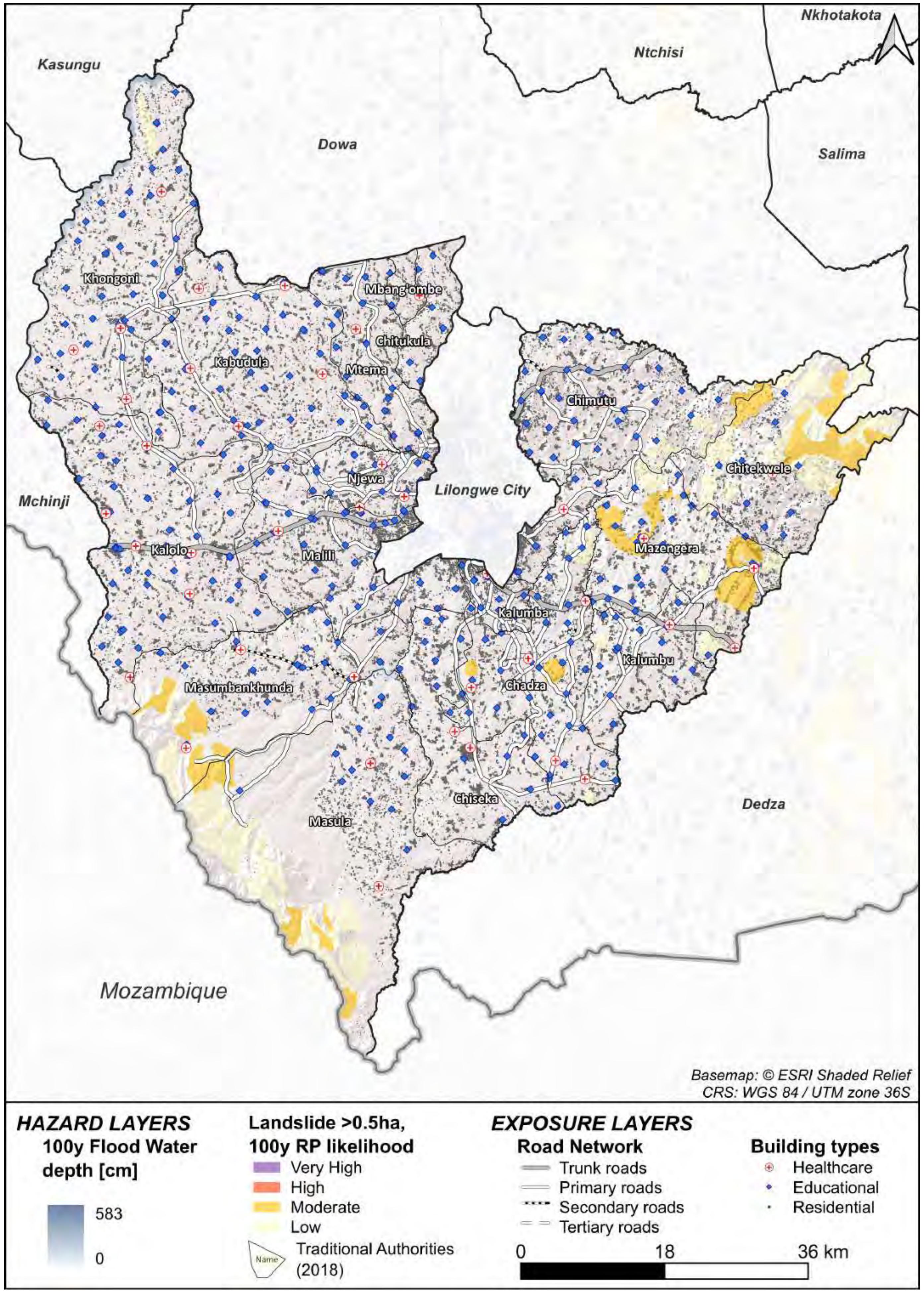


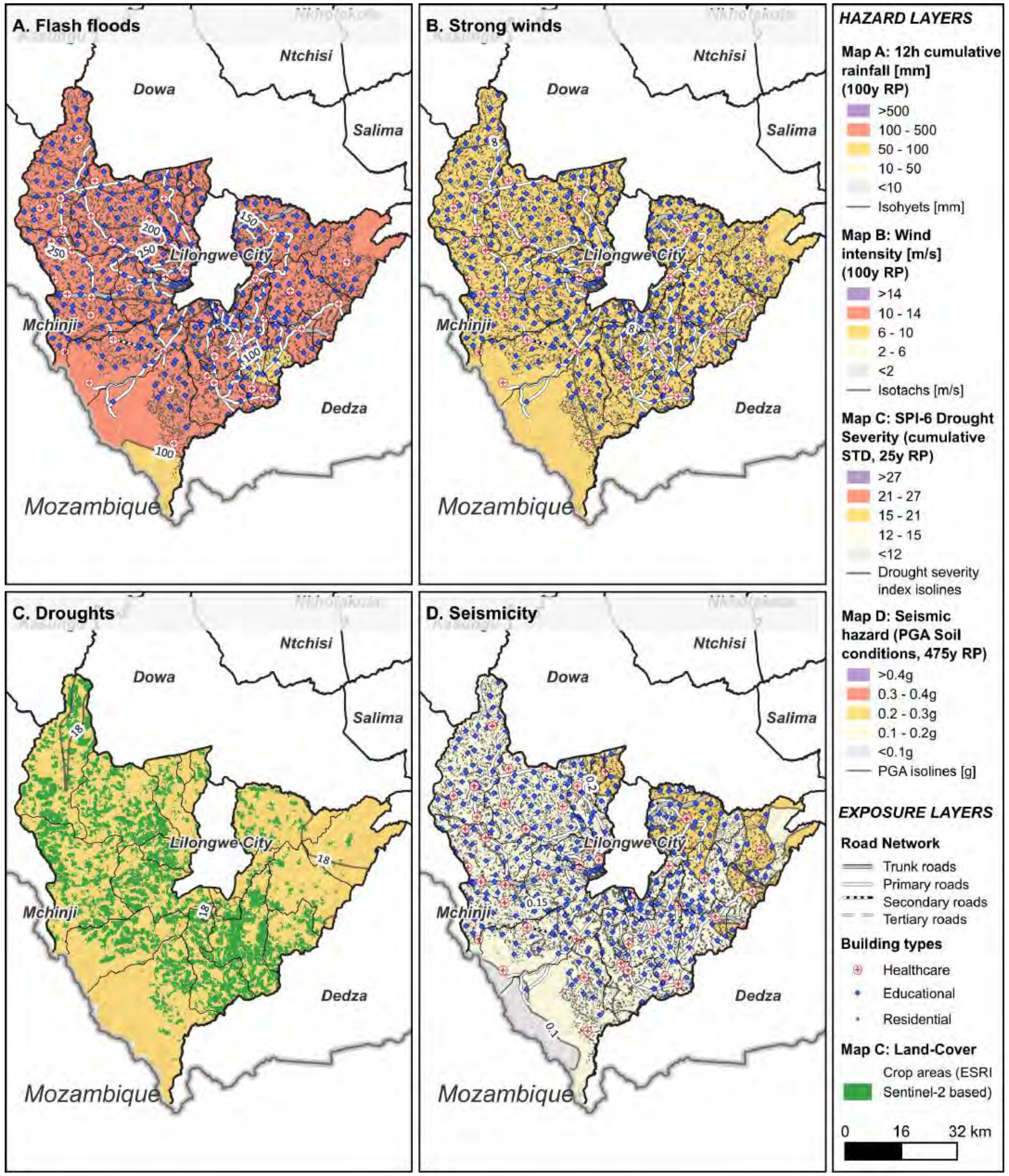
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

LILONGWE CITY

Lilongwe is Malawi's largest city and has been the capital since 1975. It serves as an important economic and transportation hub for central Malawi and is named after the Lilongwe River. All social vulnerability parameters in Lilongwe are lower than the national average.
Regarding the built environment, strong winds pose the most significant risk, followed by earthquakes. Drought on the other hand is the most critical in affecting the population. In climate projections, compound weather-related hazards are expected to increase losses in the pessimistic scenario, while drought is similarly affected by both scenarios. The ratio of average annual economic losses due to strong winds and the average number of people affected by drought is lower than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**1 132 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	5.27	-
Poverty Prevalence (%)	**16**	51*
Food Insecurity (%)	**45**	64*
Inactive Population (%)	**24**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**6850**	131 953
Ratio on total value (%)	5.19	-
Schools and Hospitals	**188 – 20**	6410 - 671
Ratio on total value (%)	2.93 – 2.98	-
Most important Crops	**Maize, Cassava, Potato**	Cassava, Maize, Sweet Potato, Groundnuts

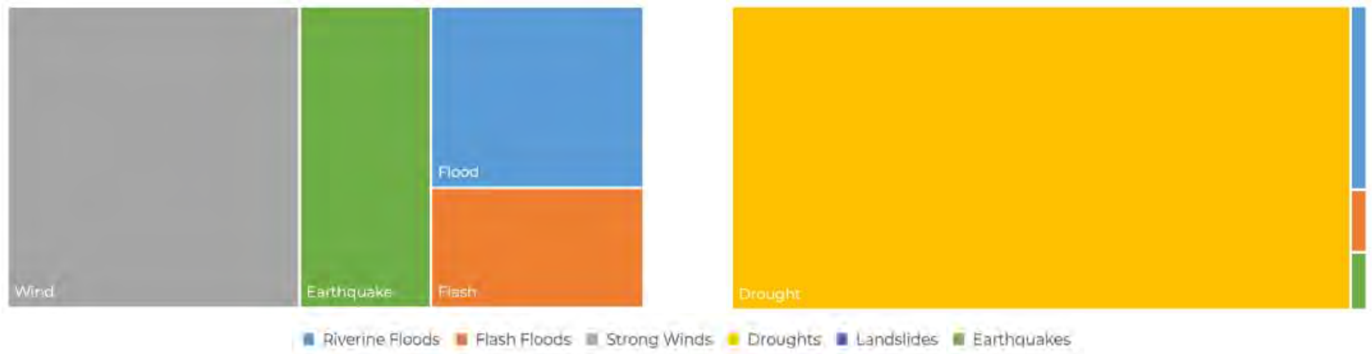
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**10.246**	-	-	-	-	-	**41 130**	-
Riverine Floods	2.079	0.29	0.542	0.30	0	0	630	0.46
Flash Floods	1.377	0.2	-	-	-	-	215	0.16
Strong Winds	4.747	0.67	-	-	-	-	0	0
Compound	8.108	-	-	-	-	-	845	-
Droughts	-	-	-	-	1.265	-	40 087	34
Landslides	0.0000034	0.0000005	-	-	-	-	0.001	0
Earthquakes	2.138	0.31	-	-	-	-	198	0.18

RISK RESULTS – Average Annual Losses CHARTS

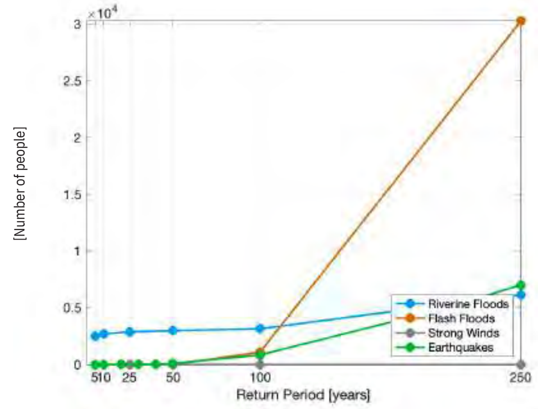
Economic Built - UP

Population

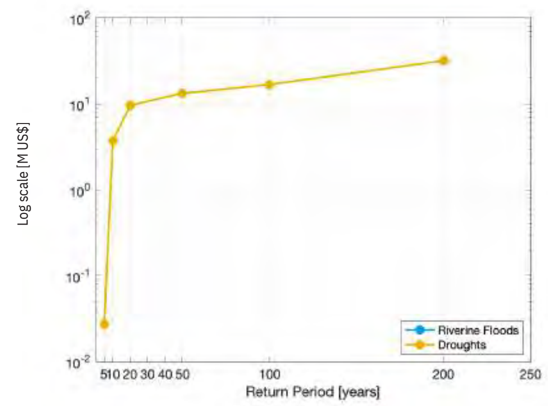


RISK RESULTS – Probable Maximum Losses CURVES

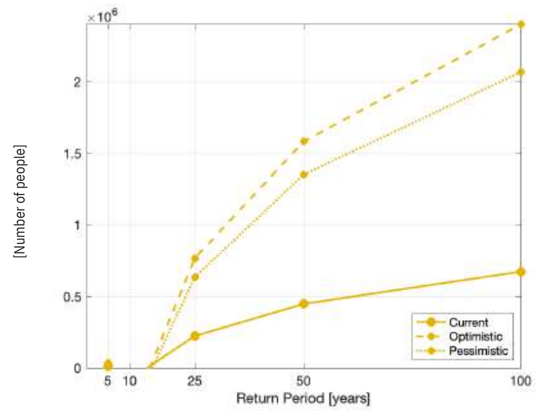
Fast-onset Weather related and Earthquakes - Affected Population



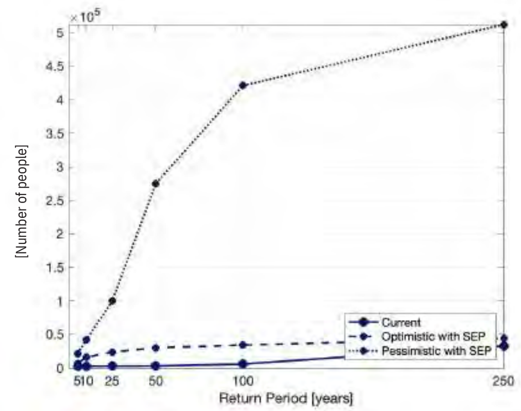
Weather related - Economic Loss



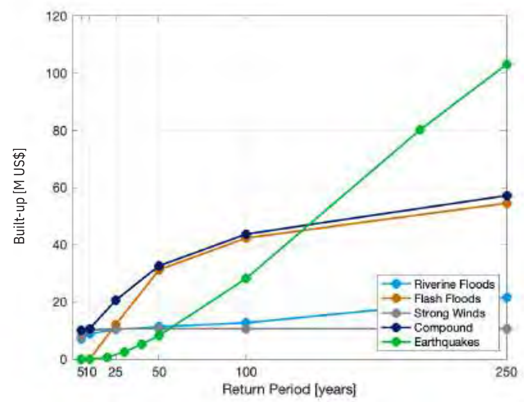
Droughts Projections - Affected Population



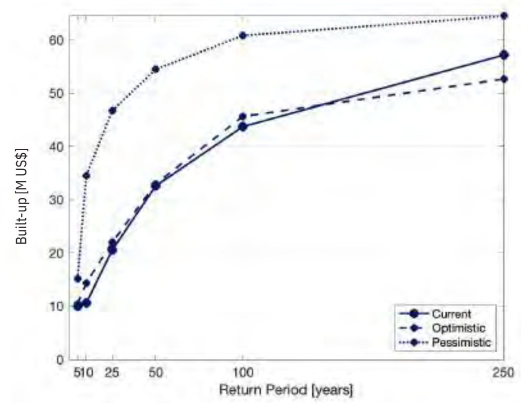
Compound Projections - Affected Population

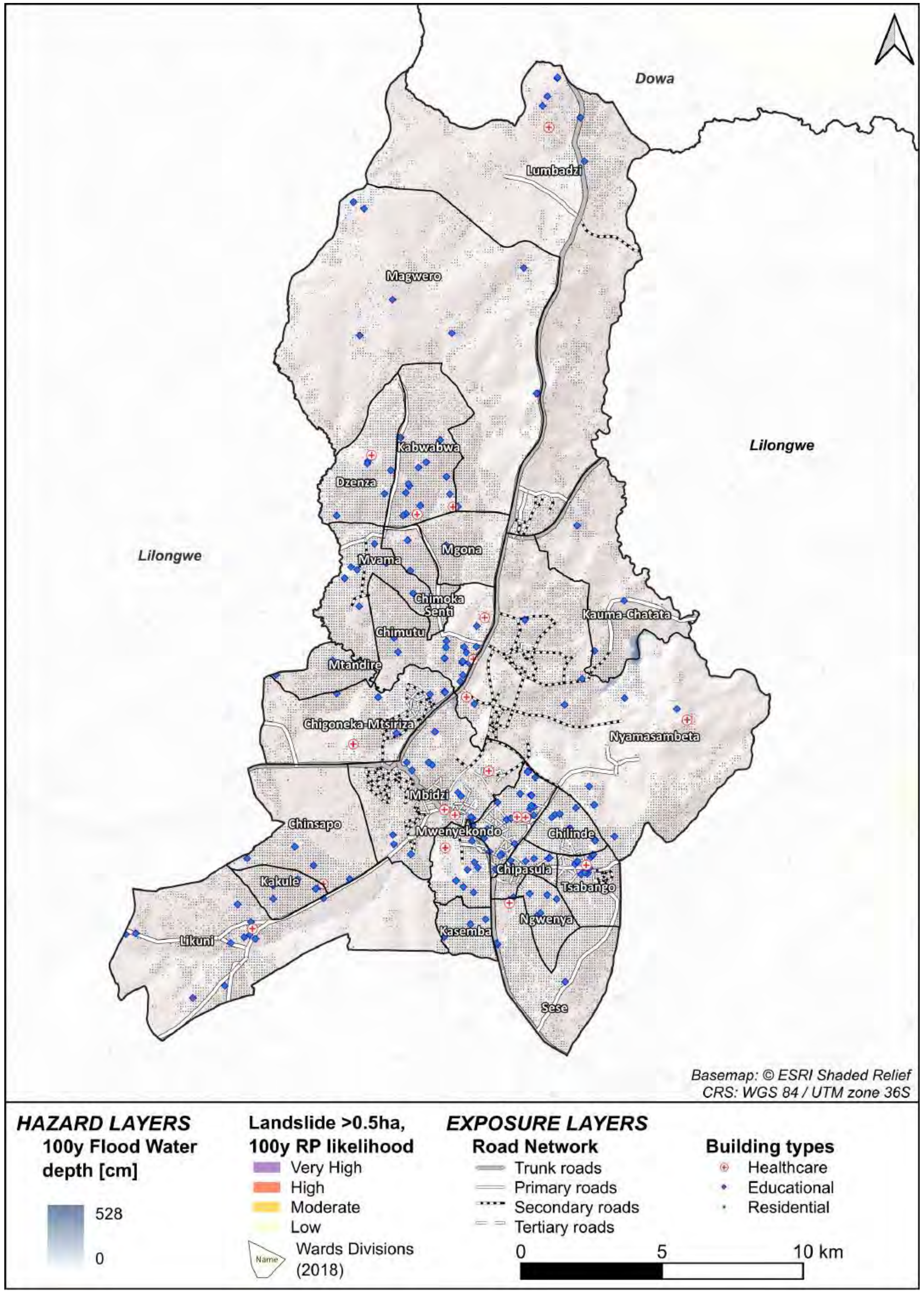


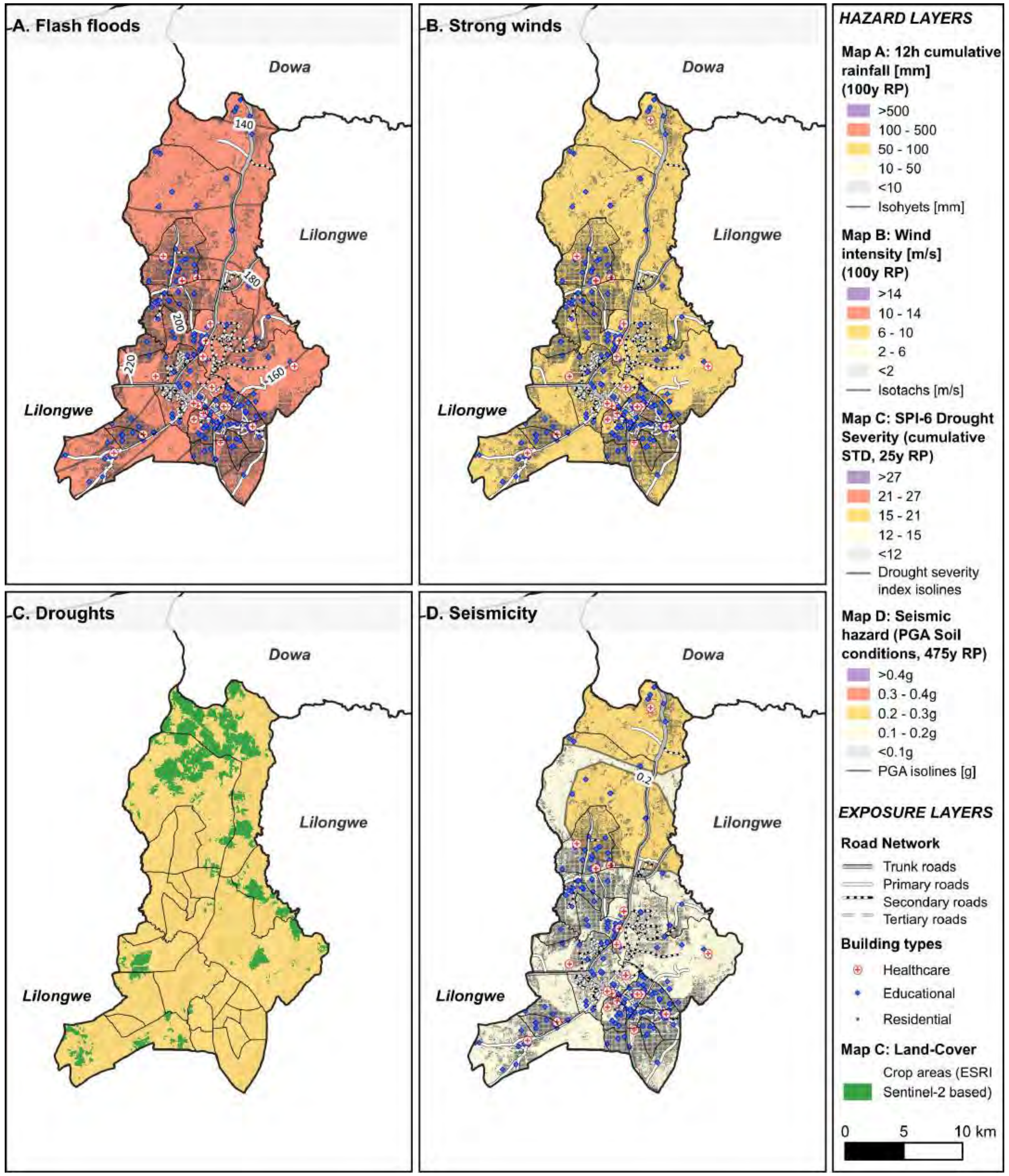
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

MACHINGA

Machinga is a district in the Southern Region of Malawi, located east along the main road which connects Zomba and Lilongwe. The district covers an area of 3,771 km². Social vulnerability parameters related to poverty prevalence and food insecurity are higher than the national average, while the inactive population is lower.
Flooding has the most severe consequences when assessing risks to the built environment in the district, followed by strong winds. Drought affects the population the most. Weather-related risks are influenced by climate change, with the greatest impact seen in the optimistic scenario. Drought, however, is similarly affected in both scenarios. The ratio of the average annual economic losses due to flooding is higher than the national average, as well as the average annual people affected due to drought. Machinga is the fourth most affected district in terms of economic losses to transportation systems.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**864 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	4.02	-
Poverty Prevalence (%)	**62**	51*
Food Insecurity (%)	**78**	64*
Inactive Population (%)	**2**	9*

* National value as weighted mean on population

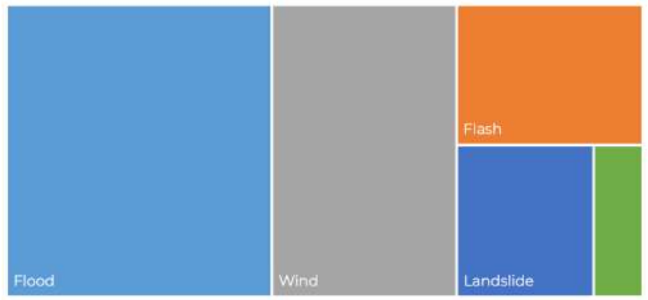
STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**5623**	131 953
Ratio on total value (%)	4.26	-
Schools and Hospitals	**192 – 23**	6410 - 671
Ratio on total value (%)	2.84 – 3.43	-
Most important Crops	**Maize, Pigeon peas, Rice, Sorghum, Groundnuts, Cassava, Sweet Potato**	Cassava, Maize, Sweet Potato, Groundnuts

RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**19.994**	-	-	-	-	-	**54 213**	-
Riverine Floods	8.355	1.52	1.950	2.08	0	-	1590	1.55
Flash Floods	2.817	0.52	-	-	-	-	809	0.8
Strong Winds	5.821	1.08	-	-	-	-	540	0.64
Compound	16.952	-	-	-	-	-	2858	-
Droughts	-	-	-	-	6.88	-	50 920	70
Landslides	2.243	0.408	-	-	-	-	359	0.4
Earthquakes	0.799	0.14	-	-	-	-	76	0.09

RISK RESULTS – Average Annual Losses CHARTS

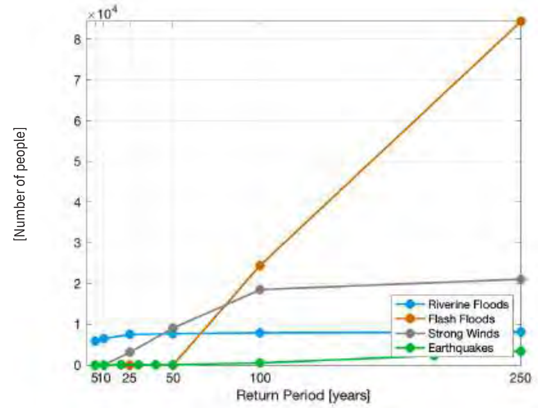
Economic Built - UP



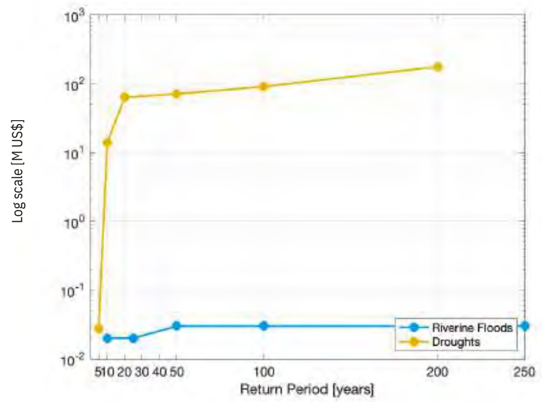
Population

RISK RESULTS – Probable Maximum Losses CURVES

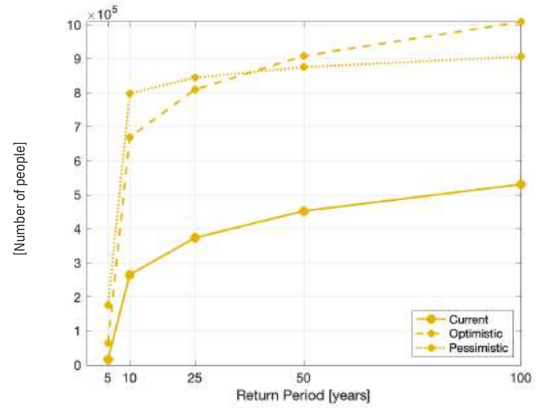
Fast-onset Weather related and Earthquakes - Affected Population



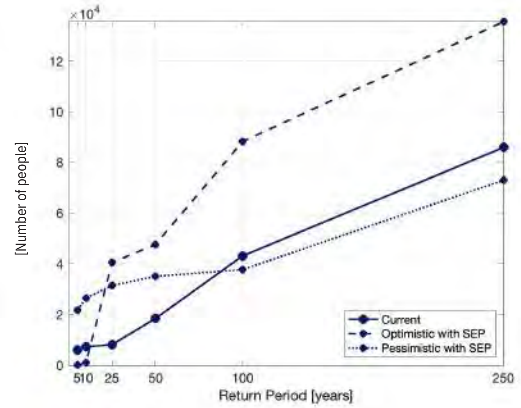
Weather related - Economic Loss



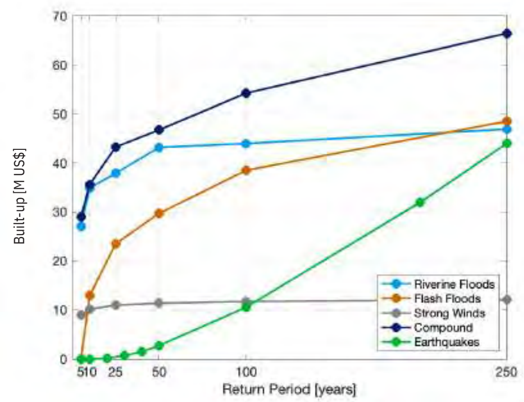
Droughts Projections - Affected Population



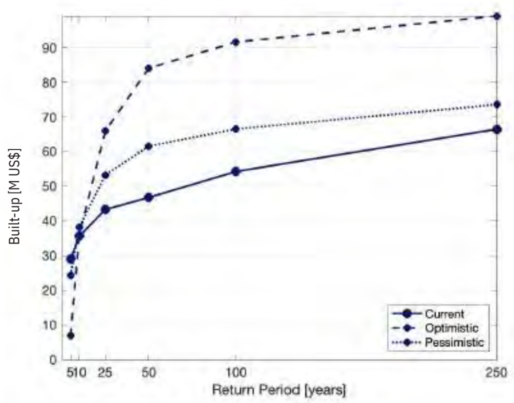
Compound Projections - Affected Population

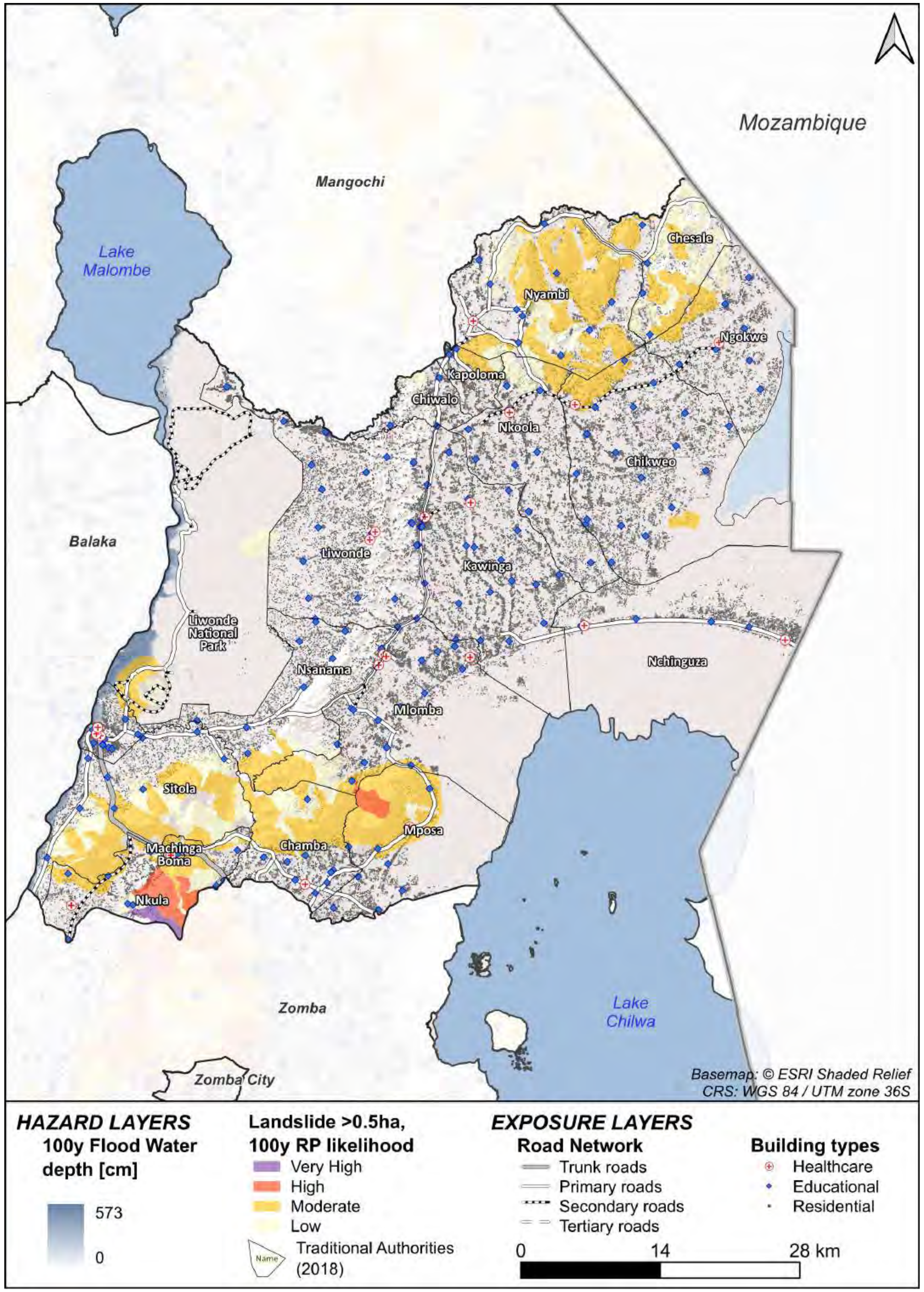


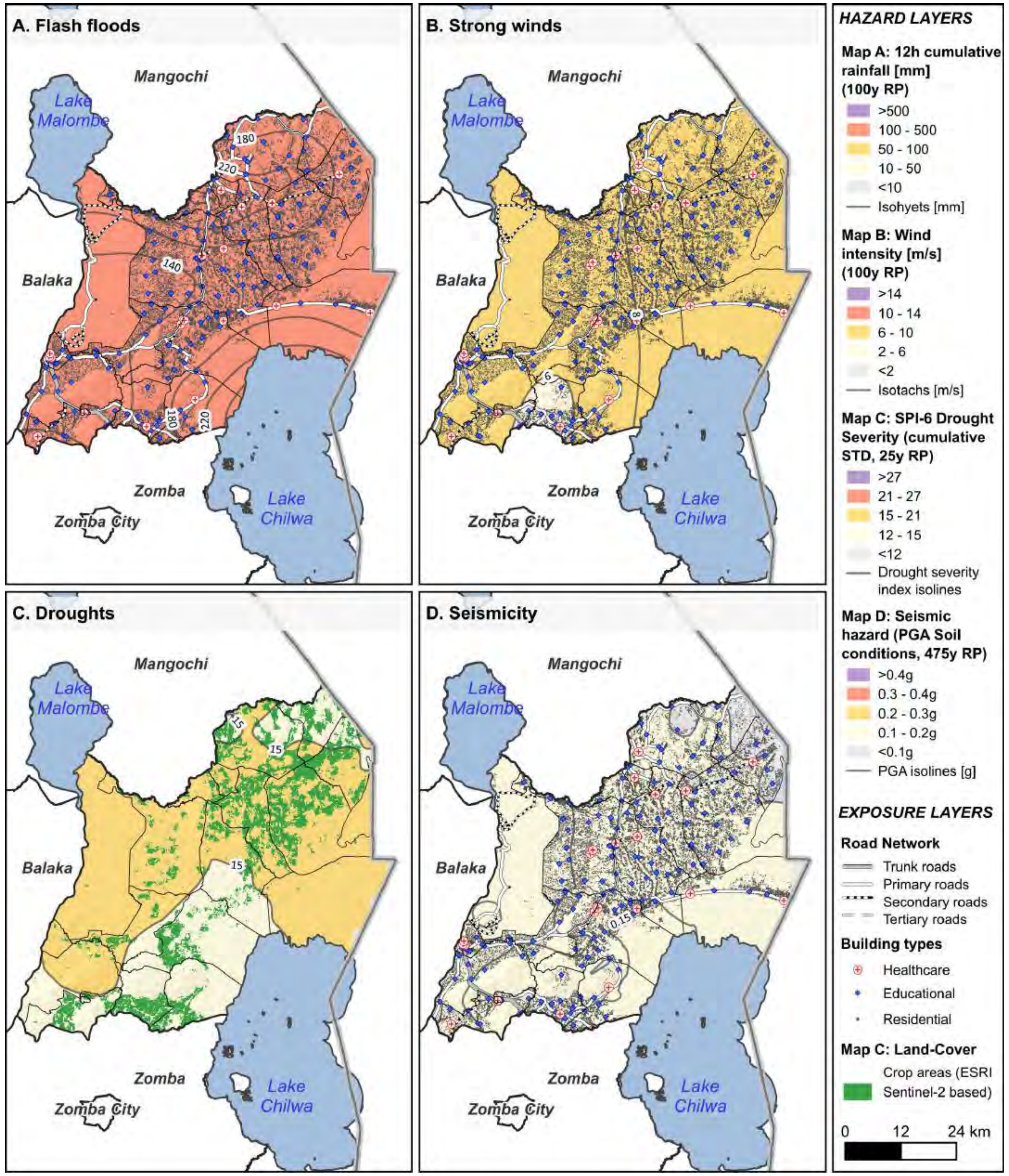
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

MANGOCHI

Mangochi is a historic district located in the Southern Region of Malawi, situated between Lake Malawi and Lake Malombe. The district covers an area of 6273 km². Social vulnerability parameters for poverty prevalence and food insecurity are higher than the national average, while the inactive population is lower. Flooding is the most critical hazard for the risk of the built environment, followed by strong winds. Strong winds significantly affect the population, followed by drought. The risks associated with compound fast-onset weather events and drought are influenced by climate change projections, with the former being most affected in the pessimistic scenario, and the latter being similarly impacted in both scenarios. The ratios of the average annual economic losses due to floods and strong winds are higher than the national average. The average annual population affected by drought is aligned with the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**1 329 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	6.18	-
Poverty Prevalence (%)	**64**	51*
Food Insecurity (%)	**73**	64*
Inactive Population (%)	**3**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**7915**	131 953
Ratio on total value (%)	6.00	-
Schools and Hospitals	**282 – 37**	6410 - 671
Ratio on total value (%)	4.40 – 5.51	-
Most important Crops	**Maize, Groundnuts, Pigeon peas, Sweet Potato, Cassava**	Cassava, Maize, Sweet Potato, Groundnuts

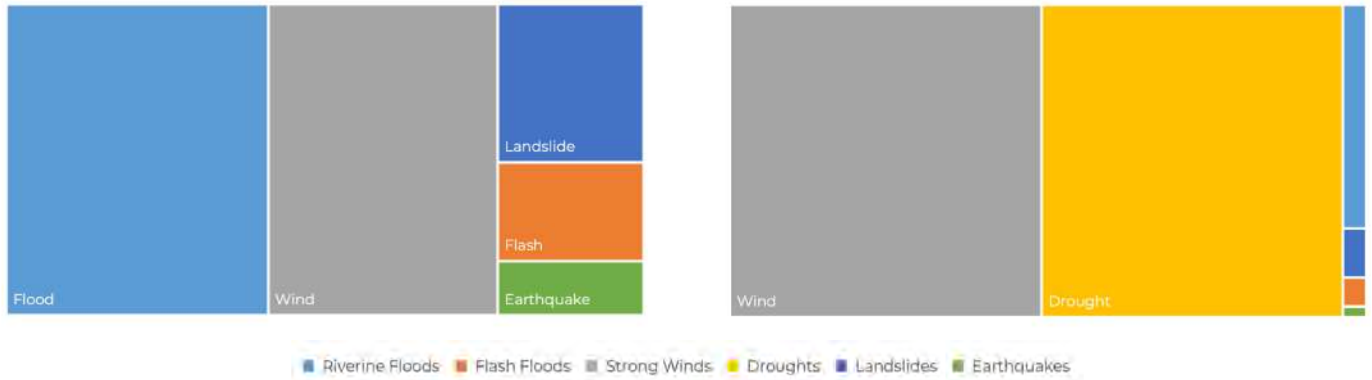
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**38.363**	**-**	**-**	**-**	**-**	**-**	**130 877**	**-**
Riverine Floods	15.846	2	0.214	0.03	0.01	-	3452	2.19
Flash Floods	2.798	0.38	-	-	-	-	446	0.3
Strong Winds	13.894	1.86	-	-	-	-	64 056	51.19
Compound	32.321	-	-	-	-	-	67 943	-
Droughts	-	-	-	-	10.043	-	62 006	56
Landslides	4.502	0.581	-	-	-	-	762	0.6
Earthquakes	1.54	0.19	-	-	-	-	166	0.12

RISK RESULTS – Average Annual Losses CHARTS

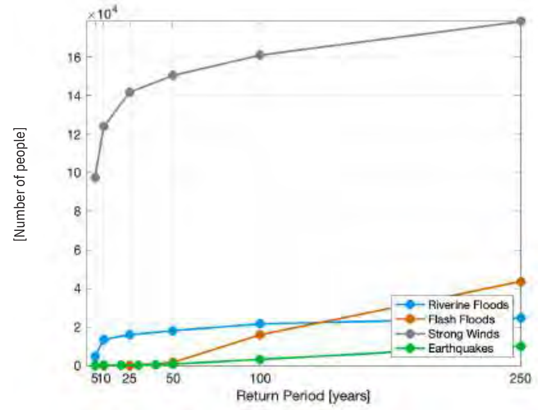
Economic Built - UP

Population

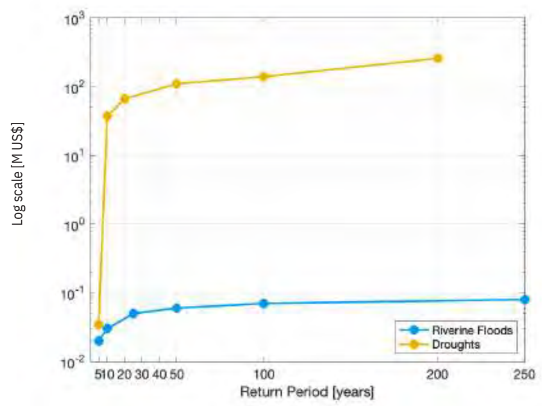


RISK RESULTS – Probable Maximum Losses CURVES

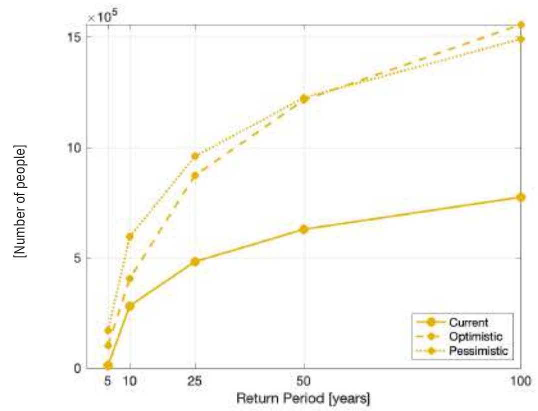
Fast-onset Weather related and Earthquakes - Affected Population



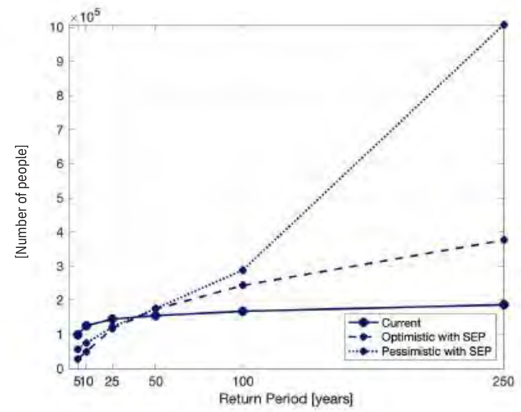
Weather related - Economic Loss



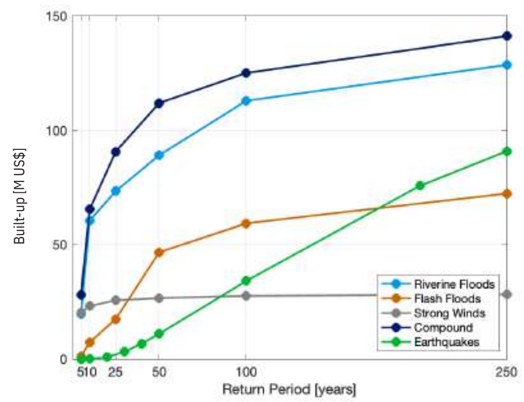
Droughts Projections - Affected Population



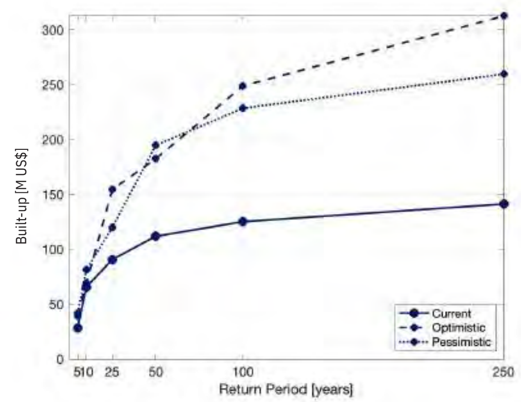
Compound Projections - Affected Population

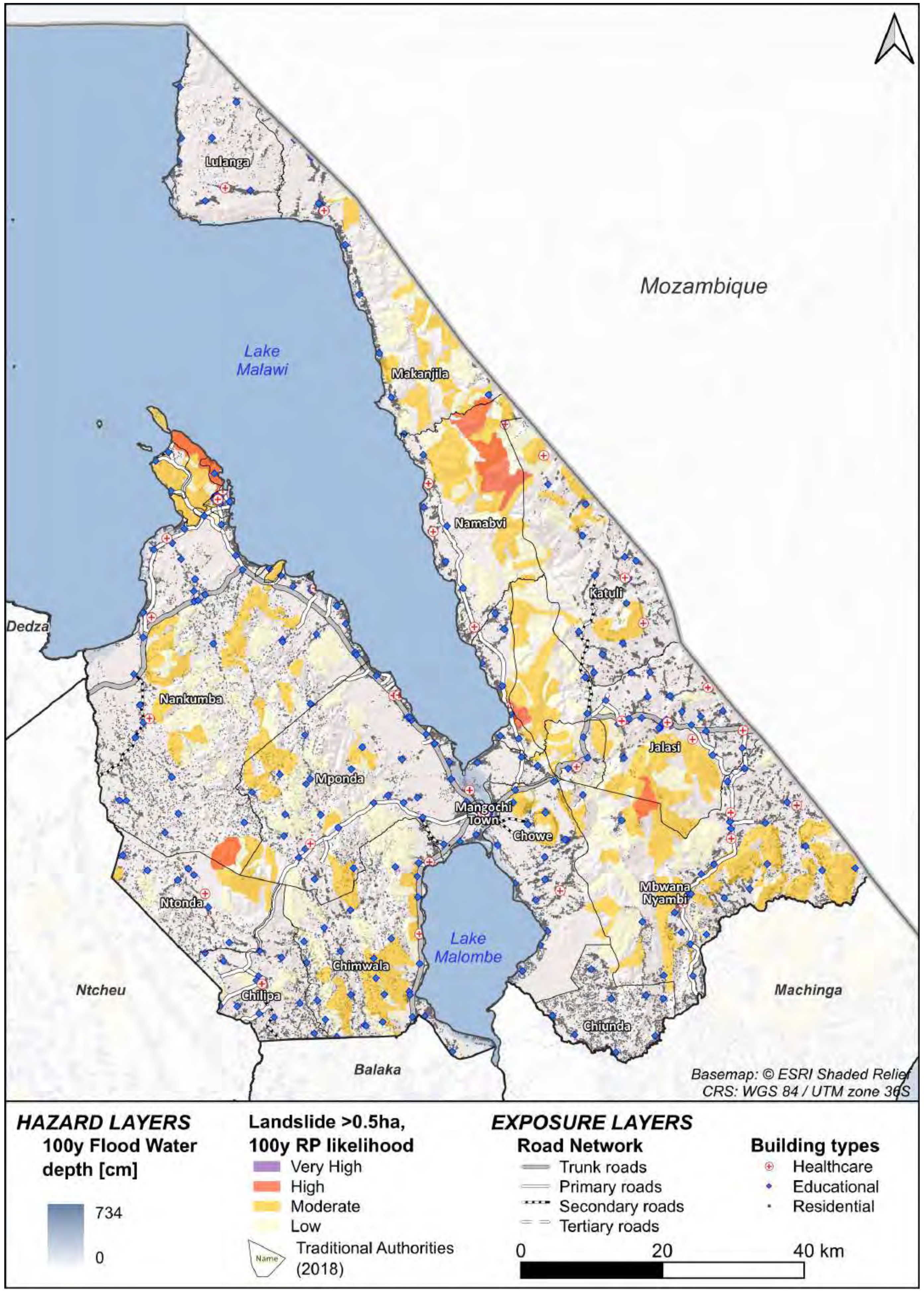


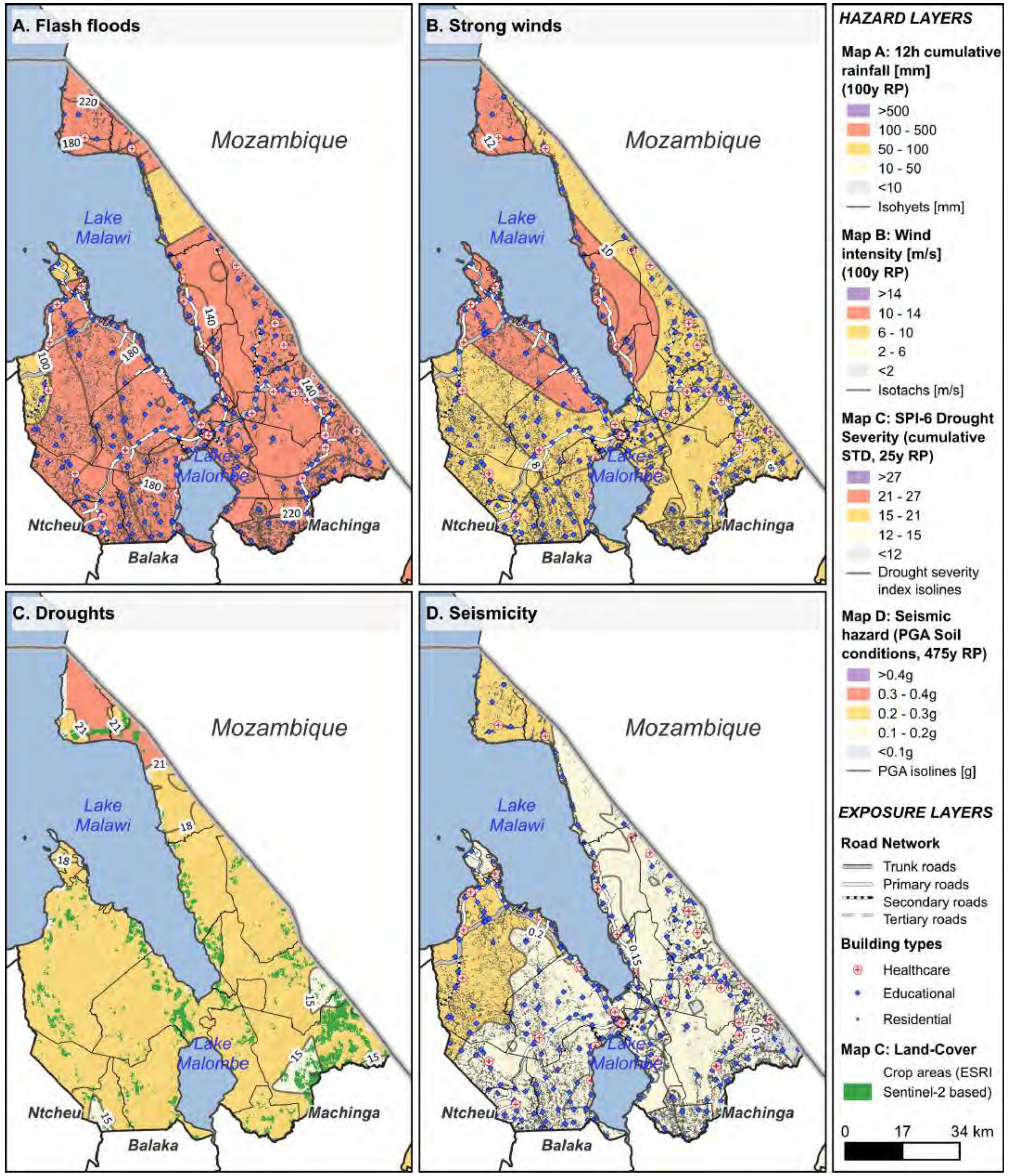
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

MCHINJI

Mchinji is a district in the Central Region of Malawi, covering an area of 3356 km². Social vulnerability parameters for poverty and food insecurity are higher than the national average, while the inactive population is lower. Strong winds pose the greatest risk to the built environment, followed by flash floods and flooding. In contrast, drought primarily affects the population. According to climate projections, compound fast-onset weather-related hazards lead to increased losses in the pessimistic scenario, while drought is influenced equally in both scenarios. The average annual economic losses due to wind are about double the national average, and the average annual number of people affected by drought is higher than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**697 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	3.24	-
Poverty Prevalence (%)	**69**	51*
Food Insecurity (%)	**73**	64*
Inactive Population (%)	**6**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**4382**	131 953
Ratio on total value (%)	3.32	-
Schools and Hospitals	**221 – 17**	6410 - 671
Ratio on total value (%)	3.45 – 2.53	-
Most important Crops	**Maize, Groundnuts, Beans, Soybeans, Sweet Potato**	Cassava, Maize, Sweet Potato, Groundnuts

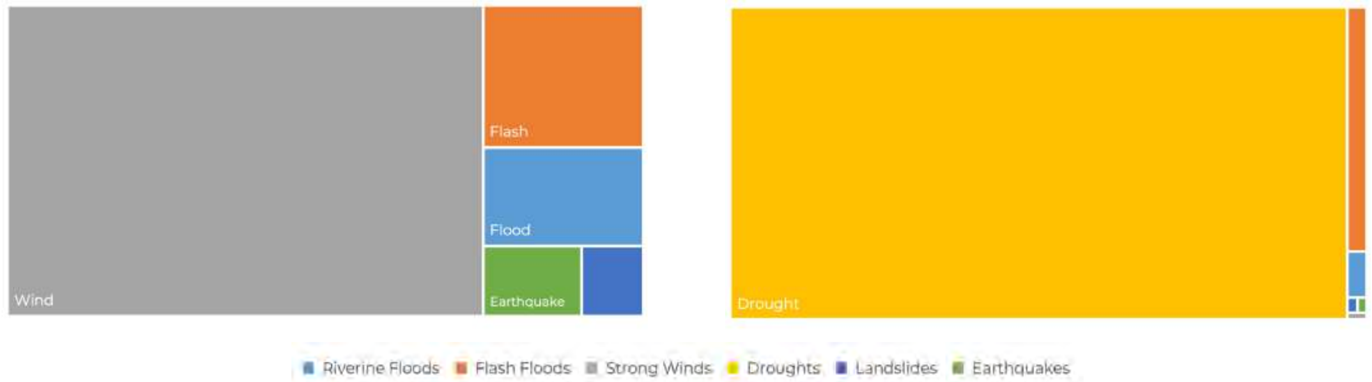
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**12.53**	-	-	-	-	-	**57 353**	-
Riverine Floods	1.009	0.23	0.657	0.15	0.01	-	252	0.29
Flash Floods	1.455	0.33	-	-	-	-	1343	1.56
Strong Winds	9.457	2.17	-	-	-	-	37	0.05
Compound	11.813	-	-	-	-	-	1588	-
Droughts	-	-	-	-	2.269	-	55 682	84
Landslides	0.275	0.064	-	-	-	-	44	0.1
Earthquakes	0.442	0.1	-	-	-	-	39	0.06

RISK RESULTS – Average Annual Losses CHARTS

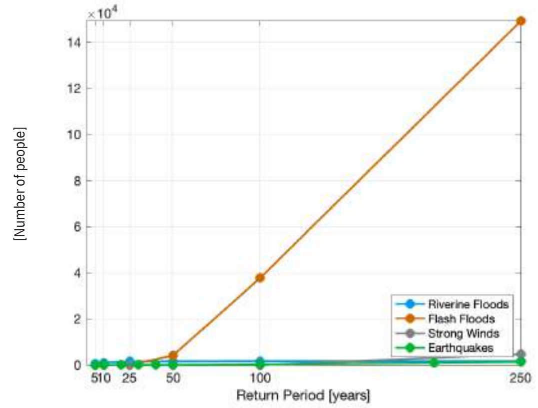
Economic Built - UP

Population

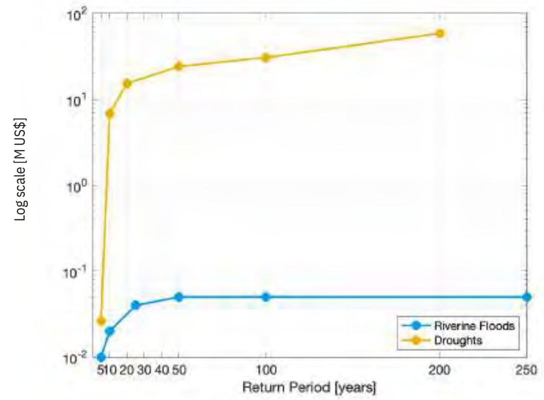


RISK RESULTS – Probable Maximum Losses CURVES

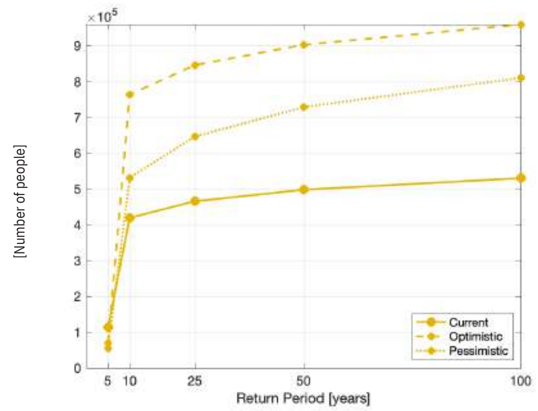
Fast-onset Weather related and Earthquakes - Affected Population



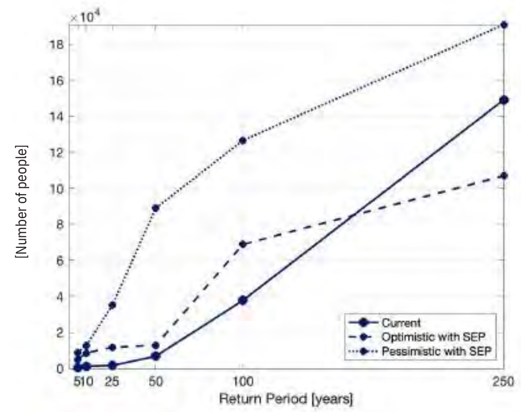
Weather related - Economic Loss



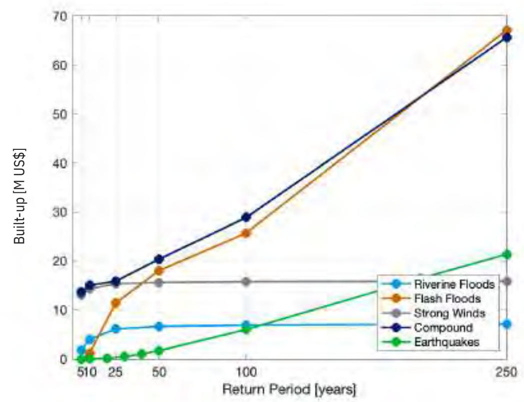
Droughts Projections - Affected Population



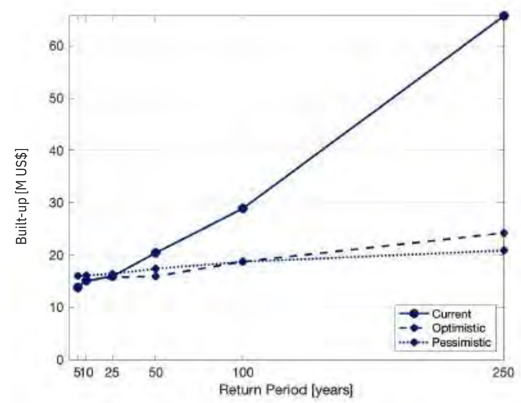
Compound Projections - Affected Population

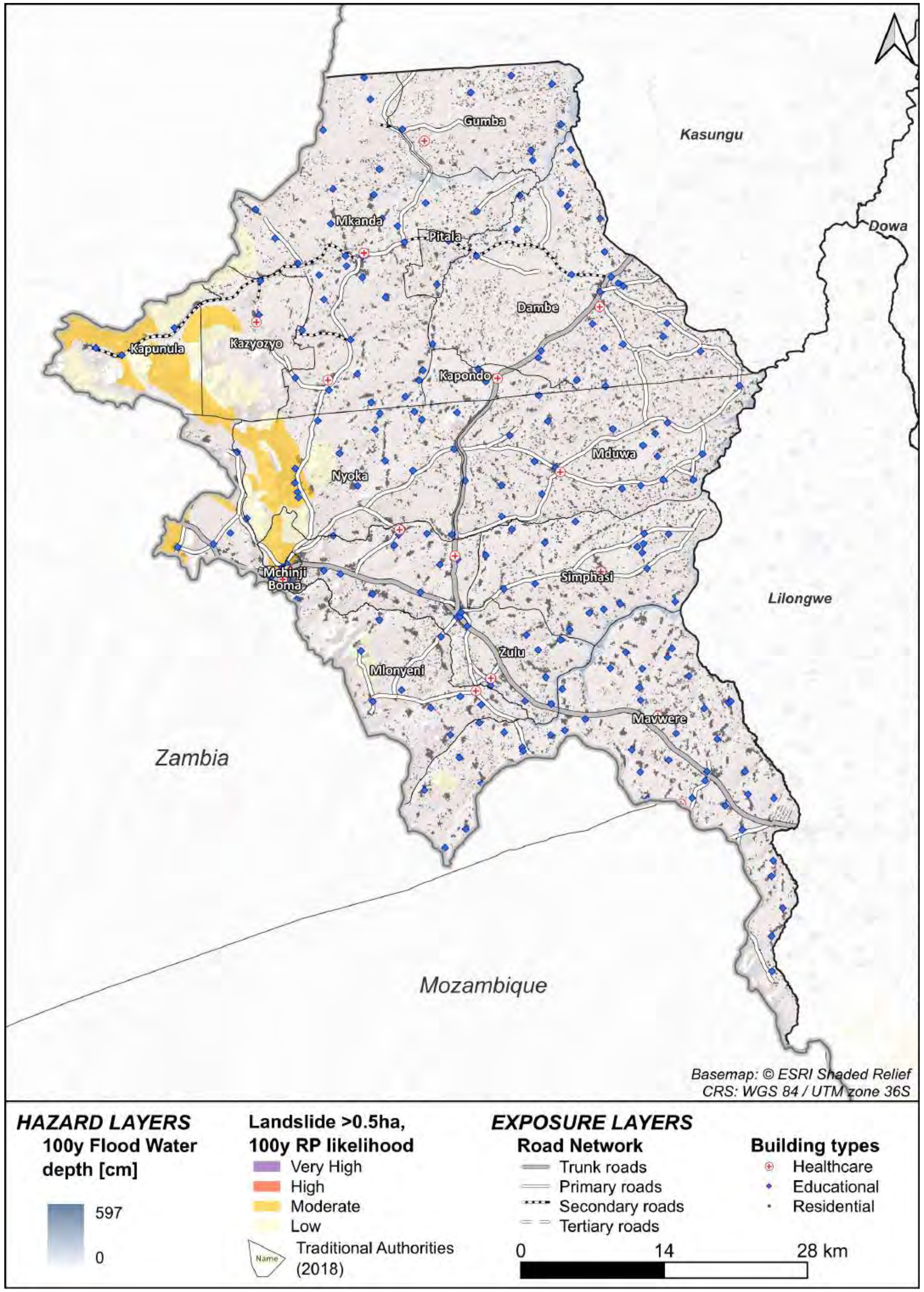


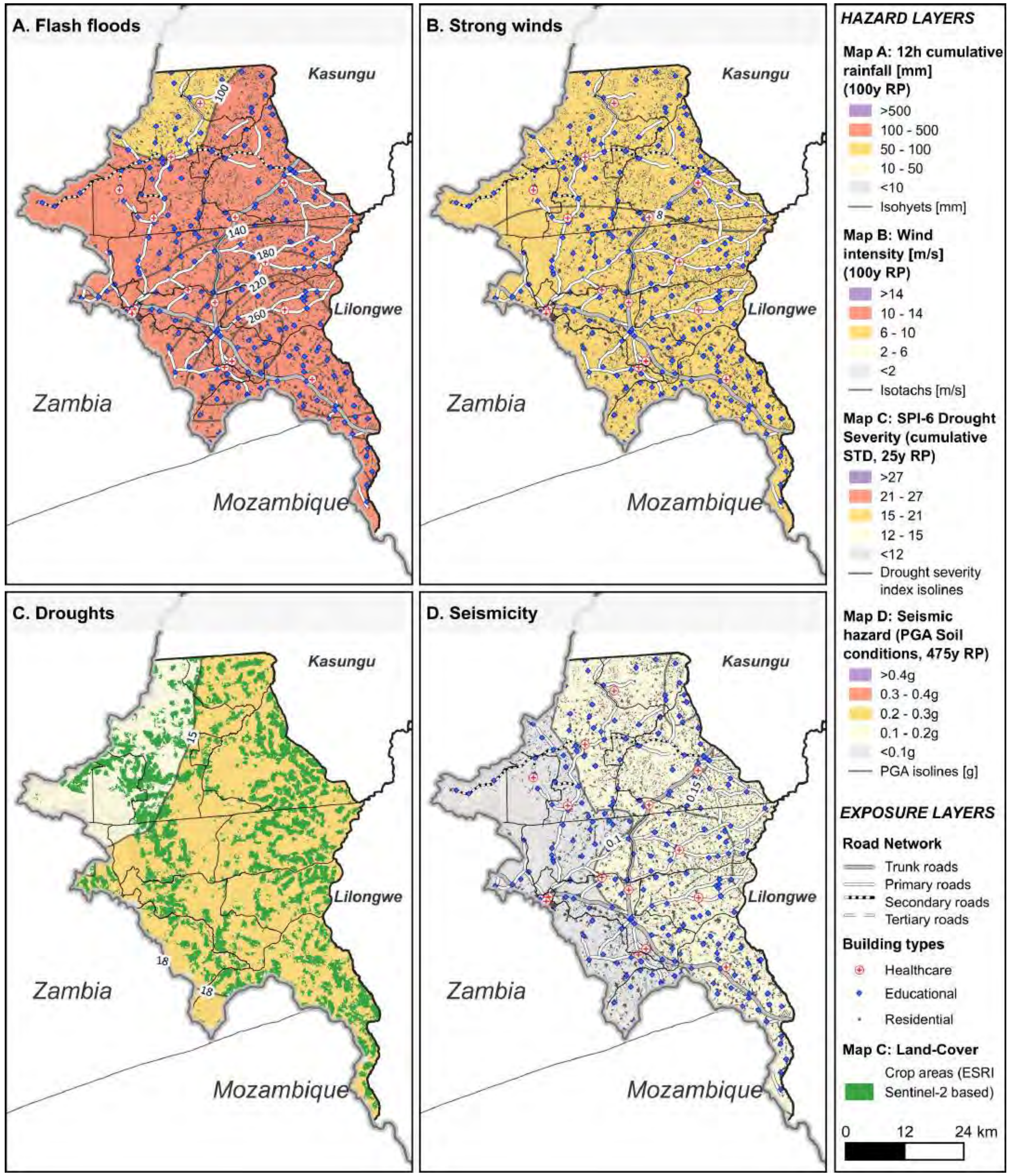
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

MULANJE

Mulanje is a district in the Southern Region of Malawi, covering an area of 2056 km². It is famous for its vast and lush tea plantations as well as the stunning Mulanje Massif, the tallest mountain (3,002m) in south-central Africa.
Social vulnerability parameters for food insecurity and the inactive population are slightly lower than the national average, while poverty prevalence is higher. The risk evaluation results indicate that landslides are the most critical hazard to the built environment, followed by flash floods. Meanwhile, drought affects the population the most. Both flash flood and drought risks are notably influenced by climate change projections. The ratio of average annual economic losses due to landslides is significantly higher than the national average. The average annual number of people affected by drought is also greater than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**792 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	3.68	-
Poverty Prevalence (%)	**55**	51*
Food Insecurity (%)	**62**	64*
Inactive Population (%)	**7**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**5060**	131 953
Ratio on total value (%)	3.83	-
Schools and Hospitals	**197 – 23**	6410 - 671
Ratio on total value (%)	3.07 – 3.43	-
Most important Crops	**Cassava, Sweet Potato, Maize, Pigeon peas, Sorghum, Groundnuts, Rice**	Cassava, Maize, Sweet Potato, Groundnuts

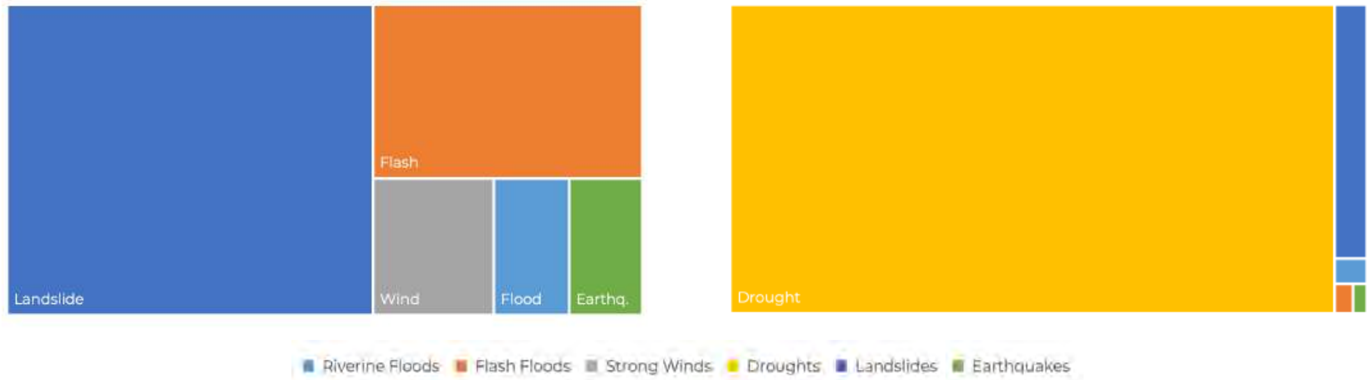
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**21.188**	-	-	-	-	-	**47 128**	-
Riverine Floods	1.111	0.22	0.115	0.05	0.04	-	199	0.2
Flash Floods	5.063	1.02	-	-	-	-	132	0.13
Strong Winds	1.782	0.36	-	-	-	-	0	0
Compound	7.816	-	-	-	-	-	305	-
Droughts	-	-	-	-	13.523	-	44 746	66
Landslides	12.292	2.502	-	-	-	-	1979	2.5
Earthquakes	1.08	0.21	-	-	-	-	98	0.12

RISK RESULTS – Average Annual Losses CHARTS

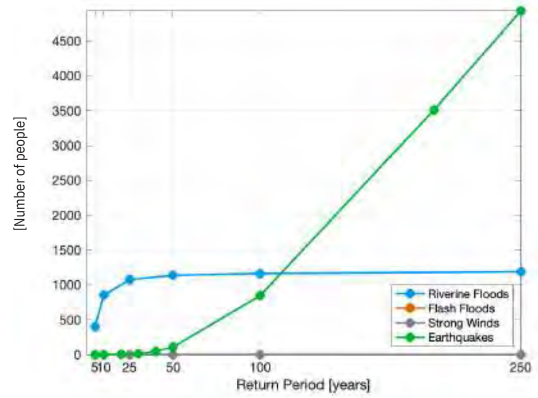
Economic Built - UP

Population

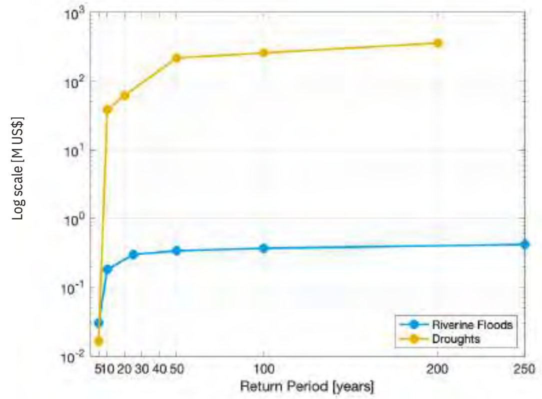


RISK RESULTS – Probable Maximum Losses CURVES

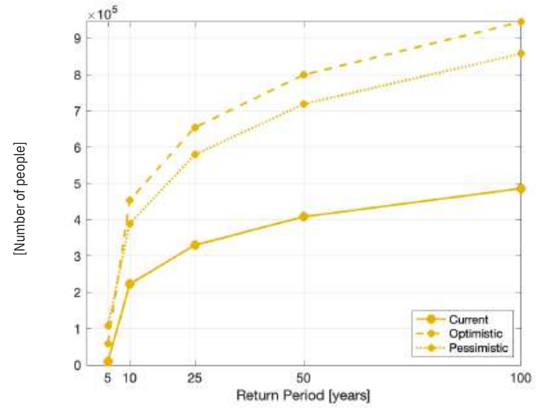
Fast-onset Weather related and Earthquakes - Affected Population



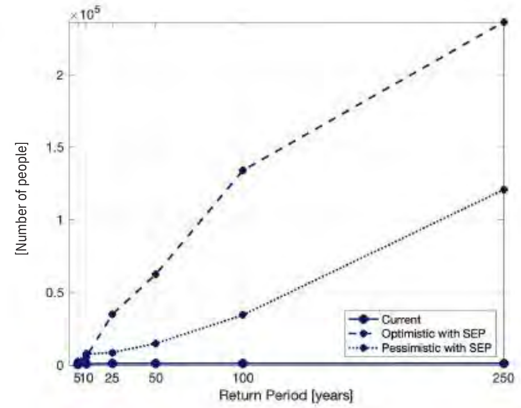
Weather related - Economic Loss



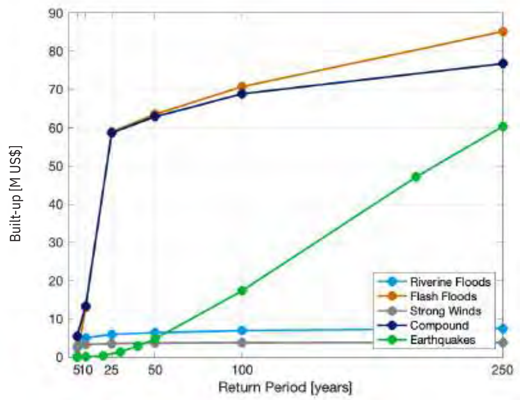
Droughts Projections - Affected Population



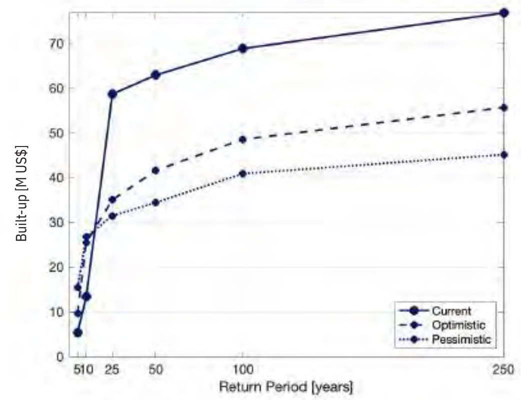
Compound Projections - Affected Population

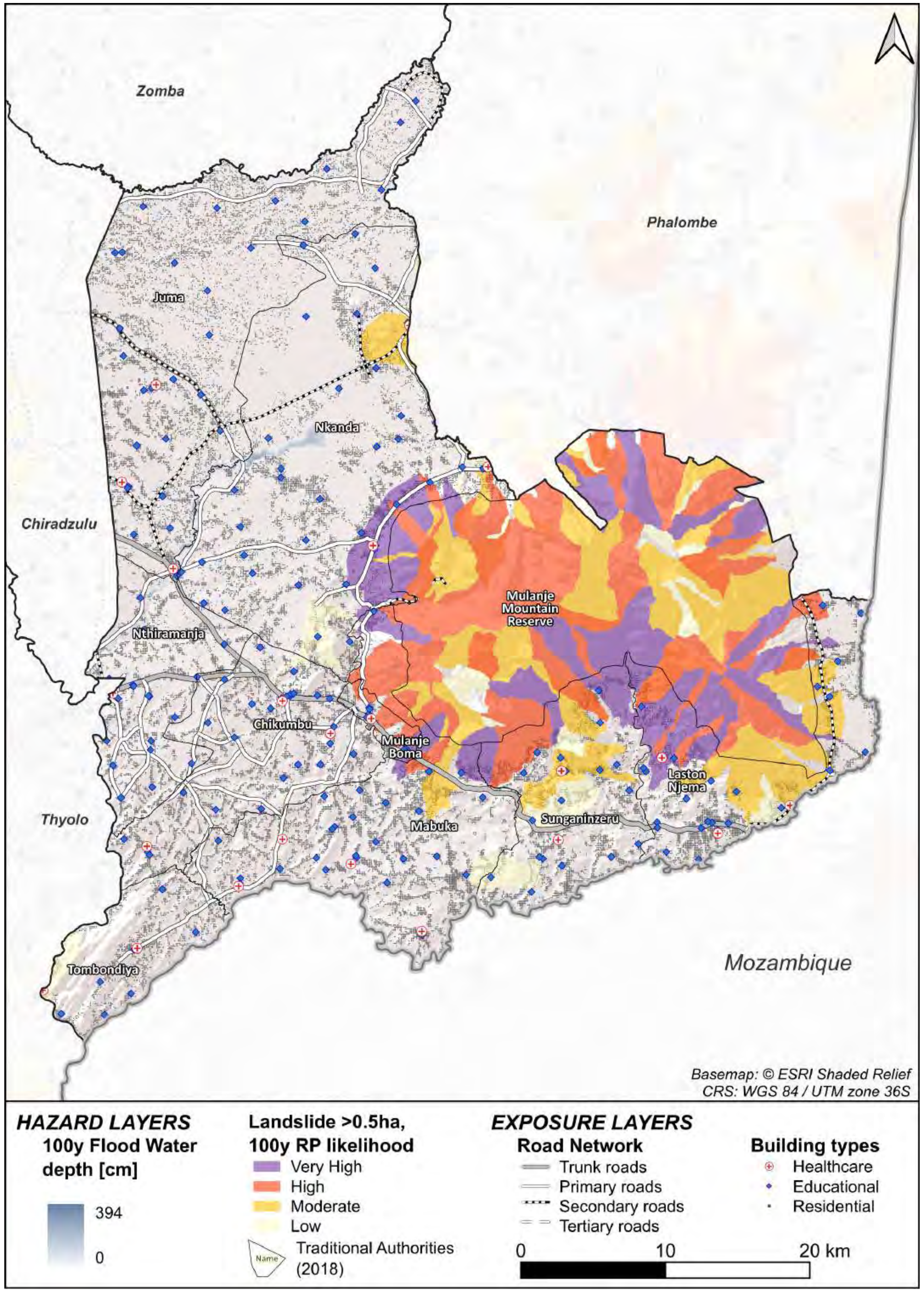


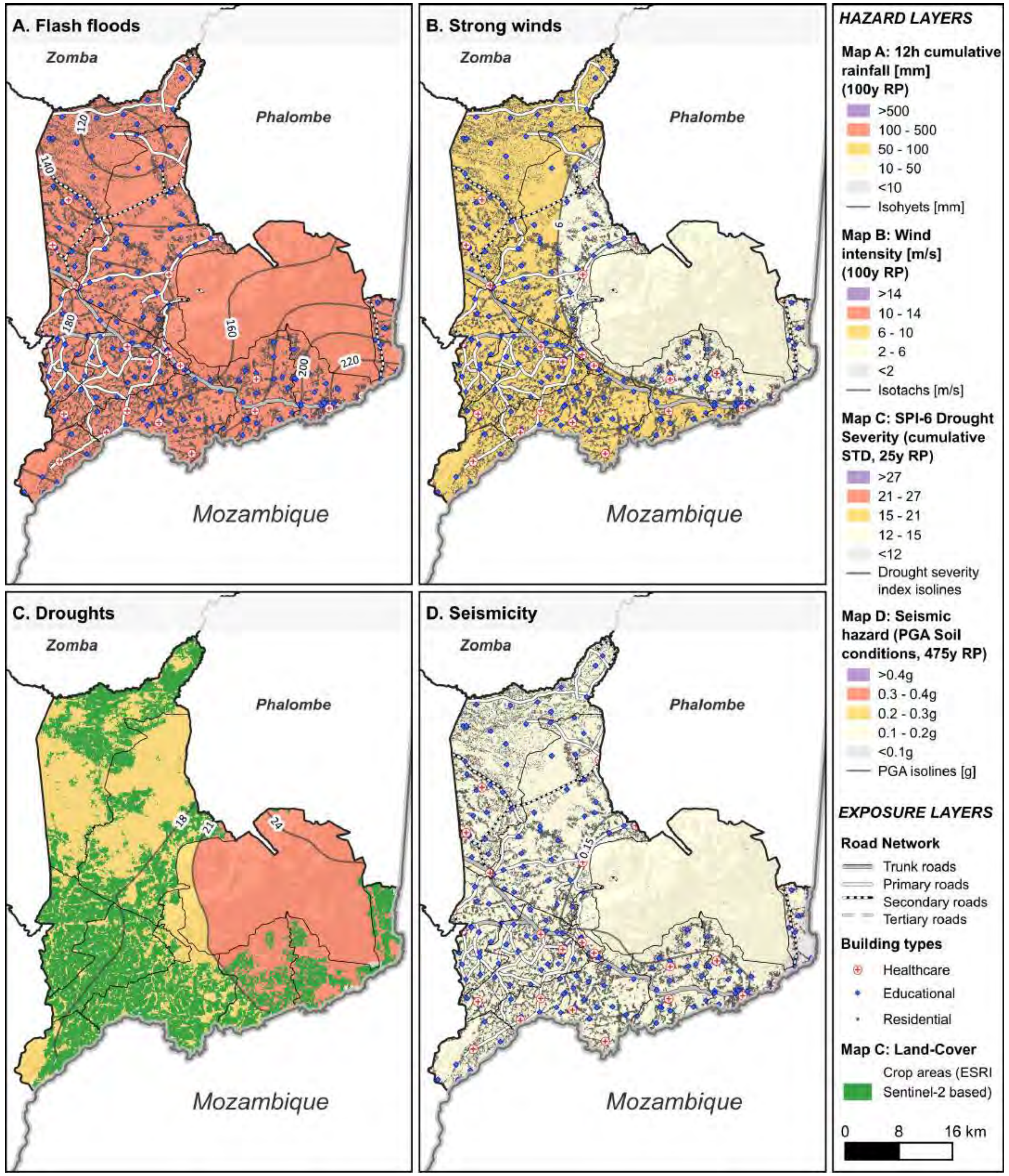
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

MWANZA

Mwanza is a district in the Southern Region of Malawi, and it is the second smallest district in terms of population, after Likoma. The district covers an area of 826 km². Social vulnerability parameters for poverty prevalence and the inactive population are slightly lower than the national average, while food insecurity is higher. Flash floods are the most significant hazard for the risk of the built environment, followed by strong winds. Drought on the other hand significantly affects the population, and its impact is influenced by climate change . The fast-onset weather-related hazards are mainly affected by the pessimistic scenario. The ratio of average annual economic losses due to flash floods and the average annual number of people affected by drought is slightly higher than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**141 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	0.66	-
Poverty Prevalence (%)	**47**	51*
Food Insecurity (%)	**75**	64*
Inactive Population (%)	**8**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**1098**	131 953
Ratio on total value (%)	0.83	-
Schools and Hospitals	**58 – 5**	6410 - 671
Ratio on total value (%)	0.90 - 0.75	-
Most important Crops	**Maize, Pigeon peas, Cassava, Sweet Potato, Groundnuts**	Cassava, Maize, Sweet Potato, Groundnuts

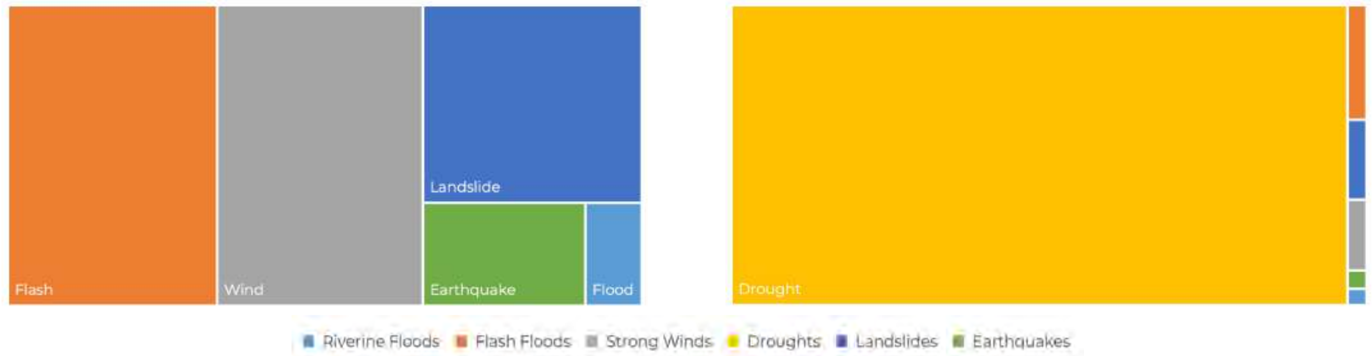
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**2.279**	-	-	-	-	-	**9333**	-
Riverine Floods	0.071	0.07	0.001	0.002	0	-	15	0.09
Flash Floods	0.769	0.72	-	-	-	-	107	0.62
Strong Winds	0.755	0.71	-	-	-	-	66	0.48
Compound	1.545	-	-	-	-	-	187	-
Droughts	-	-	-	-	4.012	-	9055	55
Landslides	0.53	0.518	-	-	-	-	74	0.5
Earthquakes	0.204	0.19	-	-	-	-	17	0.12

RISK RESULTS – Average Annual Losses CHARTS

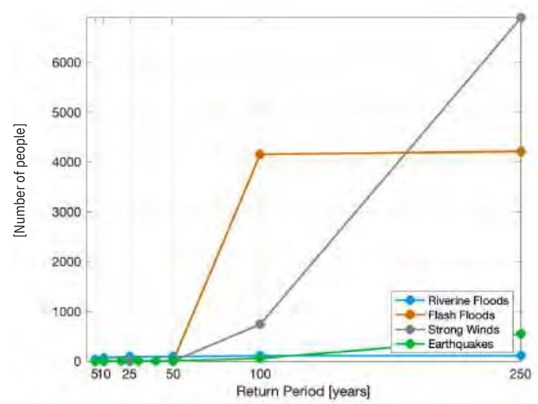
Economic Built - UP

Population

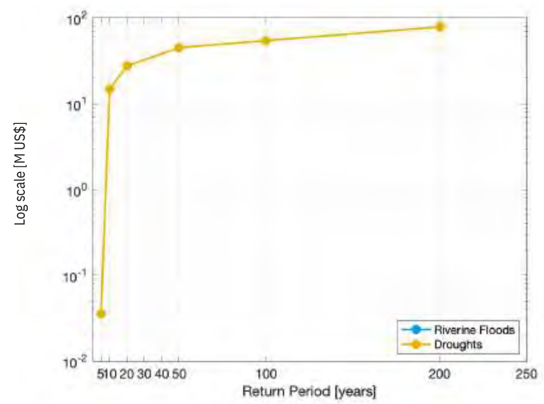


RISK RESULTS – Probable Maximum Losses CURVES

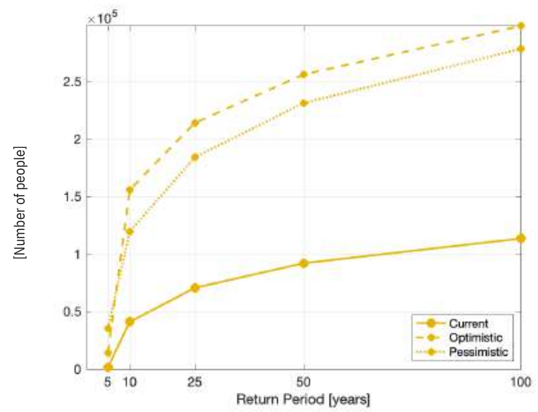
Fast-onset Weather related and Earthquakes - Affected Population



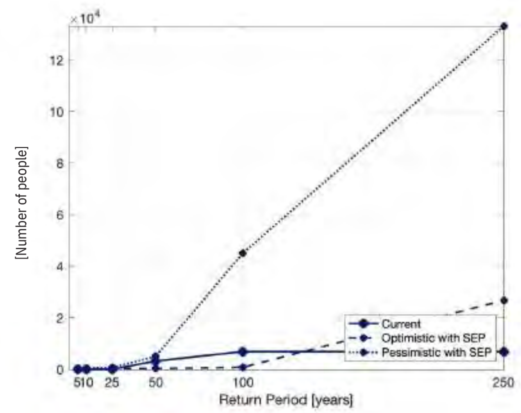
Weather related - Economic Loss



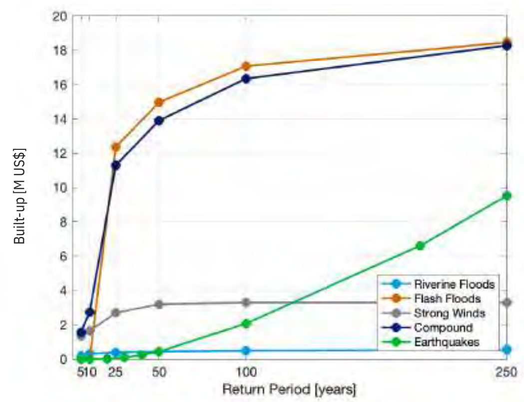
Droughts Projections - Affected Population



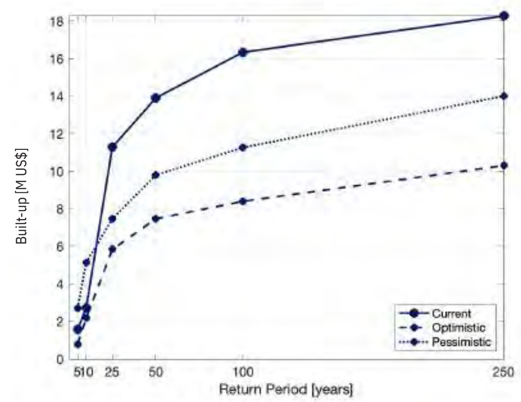
Compound Projections - Affected Population

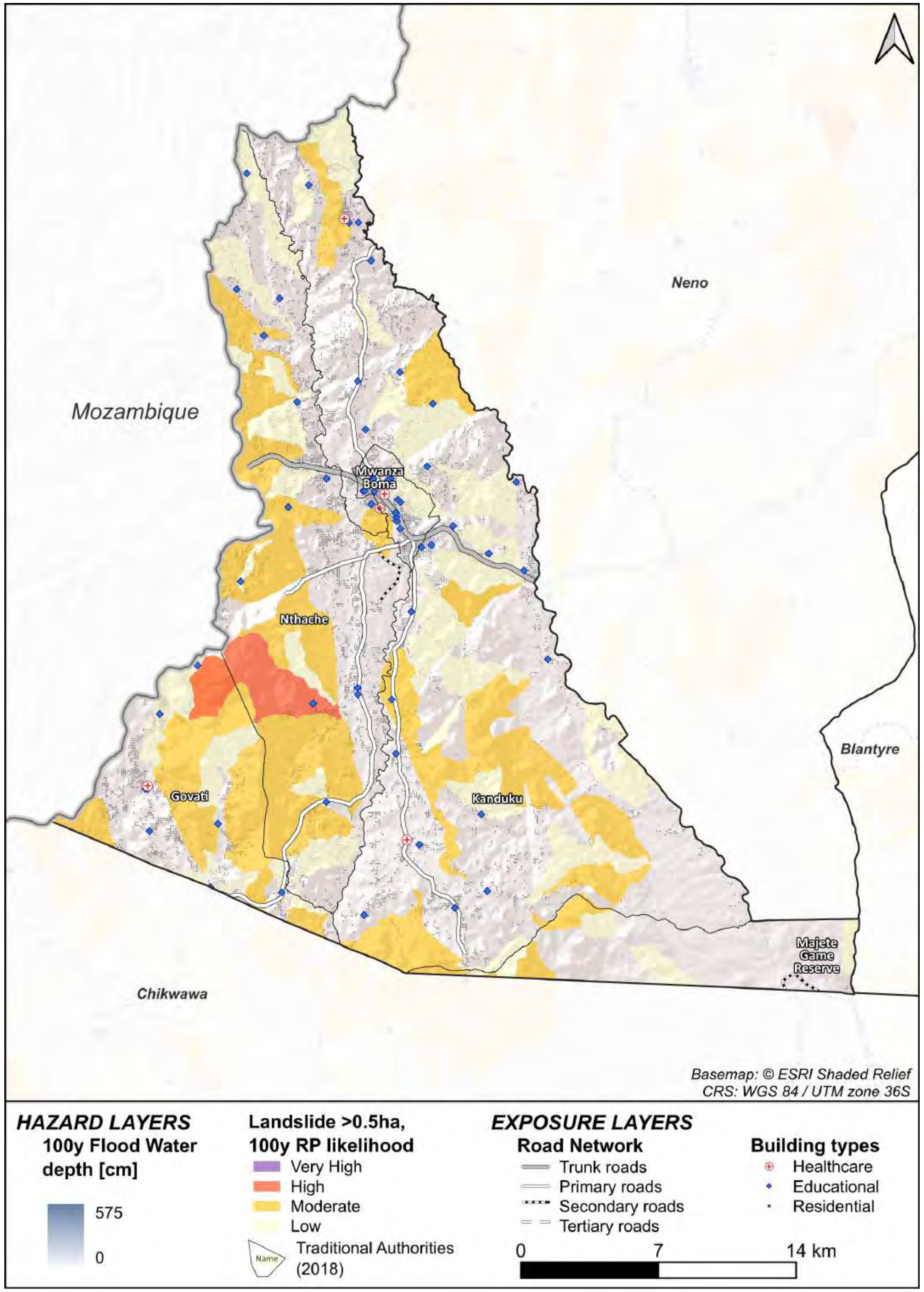


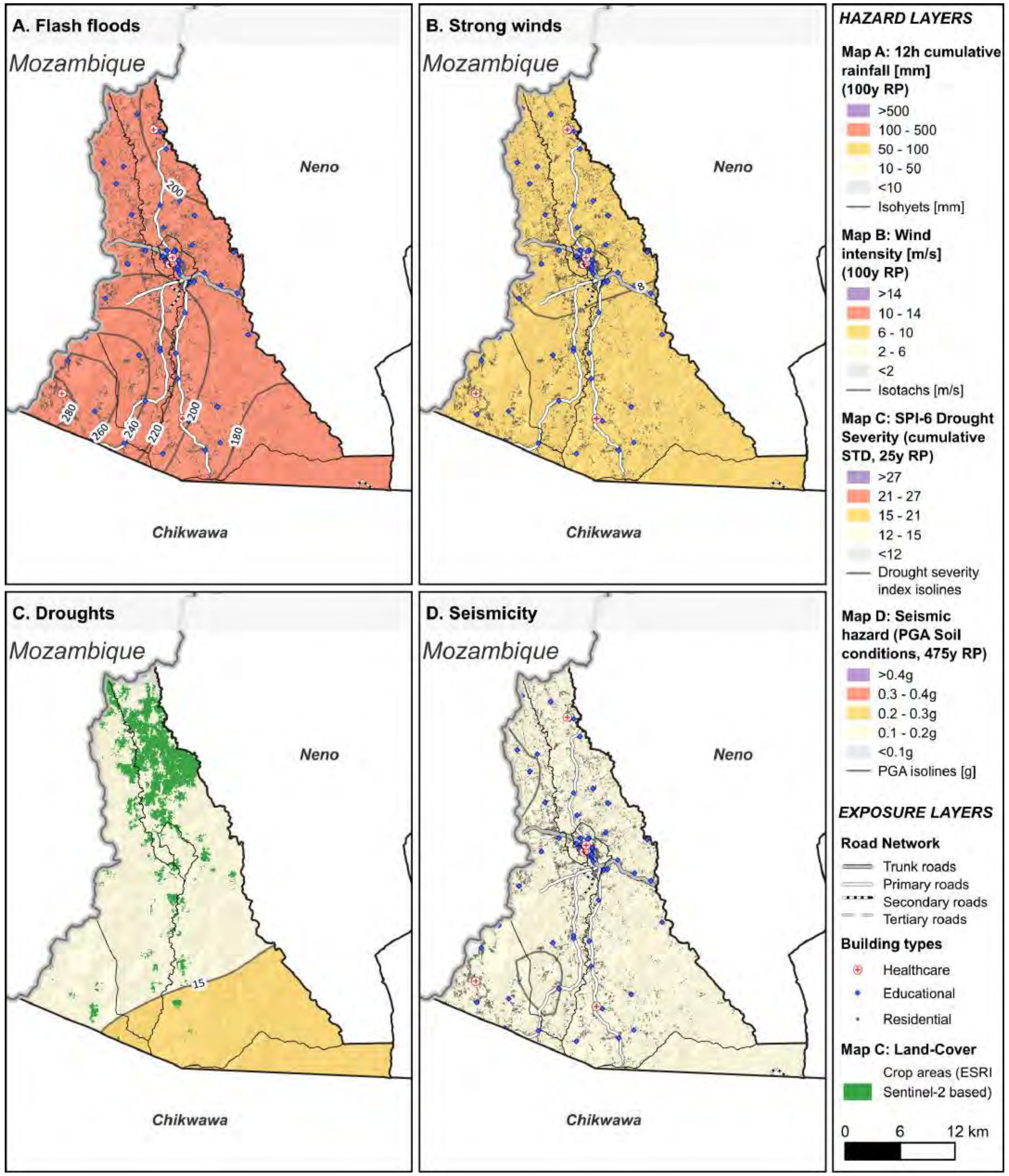
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

MZIMBA

Mzimba is a district in the Northern Region of Malawi, covering an area of 10,473 km², making it the largest district in the country. Social vulnerability parameters related to poverty prevalence and food insecurity are lower than the national average, while the inactive population aligns with the national average. Risk evaluation indicates that strong winds, flash floods, and earthquakes present the highest risks to the built environment, while drought and strong winds affect more people. In terms of climate change projections, significant changes are anticipated, particularly regarding drought and weather-related hazards. Drought risk is expected to increase, whereas the risks associated with other weather-related hazards may decrease. Strong winds constitute a significant proportion of the average annual economic losses, which is slightly higher than the national average. However, the average annual number of people affected by drought is lower than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**1 093 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	5.08	-
Poverty Prevalence (%)	**39**	51*
Food Insecurity (%)	**58**	64*
Inactive Population (%)	**10**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**6716**	131 953
Ratio on total value (%)	5.09	-
Schools and Hospitals	**625 – 51**	6410 - 671
Ratio on total value (%)	9.75 -7.60	-
Most important Crops	**Maize, Groundnuts, Beans, Cassava, Sweet Potato**	Cassava, Maize, Sweet Potato, Groundnuts

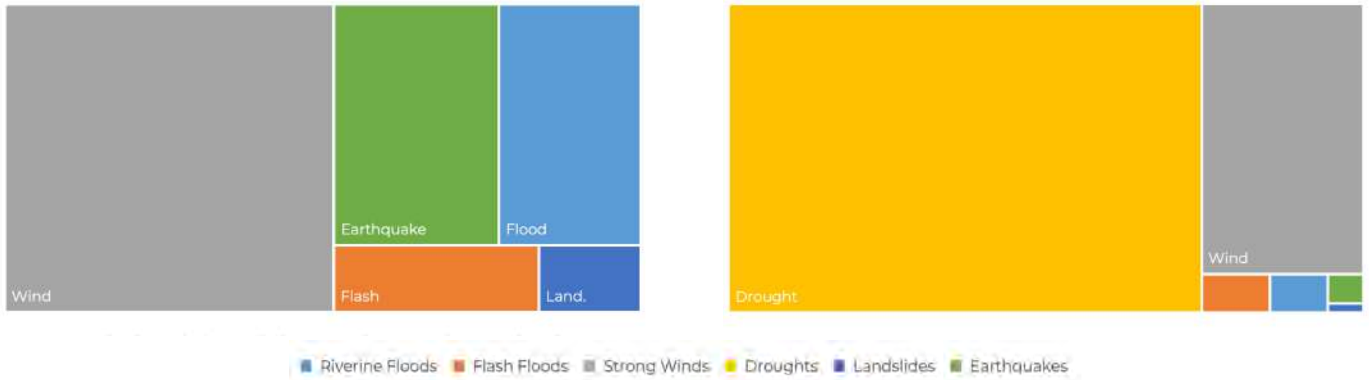
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**11.841**	-	-	-	-	-	**45 599**	-
Riverine Floods	2.067	0.44	5.462	0.38	0.01	-	516	0.49
Flash Floods	0.829	0.18	-	-	-	-	610	0.58
Strong Winds	6.13	1.31	-	-	-	-	10 165	13.33
Compound	9.021	-	-	-	-	-	11 288	-
Droughts	-	-	-	-	8.057	-	33 996	33
Landslides	0.411	0.064	-	-	-	-	73	0.1
Earthquakes	2.409	0.36	-	-	-	-	242	0.22

RISK RESULTS – Average Annual Losses CHARTS

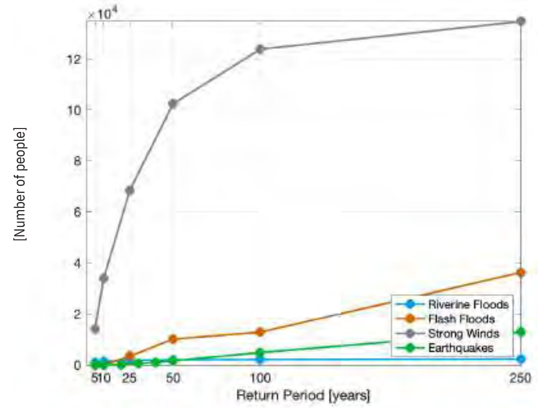
Economic Built - UP

Population

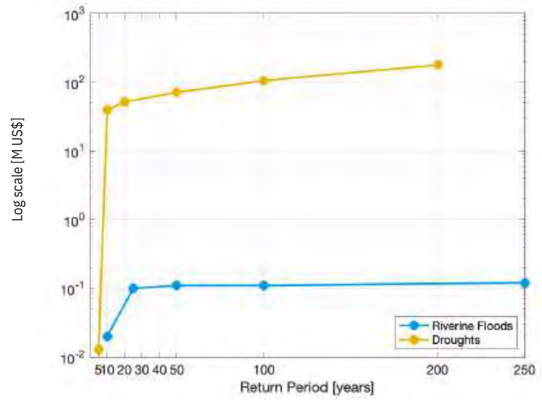


RISK RESULTS – Probable Maximum Losses CURVES

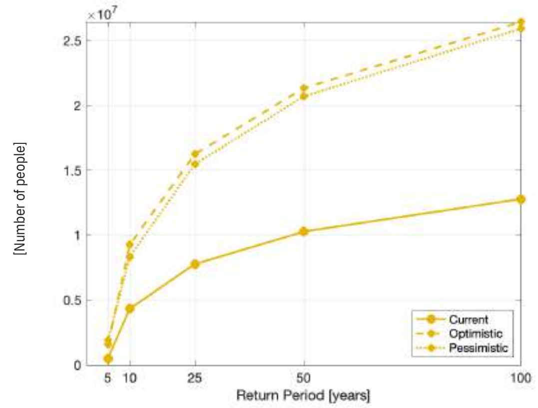
Fast-onset Weather related and Earthquakes - Affected Population



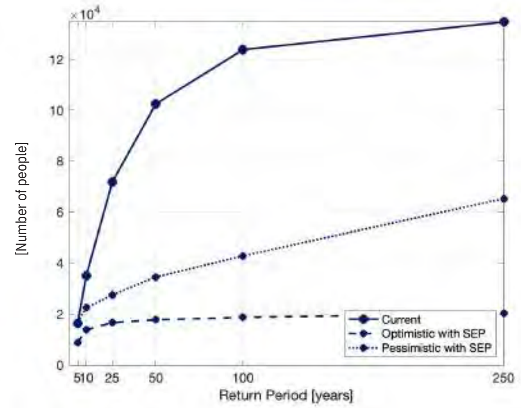
Weather related - Economic Loss



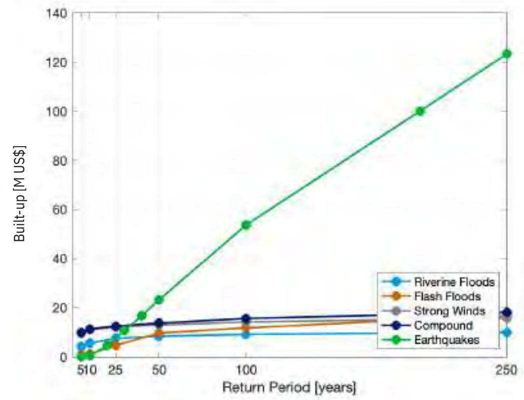
Droughts Projections - Affected Population



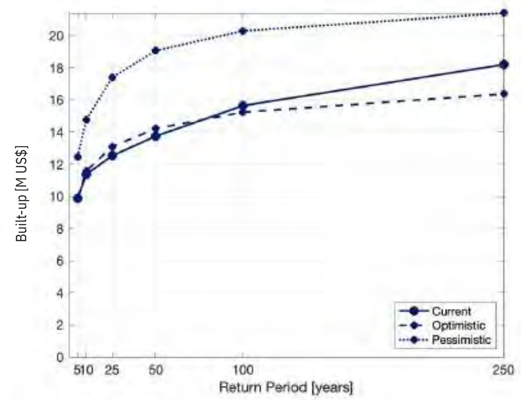
Compound Projections - Affected Population

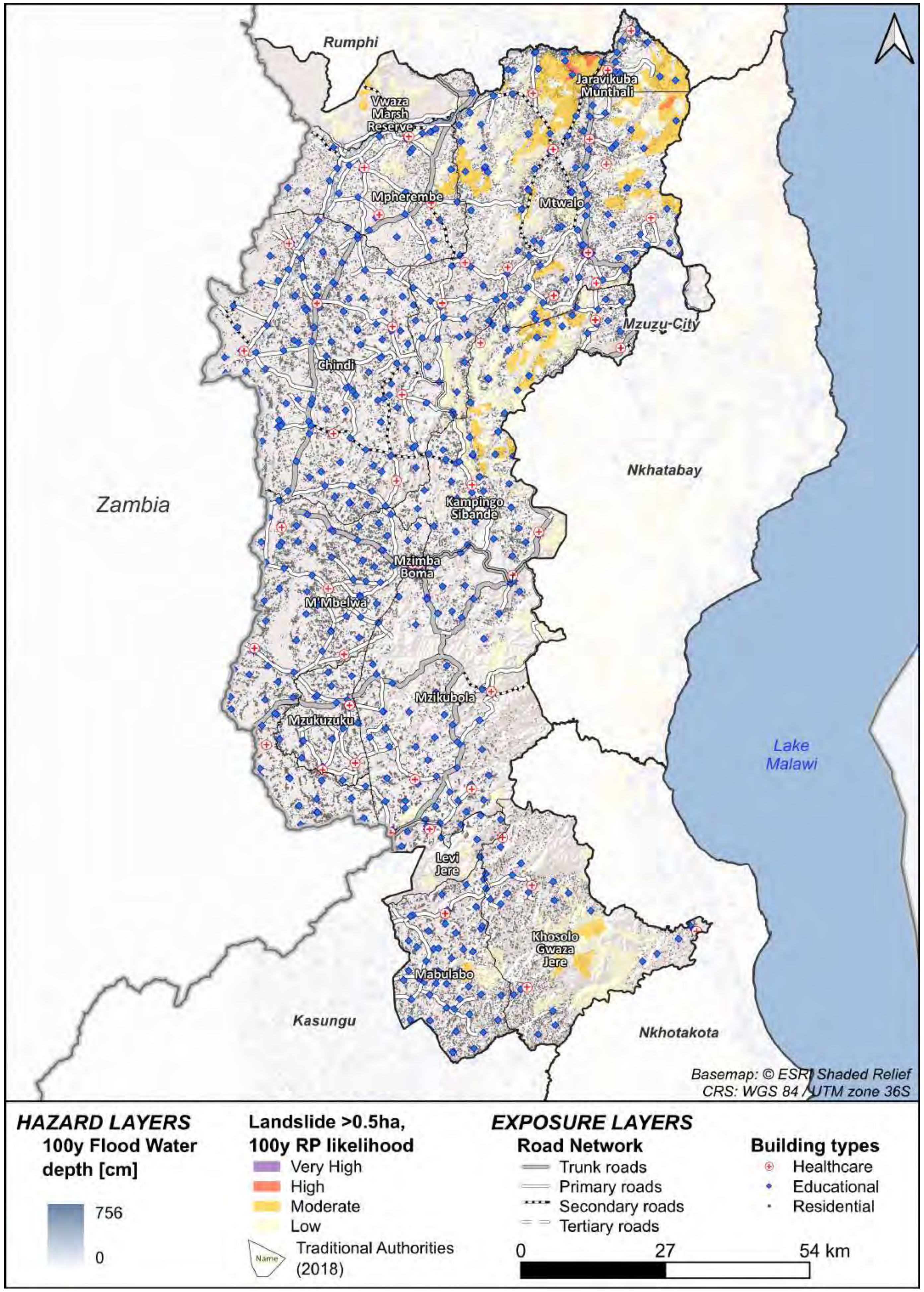


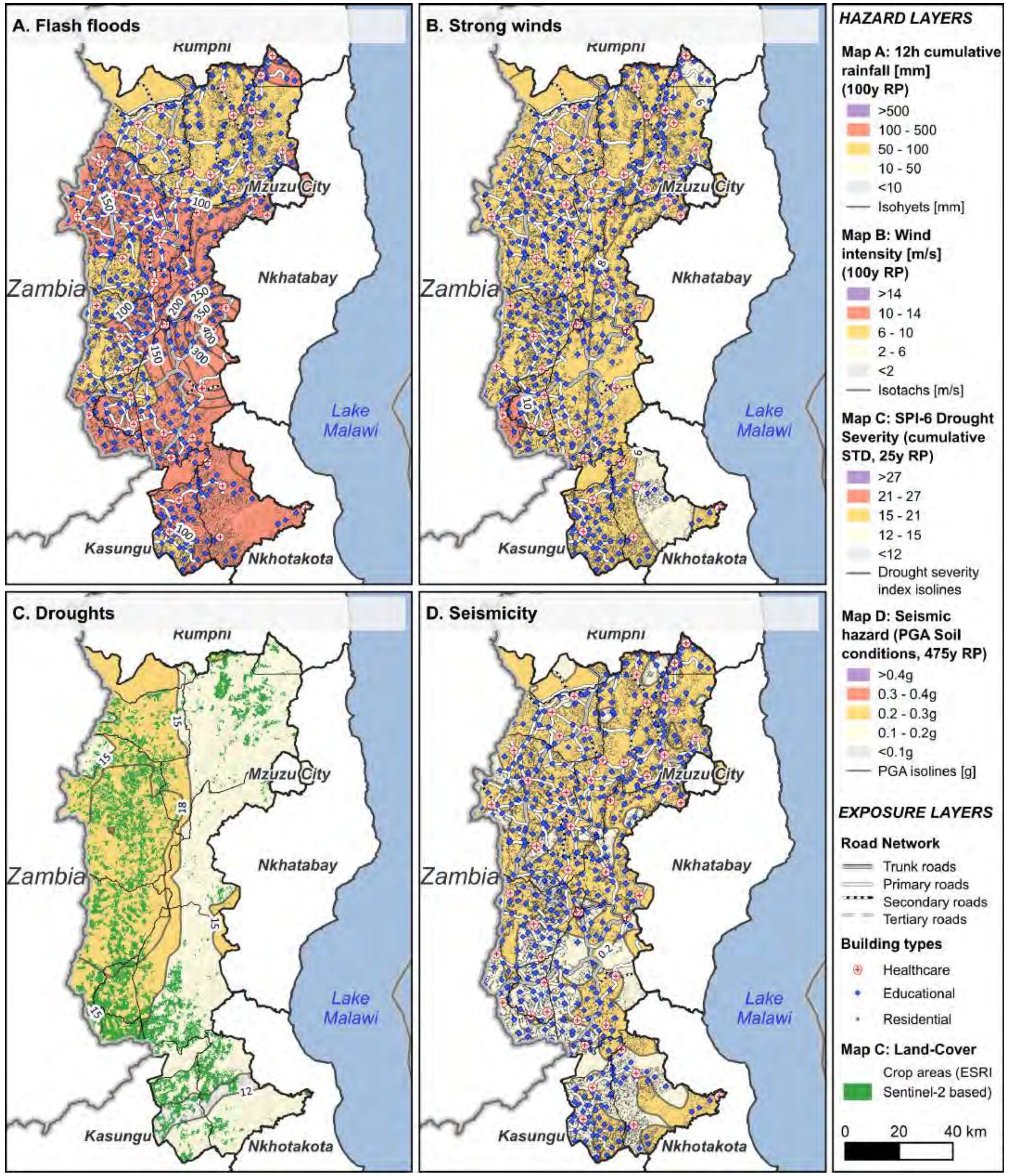
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

MZUZU CITY

Mzuzu City is the largest town in northern Malawi and the third-largest city in the country, after Lilongwe and Blantyre. It is located at the border of Mzimba and Nkhatabay districts. Social vulnerability parameters, such as poverty prevalence and food insecurity, are lower than the national average, while the inactive population is more than double the national average. Wind presents the most significant hazard to the built environment, followed by earthquakes. Drought affects more people. In climate projections, both drought and weather-related hazards are influenced by different climate scenarios. The ratio of average annual economic losses due to wind and the average annual number of people affected by drought are lower than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**249 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	1.16	-
Poverty Prevalence (%)	**12**	51*
Food Insecurity (%)	**35**	64*
Inactive Population (%)	**24**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**3826**	131 953
Ratio on total value (%)	2.90	-
Schools and Hospitals	**88 -9**	6410 - 671
Ratio on total value (%)	1.37 – 1.34	-
Most important Crops	**Maize, Cassava, Potato**	Cassava, Maize, Sweet Potato, Groundnuts

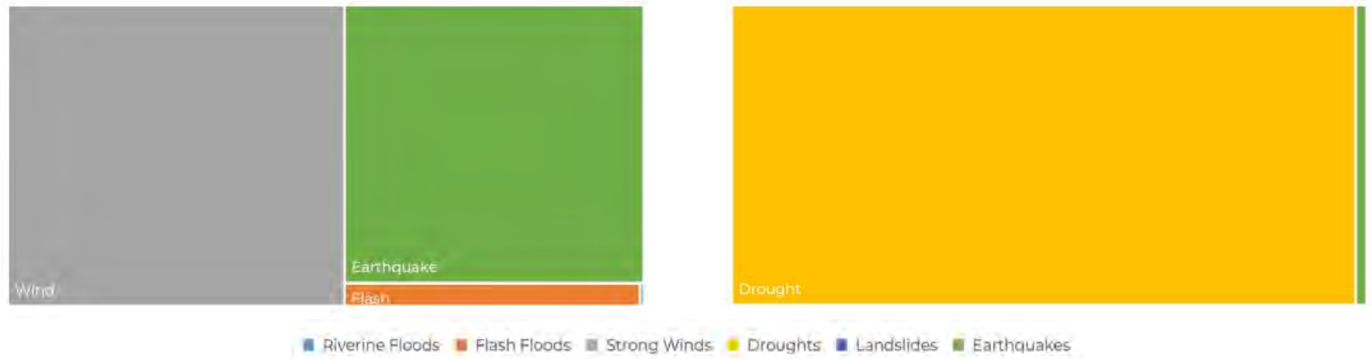
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**2.105**	-	-	-	-	-	**4132**	-
Riverine Floods	0	0	0	0	0	0	0	0
Flash Floods	0.076	0.02	-	-	-	-	0	0
Strong Winds	1.114	0.29	-	-	-	-	0	0
Compound	1.19	-	-	-	-	-	0	0
Droughts	-	-	-	-	0.146	-	4062	34
Landslides	0.001	0.001	-	-	-	-	0	0
Earthquakes	0.914	0.49	-	-	-	-	70	0.28

RISK RESULTS – Average Annual Losses CHARTS

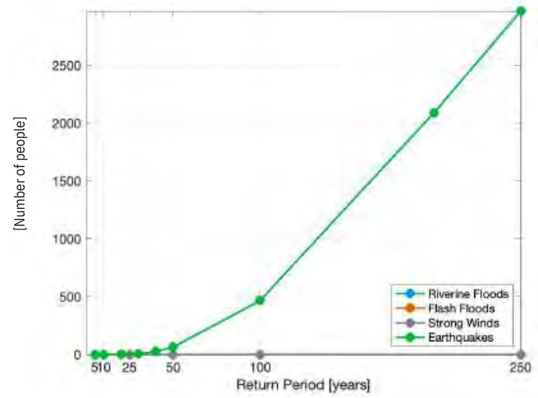
Economic Built - UP

Population

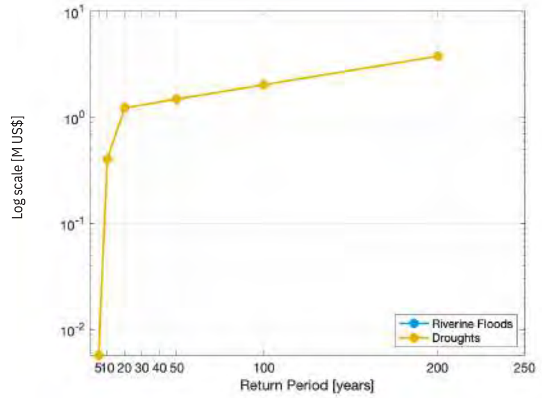


RISK RESULTS – Probable Maximum Losses CURVES

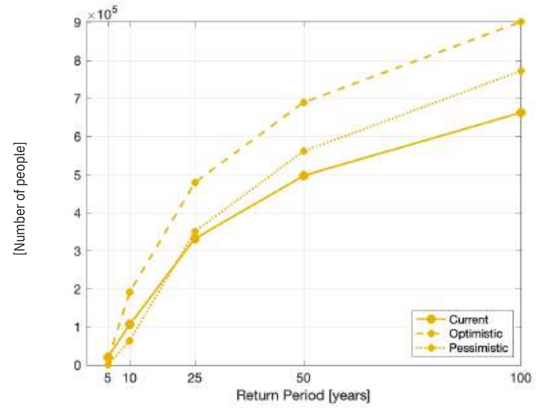
Fast-onset Weather related and Earthquakes - Affected Population



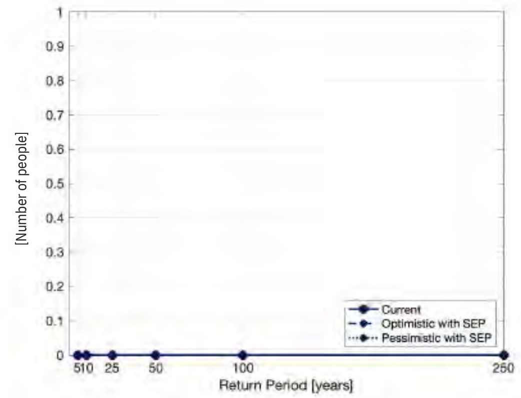
Weather related - Economic Loss



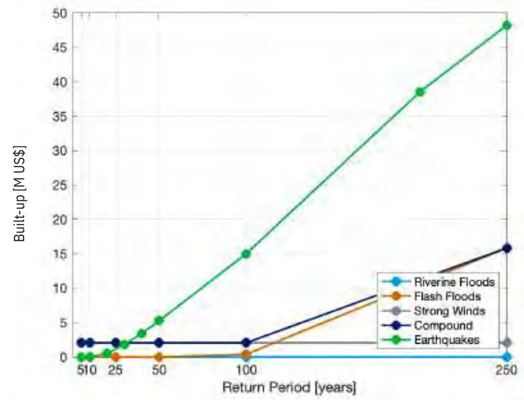
Droughts Projections - Affected Population



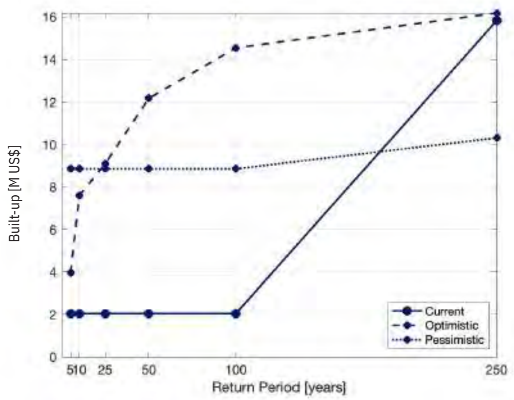
Compound Projections - Affected Population

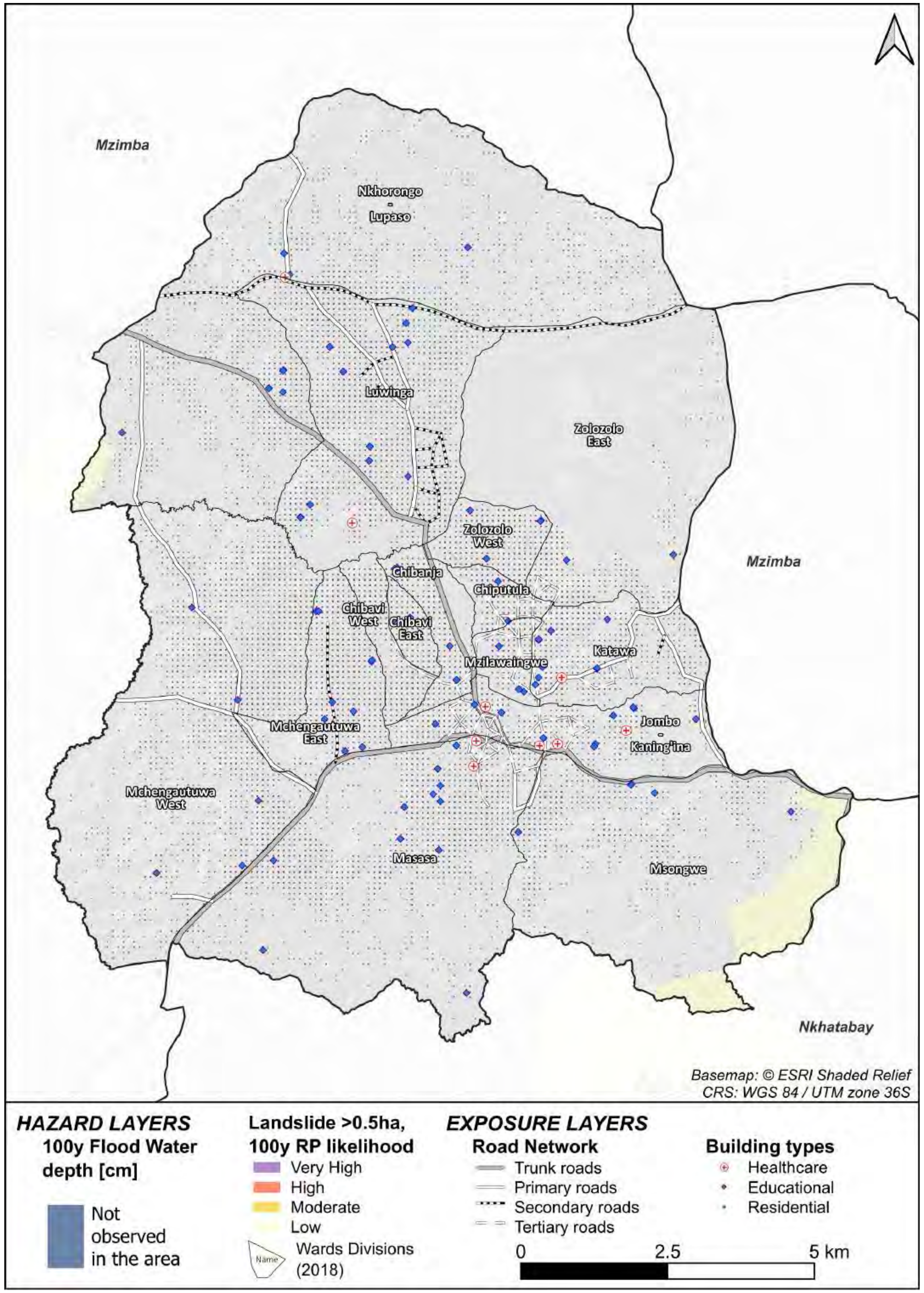


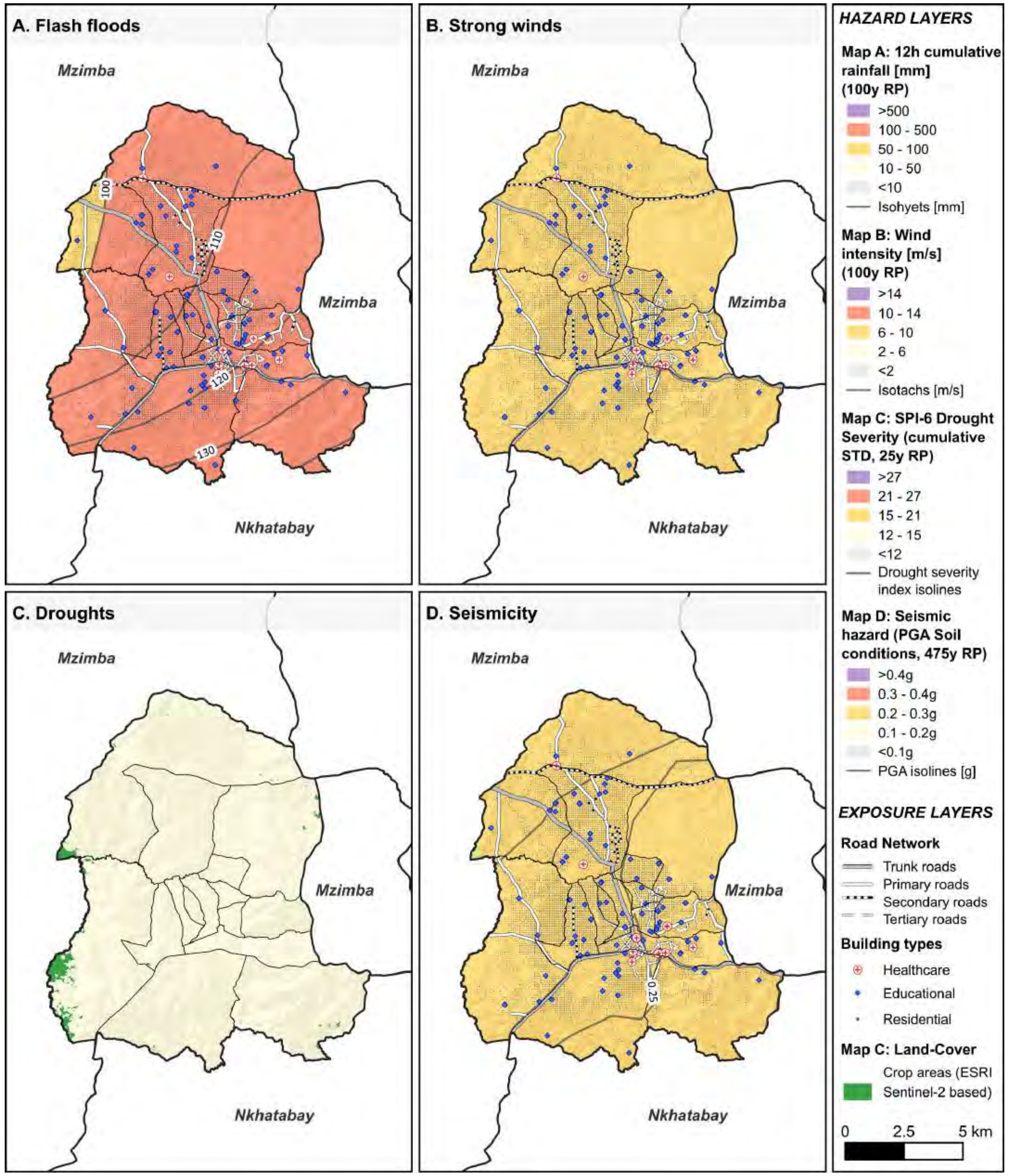
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

NENO

Neno is a district located in the Southern Region of Malawi, covering an area of 1,469 km². The district's social vulnerability indicators, such as poverty prevalence and the inactive population, are lower than the national average, although food insecurity is slightly higher. Flooding poses the highest risk to the built environment, followed by wind and flash floods. Drought, however, affects a larger portion of the population. Weather-related hazards, including floods and drought, are influenced by climate change, with both optimistic and pessimistic scenarios showing similar patterns. The ratio of average annual economic losses due to weather-related hazards in Neno is lower than the national average. Conversely, the average number of people affected by drought in Neno is higher than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**149 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	0.69	-
Poverty Prevalence (%)	**40**	51*
Food Insecurity (%)	**66**	64*
Inactive Population (%)	**8**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**1204**	131 953
Ratio on total value (%)	0.91	-
Schools and Hospitals	**75 - 10**	6410 - 671
Ratio on total value (%)	1.17 - 1.49	-
Most important Crops	**Maize, Pigeon peas, Sweet Potato, Cassava, Groundnuts**	Cassava, Maize, Sweet Potato, Groundnuts

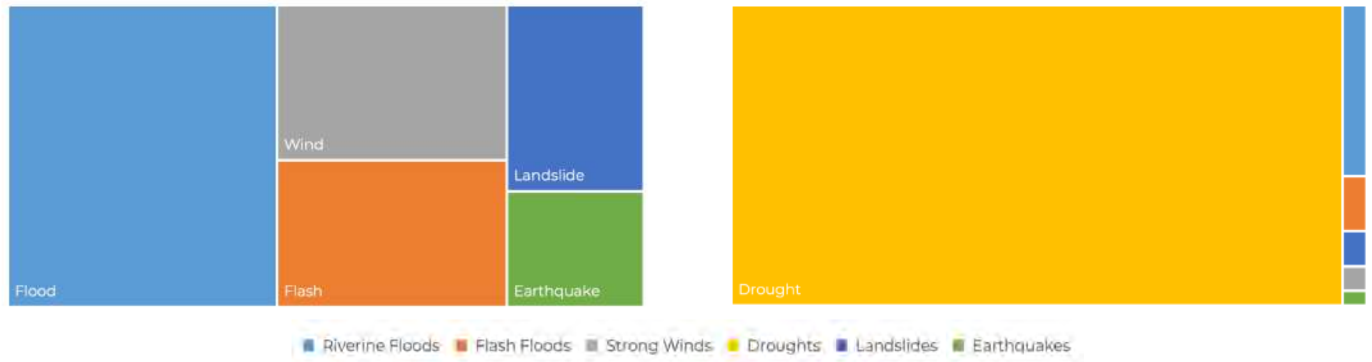
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**2.893**	-	-	-	-	-	**11 078**	-
Riverine Floods	1.241	1.06	0.135	0.06	0	-	237	1.27
Flash Floods	0.515	0.44	-	-	-	-	76	0.41
Strong Winds	0.545	0.46	-	-	-	-	34	0.23
Compound	2.261	-	-	-	-	-	338	-
Droughts	-	-	-	-	6.555	-	10 671	64
Landslides	0.39	0.335	-	-	-	-	49	0.3
Earthquakes	0.242	0.2	-	-	-	-	20	0.13

RISK RESULTS – Average Annual Losses CHARTS

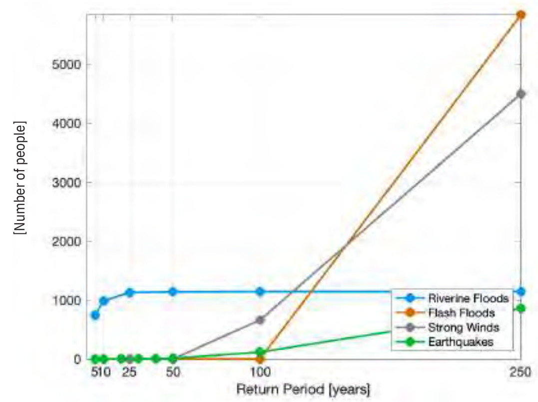
Economic Built - UP

Population

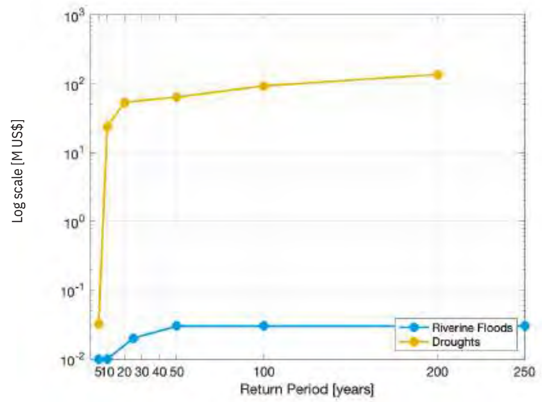


RISK RESULTS – Probable Maximum Losses CURVES

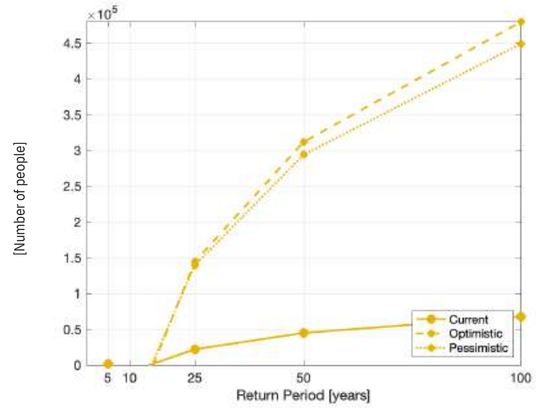
Fast-onset Weather related and Earthquakes - Affected Population



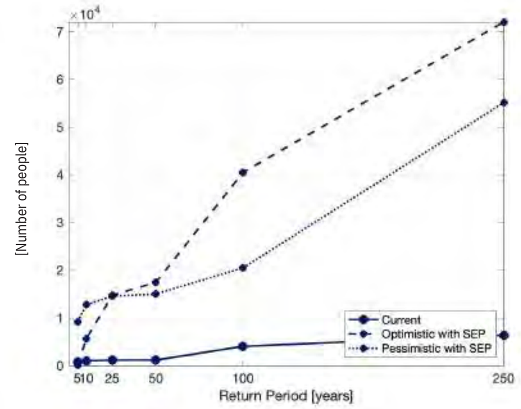
Weather related - Economic Loss



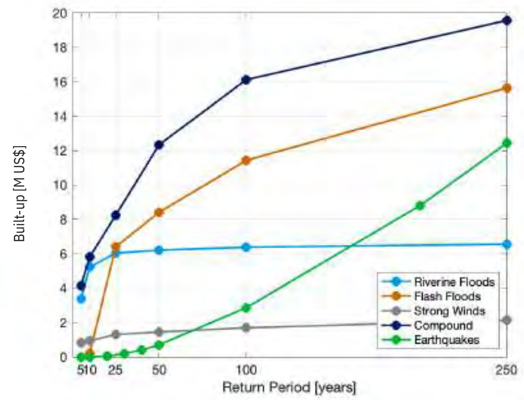
Droughts Projections - Affected Population



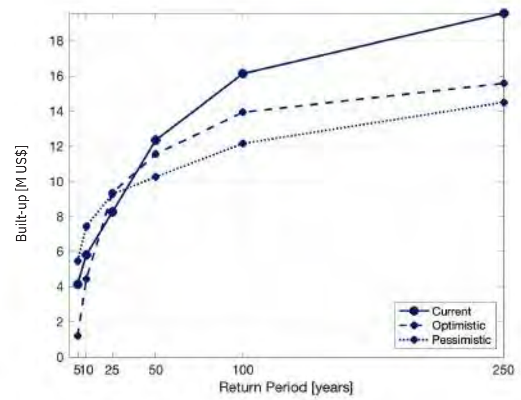
Compound Projections - Affected Population

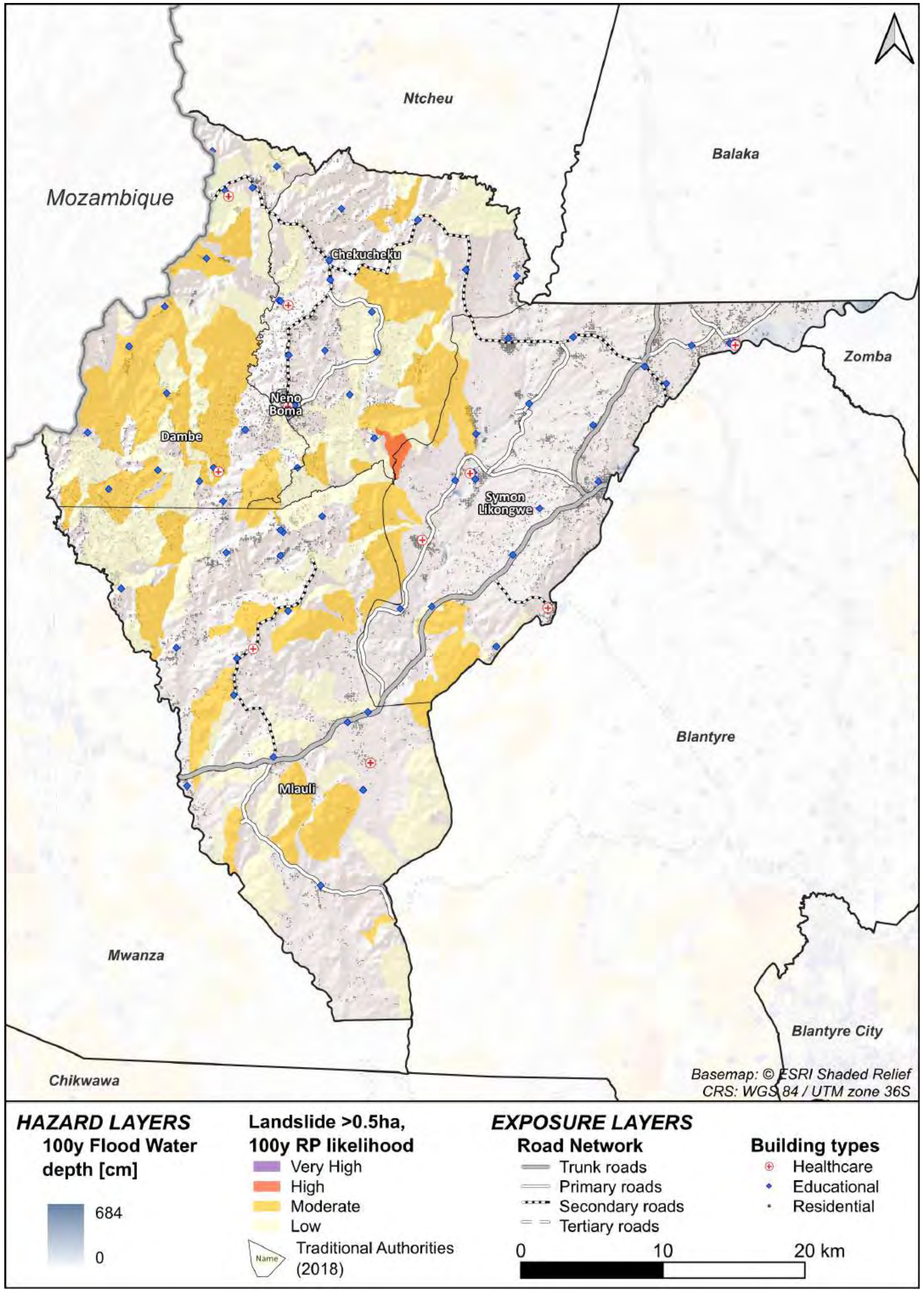


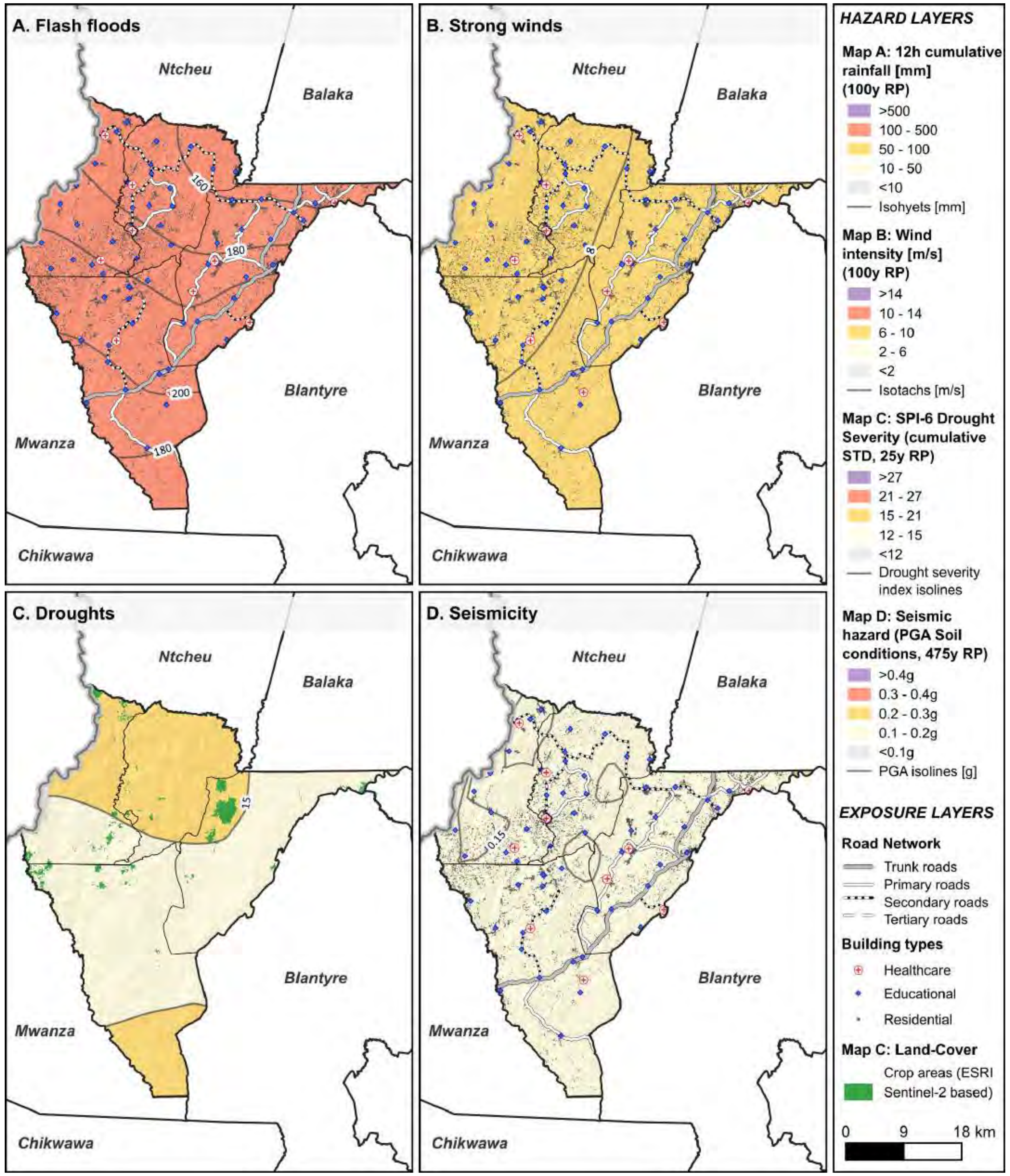
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

NKHATABAY

Nkhatabay is a lakeshore district in the Northern Region of Malawi, covering an area of 4,071 km². Lake Malawi forms the district's eastern boundary, while the western portion lies in the Viphya Mountains, bordering Mzimba. To the north, Nkhatabay borders Rumphi District.
Social vulnerability parameters such as poverty prevalence and food insecurity are lower than the national average, while the inactive population aligns with the national average. Risk evaluation indicates that floods and strong winds are the most critical hazards affecting the built environment, with strong winds having a notable impact on the population. Different climate change scenarios project changes in drought patterns, with less change expected in other weather-related hazards. The weather-related hazards and drought are influenced by climate change, with drought being affected to a greater extent. The ratio of average annual economic losses due to flooding is more than four times the national average, while the average annual number of people affected by wind is more than five times the national average. Nkhatabay is the district most affected by economic losses to the transportation system.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**330 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	1.53	-
Poverty Prevalence (%)	**22**	51*
Food Insecurity (%)	**49**	64*
Inactive Population (%)	**9**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**1784**	131 953
Ratio on total value (%)	1.35	-
Schools and Hospitals	**197 – 25**	6410 - 671
Ratio on total value (%)	3.07 – 3.73	-
Most important Crops	**Cassava, Maize, Groundnuts, Sweet Potato**	Cassava, Maize, Sweet Potato, Groundnuts

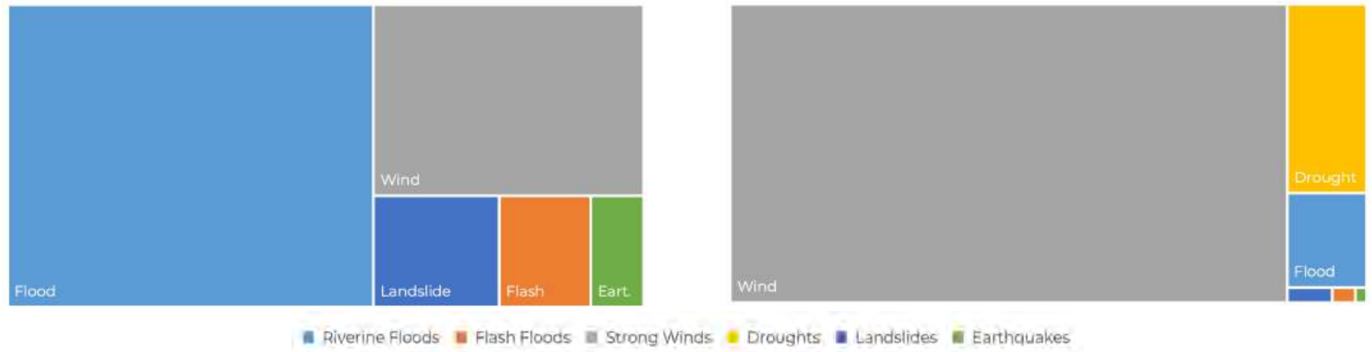
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**25.676**	-	-	-	-	-	**102 897**	-
Riverine Floods	14.756	8.31	114.809	18.70	0.1	-	4041	9.83
Flash Floods	1.36	0.89	-	-	-	-	190	0.51
Strong Winds	6.901	4.5	-	-	-	-	89 976	302.92
Compound	23.016	-	-	-	-	-	94 307	-
Droughts	-	-	-	-	3.18	-	8119	37
Landslides	1.871	1.15	-	-	-	-	377	1.1
Earthquakes	0.789	0.44	-	-	-	-	94	0.28

RISK RESULTS – Average Annual Losses CHARTS

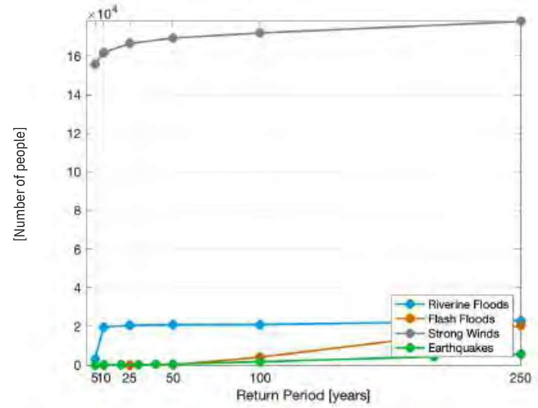
Economic Built - UP

Population

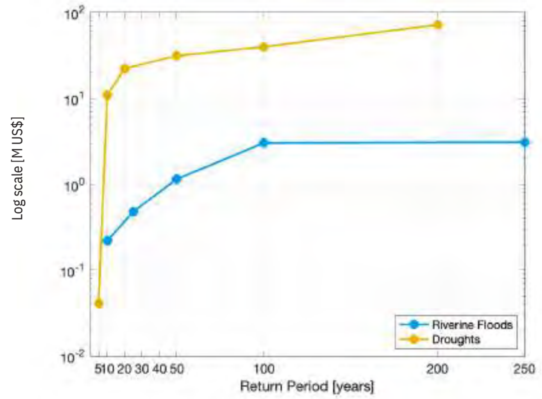


RISK RESULTS – Probable Maximum Losses CURVES

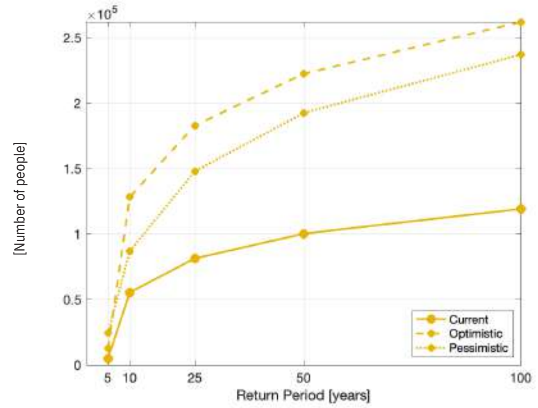
Fast-onset Weather related and Earthquakes - Affected Population



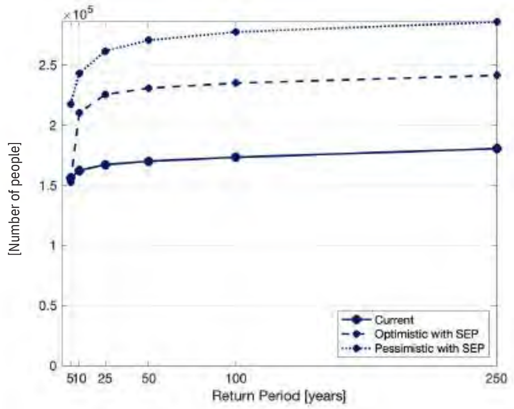
Weather related - Economic Loss



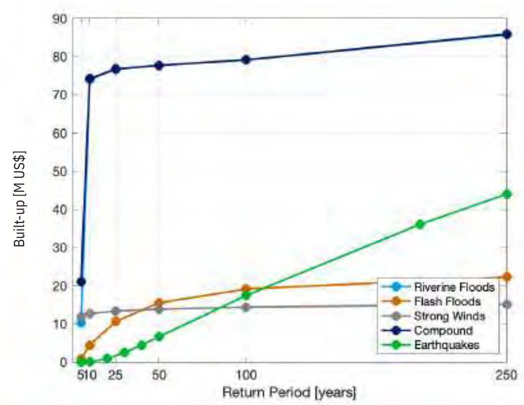
Droughts Projections - Affected Population



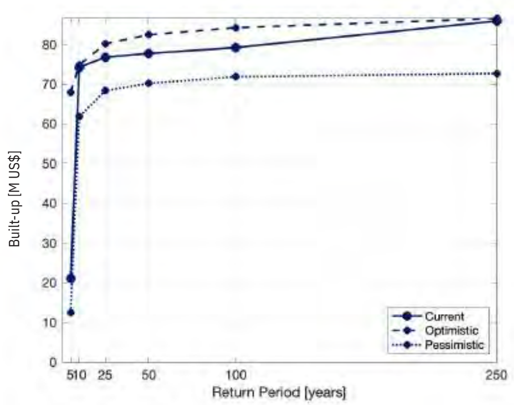
Compound Projections - Affected Population

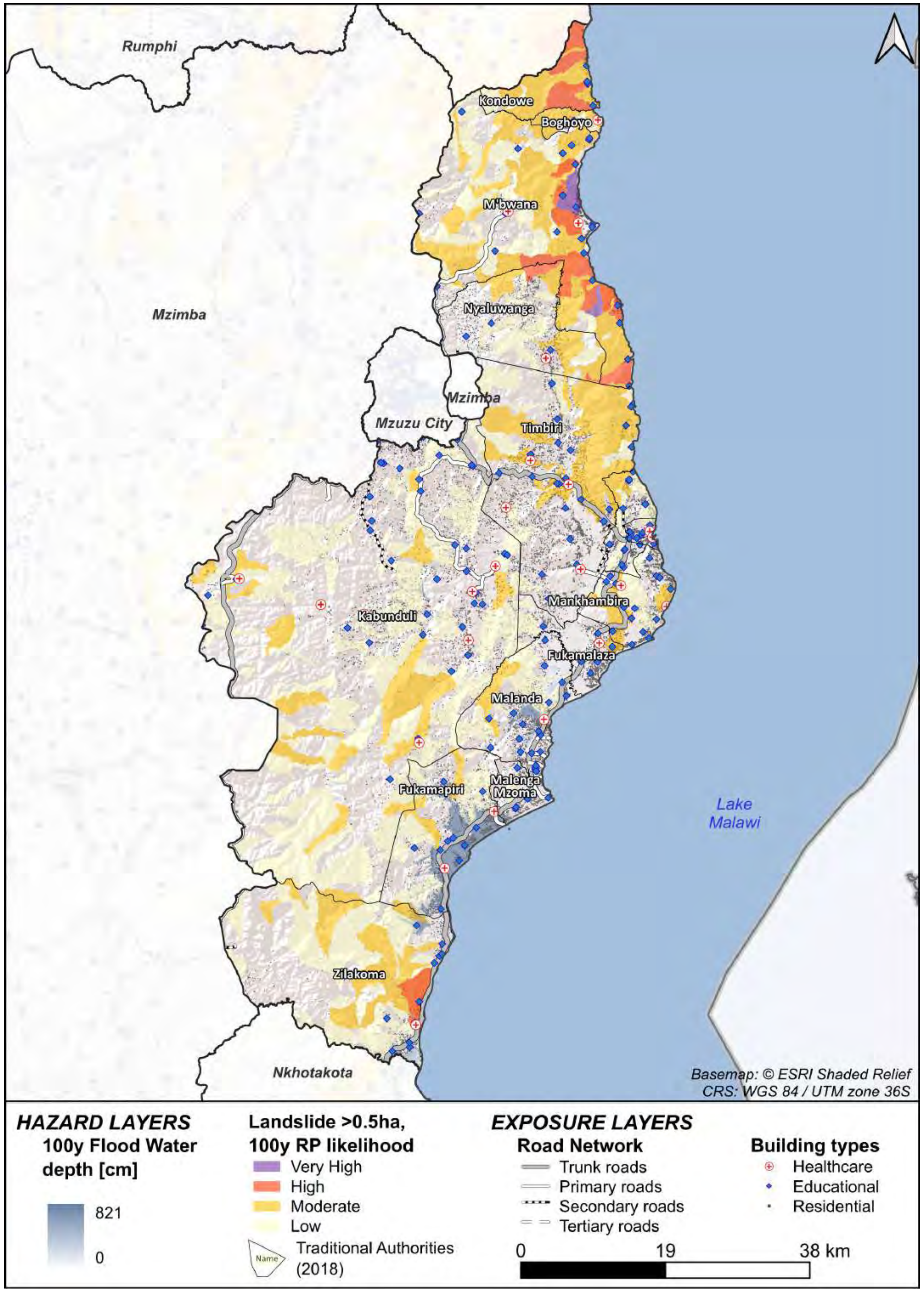


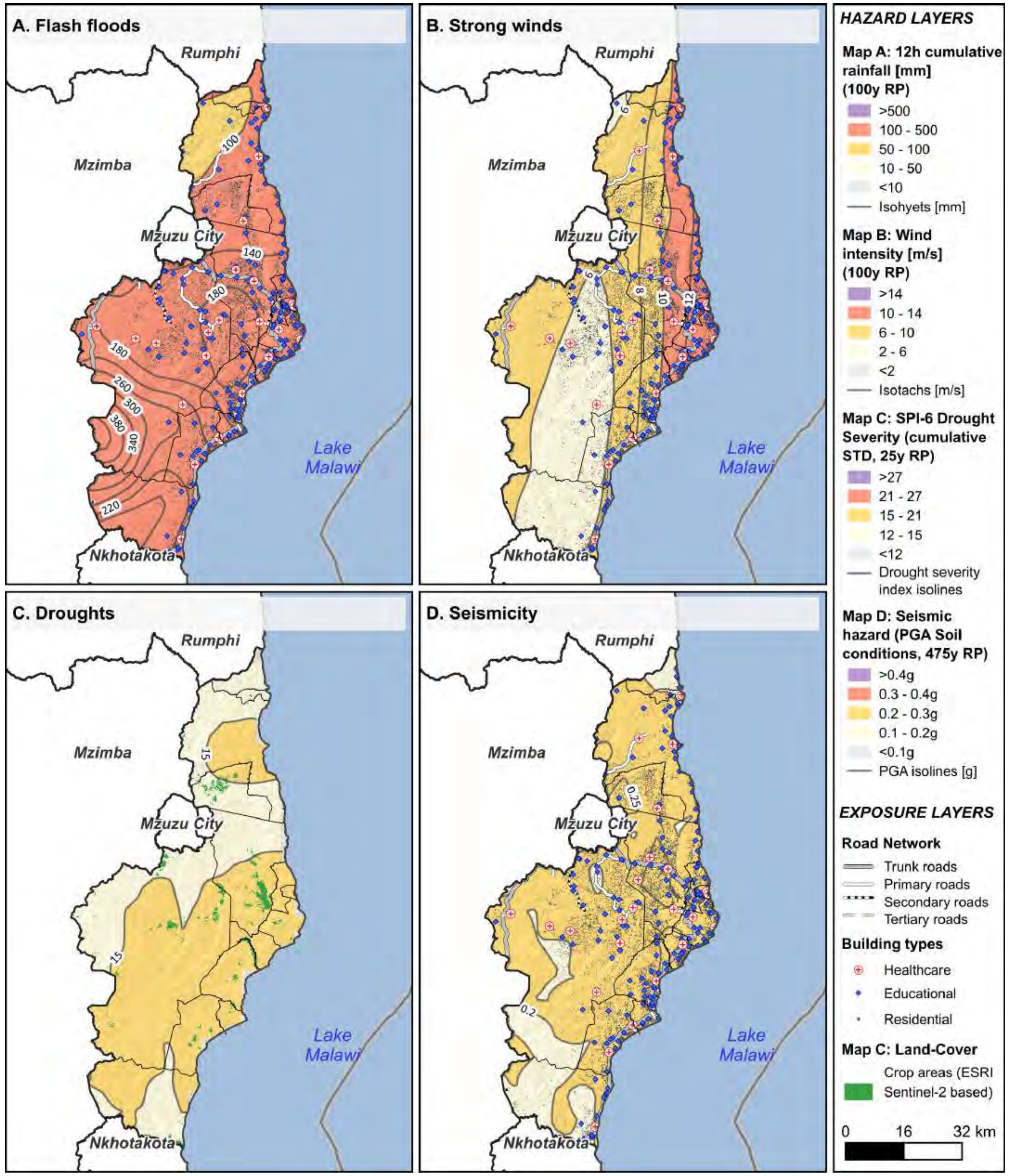
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

NKHOTAKOTA

Nkhotakota is a district in the Central Region of Malawi, covering an area of 4,259 km². It is located along the shore of Lake Malawi. All social vulnerability parameters in the district are lower than the national average.
Flooding is the most severe hazard for the risk of the built environment, followed by wind. Wind tends to affect the population the most. Both weather-related hazards and drought are influenced by climate projections, with drought being affected to a lesser extent. The ratio of average annual economic losses due to flooding is more than double the national average, while the average annual number of people affected by wind is about four times higher than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**436 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	2.03	-
Poverty Prevalence (%)	**43**	51*
Food Insecurity (%)	**54**	64*
Inactive Population (%)	**8**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**2638**	131 953
Ratio on total value (%)	2.00	-
Schools and Hospitals	**167 – 26**	6410 - 671
Ratio on total value (%)	2.61 – 3.87	-
Most important Crops	**Cassava, Maize, Groundnuts, Rice, Sweet Potato**	Cassava, Maize, Sweet Potato, Groundnuts

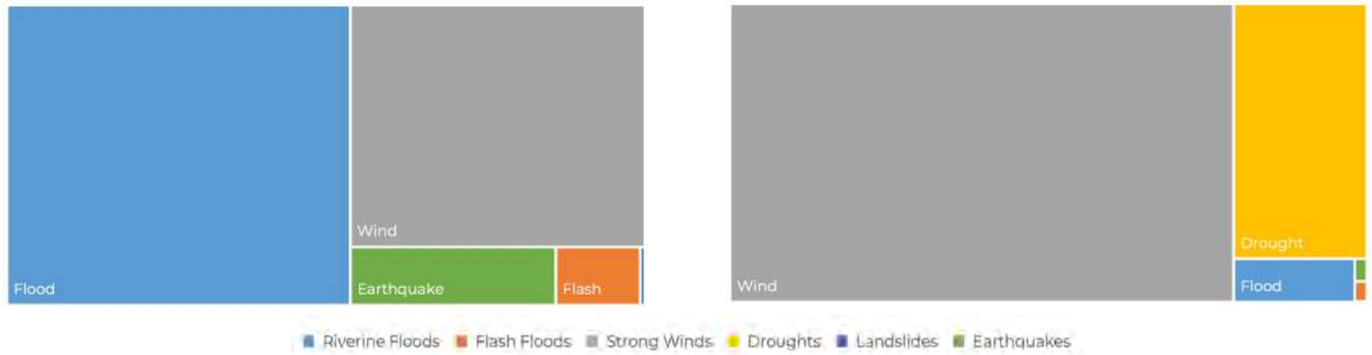
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**20.181**	-	-	-	-	-	**99 378**	-
Riverine Floods	10.855	4.12	10.991	1.38	0.52	-	2742	4.96
Flash Floods	0.519	0.23	-	-	-	-	125	0.25
Strong Winds	7.521	3.3	-	-	-	-	78 596	201.22
Compound	18.892	-	-	-	-	-	81 463	-
Droughts	-	-	-	-	4.799	-	17 769	54
Landslides	0.029	0.012	-	-	-	-	5	0
Earthquakes	1.26	0.48	-	-	-	-	141	0.32

RISK RESULTS – Average Annual Losses CHARTS

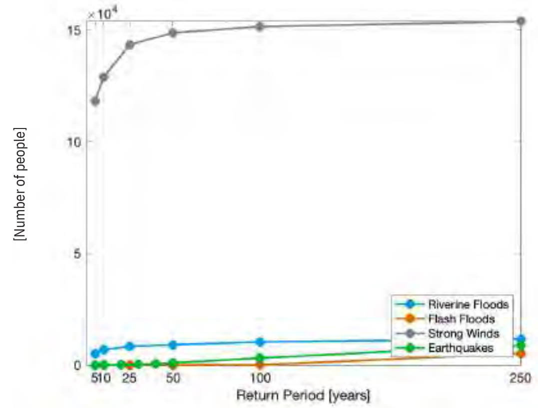
Economic Built - UP

Population

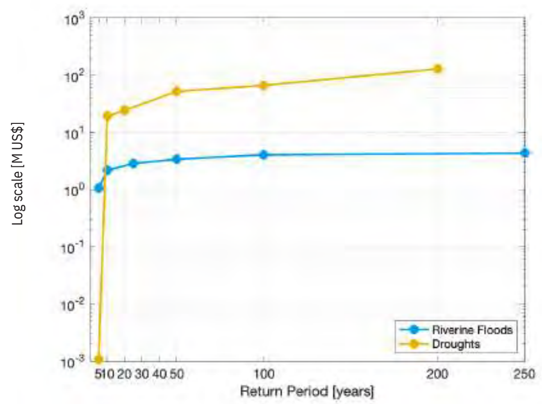


RISK RESULTS – Probable Maximum Losses CURVES

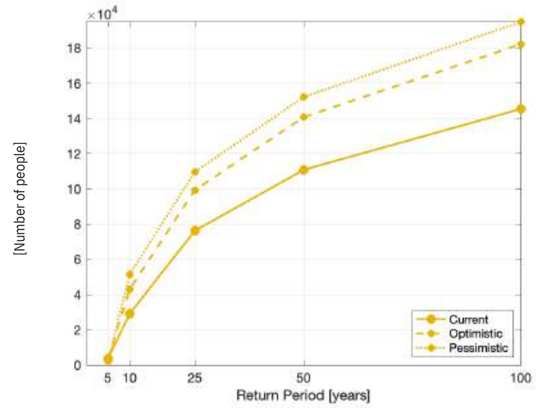
Fast-onset Weather related and Earthquakes - Affected Population



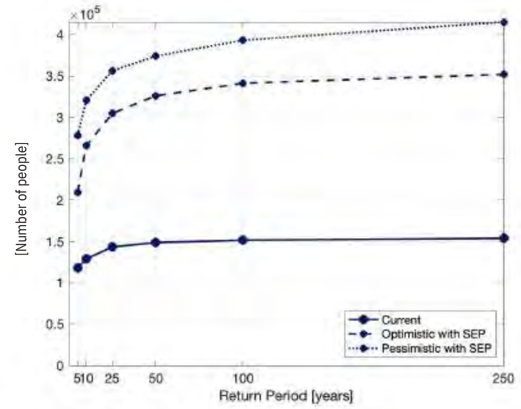
Weather related - Economic Loss



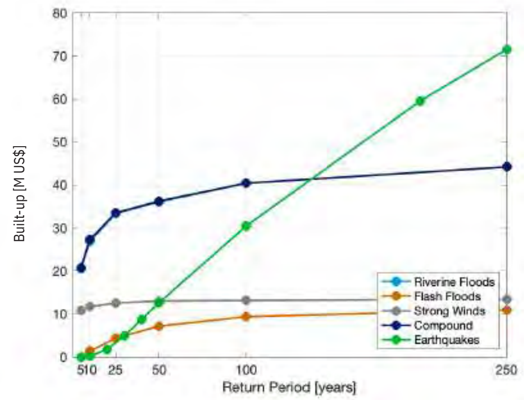
Droughts Projections - Affected Population



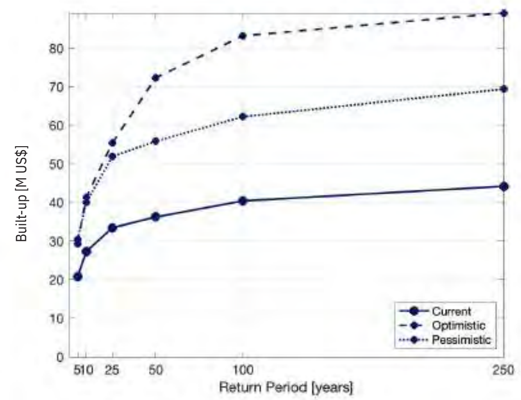
Compound Projections - Affected Population

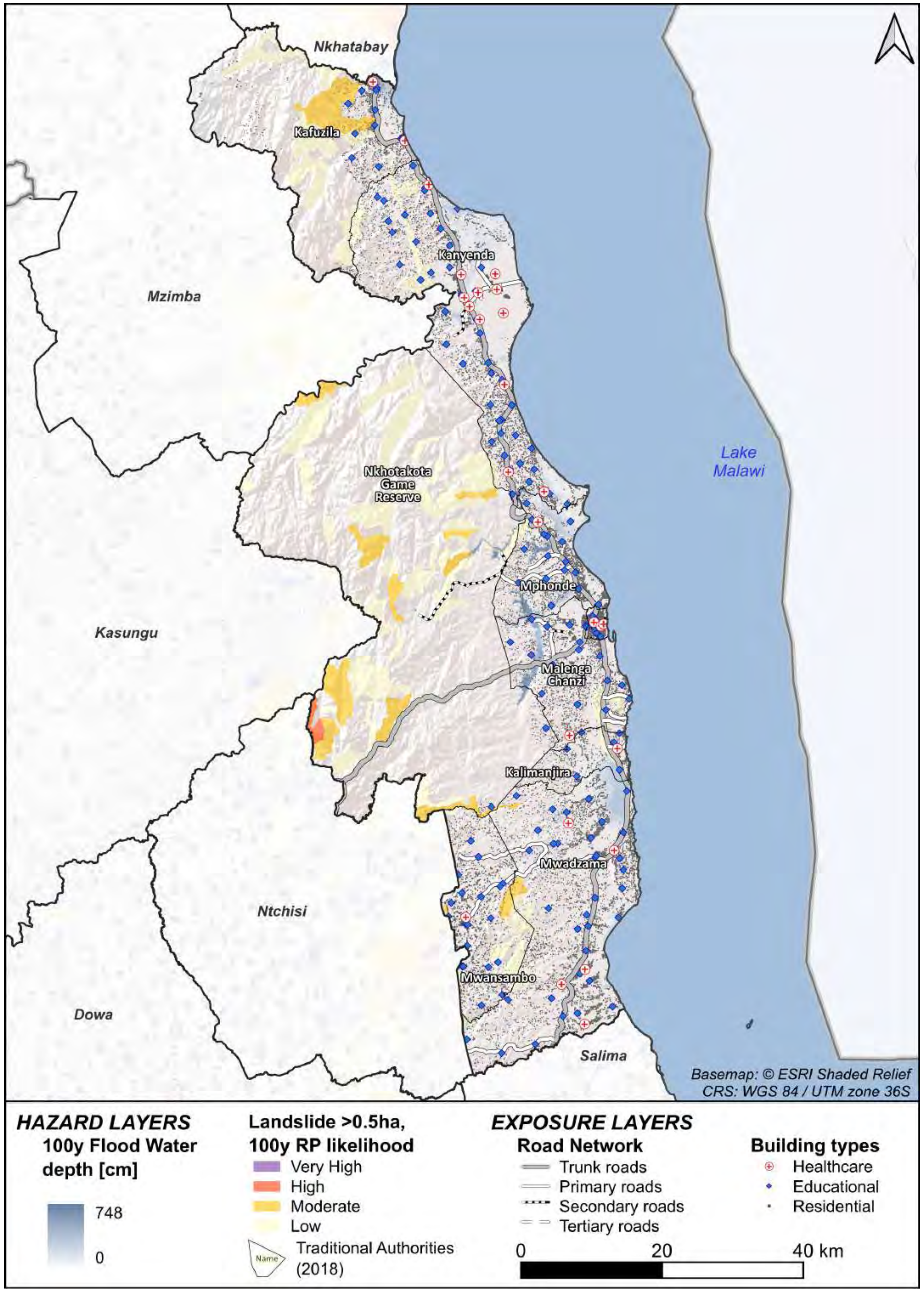


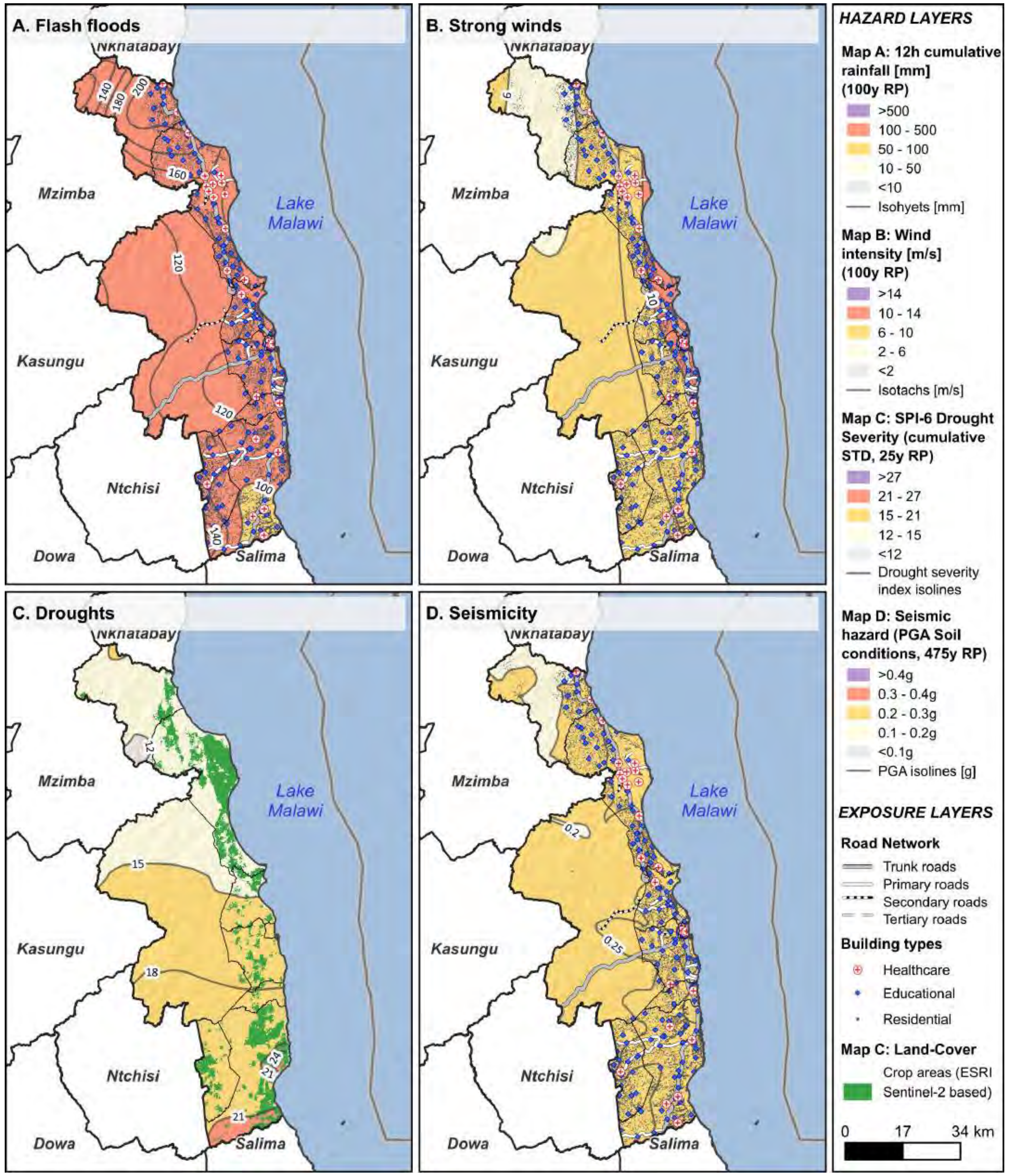
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

NSANJE

Nsanje is Malawi's southernmost district, covering an area of 1,942 km². In this district, riverine flooding is the most significant hazard in the risk of the built environment, followed by flash floods and wind. Drought affects more people. While drought is influenced by climate change, the impact is less severe compared to the fast-onset weather-related hazards. The ratio of average annual economic losses due to flooding is double the national average, while the average annual number of people affected by drought is also higher than the national average. Social vulnerability parameters, such as poverty and food insecurity, are higher than the national average, whereas the inactive population is lower.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**352 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	1.64	-
Poverty Prevalence (%)	**63**	51*
Food Insecurity (%)	**71**	64*
Inactive Population (%)	**7**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**2321**	131 953
Ratio on total value (%)	1.76	-
Schools and Hospitals	**113 – 22**	6410 - 671
Ratio on total value (%)	1.76 – 3.28	-
Most important Crops	**Maize, Pigeon peas, Sorghum, Groundnuts**	Cassava, Maize, Sweet Potato, Groundnuts

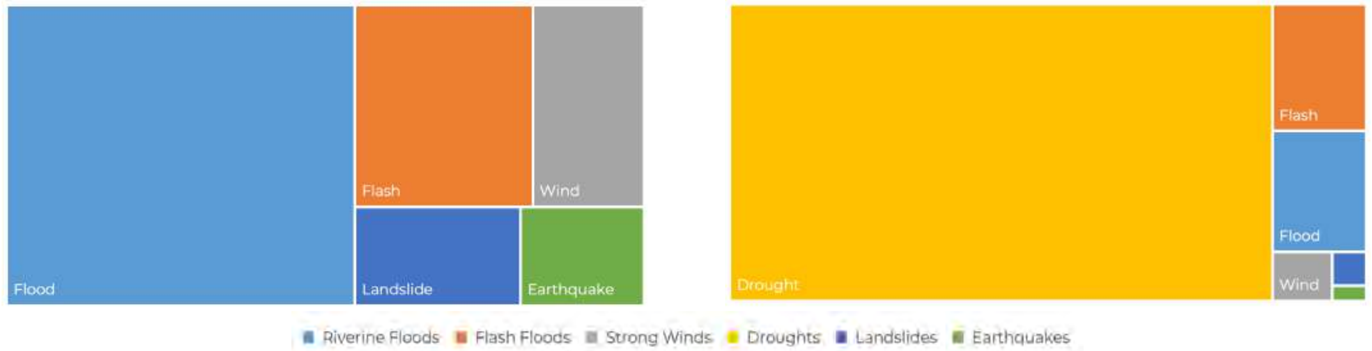
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**11.479**	-	-	-	-	-	**26 604**	-
Riverine Floods	6.272	2.73	0.017	0.005	0	-	1600	3.7
Flash Floods	2.157	0.97	-	-	-	-	1675	4.01
Strong Winds	1.351	0.61	-	-	-	-	412	1.22
Compound	9.772	-	-	-	-	-	3687	-
Droughts	-	-	-	-	1.25	-	22 683	76
Landslides	0.976	0.44	-	-	-	-	162	0.5
Earthquakes	0.731	0.32	-	-	-	-	72	0.2

RISK RESULTS – Average Annual Losses CHARTS

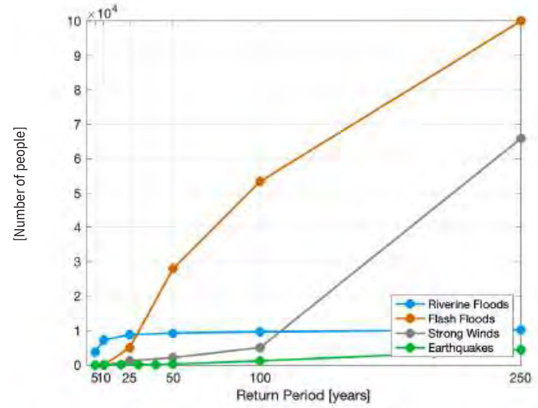
Economic Built - UP

Population

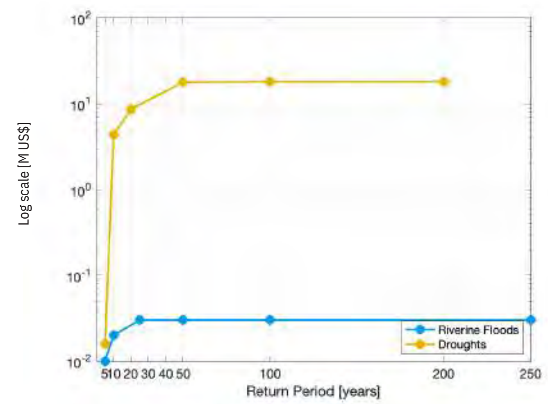


RISK RESULTS – Probable Maximum Losses CURVES

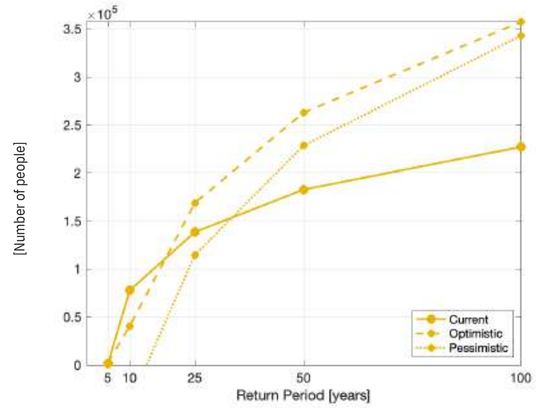
Fast-onset Weather related and Earthquakes - Affected Population



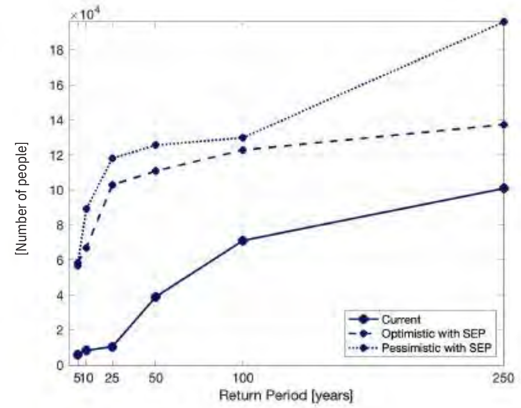
Weather related - Economic Loss



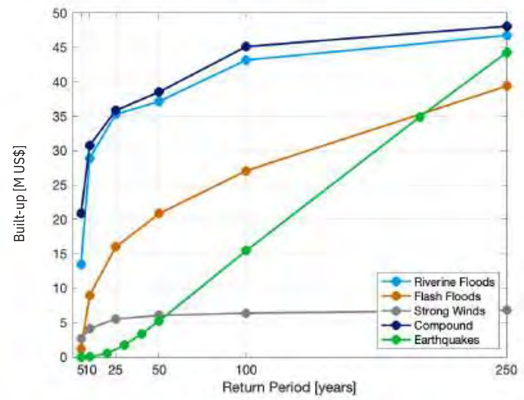
Droughts Projections - Affected Population



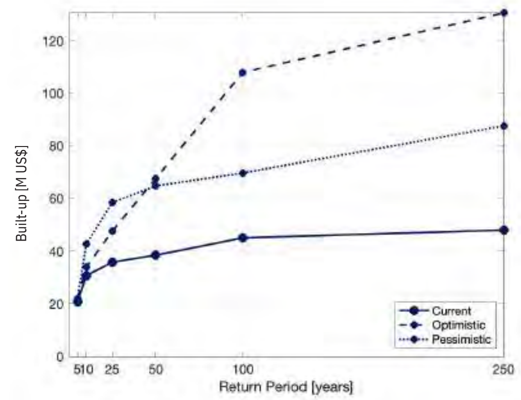
Compound Projections - Affected Population

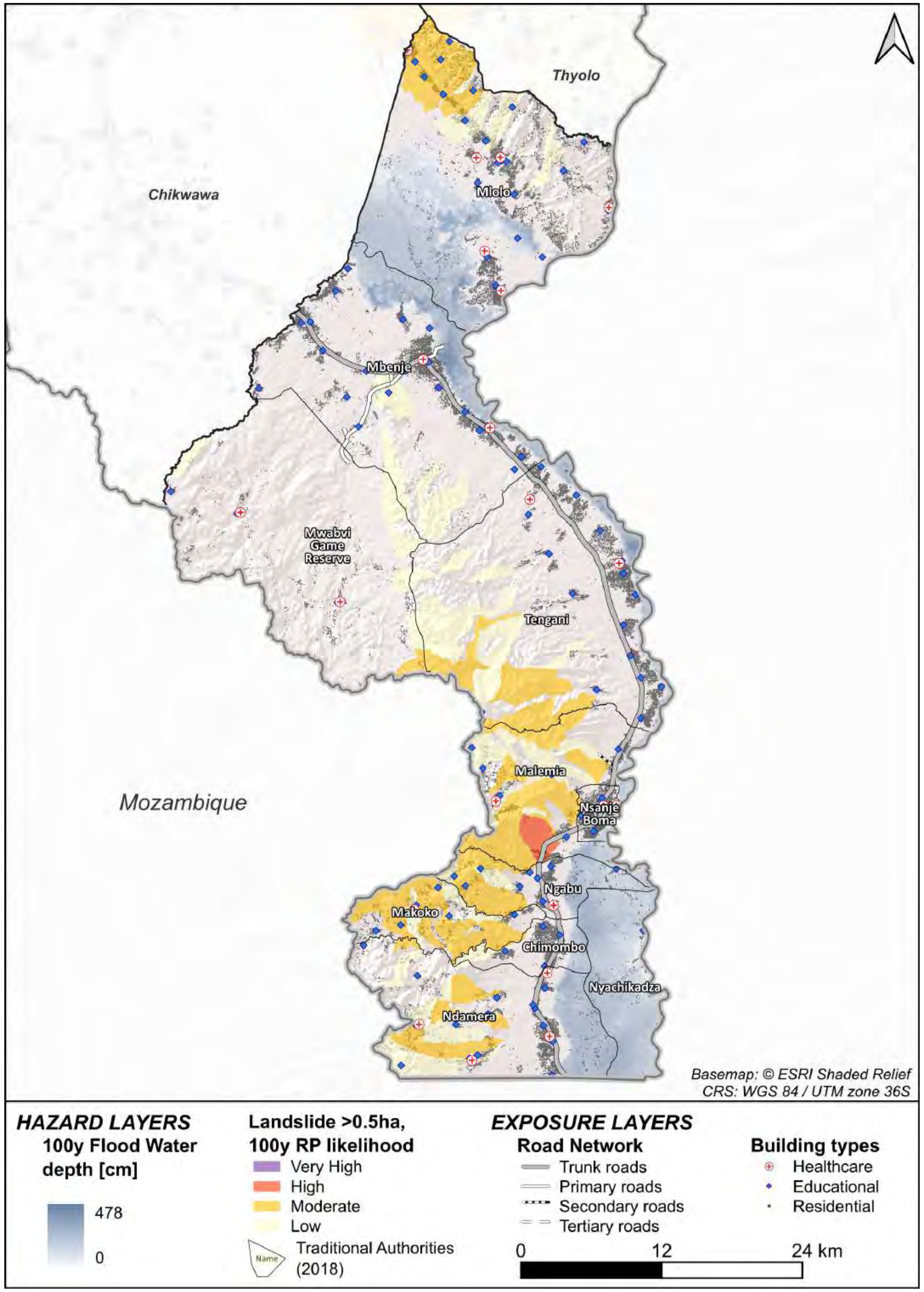


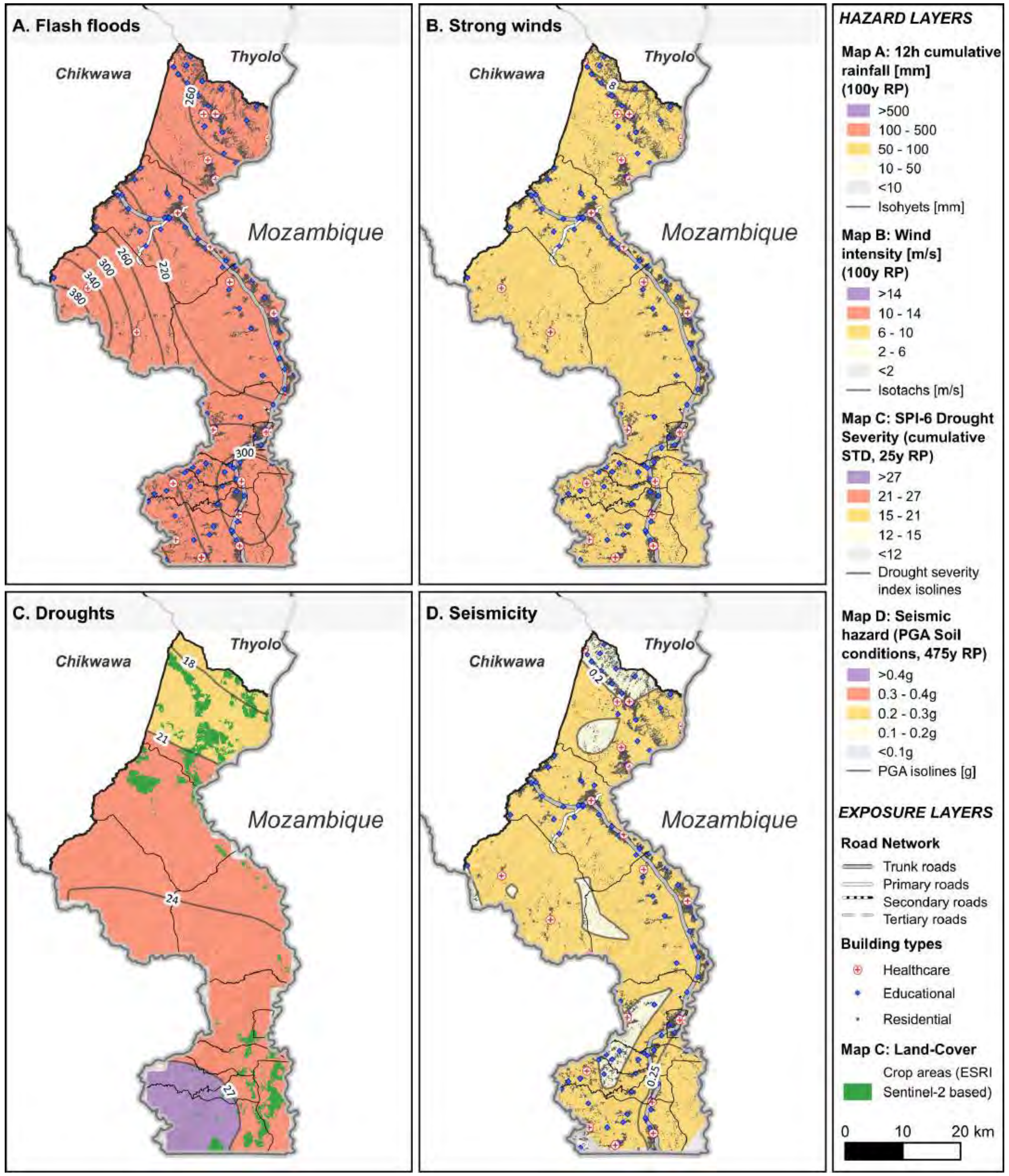
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

NTCHEU

Ntcheu is a district in the Central Region of Malawi, covering an area of 3,424 km². Social vulnerability indicators, such as poverty prevalence and food insecurity, are higher than the national average, while the inactive population is lower.
Strong winds are the greatest hazard for the risk of the built environment, followed by flash floods and earthquakes. Drought is the predominant hazard affecting the population in the district. Both weather-related risks and drought are influenced by climate change, with the pessimistic scenario particularly affecting the former. The ratio of the average annual economic losses due to landslides and other weather-related hazards is lower than the national average. The district's average annual number of people affected by drought is aligned with the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**728 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	3.39	-
Poverty Prevalence (%)	**57**	51*
Food Insecurity (%)	**67**	64*
Inactive Population (%)	**5**	9*

* National value as weighted mean on population

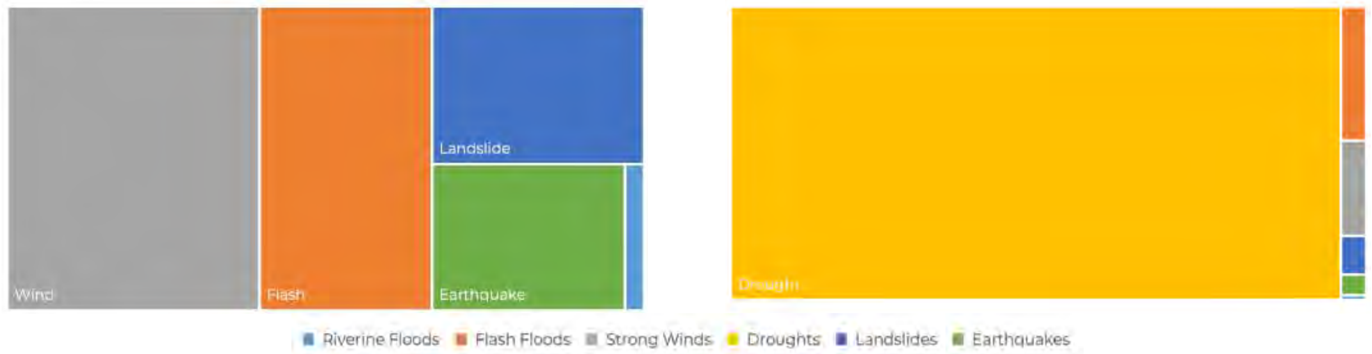
STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**5074**	131 953
Ratio on total value (%)	3.85	-
Schools and Hospitals	**284 – 38**	6410 - 671
Ratio on total value (%)	4.43 – 5.66	-
Most important Crops	**Mazie, Beans, Groundnuts, Sweet potato, Potato**	Cassava, Maize, Sweet Potato, Groundnuts

RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**7.895**	-	-	-	-	-	**39 044**	-
Riverine Floods	0.117	0.02	0.010	0.001	0	-	26	0.03
Flash Floods	2.156	0.44	-	-	-	-	712	0.82
Strong Winds	3.151	0.65	-	-	-	-	505	0.72
Compound	5.361	-	-	-	-	-	1227	-
Droughts			-	-	8.276	-	37 501	52
Landslides	1.376	0.281	-	-	-	-	207	0.3
Earthquakes	1.158	0.23	-	-	-	-	109	0.15

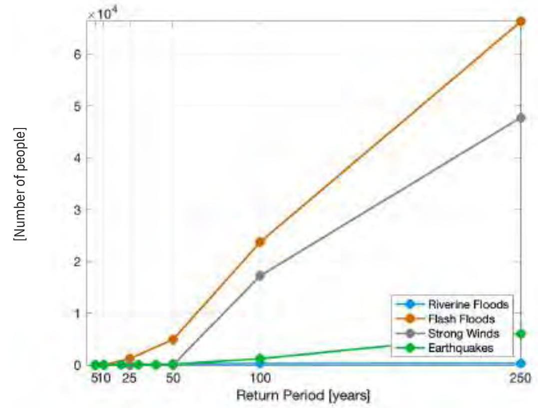
RISK RESULTS – Average Annual Losses CHARTS

Economic Built - UP
Population

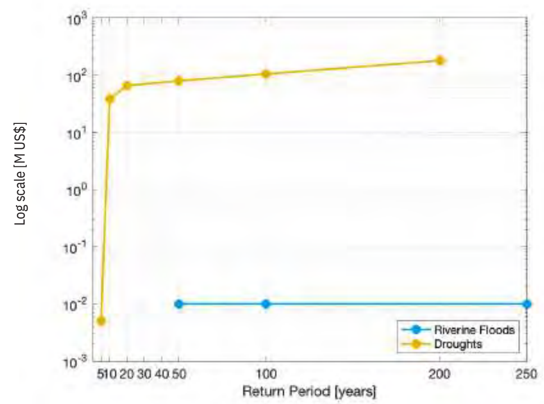


RISK RESULTS – Probable Maximum Losses CURVES

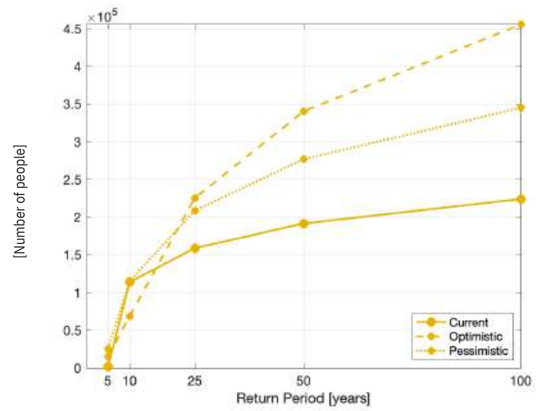
Fast-onset Weather related and Earthquakes - Affected Population



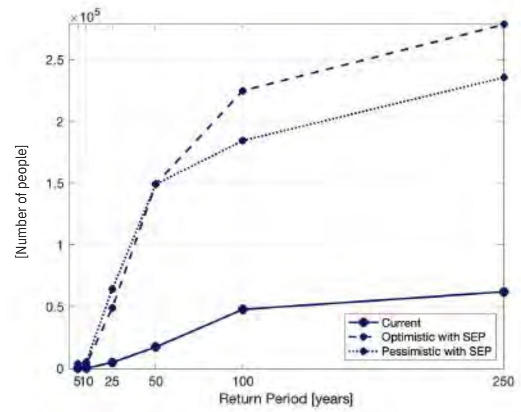
Weather related - Economic Loss



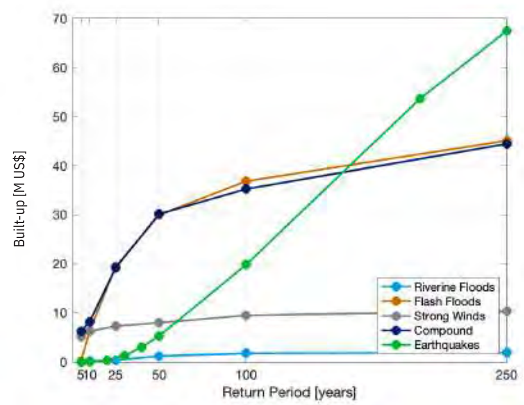
Droughts Projections - Affected Population



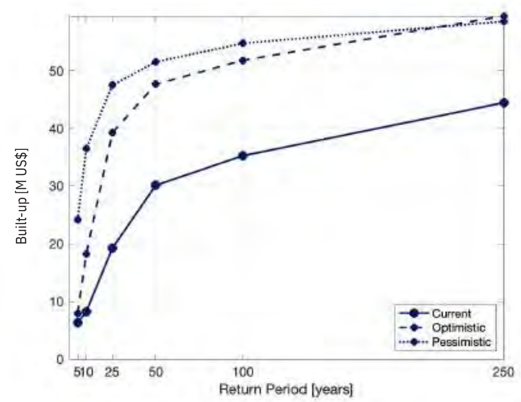
Compound Projections - Affected Population

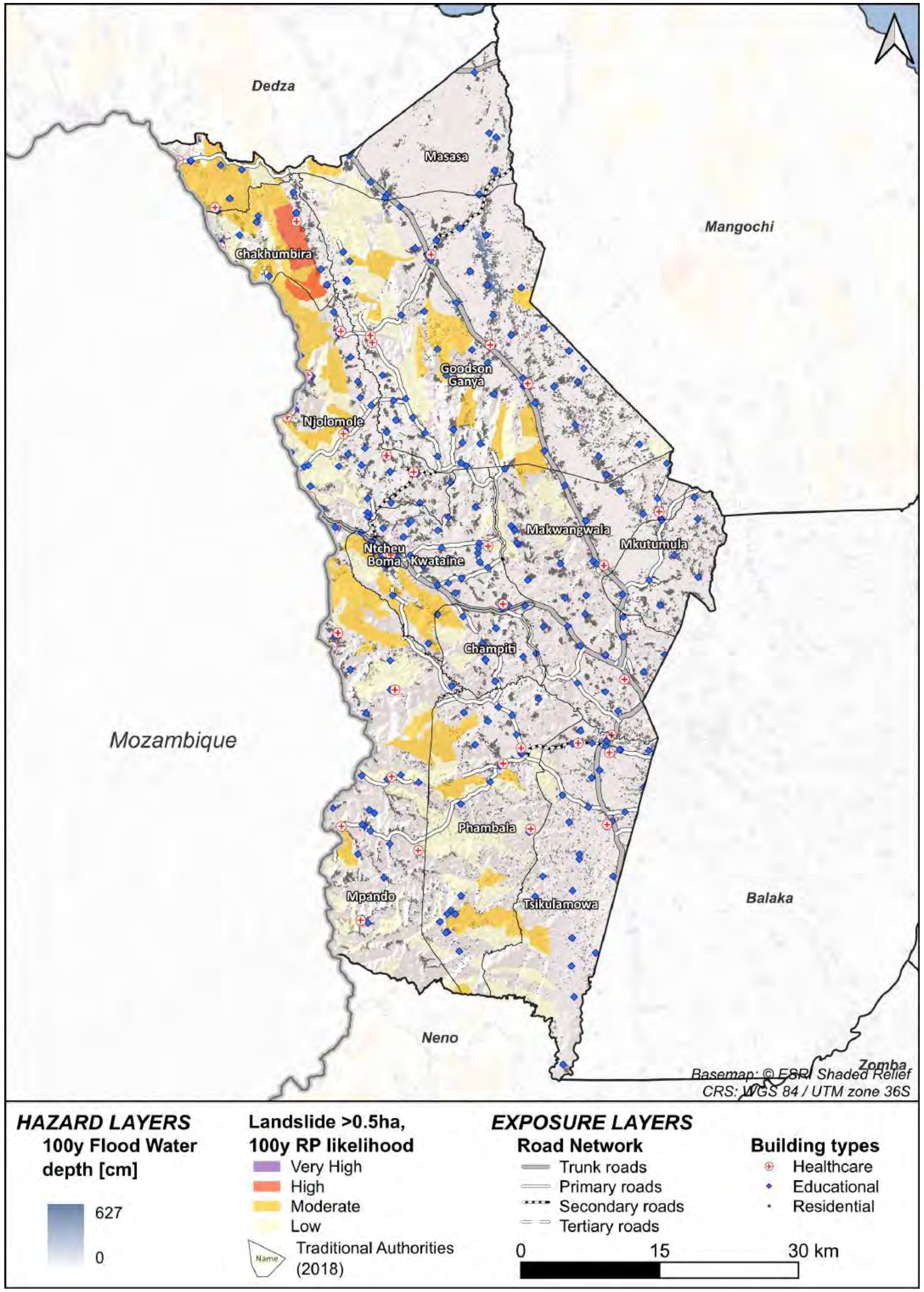


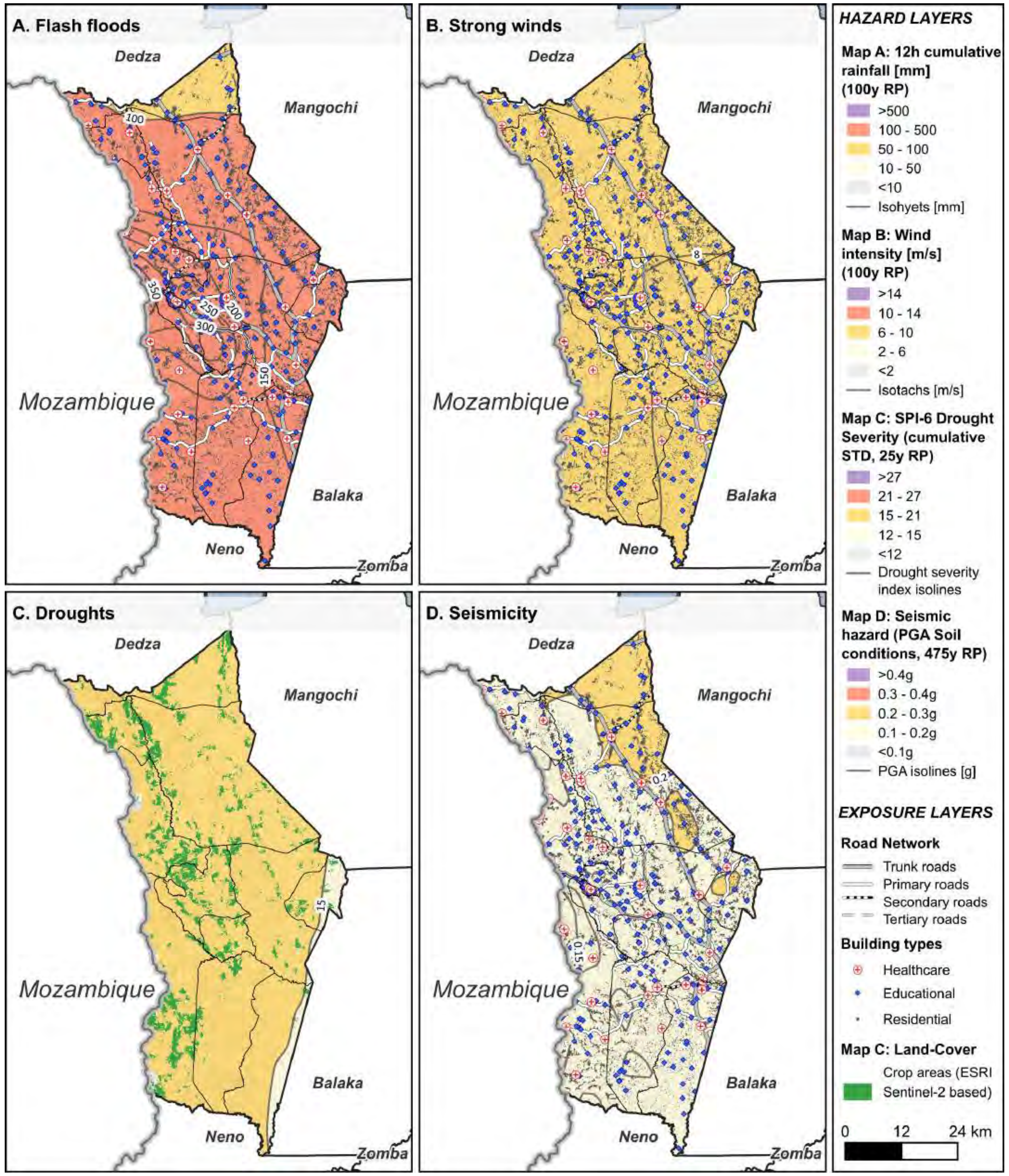
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

NTCHISI

Ntchisi is a district located in the Central Region of Malawi, covering an area of 1,655 km². The district lies at an elevation between 1,300 and 1,700 meters above sea level. Social vulnerability indicators for poverty are slightly higher than the national average, while food insecurity and the inactive population are lower.
The risk evaluation shows that strong winds are the primary hazard for the risk of the built environment, followed by earthquakes. Drought affects the population significantly. Climate projections suggest that weather-related hazards are expected to increase in the future under both pessimistic and optimistic scenarios. The increase in losses is especially pronounced in the pessimistic scenario, while drought is influenced by both scenarios. The ratio of the average annual economic losses due to strong winds, however, is lower than the national average. On the other hand, the average annual number of people affected by drought is higher than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**356 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	1.66	-
Poverty Prevalence (%)	**55**	51*
Food Insecurity (%)	**63**	64*
Inactive Population (%)	**5**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**2648**	131 953
Ratio on total value (%)	2.01	-
Schools and Hospitals	**153 – 13**	6410 - 671
Ratio on total value (%)	2.39 - 1.94	-
Most important Crops	**Maize, Beans, Groundnuts, Potatoes, Sweet Potato**	Cassava, Maize, Sweet Potato, Groundnuts

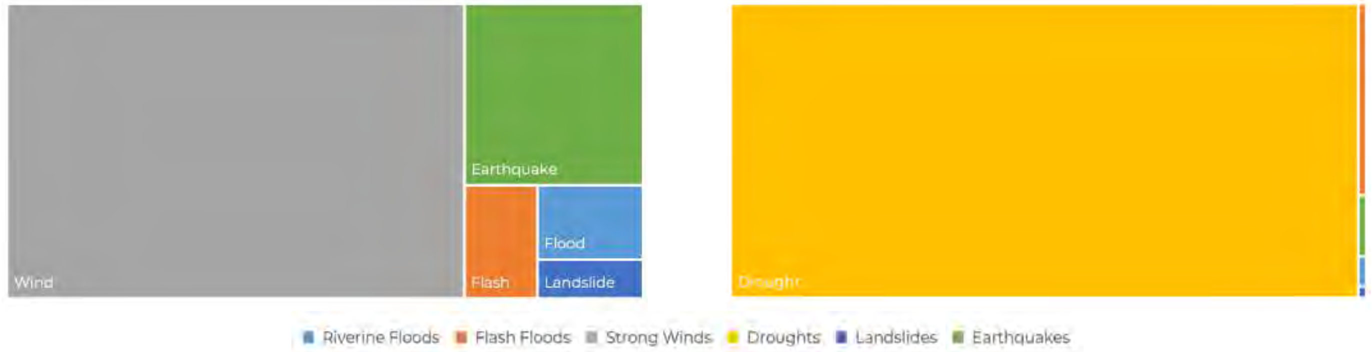
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**3.629**	-	-	-	-	-	**22 267**	-
Riverine Floods	0.152	0.06	0.207	0.08	0	-	28	0.06
Flash Floods	0.16	0.06	-	-	-	-	181	0.4
Strong Winds	2.611	0.98	-	-	-	-	0	0
Compound	2.919		-	-	-	-	209	-
Droughts	-	-	-	-	2.163	-	21 989	65
Landslides	0.08	0.031	-	-	-	-	11	0
Earthquakes	0.63	0.24	-	-	-	-	58	0.16

RISK RESULTS – Average Annual Losses CHARTS

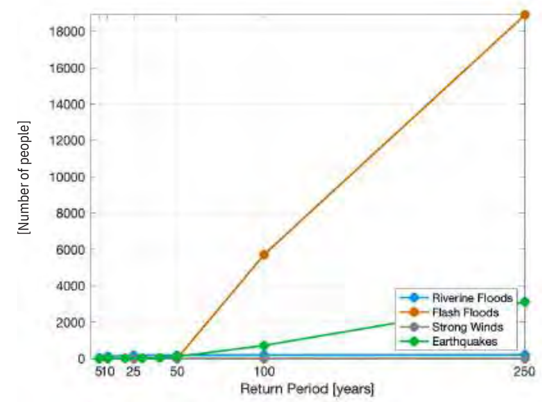
Economic Built - UP

Population

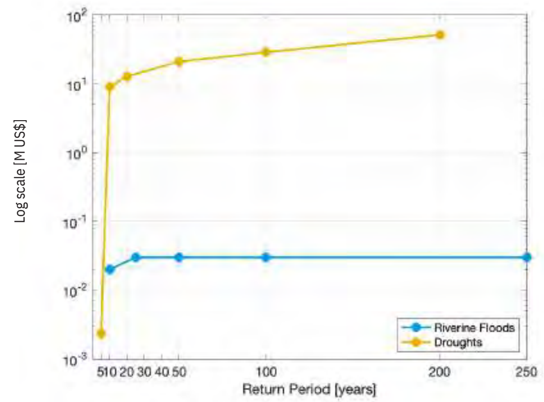


RISK RESULTS – Probable Maximum Losses CURVES

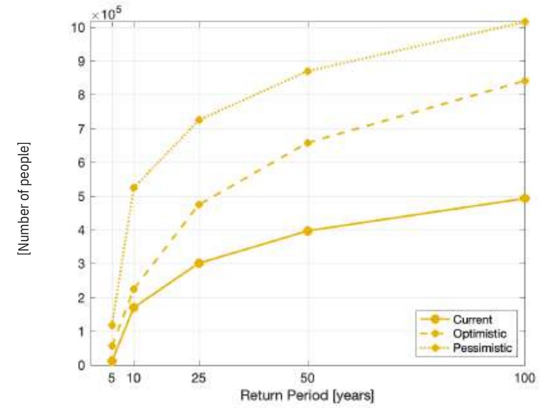
Fast-onset Weather related and Earthquakes - Affected Population



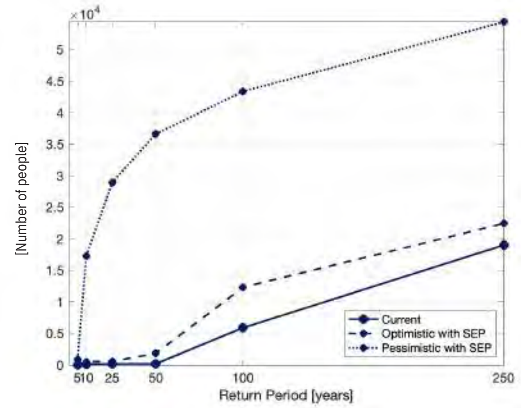
Weather related - Economic Loss



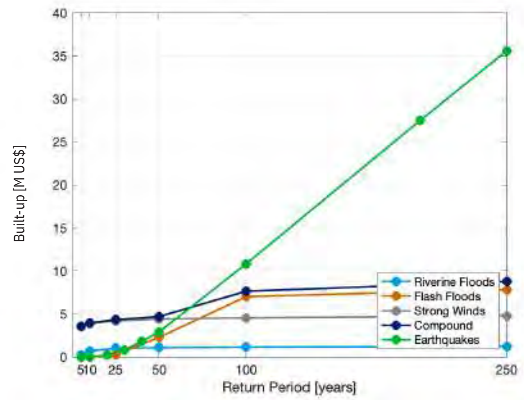
Droughts Projections - Affected Population



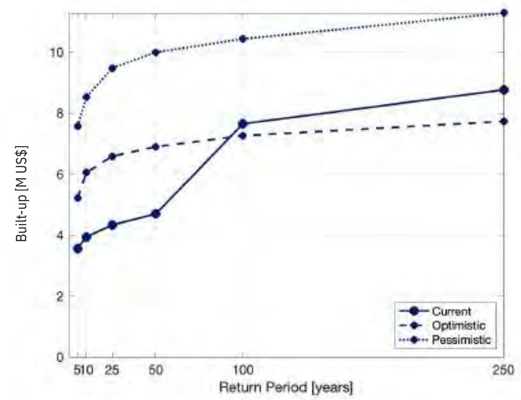
Compound Projections - Affected Population

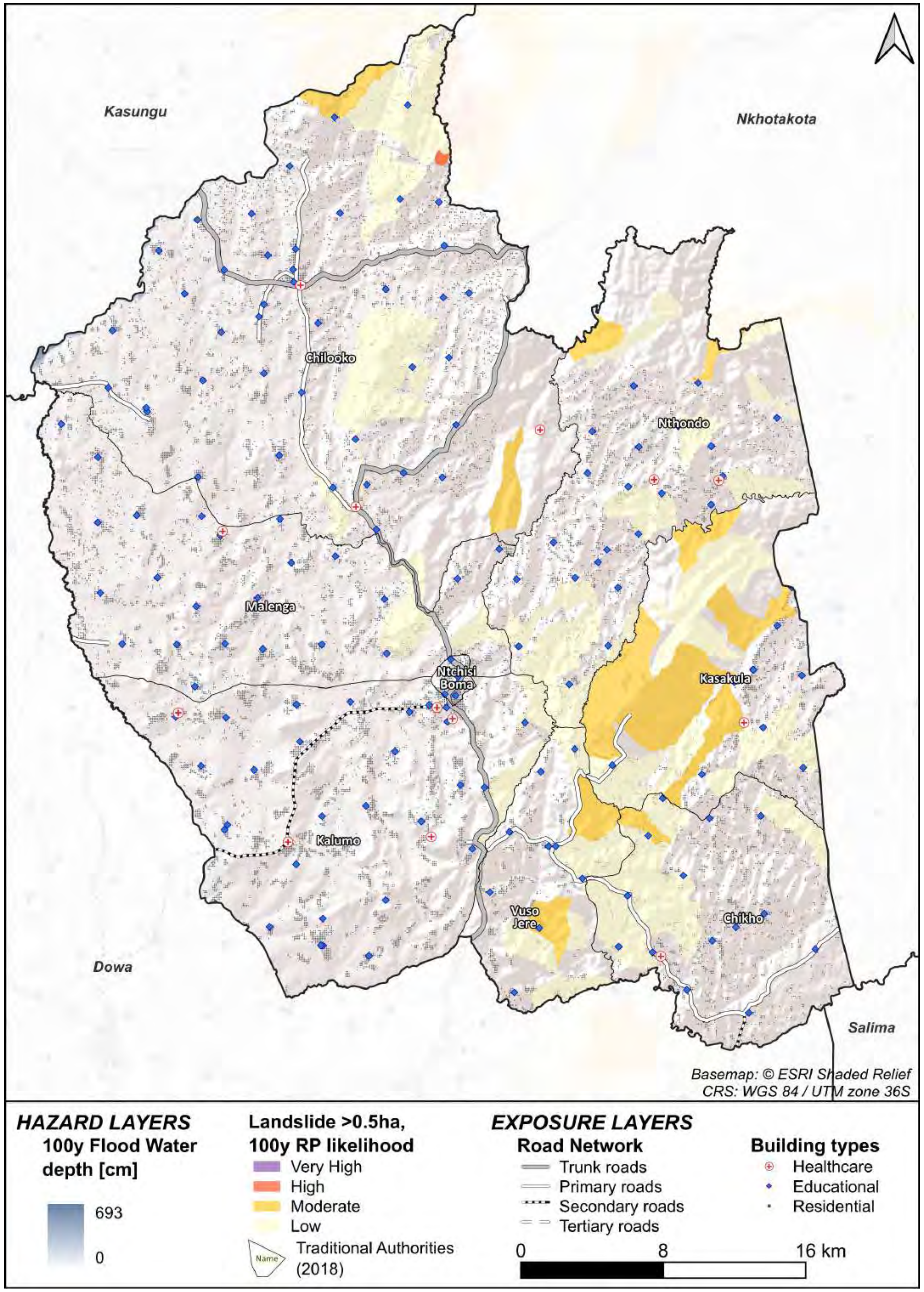


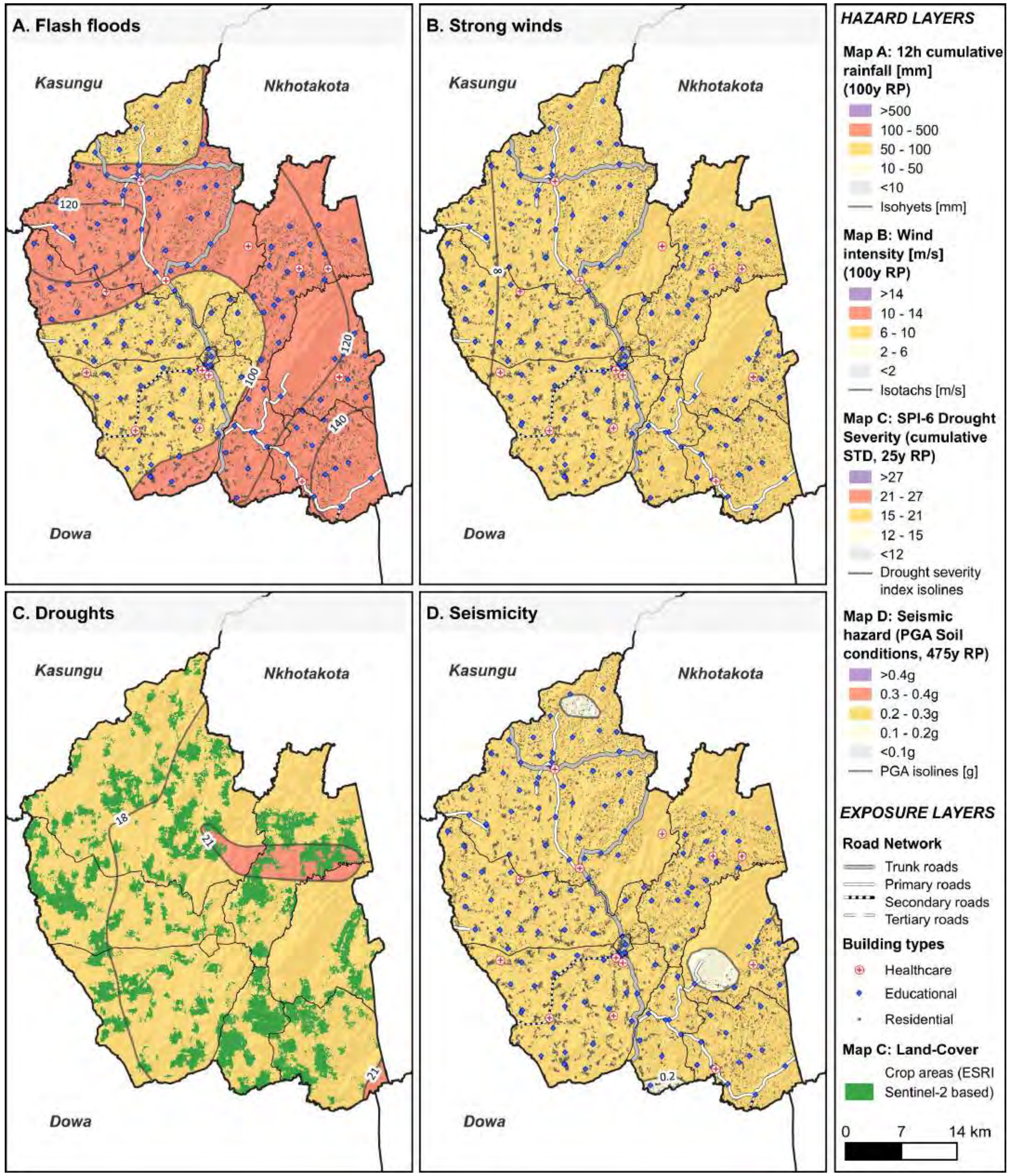
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

PHALOMBE

Phalombe is a district in the Southern Region of Malawi, covering an area of 1,394 km². Social vulnerability indicators for poverty prevalence and food insecurity are higher than the national average, while the inactive population is lower.
The risk of the built environment shows that landslides are the major cause, followed by floods and flash floods in the district. However, drought predominantly affects a larger portion of the population. Climate projections suggest that weather-related hazards are expected to increase in the future under both pessimistic and optimistic scenarios. In these projections, the increase in losses due to weather-related hazards is more pronounced in the optimistic scenario, while drought is particularly affected under the pessimistic scenario. The ratio of the average annual economic losses due to landslides is three times the national average, and the average annual number of people affected by drought is higher than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**497 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	2.31	-
Poverty Prevalence (%)	**64**	51*
Food Insecurity (%)	**76**	64*
Inactive Population (%)	**5**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**3199**	131 953
Ratio on total value (%)	2.42	-
Schools and Hospitals	**100 – 15**	6410 - 671
Ratio on total value (%)	1.56 - 2.24	-
Most important Crops	**Maize, Pigeon peas, Sorghum, Sweet Potato, Groundnuts, Rice, Cassava**	Cassava, Maize, Sweet Potato, Groundnuts

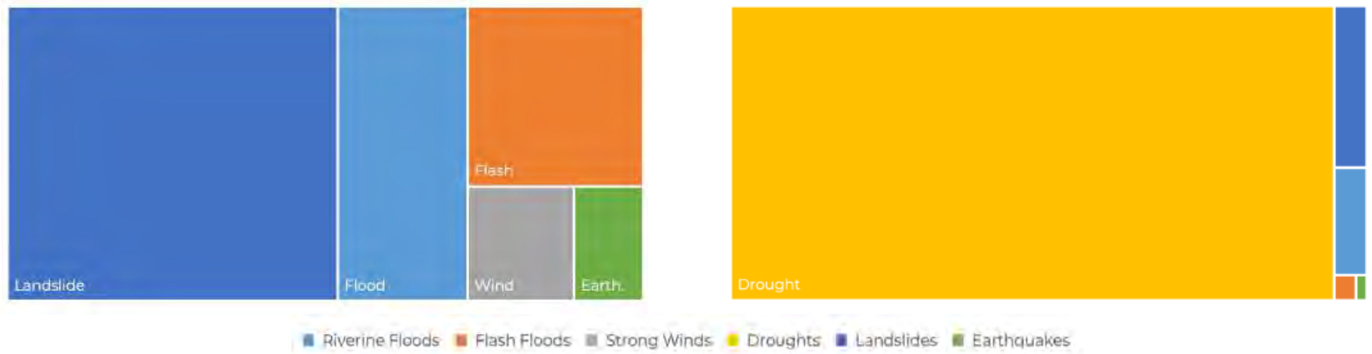
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**12.654**	-	-	-	-	-	**34274**	-
Riverine Floods	2.625	0.82	0.005	0.22	0.01	-	645	1.04
Flash Floods	2.164	0.69	-	-	-	-	102	0.17
Strong Winds	0.837	0.27	-	-	-	-	0	0
Compound	5.444	-	-	-	-	-	747	-
Droughts	-	-	-	-	5.384	-	32505	71
Landslides	6.665	2.113	-	-	-	-	971	2
Earthquakes	0.545	0.17	-	-	-	-	51	0.1

RISK RESULTS – Average Annual Losses CHARTS

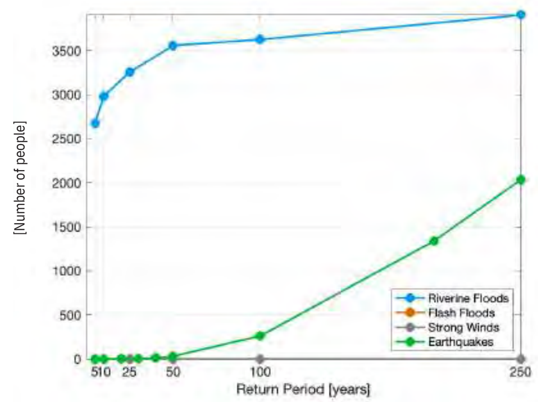
Economic Built - UP

Population

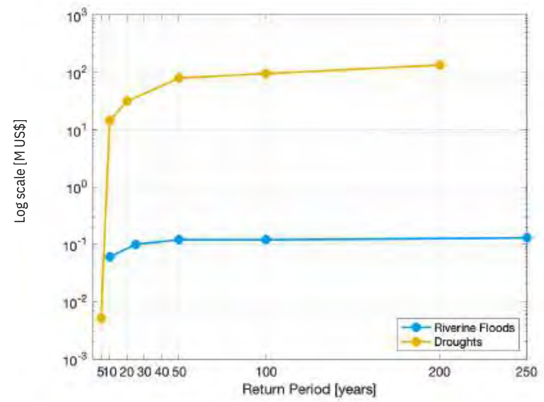


RISK RESULTS – Probable Maximum Losses CURVES

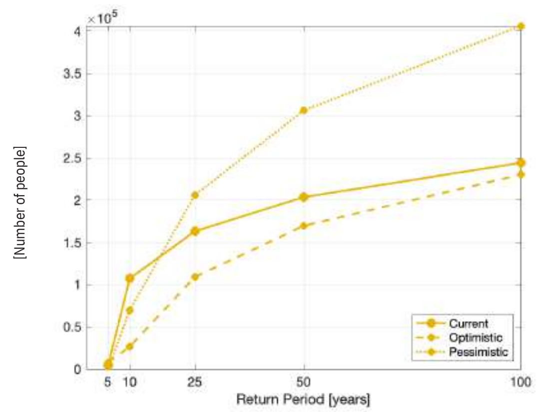
Fast-onset Weather related and Earthquakes - Affected Population



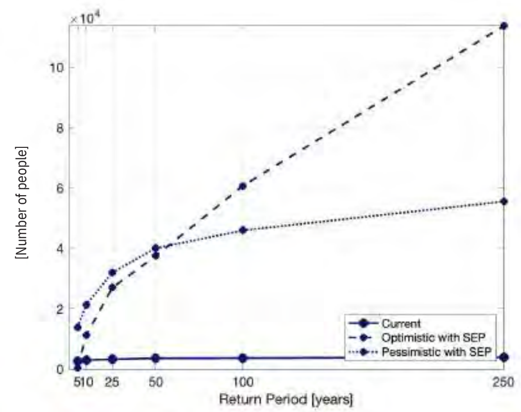
Weather related - Economic Loss



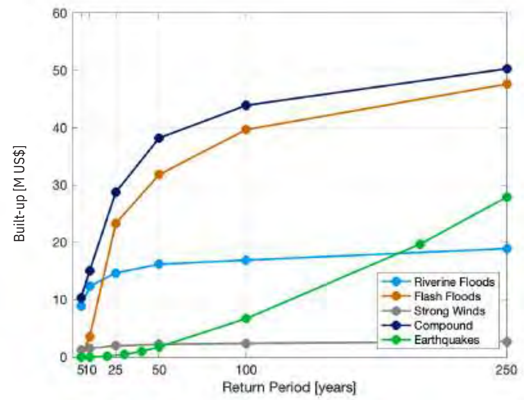
Droughts Projections - Affected Population



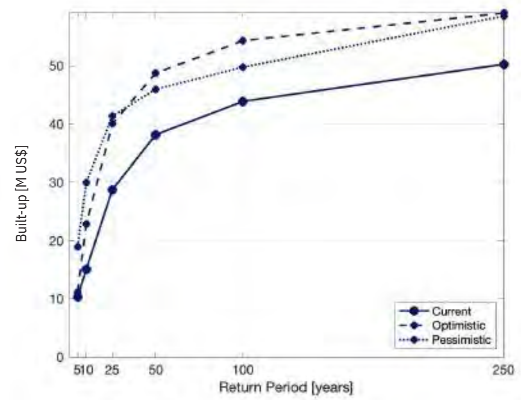
Compound Projections - Affected Population

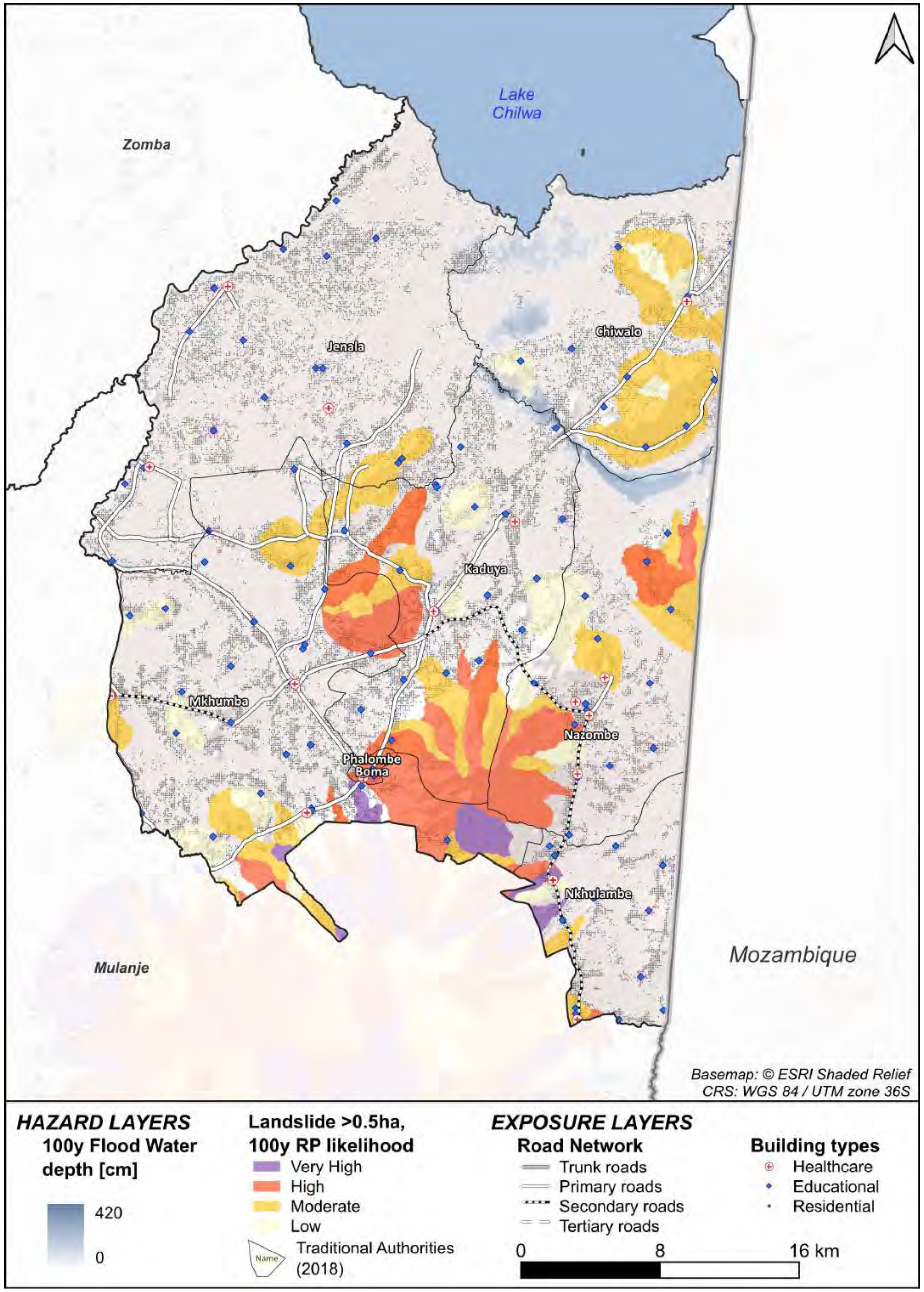


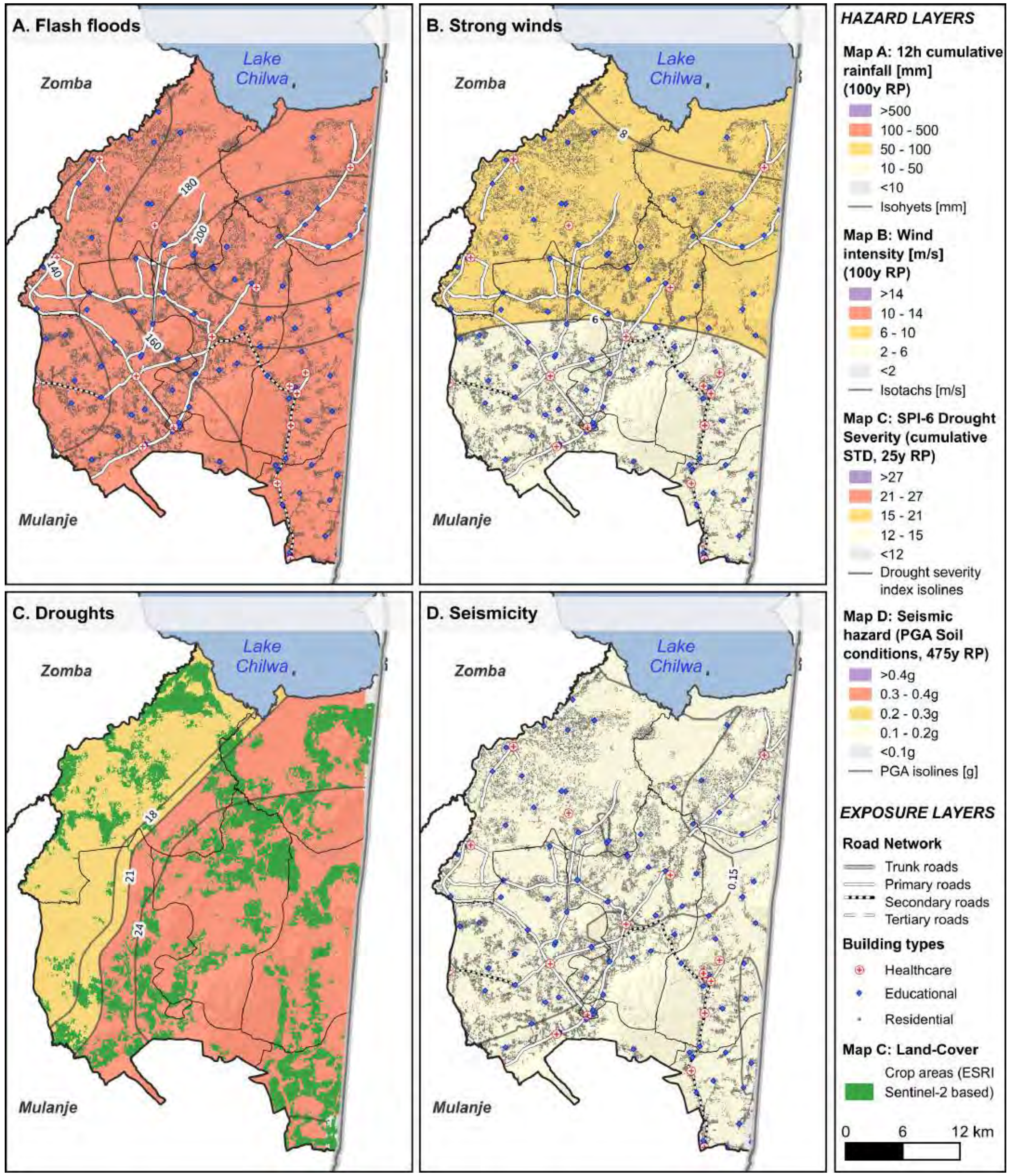
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

RUMPHI

Rumphi is a district in the Northern Region of Malawi, covering an area of 4,769 km², and it has the lowest population density among the districts. Social vulnerability parameters, including poverty and food insecurity, are lower than the national average, while the inactive population is higher. Floods are the primary hazard, followed by flash floods and landslides, for the risk of the built environment. Drought predominantly affects a larger portion of the population, followed by strong winds and flash floods. In climate projections, drought and other weather-related hazards are influenced by different climate scenarios. Drought risk is expected to increase, while weather-related risks are projected to decrease. The ratio of average annual economic losses due to floods, flash floods, and landslides is significantly higher than the national average. The average annual number of people affected by drought is lower than the national average. Additionally, Rumphi is the second-most affected district in terms of economic losses related to transportation systems.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**256 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	1.19	-
Poverty Prevalence (%)	**26**	51*
Food Insecurity (%)	**38**	64*
Inactive Population (%)	**16**	9*

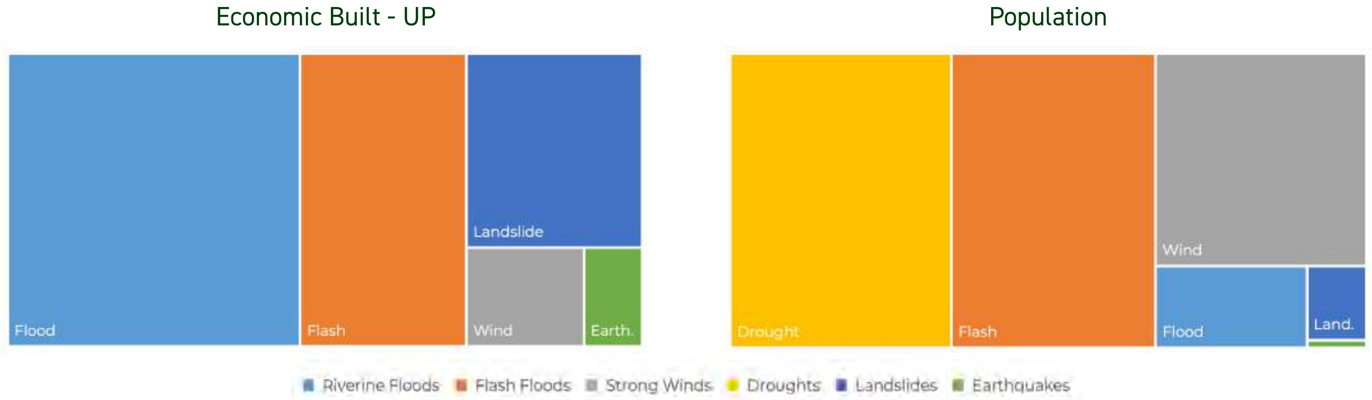
* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**1686**	131 953
Ratio on total value (%)	1.28	-
Schools and Hospitals	**206 – 19**	6410 - 671
Ratio on total value (%)	3.21 – 2.83	-
Most important Crops	**Maize, Cassava, Beans, Groundnuts**	Cassava, Maize, Sweet Potato, Groundnuts

RISK RESULTS – Average Annual Losses TABLE

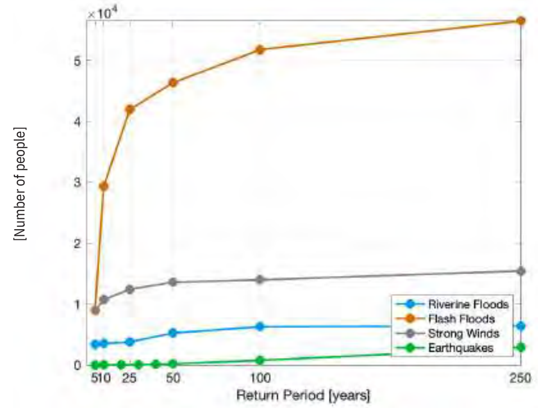
HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**15.442**	**-**	**-**	**-**	**-**	**-**	**21 006**	**-**
Riverine Floods	7.131	4.24	41.388	6.13	0.01	-	1389	4.2
Flash Floods	4.049	2.52	-	-	-	-	6742	21.26
Strong Winds	0.965	0.6	-	-	-	-	5030	20.55
Compound	12.118	-	-	-	-	-	13 148	-
Droughts	-	-	-	-	1.904	-	7314	32
Landslides	2.844	1.897	-	-	-	-	495	1.9
Earthquakes	0.48	0.28	-	-	-	-	49	0.19

RISK RESULTS – Average Annual Losses CHARTS

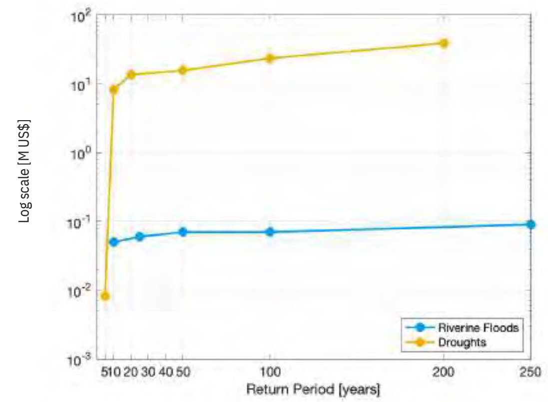


RISK RESULTS – Probable Maximum Losses CURVES

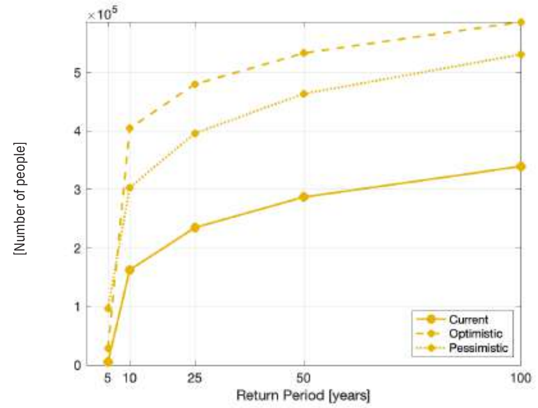
Fast-onset Weather related and Earthquakes - Affected Population



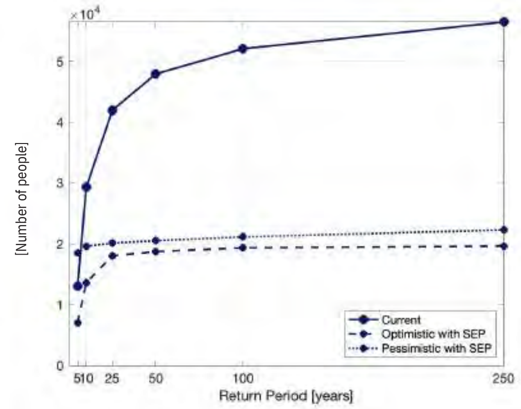
Weather related - Economic Loss



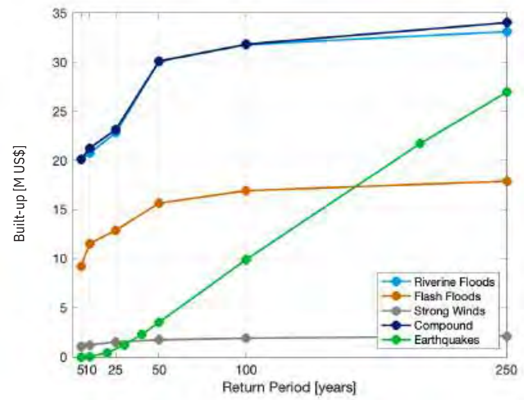
Droughts Projections - Affected Population



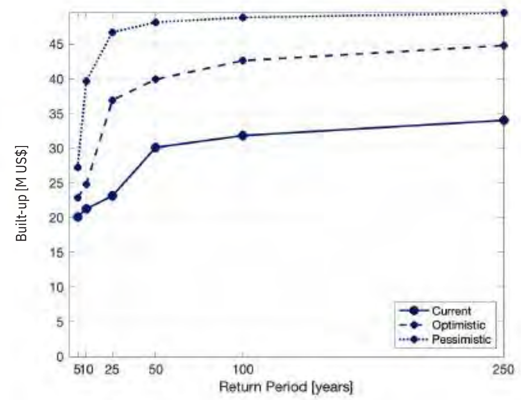
Compound Projections - Affected Population

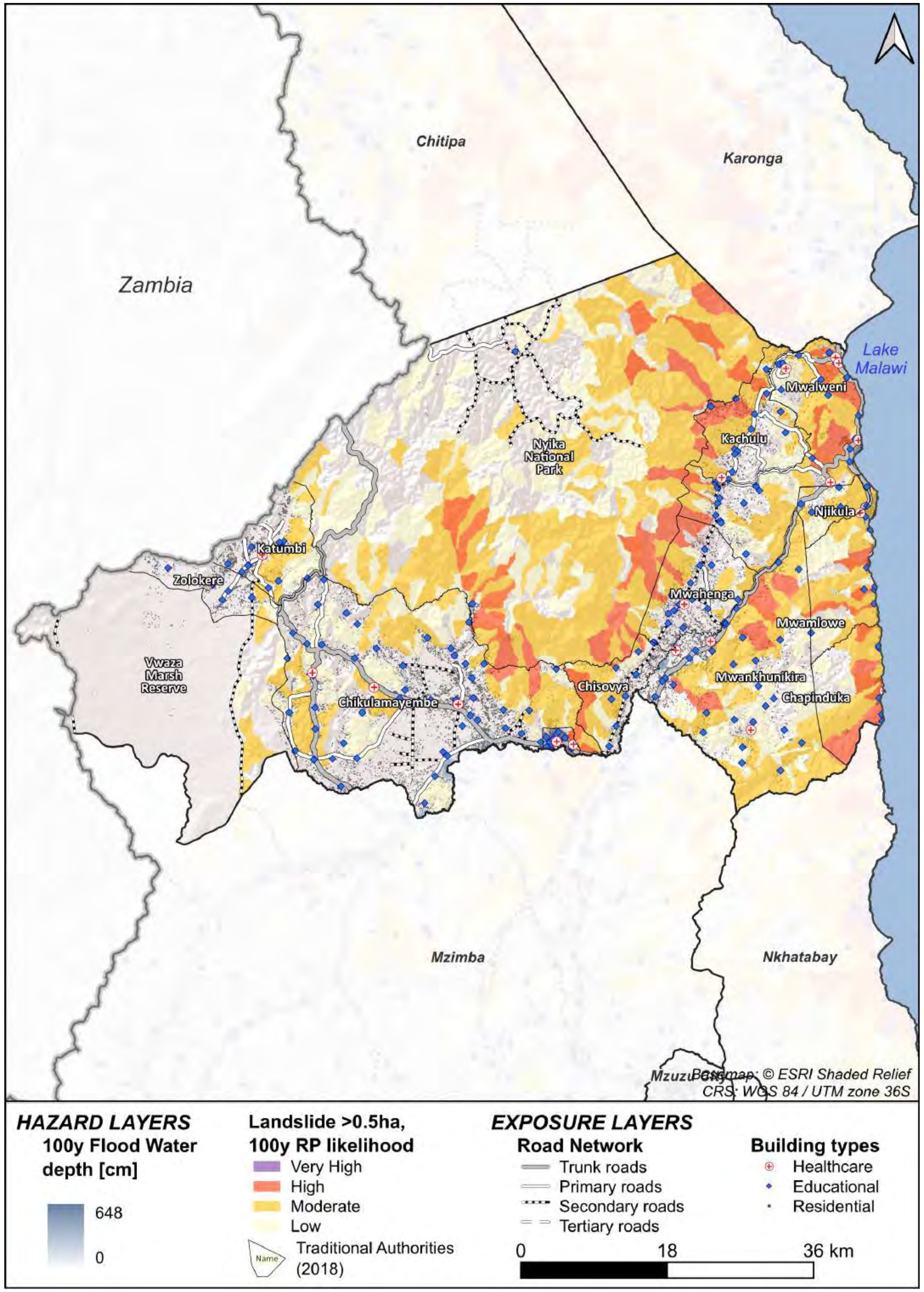


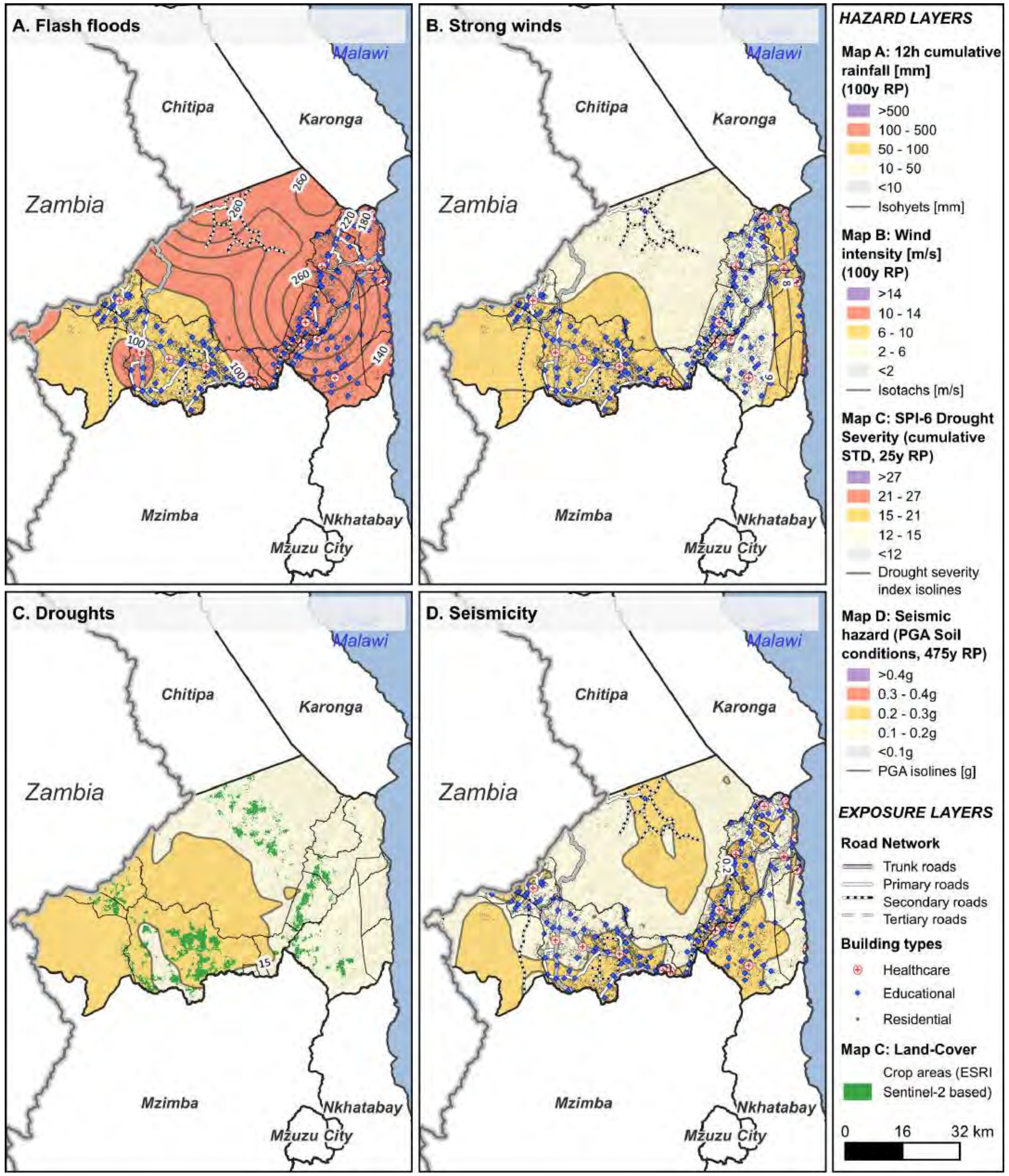
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

SALIMA

Salima is a district in the Central Region of Malawi, covering an area of 2,196 km². Social vulnerability parameters related to food insecurity and the inactive population are comparable with the national average, while poverty prevalence is higher. Floods and strong winds, respectively, are the principal hazards for the risk of the built environment. Strong winds also affect a larger portion of the population. In the climate projections, drought losses increase in the pessimistic scenario, while weather-related hazards are influenced by both the pessimistic and optimistic scenarios. The ratio of average annual economic losses due to floods is more than double the national average, and the average annual number of people affected by wind is significantly higher than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**555 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	2.58	-
Poverty Prevalence (%)	**63**	51*
Food Insecurity (%)	**64**	64*
Inactive Population (%)	**9**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**3525**	131 953
Ratio on total value (%)	2.67	-
Schools and Hospitals	**151 – 18**	6410 - 671
Ratio on total value (%)	2.36 – 2.68	-
Most important Crops	**Maize, Groundnuts, Rice, Cassava, Sweet Potato**	Cassava, Maize, Sweet Potato, Groundnuts

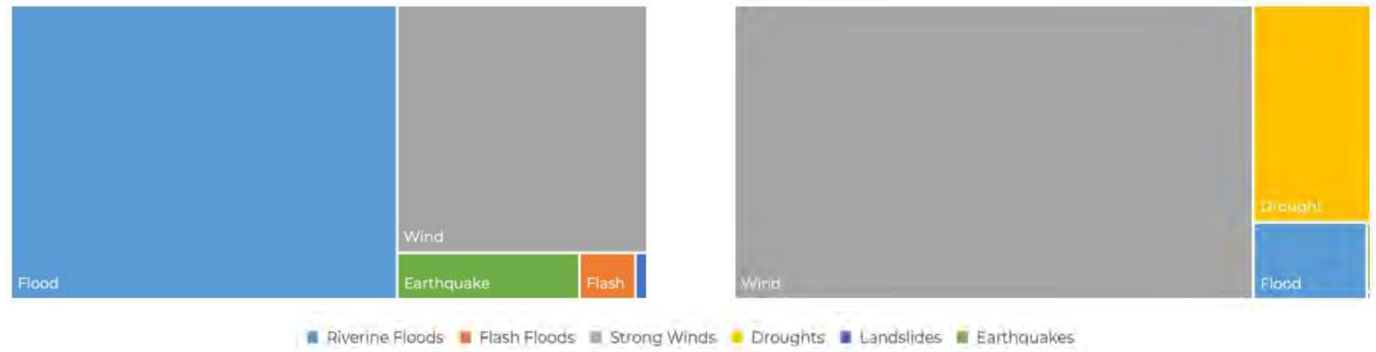
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**32.703**	-	-	-	-	-	**106 355**	-
Riverine Floods	19.845	5.64	2.491	0.70	0.02	-	4949	7.39
Flash Floods	0.451	0.13	-	-	-	-	0	0
Strong Winds	10.841	3.13	-	-	-	-	86 340	157.62
Compound	31.131	-	-	-	-	-	91 766	-
Droughts	-	-	-	-	2.436	-	14 420	33
Landslides	0.097	0.028	-	-	-	-	16	0
Earthquakes	1.475	0.42	-	-	-	-	153	0.28

RISK RESULTS – Average Annual Losses CHARTS

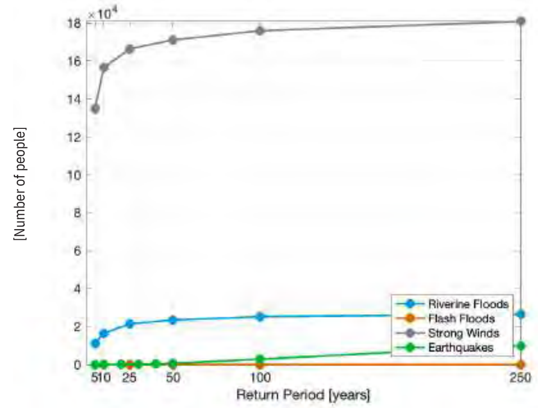
Economic Built - UP

Population

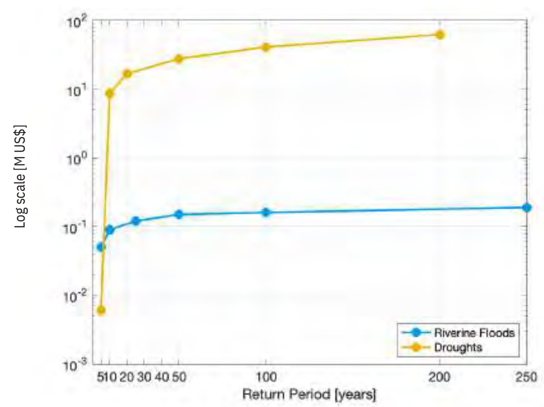


RISK RESULTS – Probable Maximum Losses CURVES

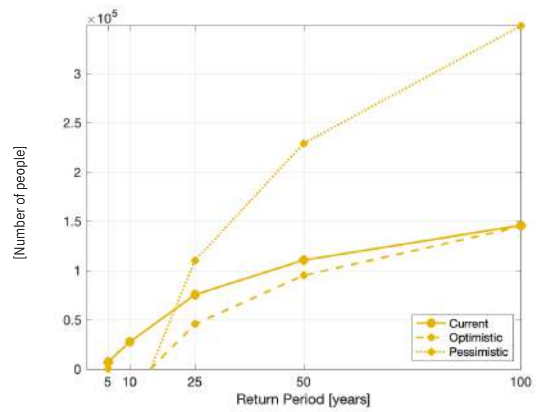
Fast-onset Weather related and Earthquakes - Affected Population



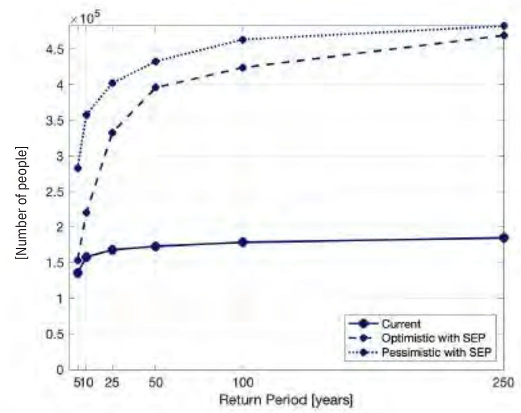
Weather related - Economic Loss



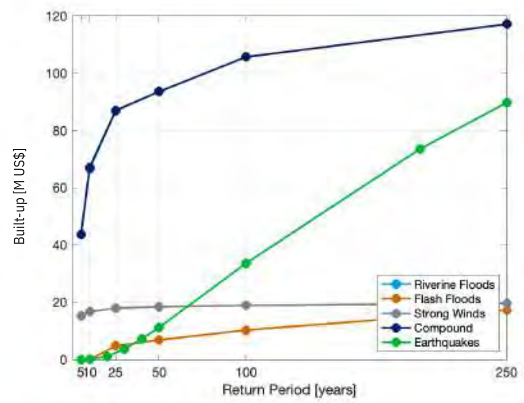
Droughts Projections - Affected Population



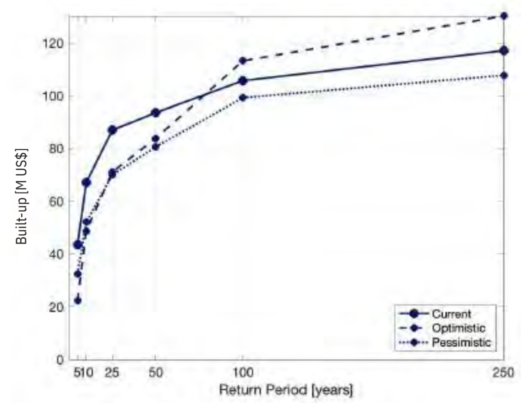
Compound Projections - Affected Population

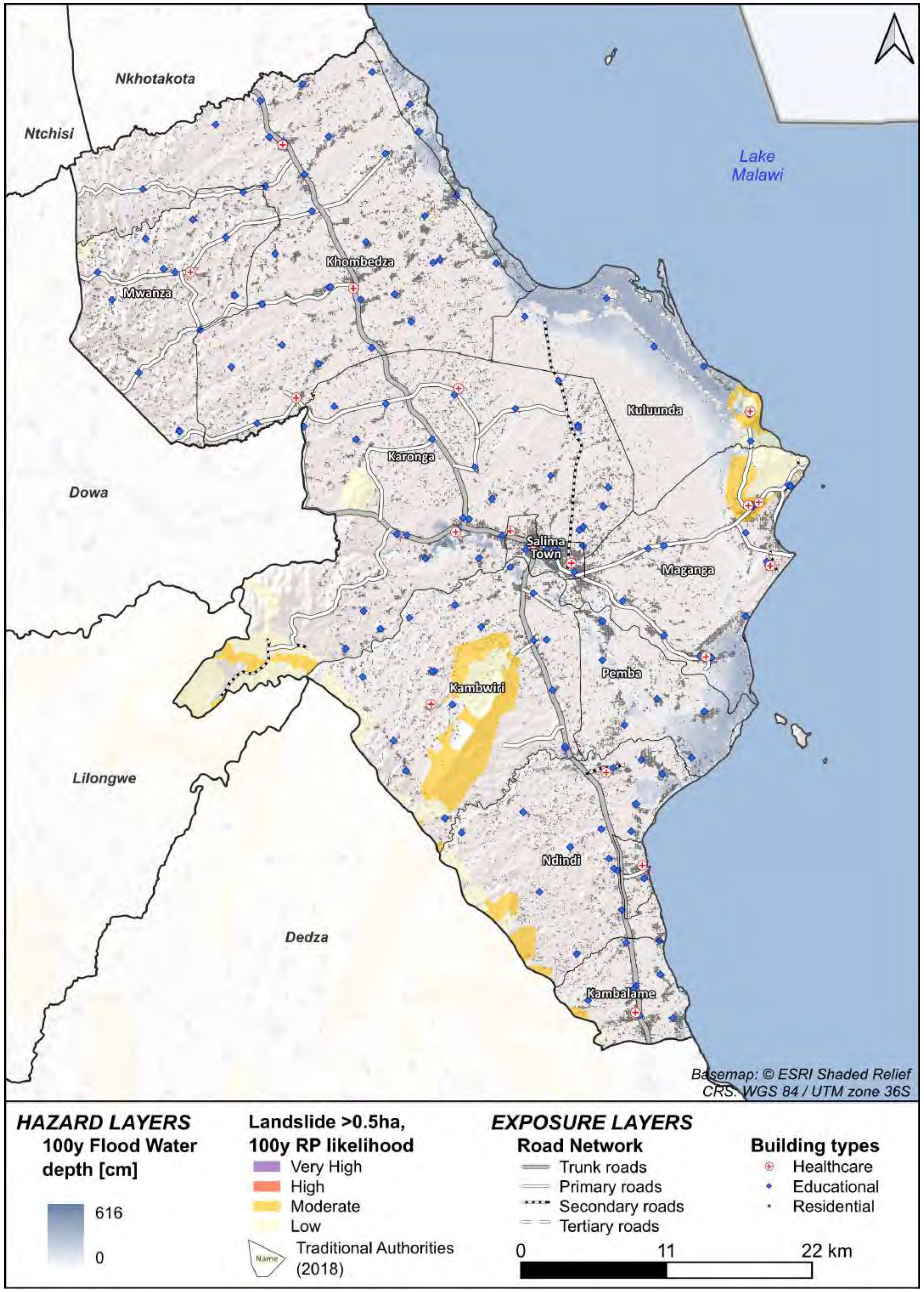


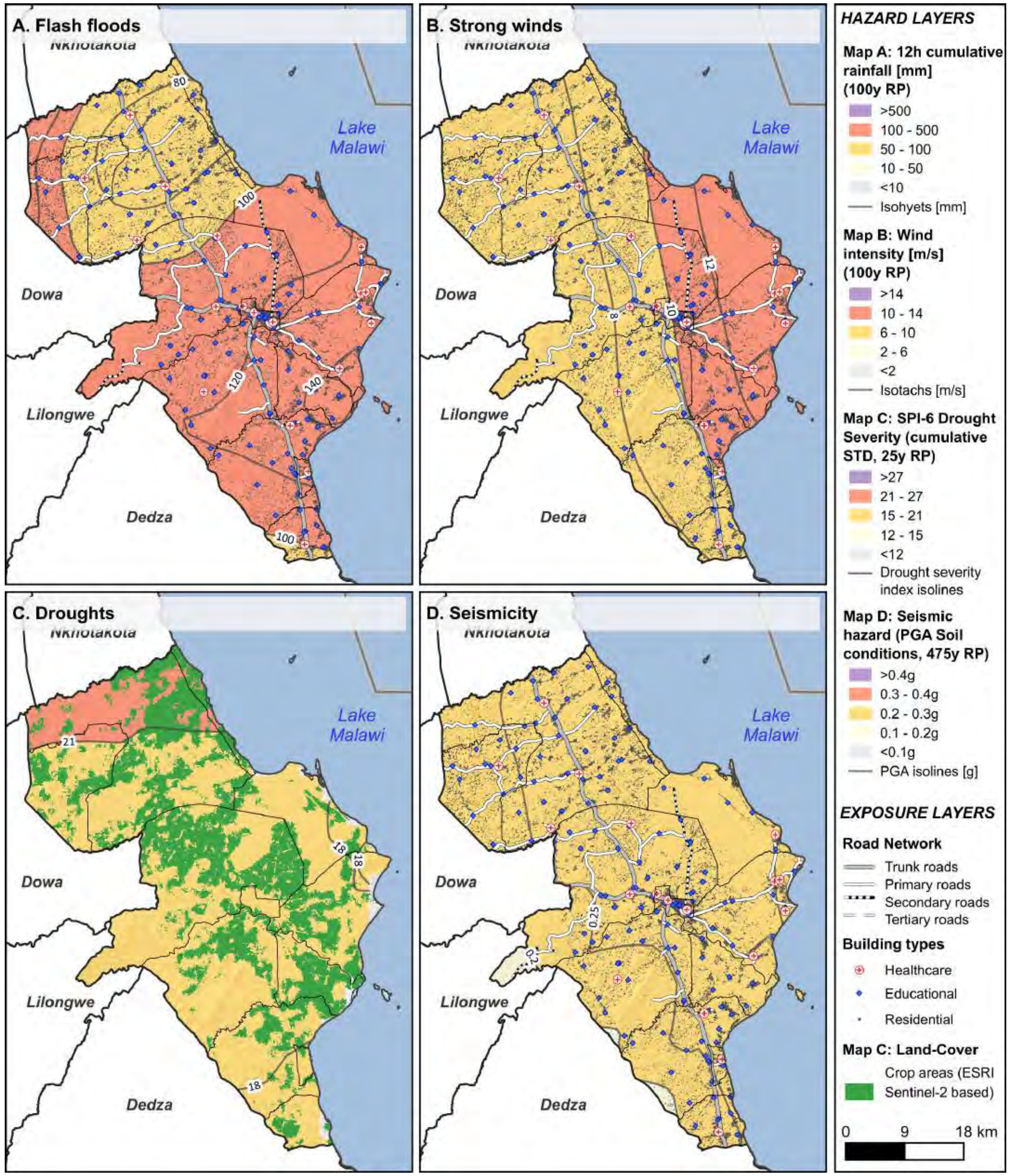
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

THYOLO

Thyolo is a district in the Southern Region of Malawi, covering an area of 1,715 km². Known as the tea capital of Malawi, the climate in Thyolo is ideal for tea cultivation. Social vulnerability parameters related to food insecurity and the inactive population are higher than the national average, while poverty prevalence is on par with the national average. Flash floods and strong winds are the most critical hazards for the risk of the built environment, followed by landslides. . Drought predominantly affects the population, and its impact is influenced by climate projections, although to a lesser extent than other weather-related hazards. The ratio of average annual economic losses due to flash floods is more than double the national average, and the average annual number of people affected by drought is also higher than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**839 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	3.90	-
Poverty Prevalence (%)	**49**	51*
Food Insecurity (%)	**68**	64*
Inactive Population (%)	**15**	9*

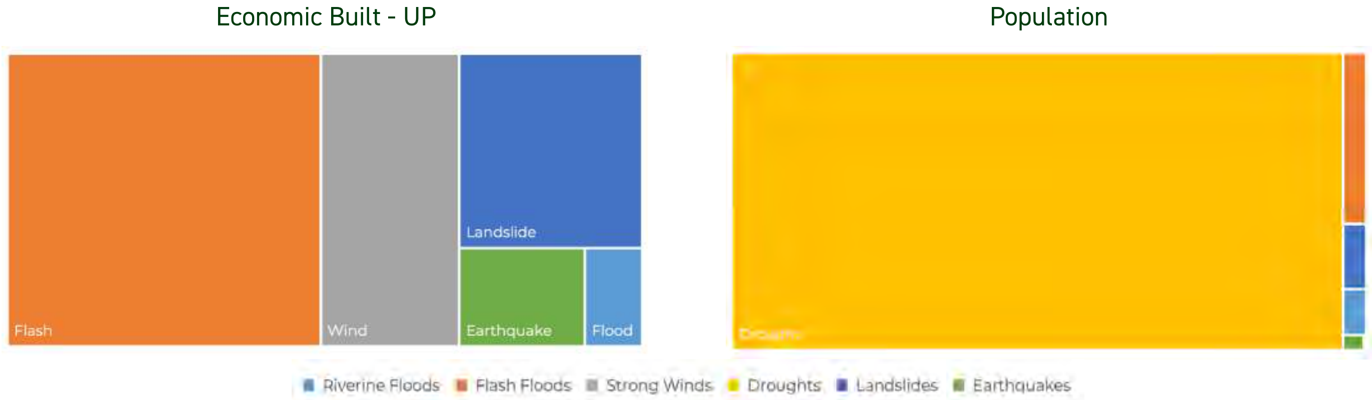
* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**5396**	131 953
Ratio on total value (%)	4.09	-
Schools and Hospitals	**216 - 22**	6410 - 671
Ratio on total value (%)	3.37 – 3.28	-
Most important Crops	**Cassava, Sweet Potato, Maize, Pigeon peas, Sorghum, Groundnuts**	Cassava, Maize, Sweet Potato, Groundnuts

RISK RESULTS – Average Annual Losses TABLE

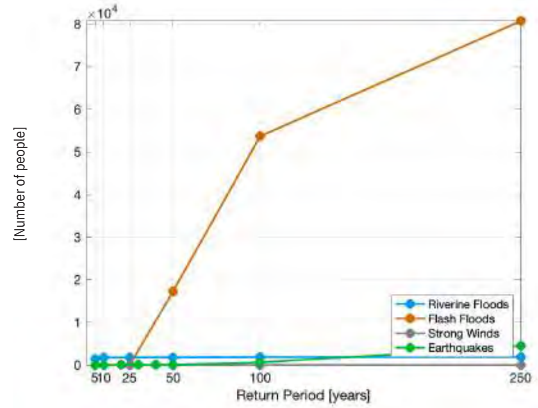
HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**16.575**	-	-	-	-	-	**63 796**	-
Riverine Floods	0.507	0.09	0.152	0.09	0.01	-	360	0.34
Flash Floods	8.245	1.53	-	-	-	-	1343	1.29
Strong Winds	3.638	0.68	-	-	-	-	12	0.01
Compound	12.263	-	-	-	-	-	1714	-
Droughts	-	-	-	-	12.915	-	61 465	70
Landslides	3.199	0.607	-	-	-	-	513	0.6
Earthquakes	1.113	0.21	-	-	-	-	104	0.12

RISK RESULTS – Average Annual Losses CHARTS

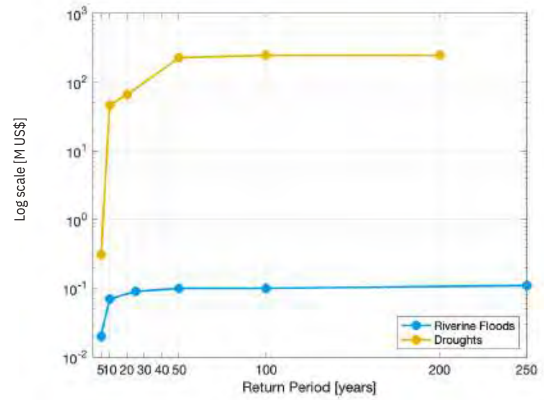


RISK RESULTS – Probable Maximum Losses CURVES

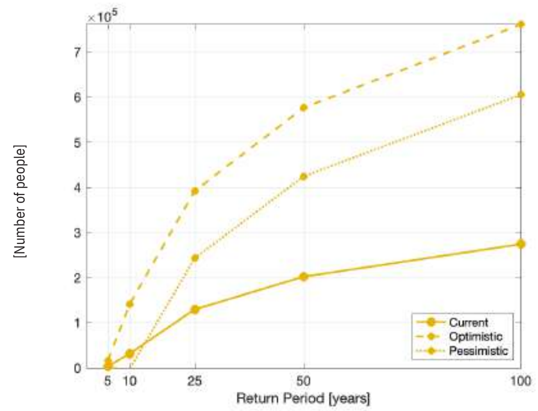
Fast-onset Weather related and Earthquakes - Affected Population



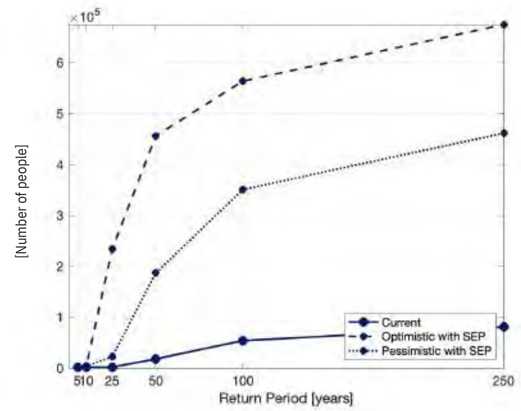
Weather related - Economic Loss



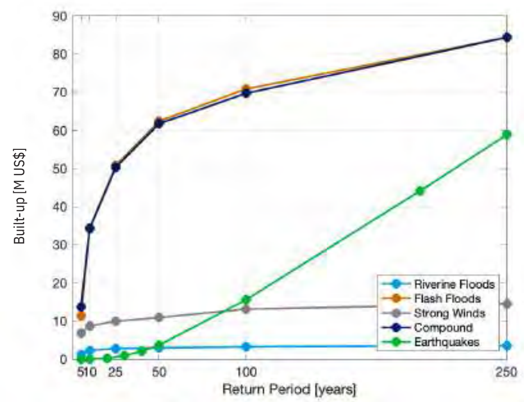
Droughts Projections - Affected Population



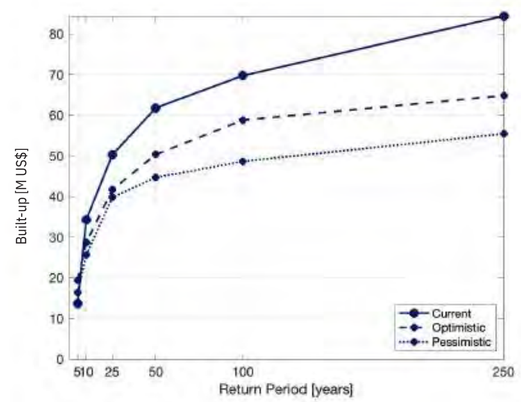
Compound Projections - Affected Population

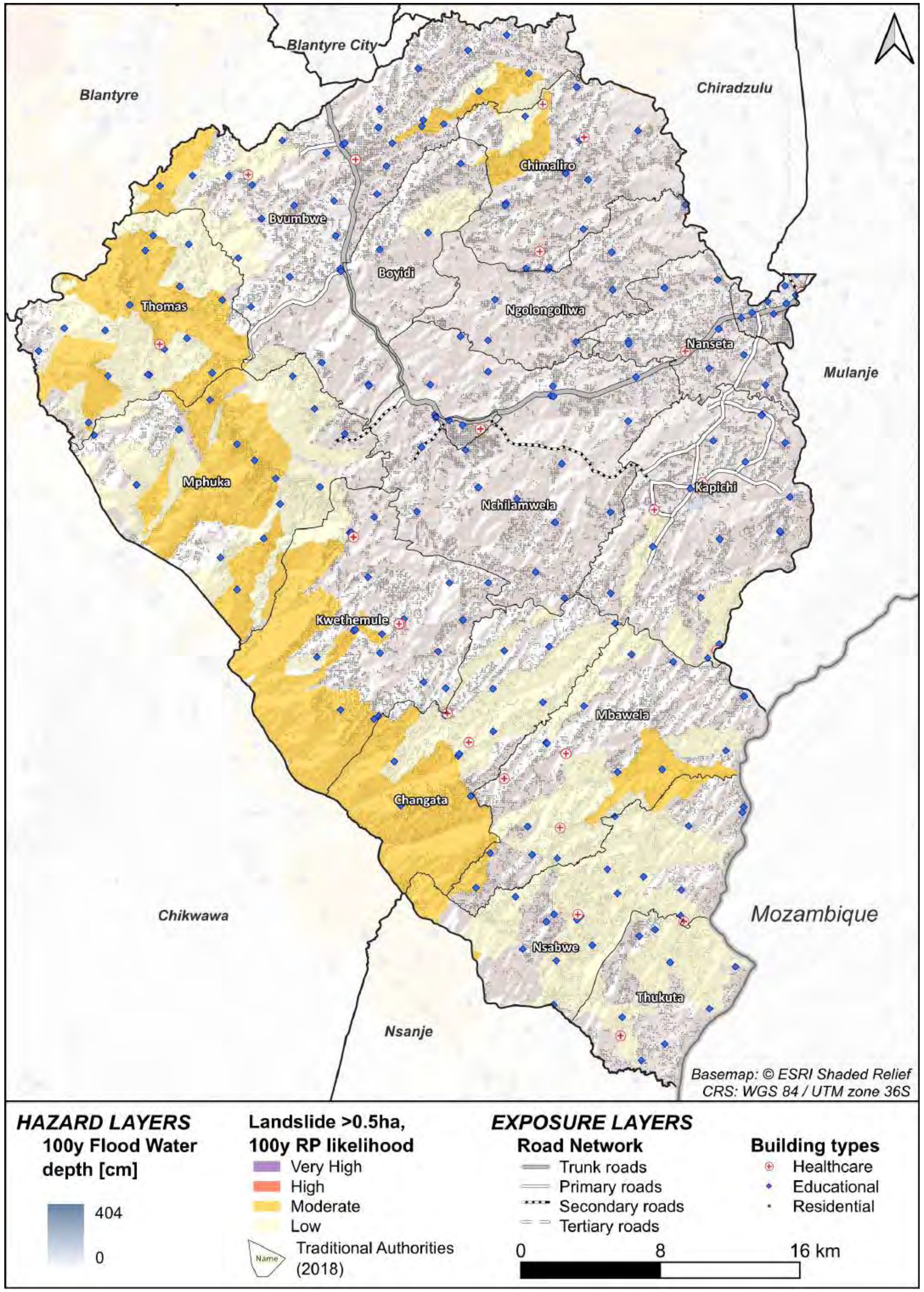


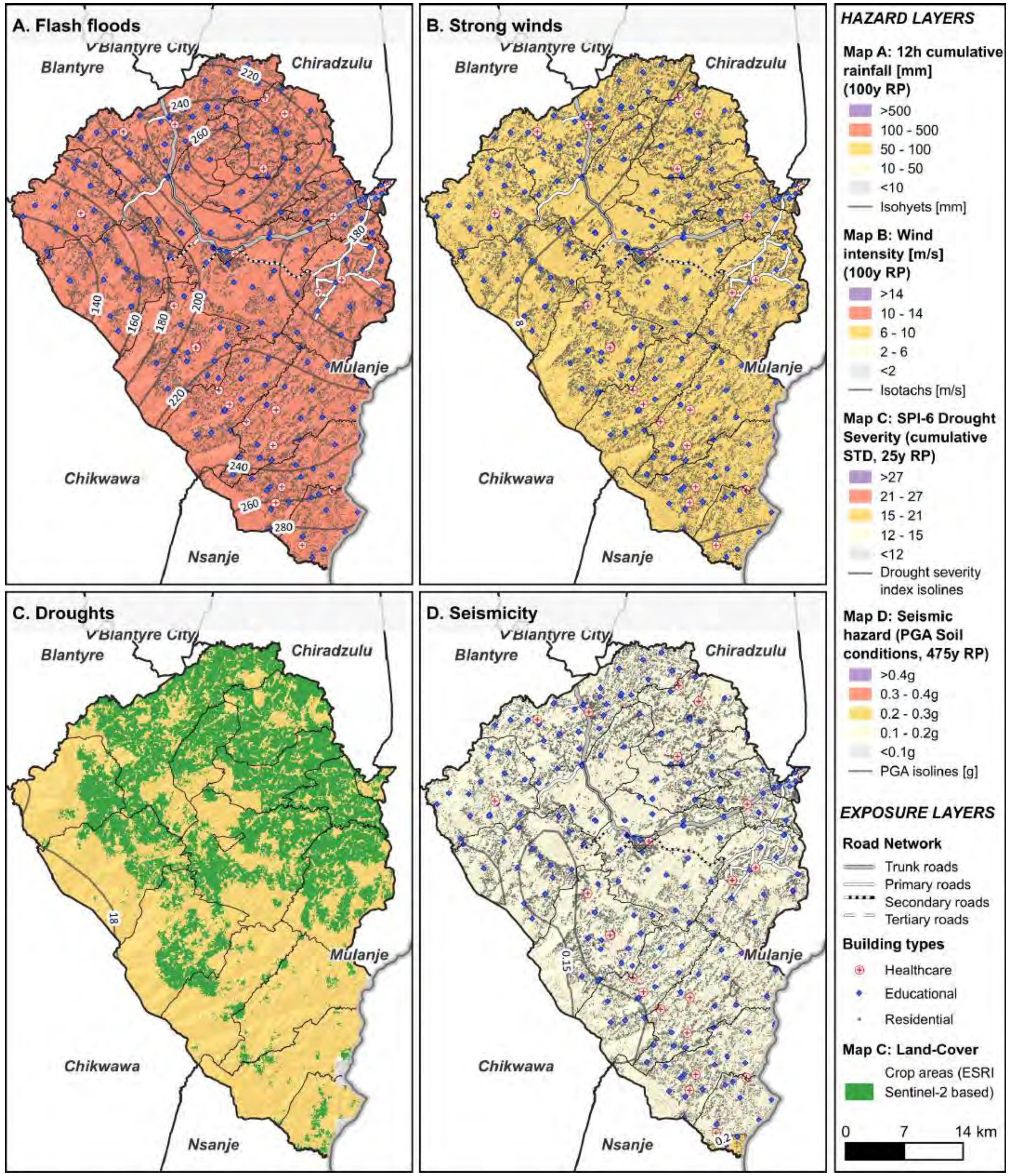
Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss







CRS: WGS 84 / UTM zone 36S

ZOMBA

Zomba district is located in the Southern Region of Malawi, covering a total area of 2,363 km². Social vulnerability parameters show that food insecurity is higher than the national average, while the inactive population aligns with the national average and poverty prevalence is slightly lower. Landslides pose the greatest risk to the built environment, followed by wind and flash floods. However, drought has the most widespread impact on the population in the district. Climate projections indicate that losses due to weather-related hazards are expected to increase in the future under optimistic scenarios. In these projections, weather-related hazards lead to higher losses in the optimistic scenario, while drought is affected by both pessimistic and optimistic scenarios. The ratio of the average annual economic losses due to landslides is double the national average, and the average annual number of people affected by drought is lower than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**820 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	3.81	-
Poverty Prevalence (%)	**49**	51*
Food Insecurity (%)	**73**	64*
Inactive Population (%)	**9**	9*

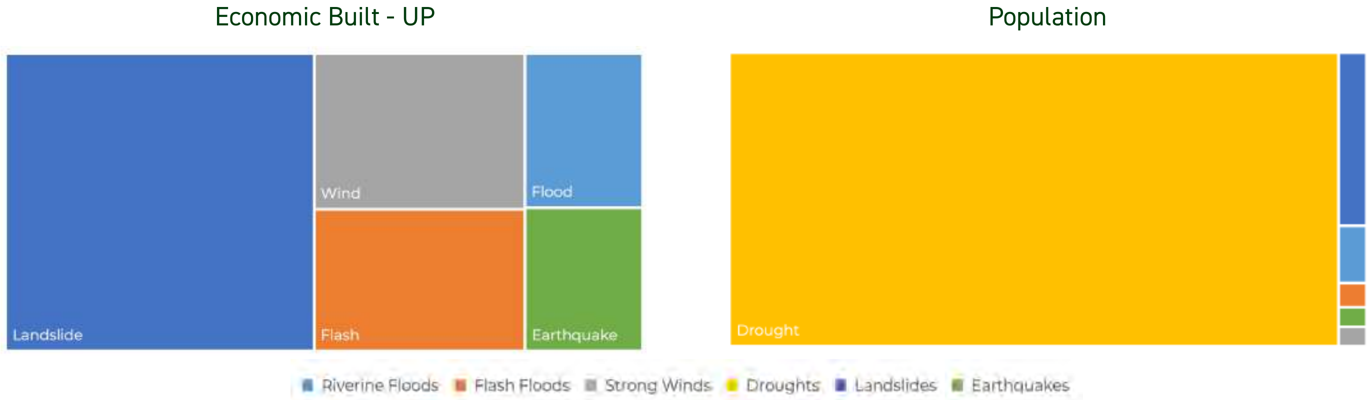
* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**5631**	131 953
Ratio on total value (%)	4.27	-
Schools and Hospitals	**232 - 22**	6410 - 671
Ratio on total value (%)	3.62 – 3.28	-
Most important Crops	**Maize, Pigeon peas, Cassava, Groundnuts, Sweet Potato**	Cassava, Maize, Sweet Potato, Groundnuts

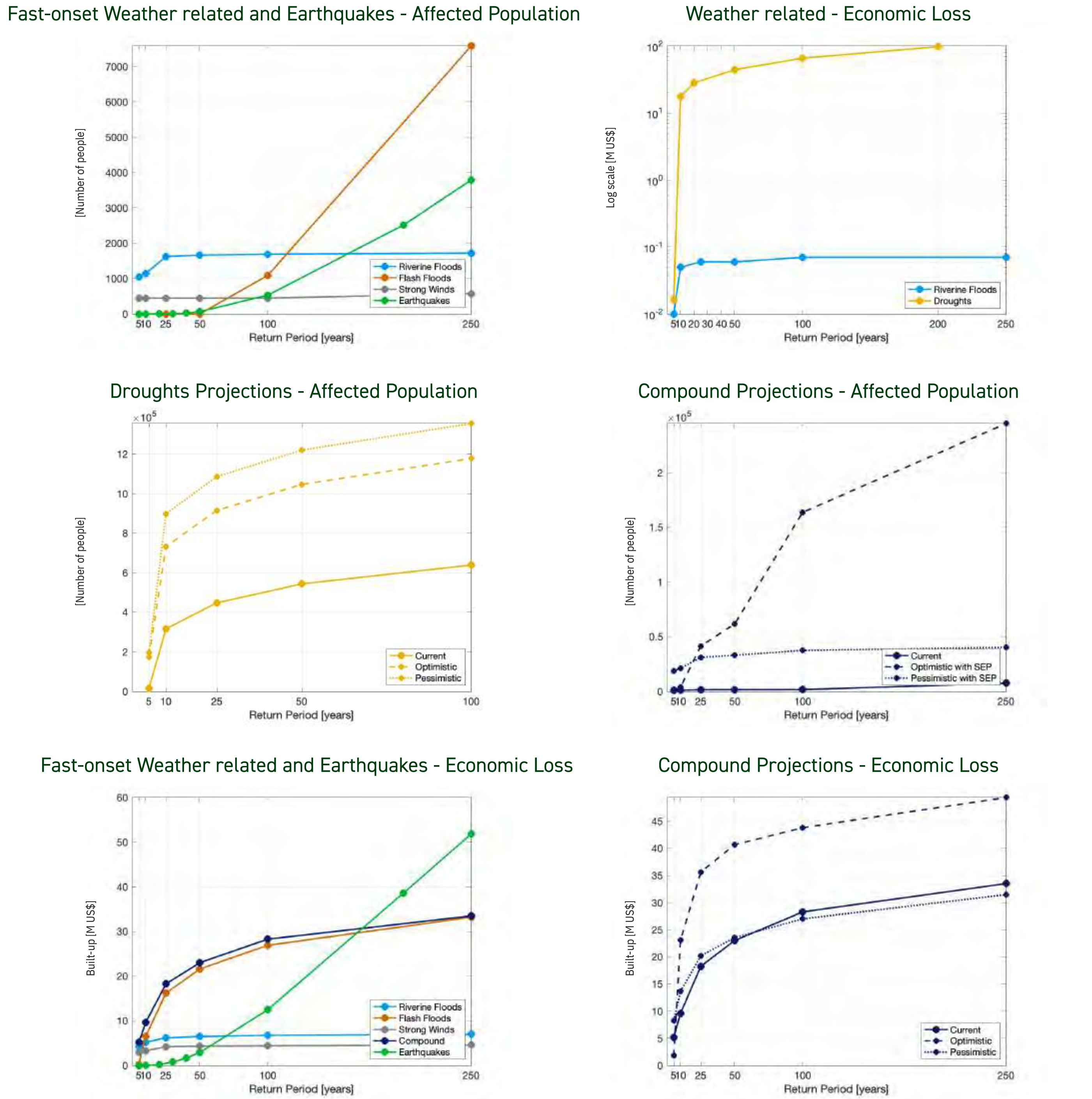
RISK RESULTS – Average Annual Losses TABLE

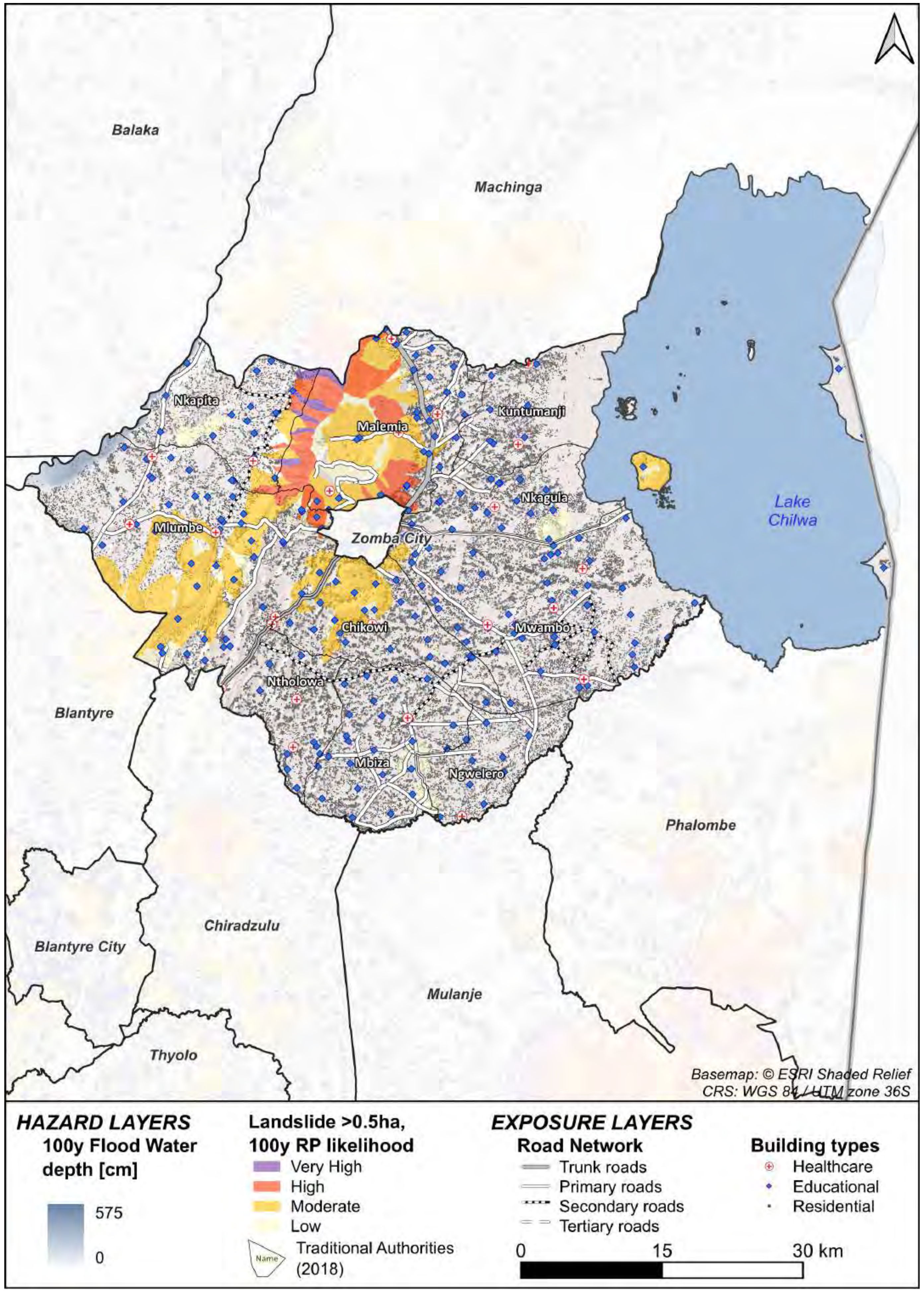
HAZARDS	ECONOMIC LOSS				AGRICULTURE LOSS		AFFECTED POPULATION	
	Built-up (M US$)	(‰)	Roads (M US$)	(‰)	Production (M US$)	(‰)	(Units)	(‰)
Multi-Risk	**11.68**	-	-	-	-	-	**33246**	-
Riverine Floods	1.123	0.27	0.152	0.09	0.01	-	281	0.34
Flash Floods	1.844	0.43	-	-	-	-	119	0.15
Strong Winds	2.032	0.48	-	-	-	-	95	0.15
Compound	4.965	-	-	-	-	-	494	-
Droughts	-	-	-	-	4.018	-	31808	41
Landslides	5.674	1.025	-	-	-	-	848	1
Earthquakes	1.041	0.19	-	-	-	-	96	0.12

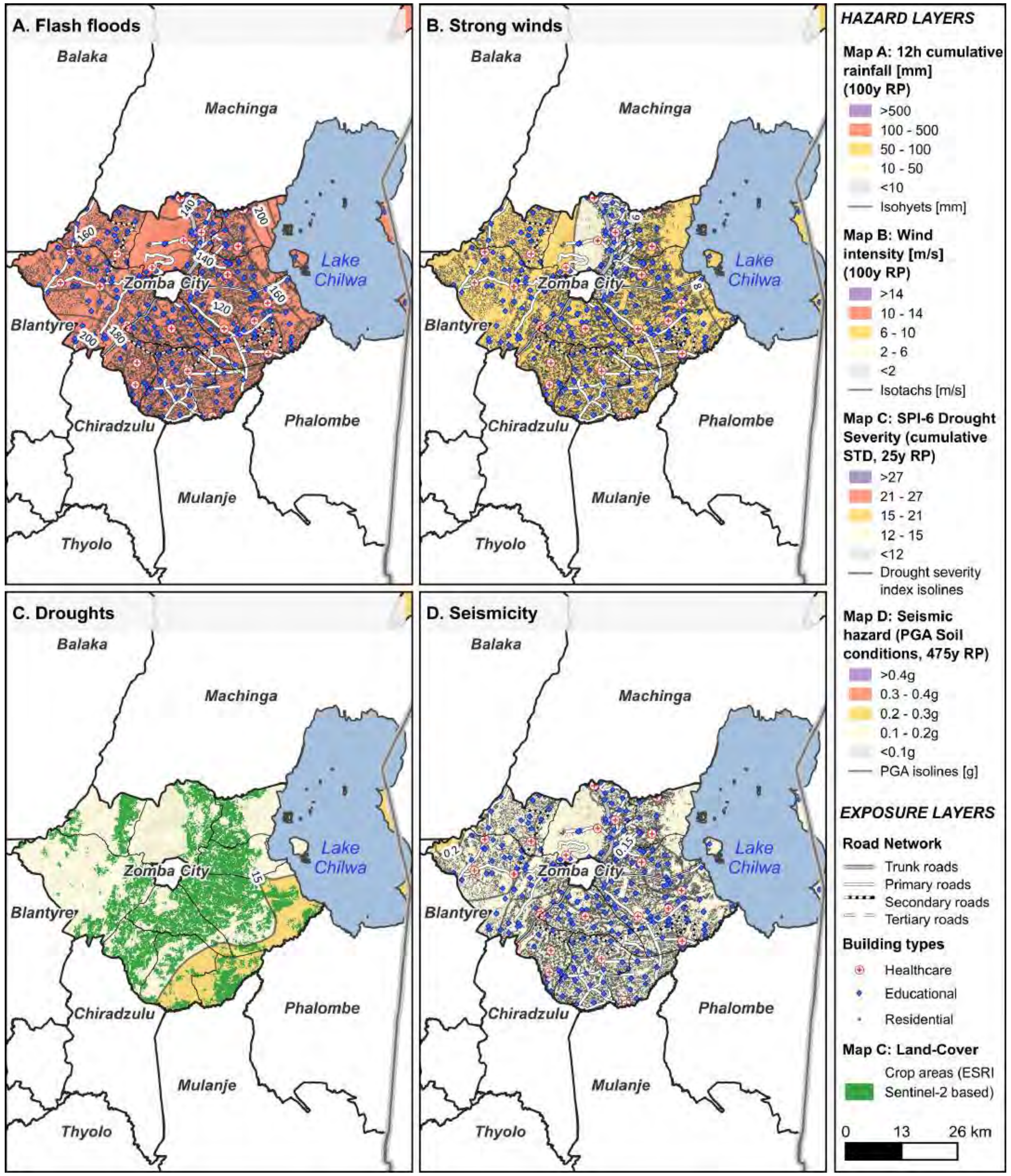
RISK RESULTS – Average Annual Losses CHARTS



RISK RESULTS – Probable Maximum Losses CURVES







CRS: WGS 84 / UTM zone 36S

ZOMBA CITY

Zomba city is located in the centre of Zomba District in the Southern Region of Malawi. It covers an area of 39 km² and is the fourth largest urban centre in the country, following Blantyre, Lilongwe, and Mzuzu. The city lies at the foot of the Zomba Plateau. Social vulnerability parameters, including poverty and food insecurity, are lower than the national average, while the inactive population is higher. Landslides are the most significant hazard to the built environment in the district. Drought affects the largest population, followed by landslides. Climate projections indicate that weather-related hazards will increase the losses in the optimistic scenario, particularly for higher return periods, while drought is influenced by both pessimistic and optimistic scenarios. The ratio of the average annual economic losses due to landslides is three times the national average, and the average annual number of people affected by drought is lower than the national average.

EXPOSURE and VULNERABILITY INDICATORS

SOCIAL VULNERABILITY INDICATORS	DISTRICT	MALAWI
Population (Units)	**120 000**	21 500 000 (NSO, 2024)
Ratio on total population (%)	0.56	-
Poverty Prevalence (%)	**14**	51*
Food Insecurity (%)	**42**	64*
Inactive Population (%)	**28**	9*

* National value as weighted mean on population

STOCK INDICATORS	DISTRICT	MALAWI
Built-up Total (M US$)	**868**	131 953
Ratio on total value (%)	0.66	-
Schools and Hospitals	**47 – 10**	6410 - 671
Ratio on total value (%)	0.73 – 1.49	-
Most important Crops	**Maize**	Cassava, Maize, Sweet Potato, Groundnuts

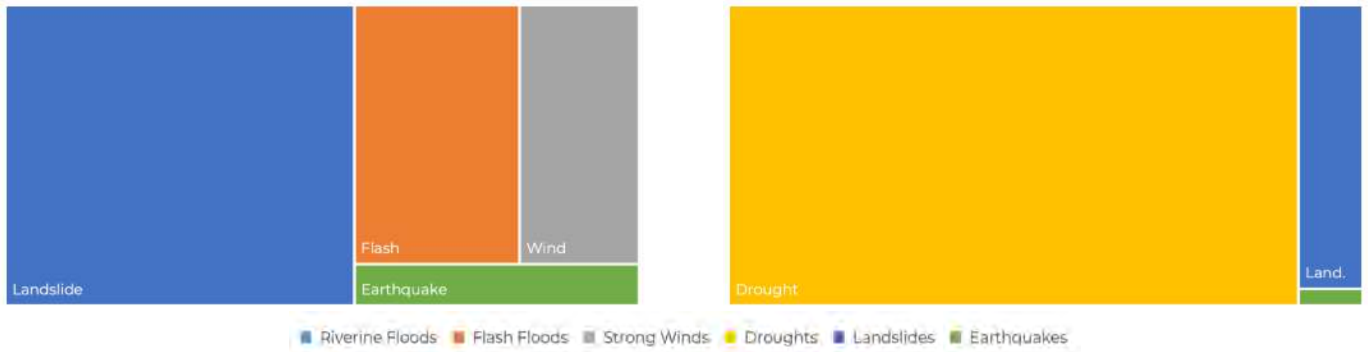
RISK RESULTS – Average Annual Losses TABLE

HAZARDS	ECONOMIC LOSS Built-up (M US$)	(‰)	Roads (M US$)	(‰)	AGRICULTURE LOSS Production (M US$)	(‰)	AFFECTED POPULATION (Units)	(‰)
Multi-Risk	**2.186**	**-**	**-**	**-**	**-**	**-**	**1952**	**-**
Riverine Floods	0	0	0.0001	0.0001	0	0	0	0
Flash Floods	0.5	0.22	-	-	-	-	0	0
Strong Winds	0.362	0.14	-	-	-	-	0	0
Compound	0.826	-	-	-	-	-	0	-
Droughts	-	-	-	-	0	-	1754	34
Landslides	1.223	1.496	-	-	-	-	187	1.5
Earthquakes	0.137	0.16	-	-	-	-	11	0.09

RISK RESULTS – Average Annual Losses CHARTS

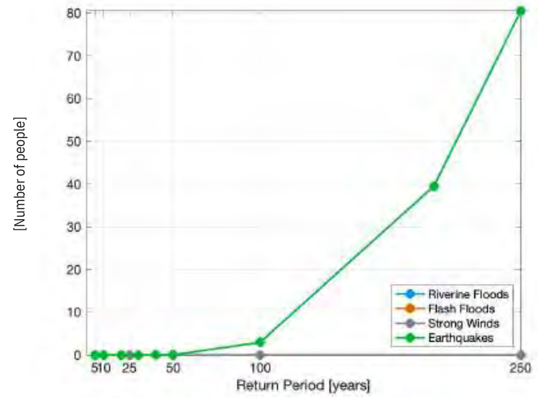
Economic Built - UP

Population

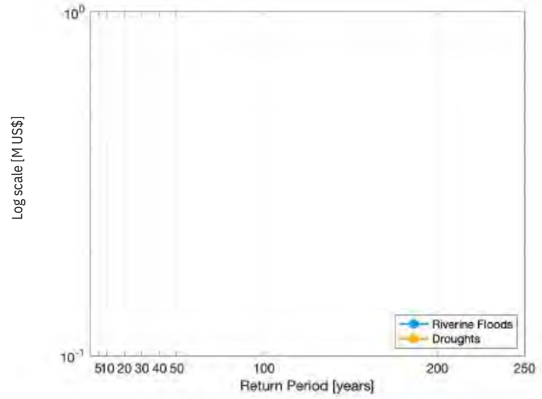


RISK RESULTS – Probable Maximum Losses CURVES

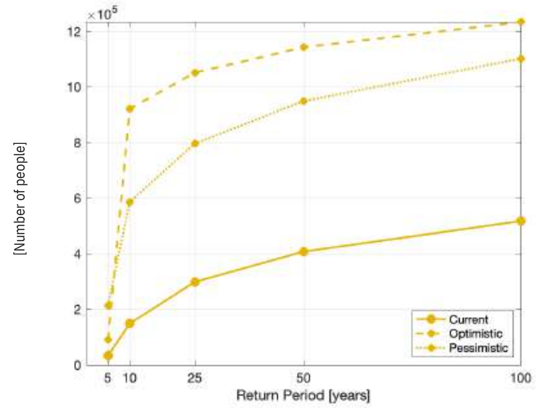
Fast-onset Weather related and Earthquakes - Affected Population



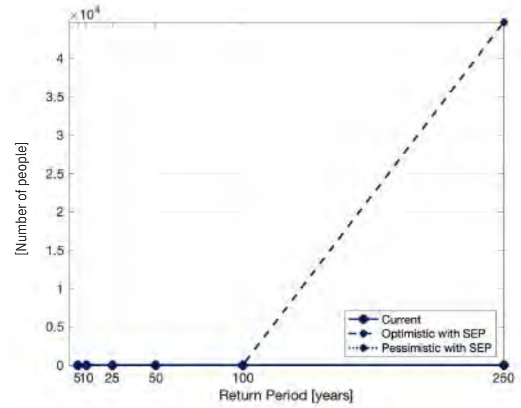
Weather related - Economic Loss



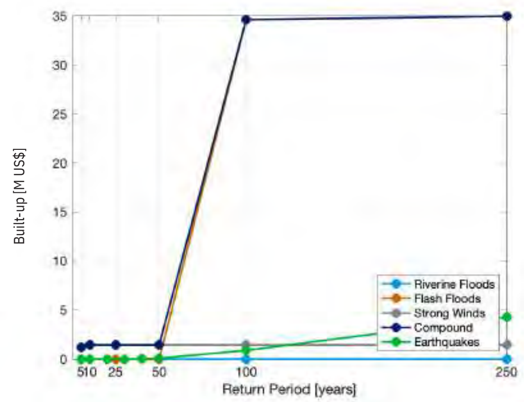
Droughts Projections - Affected Population



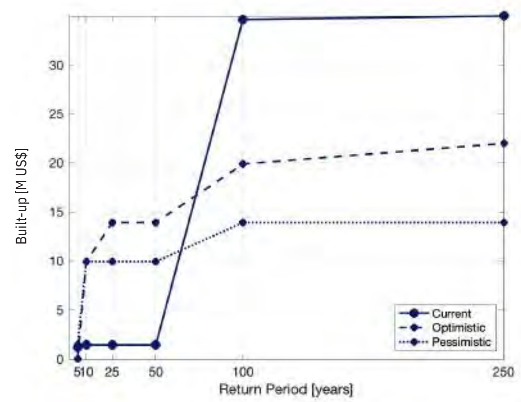
Compound Projections - Affected Population

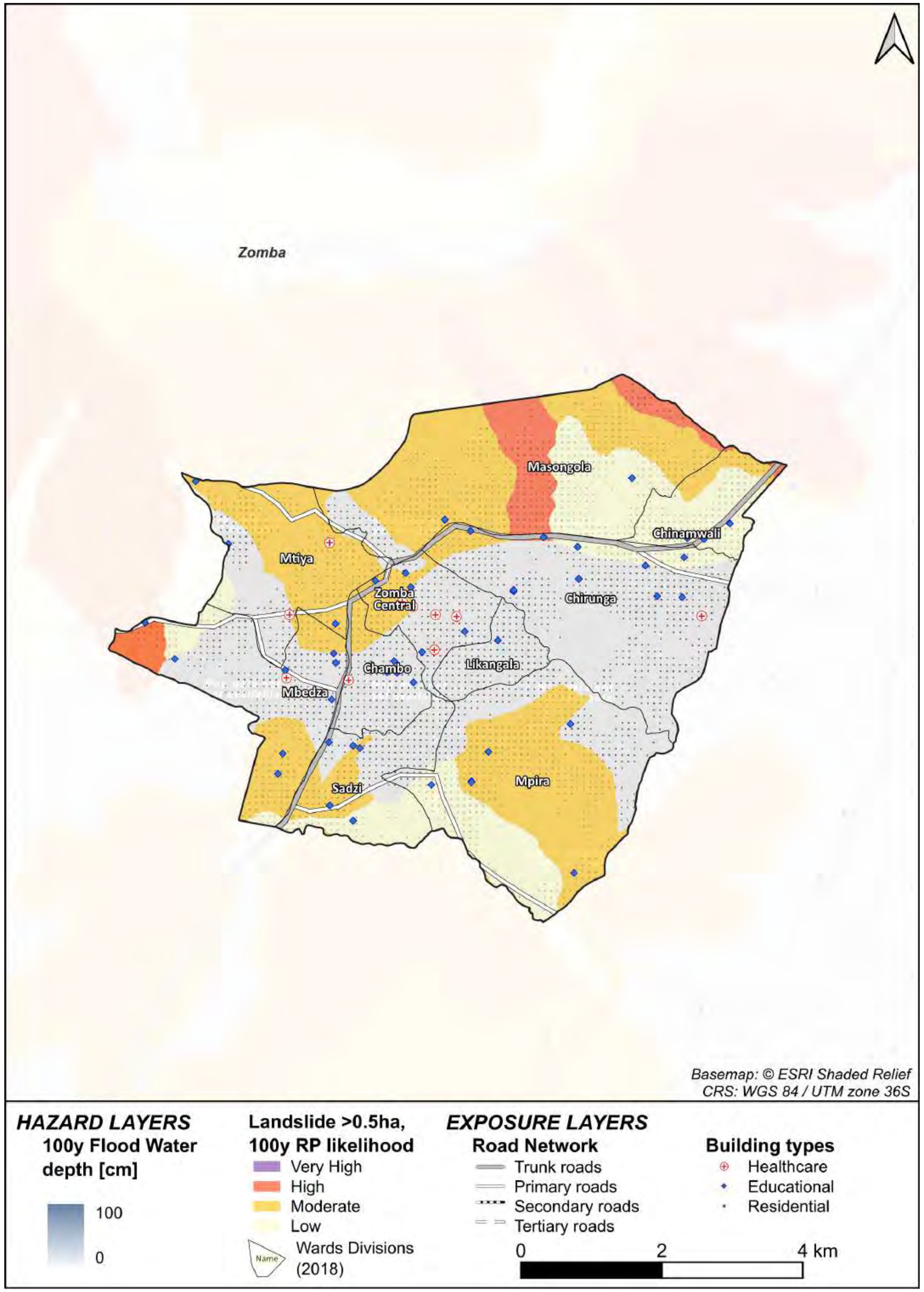


Fast-onset Weather related and Earthquakes - Economic Loss



Compound Projections - Economic Loss





CRS: WGS 84 / UTM zone 36S

Glossary

AVERAGE ANNUAL LOSS (AAL)
Expected loss per year, averaged over many years. As such, AAL represents the funds which are required annually in order to cumulatively cover the average disaster loss over time.

CLIMATE MODEL
A numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for some of its known properties.

CURRENT CLIMATE CONDITIONS
Observed climate conditions in the 1981 - 2019 period from the Global Reanalysis data bias corrected with local data.

EARTHQUAKE
The shaking of the surface of the Earth resulting from a sudden release of energy in the Earth's lithosphere that creates seismic waves.

EXPOSURE
People, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas.

HAZARD
A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.

HAZARD PROFILE
A hazard profile is a detailed description or assessment of a specific natural or man-made hazard, outlining its nature, frequency, severity, and spatial distribution.

DISASTER RISK
The potential loss of life, injury, or destroyed, or damaged assets which could occur to a system, society, or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability, and capacity.

DROUGHT
Droughts, defined as unusual and temporary deficits in water supply, are a persistent hazard, potentially impacting human and environment systems.

FLOODS
Flood hazard in this risk assessment includes riverine and flash floods. Riverine floods are a type of flooding that occurs when rivers overflow their banks due to excessive rainfall, snowmelt, or upstream water flow exceeding the river's capacity, inundating surrounding areas, known as floodplains. Flash floods are rapid-onset floods caused by intense rainfall, dam breaks, or sudden snowmelt, leading to a quick and significant rise in water levels.

LANDSLIDE
The movement of a mass of rock, debris, or earth down a slope. Landslides are a type of 'mass wasting,' which denotes any down-slope movement of soil and rock under the direct influence of gravity.

OPTIMISTIC CLIMATE SCENARIO (LOW EMISSIONS)
Projected climate conditions between 2061-2100, considering the IPCC SSP1-RCP2.6 scenario, designed with the aim of simulating a development that is compatible with the global 2°C target, assuming climate mitigation measures being taken.

PESSIMISTIC CLIMATE SCENARIO (HIGH EMISSIONS)
Projected climate conditions between 2061- 2100, considering the IPCC SSP5-RCP8.5 scenario, which foresees high radiative forcing by the end of century, driven by the economic success of industrialized and emerging economies, coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world.

PROBABLE MAXIMUM LOSS (PML)
The PML curve describes the loss which could be expected corresponding to a given likelihood. It is expressed in terms of the annual probability of exceedance or its reciprocal, the return period. Typically, PML is relevant to define the size of reserves which, insurance companies or a government should have available to manage losses.

RISK
The combination of the probability of an event and its negative consequences, calculated in terms of "potential losses" for some particular cause, place, and period.

RISK PROFILE
A risk profile is a comprehensive assessment that describes the potential risks posed by specific hazards to a particular area, organization, or population. It outlines the likelihood and potential impacts of various threats, combining information on vulnerability, exposure, and the consequences of different hazards. A multi-hazard risk profile considers the interactions and combined effects of various hazards occurring either simultaneously, sequentially, or independently.

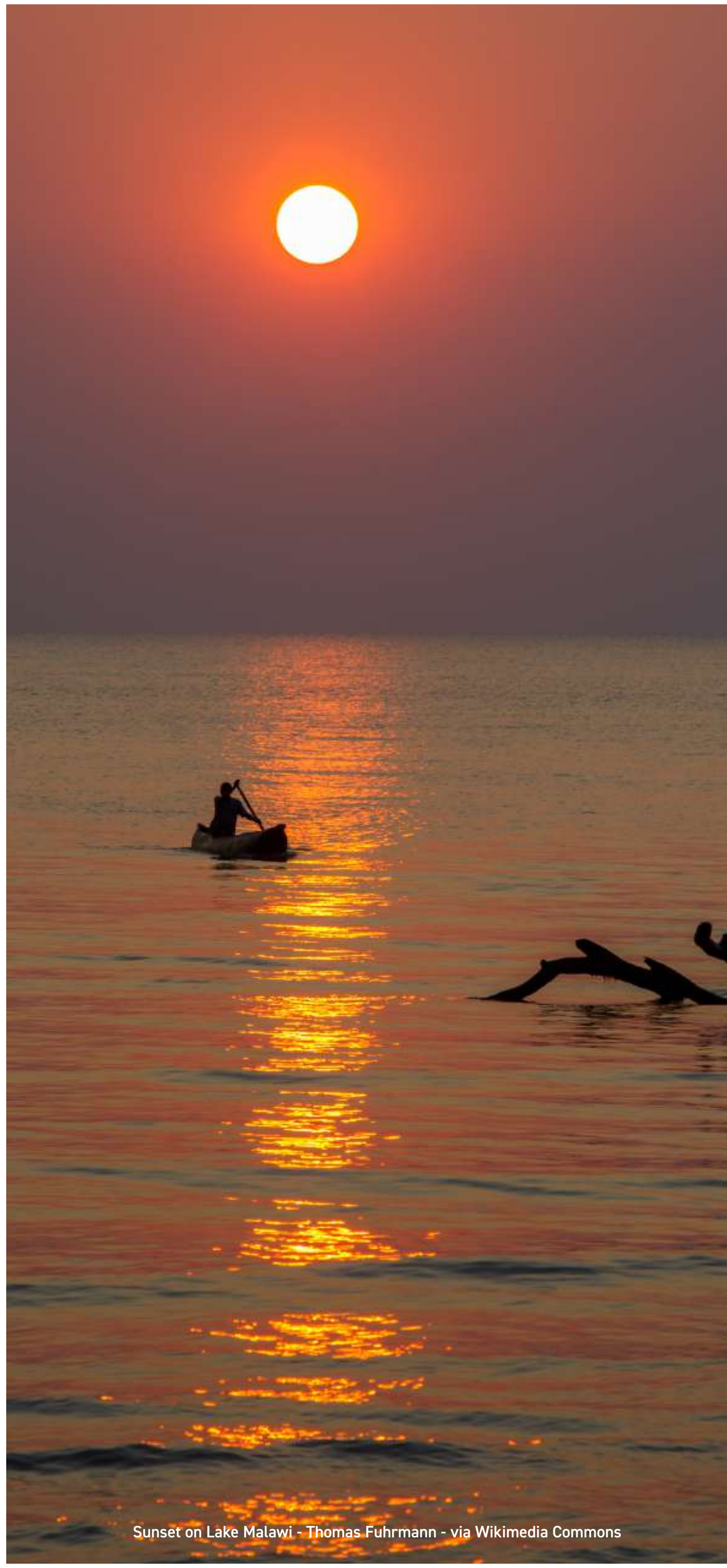
RISK TRANSFER
The process of formally or informally shifting the financial consequences of particular risks from one party to another, whereby a household, community, enterprise, or State authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party.

RESIDUAL RISK
Disaster risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained.

RETURN PERIOD
The average interval between the occurrence of a hazard of a given magnitude and an equal or a larger magnitude usually expressed in years, T. This does not mean that an event will occur exactly after every T number of years. A T-year event has a probability of the occurrence of 1 in T in any given year.

RESILIENCE
The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.

VULNERABILITY
The conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards.


Sunset on Lake Malawi - Thomas Fuhrmann - via Wikimedia Commons

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- Depiction of vulnerable population…an elderly person who was affected by Moderate Tropical Storm Ana in Chikwawa - DoDMA
- Depiction of people at risk…children playing on a damaged bridge in Phalombe - DoDMA
- Depiction of aerial view of a disaster - DoDMA

Maps:

Coordinate Reference System: WGS84 - UTM Zone 36S
Basemap: ESRI Shaded Relief

Multi-Hazard Risk Atlas MALAWI

Department of
Disaster Management
Affairs