DISASTER RISK PROFILE

Malawi

Drought Flood Landslide Earthquake

Africa Disaster Risk Financing Initiative

Building Disaster Resilience in Sub-Saharan Africa

WORLD BANK GROUP

GFDRR
Global Facility for Disaster Reduction and Recovery

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INTRODUCTION

Overview

The Africa Disaster Risk Financing (ADRF) Initiative is one of five Result Areas of the European Union (EU) - Africa, Caribbean and Pacific (ACP) cooperation program *Building Disaster Resilience in Sub-Saharan Africa*, which is implemented by several partners, including the African Development Bank (AfDB), African Union Commission (AUC), the United Nations International Strategy for Disaster Reduction (UNISDR) and the World Bank (WB)-managed Global Facility for Disaster Reduction and Recovery (GFDRR). The Program's overall objective is to strengthen the resilience of Sub-Saharan African regions, countries and communities to the impacts of disasters, including the potential impact of climate change, to reduce poverty and promote sustainable development.

The ADRF Initiative, launched in 2015 and implemented by GFDRR and the World Bank, supports the development of risk financing strategies at regional, national and local levels to help African countries make informed decisions to improve post-disaster financial response capacity to mitigate the socio-economic, fiscal and financial impacts of disasters. One of the operational components to achieve this objective is to create an enabling data environment for risk financing. This aims to build the understanding and awareness of disaster and climate risks in Sub-Saharan Africa, providing a fundamental input to developing disaster risk financing strategy, approaches, and tools for financing risks. One of the activities is to develop national-level multiple-peril country risk profiles using globally available and readily accessible local datasets, in combination with scientifically proven methodologies. These are used to catalyze dialogue with government counterparts in the region on the primary disaster risks they face to formulate Disaster Risk Management strategies, such as financial protection and risk reduction investment programs. Furthermore, the risk profiles provide datasets that are a critical input for developing risk financing and insurance strategies.

National Risk Profiles

To create an enabling environment for dialogue on risk financing strategies and to further the understanding of disaster risk, national risk profiles have been developed for **eight countries** in the region. The risk profiles provide **visual information and data on the hazards, exposure, and risk for multiple hazards** in each country. The profiles provide an overview of which hazards, sectors and regions are most at risk of disasters, and contribute most to the national level of risk.

Specifically, the national risk profiles provide the estimated impact of disasters on population, building stock, transport networks, critical facilities, and agriculture at the national and sub-national levels. These profiles can guide initial strategic dialogue on financial protection and / or risk reduction investment opportunities to manage disaster risk, as well as help identify priorities for more detailed risk assessments if specific interventions are to be made.

Countries and Hazards

	Drought	Flood	Landslide	Earthquake	Volcano	Cyclone
Cabo Verde	✓	✓	✓	✓	✓	✓
Ethiopia	✓	✓	✓	✓	✓	
Kenya	✓	✓	✓	✓	✓	
Malawi	✓	✓	✓	✓		
Mali	✓	✓	✓			
Mozambique	✓	✓	✓	✓		✓
Niger	✓	✓	✓			
Uganda	✓	✓	✓	✓	✓	

METHODOLOGY AND LIMITATIONS

Use

These risk profiles provide a preliminary view of disaster risk at the national level, and distribution of risk across regions of the country and types of assets. They enable the identification and prioritization of risk drivers, to guide risk management activities and identify the need for further, more detailed risk assessment.

Due to limitations in the content and resolution of the publicly available global and national level exposure and hazard data used in their development, these profiles do not provide sufficient detail for taking final decisions on disaster management investments and policies, or for planning subnational and local scale mitigation projects, such as construction of flood defenses. Such decisions should be informed by a local, and possibly sector-specific disaster risk assessment, which estimates risk at a higher resolution with more locally-specific exposure, hazard, and vulnerability input data.

These risk profiles present a substantial part of the analysis results. However, it has not been possible to present all results in these documents. Full results for all asset types are available from GFDRR Innovation Lab.

Risk

Risk calculations require input data describing the hazard, assets ('exposure'), and vulnerability of those assets.

Disaster risk to structural and infrastructure assets is quantified here by estimating the cost to repair and/or replace assets damaged or destroyed in a disaster, i.e. due to ground shaking, flood depth or wind speed, over various time horizons. Assets analyzed are private and government-owned building stock, critical facilities (education and health), and transport networks (road, rail, and bridges).

Risk to population is quantified by assessing the number of people that are expected to be affected by the hazard.

For volcanoes, an indicative measure of volcano risk is given by estimating population and value of assets exposed to the volcanic hazards (no estimation of impact is made).

Losses additional to those incurred due to physical damage are not included in this analysis (e.g., business interruption due to disrupted infrastructure or supply chains).

The cost or number affected is estimated for most hazards at three time periods: a decade (this refers to the 1 in 10 year return period, or 10% chance of a loss being exceeded in any given year); a person's lifetime (1 in 50, or 2% in any year), or for an extreme event (1 in 250, or 0.4% in any year).

Hazard and Vulnerability Data

Drought hazard analysis comprises agricultural (soil moisture deficit) and hydrological (river flow) drought. Drought duration and deficit volume per year are determined by event-based modeling to estimate population affected by water scarcity. Monetary loss reflects the loss in yield and long term average price for each modelled per crop.

River flood risk (urban/surface flooding is excluded) is estimated at 1km resolution using global meteorological data, global hydrological and flood-routing models. Loss estimates are generated by simulating rainfall statistics for 10,000 years based on 40 years of previous rainfall data. Damage functions for four types of buildings, and for roads/railways, are used to estimate loss as a function of flood depth. Population are considered 'affected' if flooding of any depth occurs in the same 1km area. Agriculture loss is estimated by assuming that catastrophic flooding will result in a loss of the annual crop yield.

Earthquake hazard describes the distribution of ground shaking intensity (i.e., peak ground acceleration), based on the locations of known seismic faults and location/size of previous earthquakes. Losses are estimated using fragility and vulnerability models that translate ground shaking into the expected level of (a) damage to different types of structure, and (b) displacement of roads and rails. Based on damage to buildings, a casualty model has been used to estimate the risk of fatalities as well as the population affected by ground shaking. This study includes losses due to damage from earthquake ground shaking only. Secondary hazards (liquefaction and fire following an earthquake) are not accounted for. Landslide hazard is considered under the separate landslide section, where ground shaking is considered as a potential trigger of landslides.

Landslide susceptibility has been defined across each country using an assessment of factors that increase potential for landslides (including slope, vegetation and soil types) combined with landslide trigger events (rainfall and seismic shaking) to create landslide hazard maps. Long-term average annual cost to structures and transport networks has been estimated using vulnerability of different asset types to landslides, based on extensive literature review, empirical data, and expert judgement.

DISASTER RISK PROFILES

METHODOLOGY AND LIMITATIONS

Average annual population affected, and fatalities, are estimated.

Volcanic eruption scenarios at a small number of key volcanoes are used to estimate the population, and replacement cost of structures and infrastructure exposed to ashfall hazard (i.e. are located in an area that could receive ash in an eruption) and topographic analysis is used to determine the assets and population exposed to flow hazards. Full quantification of risk at all volcanoes is not possible due to limited information on potential frequency and eruption style at many volcanoes in Sub-Saharan Africa.

Cyclone and storm surge hazards are assessed using a record of historical cyclone tracks and wind field modelling, to determine maximum wind speeds on land and accompanying water levels along the coast. Vulnerability of structures to wind and surge is estimated based on previously observed damage sustained at different wind speeds and literature on flood depth impact of different types of structures.

Asset Database

Open and freely available national, regional, and global data sets are used to develop, for the first time, a database of population and multiple built asset types for risk analysis. This is used to inform this risk assessment, in a region where there is significant variability in the availability and content of inventories describing building stock and infrastructure.

Population density is described using WorldPop data. Building stock is described using six development types: rural, residential, high-density residential, informal, urban, and industrial, based on land use data and satellite imagery. In each cell of a 0.5 km resolution grid, the number of buildings and total floor area of each development type is given. The number of buildings is further disaggregated into different construction types to account for the impact different levels of structural vulnerability in the risk analysis.

Critical facilities include education and health facilities. Where possible, the assets have been analyzed using accurate geolocation given in an available building inventory. However, many assets had no geolocation given and were distributed using building density as a proxy for their location; the proportion of geolocated assets varies by country. Education facilities (classified as primary school, secondary school, or universities) and health facilities (hospital or clinics) have been assigned an estimated construction type based on interviews with structural engineers in each country and used to approximate construction cost per square meter.

Transportation data include roads, railways, and bridges, where present. Road surface type (paved, unpaved) is also included where available. Agriculture exposure is described by crop type and subnational distribution, average annual yield, and crop price for risk calculations.

Replacement costs for building stock and critical facilities are calculated using construction cost per square meter for each building or facility type, and cost per kilometer for roads based on road type and for railway lines, based on terrain. Estimates of replacement cost were developed through interviews with local engineering and construction professionals (numbers and sources varied in each country). These were validated and adjusted where necessary using several sources, including site surveys and international literature on construction. Replacement costs used are representative of typical building infrastructure and replacement costs for the entire country. Subnational variations in costs and building distributions (due to cost of materials and labor) will vary and are not accounted for.

RISK SUMMARY

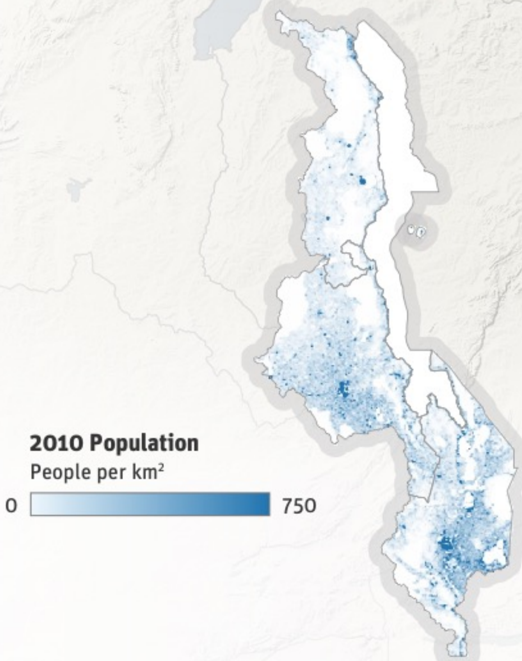
MALAWI

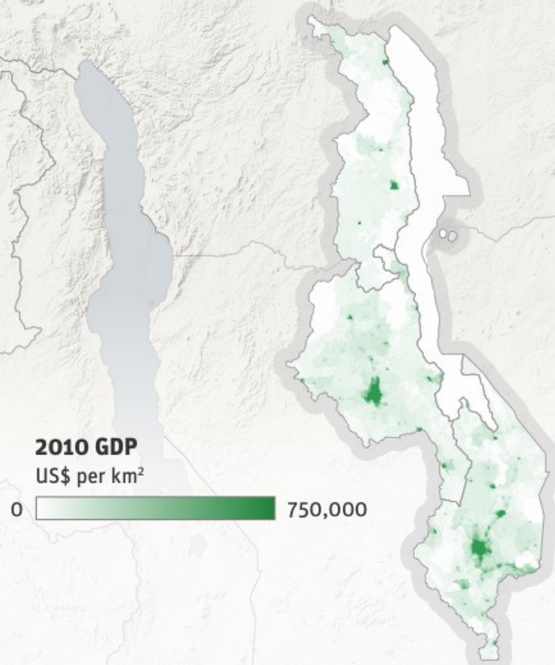
GDP $6.4 billion* Population 17.5 million* *2015 estimates

Malawi has a population of 17.5 million (2015) and has a current growth rate of 3% each year. The country has a relatively high rural population (84% in 2015)[1]. Two-thirds of the urban population is concentrated in the two major cities, Lilongwe and Blantyre (both about 1 million)[1]. The country is one of the least developed countries in the world (Malawi's Human Development Index is 0.418)[2] and about 50% of the population lives below the poverty line[1].

Malawi's agricultural sector accounts for 29% of GDP and over 80% of overall employment[1]. The most important products are tobacco, tea, sugar, and coffee. The industrial sector, including food processing, construction materials and furniture production, accounts for a further 19% of GDP with the service sector contributing the remaining 52%.

Rain-fed agriculture in Malawi is widespread with harvests vulnerable to rainfall variability. A large portion of the population is at risk of food insecurity due to drought and floods.





The town of Zomba and surrounding landscape, in the 1990s

RISK SUMMARY

MALAWI

All $ amounts are in USD

Drought | Flood | Landslide | Earthquake

Floods and droughts pose the most significant and recurring risk to Malawi, with the highest impacts occurring in the central and southern regions.

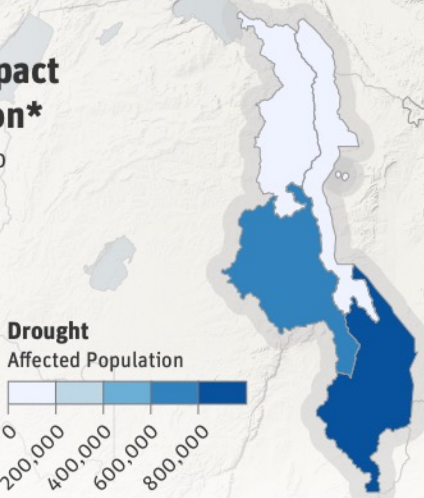
Flooding poses a threat to all low-lying regions around Lake Malawi, with over 100,000 people affected by floods each year, on average.

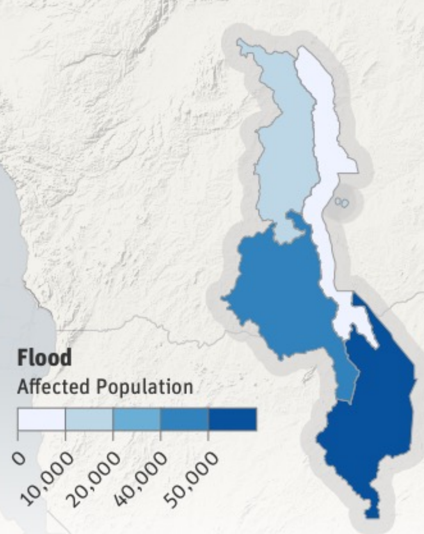
Droughts affect most people: on average, 1.5 million people are affected by drought every year, but this number can be substantially higher in dry years. A much smaller number of people are at risk from **earthquakes and landslides**.

Future changes in Malawi's population and economy, coupled with changes in the climate, are expected to increase the impacts of droughts, floods and landslides.

Modeled Impact on Population*

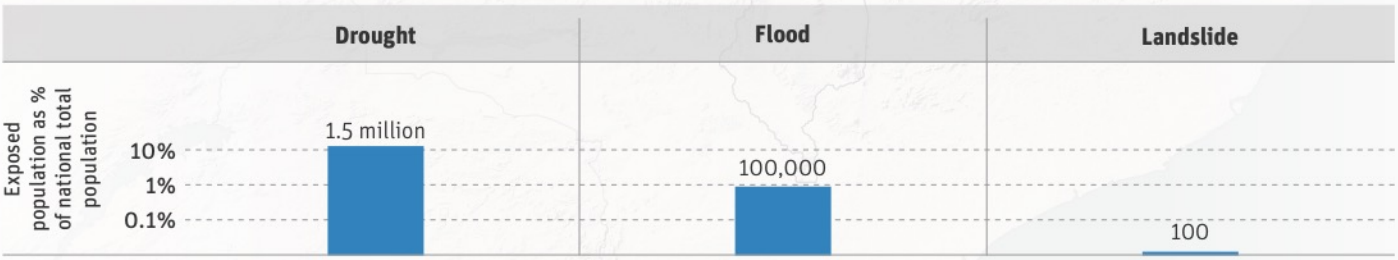
*All data is from 2010





Modeled Impact*

*All data is from 2010



Hazard Summary Table

HAZARD	IMPACT
	Around 1.5 million people are affected by water scarcity each year on average, mainly in the Central and Southern regions of Malawi.
	On average, 100,000 people and 200 education and healthcare facilities are affected nationally by river flooding each year.
	Landslide is a very localized hazard with low overall risk in Malawi; on average up to $150,000 of damage would be expected to building stock per year, with over 100 people at risk.
	Damaging earthquakes in Malawi are infrequent, but it is estimated that around 200,000 people could experience at least light ground shaking at least once every 50 years.

DROUGHT
MALAWI

Droughts are sustained periods of below-normal water availability. Droughts occur due to natural atmospheric variability (e.g. El Niño conditions) and desertification caused by land degradation. Increasing rainfall variability and extremes are increasing drought hazards. Malawi has faced recurrent droughts in recent time, contributing to severe food crises.

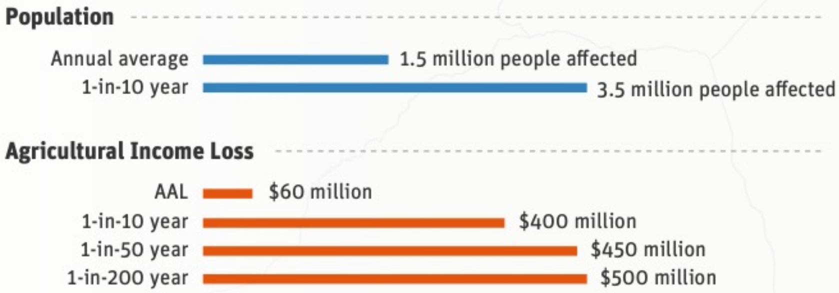
This risk profile assesses hydrological drought impacts on population and the effects of agricultural drought on crop income. Hydrological drought is characterized by estimating the potential deficit of water availability in rivers and reservoirs. Deficits in precipitation lead to water stress in all regions but mainly in the Central and Southern regions (see map). Agricultural drought is assessed by estimating the potential for lack of rainfall and its impact on rainfed crops.

The bars below indicate the number of people located in areas affected by a lack of water availability. Agricultural income loss refers to the value of crops lost due to agricultural drought, based on long-term crop prices and estimated yield loss. These are modeled estimates and are inherently uncertain. Based on the historical numbers recorded from previous droughts, the modeled numbers for affected population appear to be realistic but preliminary estimates given limited data. Further analysis with more detailed modeling and validation data would further improve these numbers.

Key Facts

- Droughts are a recurrent hazard in Malawi. They have contributed to severe food crises such as 2005, 2012 and 2016/2017, which was in part due to the El Niño induced drought.
- The 2016/2017 drought left more than 6 million people in need of food assistance in Malawi.
- The drought in 2012 resulted in a large but uncertain death toll in Malawi, estimated to be somewhere between 300 and 3,000 people.

Modeled Impact



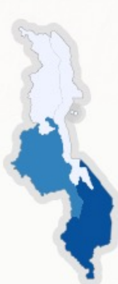
AAL = Average Annual Loss; 1-in-10 year return period equates to a 10% annual probability; 1-in-50 to 2% annual probability; and 1-in-200 to 0.4% annual probability.

The distribution of drought risk is determined by the occurrence of drought hazard/events, the location where assets intersect with this hazard, and the vulnerability of those assets. For more detail, see the Methodology section.

MALAWI

Hydrological drought risk is greatest in the Central and Southern regions of Malawi, in part due to the concentration of population there. In the Central Region, 700,000 people live in areas expected to experience some level of water scarcity each year, with a further 900,000 in the Southern region.

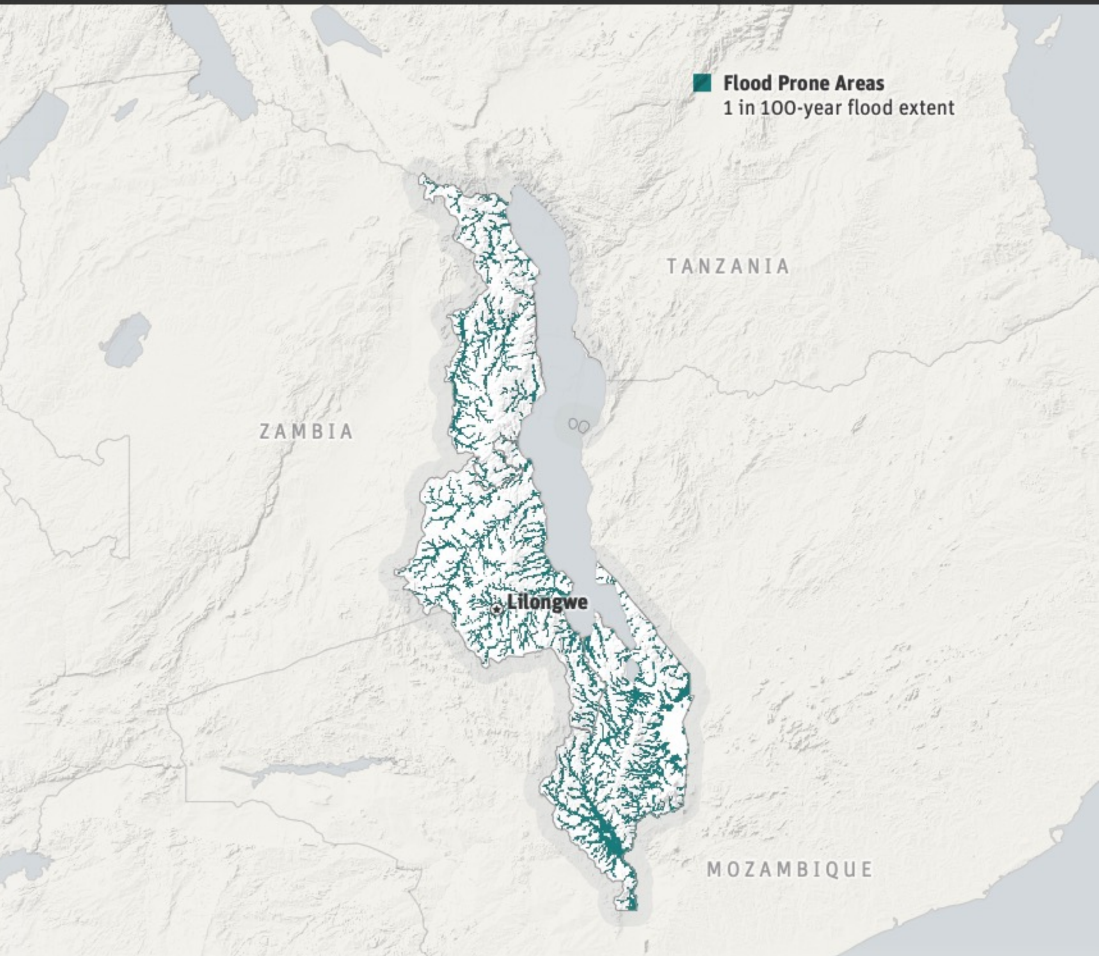
Loss of crops and income due to agricultural drought is also greatest in the south of the country. It is estimated that on average, once every 10 years a loss of $380 million in agricultural income will occur in Malawi. The Southern and Central regions provide the greatest contribution to national crop losses. On an annual basis, the national agricultural income loss is $ 60 million due to drought. The losses in the Southern region account for 75% of this loss.

	Asset Distribution	Average annual affected (water scarcity) Per Province	Average Annual Loss per Province Relative to national total
Population Pop. exposed to water scarcity			

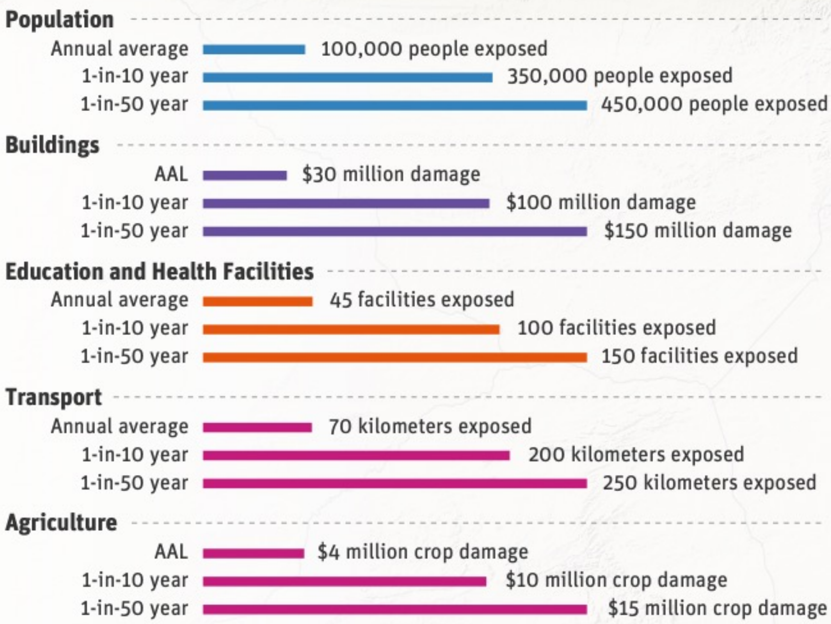
FLOOD
MALAWI

Malawi consists of two water drainage systems: the Lake Malawi system and the Lake Chilwa System. The first one dominates the country and several rivers flow into Lake Malawi such as the Songwe, South Rukuru and North Rukuru. The only outlet of Lake Malawi is the River Shire which flows towards the south into Mozambique and the Zambezi River. The Lake Chilwa system is a small internal drainage system in the southeast of Malawi.

The national scale of these profiles means the focus is on river flooding, and surface flooding (including urban flood) is not included in the risk estimates. Here, the flood potential of the various rivers flowing into Lake Malawi can be seen in the main map. Also, the flood potential from the Shire River in the southern part of Malawi is evident from this map. In Malawi, the greatest flood potential occurs during and following the most intense and sustained rainfalls in the rainy season between November and April, with the highest rainfall in December and January.



Modeled Impact



AAL = Average Annual Loss; 1-in-10 year return period equates to a 10% annual probability; and 1-in-50 to 2% annual probability.

Key Facts

- The flooding in 2015 was an extreme event with the highest rainfall on record for Malawi and constitutes a 1 in 500 year event[3]. This event killed nearly 200 people in Malawi and caused more than $400 million of damage (about 10% of the national GDP). More than 200,000 people were displaced in Malawi, while the flood affected over 1 million people overall. Given its extremity, the impact of this event is beyond the estimates for affected population or damage provided for the various return periods herein.

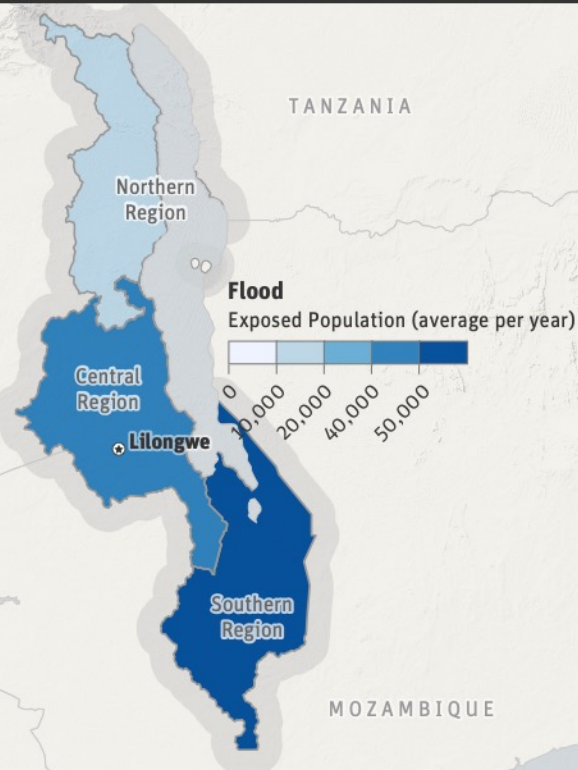
The distribution of flood risk is determined by the occurrence of flood events, the location where assets intersect with these hazards, and the vulnerability of those assets. For more detail, see the Methodology section.

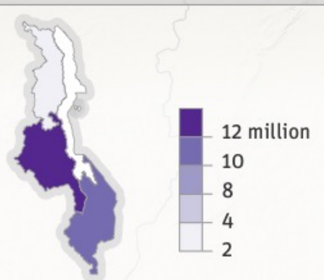
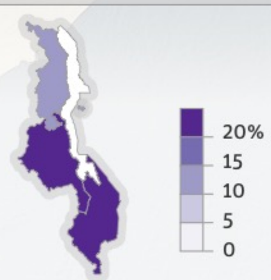
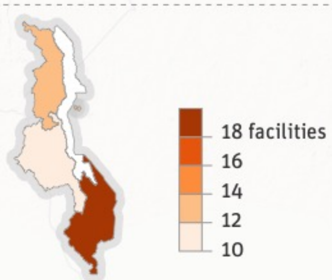
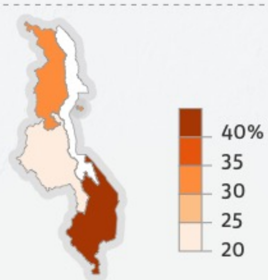
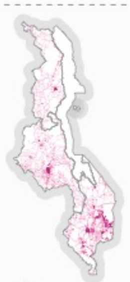
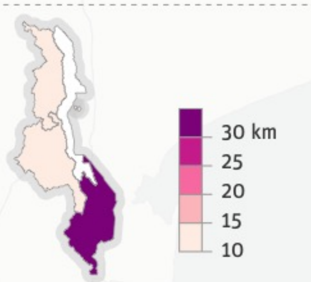
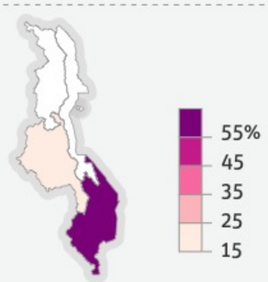
FLOOD
MALAWI

There is high flood hazard across Malawi. Damage to the private building stock of about $150 million may occur in at least one flood in a person's lifetime. It is expected that on average each year, over 100,000 people will be affected by flooding based on the modeling results. With climate change and increased population, this number will very likely increase in the coming decades. On average, each year flooding is expected to affect around 45 education and health facilities and 70 kilometers of the transport network.The average annual agricultural losses would be expected to reach around $4 million. These numbers increase substantially for more extreme events.

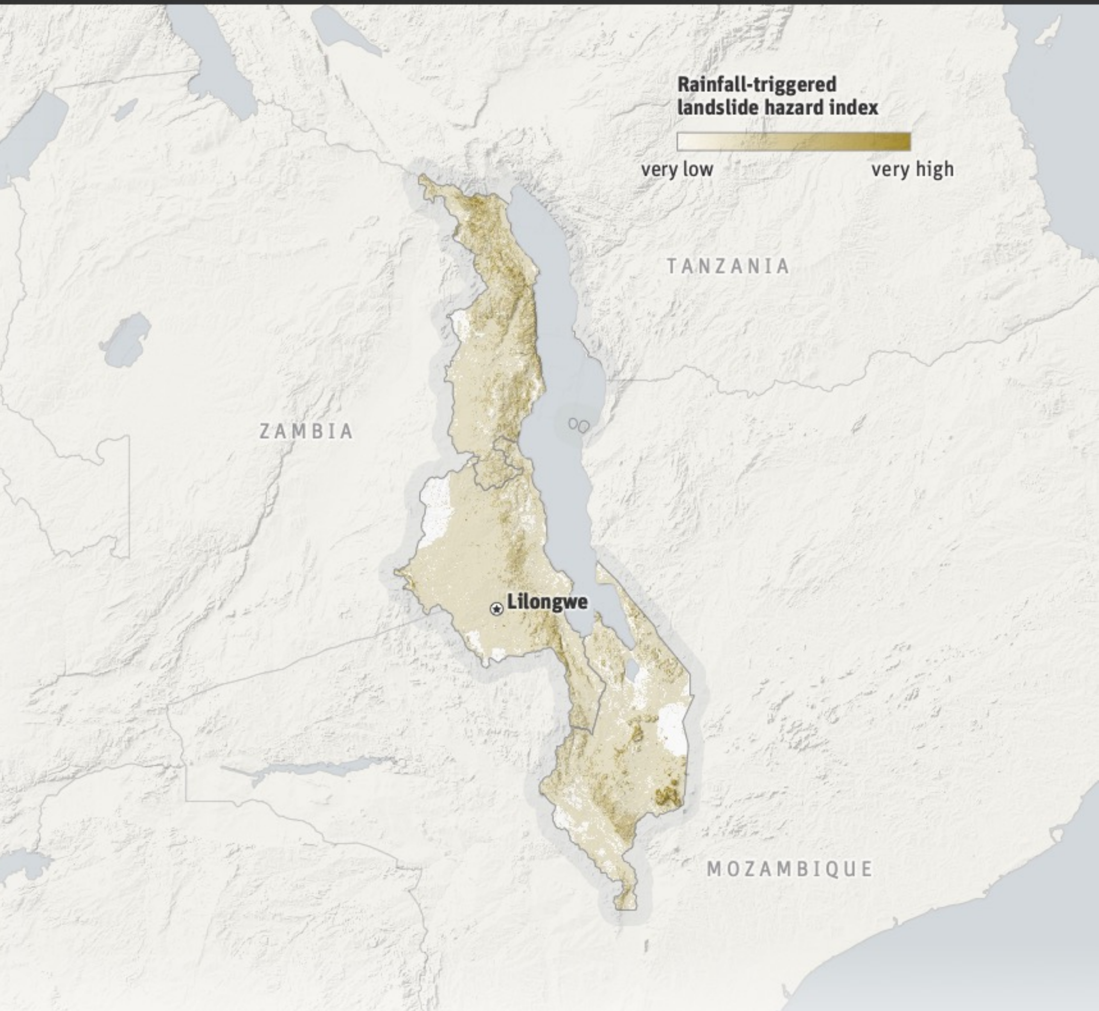
The areas contributing most to the national estimated building damage and affected population are the Southern and Central regions. Both regions have a high risk relative to population, whereas the Southern region has the highest risk to value relative to building stock, transport and education and health facilities.

A validation of the results against the 2015 flood event in Malawi has shown that the model represents well the number of affected people, facilities and roads. The cost of damage to buildings, however, is much higher in the modeling results compared to recorded damage so further detailed analysis of flood damage to buildings in particular is required to refine these results.



	Asset Distribution	Average Annual Loss Per Province	Average Annual Loss per Province Relative to national total
Buildings $ Damage			
Education and Health Facilities Facilities exposed			
Transport Km exposed			

LANDSLIDE
MALAWI

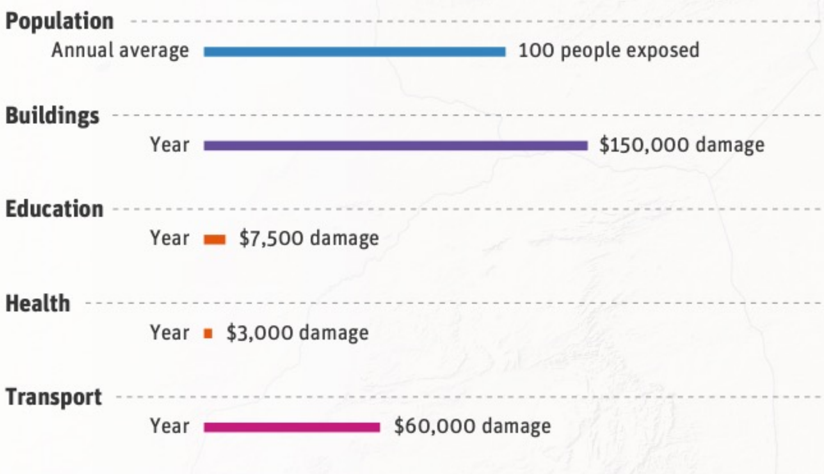


Malawi has areas of moderate landslide running from north to south along the highland areas and east of the Shire River in the south near Blantyre. High to very high hazard occurs at the Mulanje Massif in the southeast, and north of Zomba at the Malosa Complex. High hazard also occurs to the east of Dedza, along the edge of Lake Malawi and in the northern border highlands.

Various factors contribute to the widespread landslide hazard in Malawi, including high annual rainfall, complex hydrological networks, the presence of the tectonically active East African Rift system, and soils susceptible to mass movement and weathering, and deforestation.

Damage due to landslide has been estimated across the whole country using a novel method that enables estimation of annual average risk using landslide susceptibility factors combined with earthquake and rainfall triggers, and the potential impact of different size landslides on the population, buildings, and transport networks.

Modeled Impact



Key Facts

- The 1992 Phalombe landslide in the Mulanje Massif, southern Malawi, killed 500 people and caused a landslide dam that later failed and cause widespread flooding.
- In 1946, 22 people were killed in landslides at Zomba Mountain, Southern region. Two villages, 24 bridges, roads, crops, and power and water supplies were destroyed. The town of Zomba, with a population of over 100,000, is at risk of landslide here.

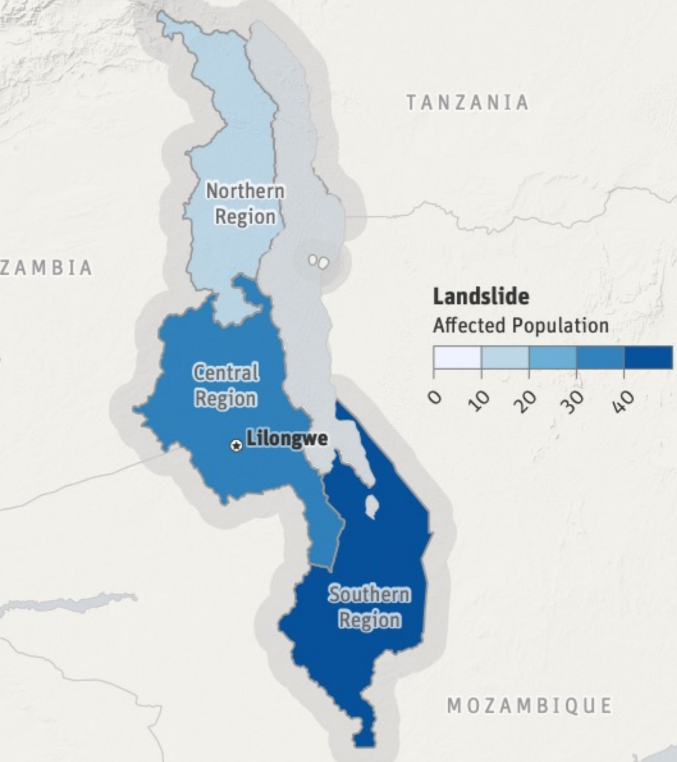
i Landslide risk is a function of population and assets being located in areas susceptible to landslides (based on slope angle, vegetation cover and soil type), and the potential for earthquakes and rainfall to trigger landslides there. For more detail, see the Methodology section.

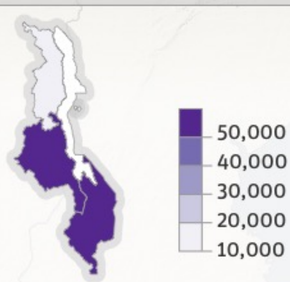
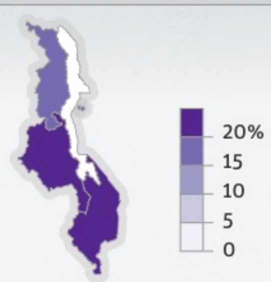
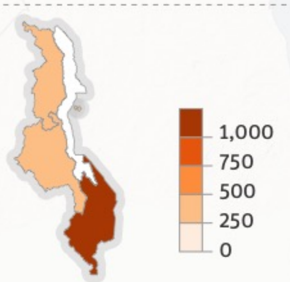
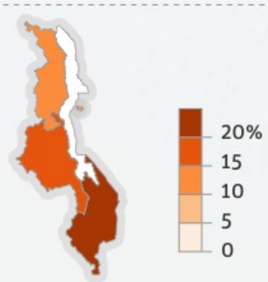
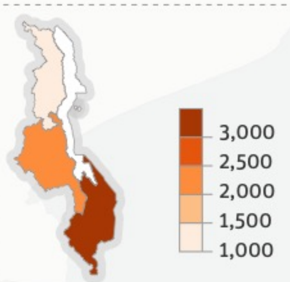
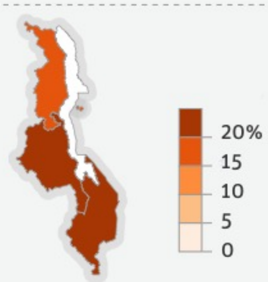
MALAWI

Despite the widespread moderate to high landslide hazard, the risk to population, and the built environment is estimated to be relatively low.

On average, each year 100 people are at risk of being affected by landslides, with the modelling suggesting a long term average of 10 fatalities per year nationally. The annual average damage to building stock is expected to be $150,000, and in any given year landslides could affect areas contributing up to $300,000 of national GDP. This analysis also suggests that road and rail transport networks could sustain losses of $60,000 per year on average. Socio-economic changes and climate change-induced increases in rainfall-triggered landslides could increase the number of people affected annually to 300 by 2050.

The Southern region contributes the majority of damage costs and affected population to the national landslide risk profile.



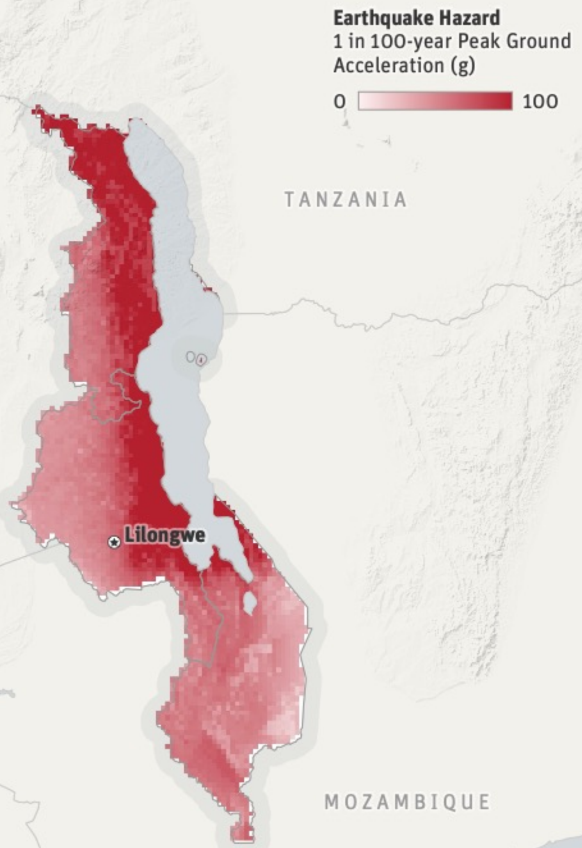
	Asset Distribution	Average Annual Loss Per Province	Average Annual Loss per Province Relative to national total
Buildings $ Damage			
Health Facilities $ Damage			
Education Facilities $ Damage			

MALAWI

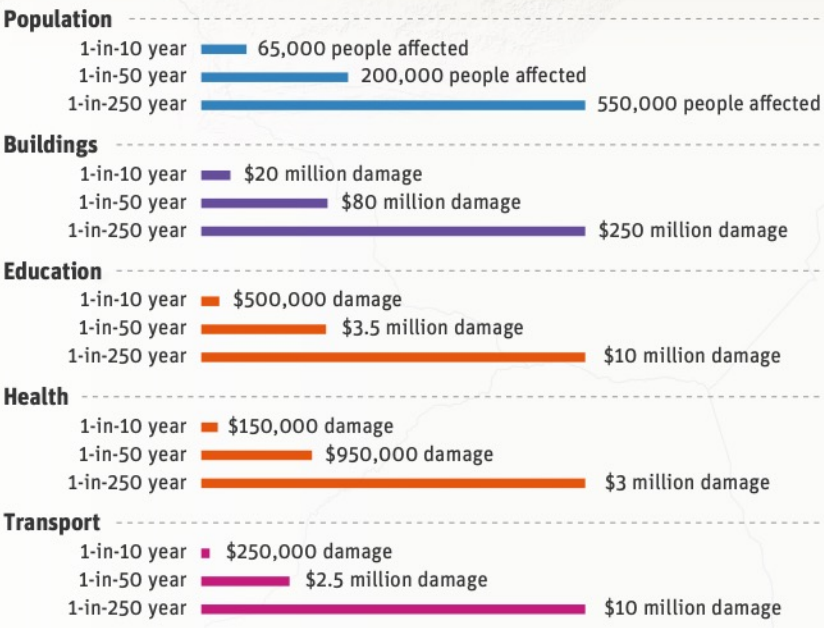
Earthquakes pose the threat of building damage and collapse, particularly where seismic-resistant design of buildings is not generally applied, as in Malawi. They can also cause damage and disruption to transport networks and essential services due to ground motion displacing roads, rails, bridges and other essential services. Earthquakes can cause sufficient ground shaking to trigger rockfalls and landslides in areas susceptible to such hazards (i.e. steep terrain).

Malawi is located at the southern end of the East African Rift, and seismicity associated with this system extends from the north into central and southern Malawi. The main areas of seismic hazard occur along the Western branch of the Rift beneath and south of Lake Malawi. Cities on the western shore of Lake Malawi are all located in the area of highest hazard: Karonga, Chilumba, Nkhata Bay, Nkhotakota, and Chipoka.

In these areas, strong ground shaking would be expected to occur at least once in a person's lifetime. Buildings of poor and moderate quality construction could sustain damage, but extent of damage would be strongly dependent on local seismic and construction factors. Very strong earthquakes with moderate damage could be expected here at least once in about 500 years. Further west and south, there is a moderate shaking hazard with potential for light damage at least once in a person's lifetime and strong shaking at least once in a 500-year period. The capital city Lilongwe is located on the southwestern edge of the high hazard area and could be affected by strong earthquakes over long timescales.



Modeled Impact



AAL = Average Annual Loss; 1-in-10 year return period equates to a 10% annual probability; 1-in-50 to 2% annual probability; and 1-in-250 to 0.4% annual probability.

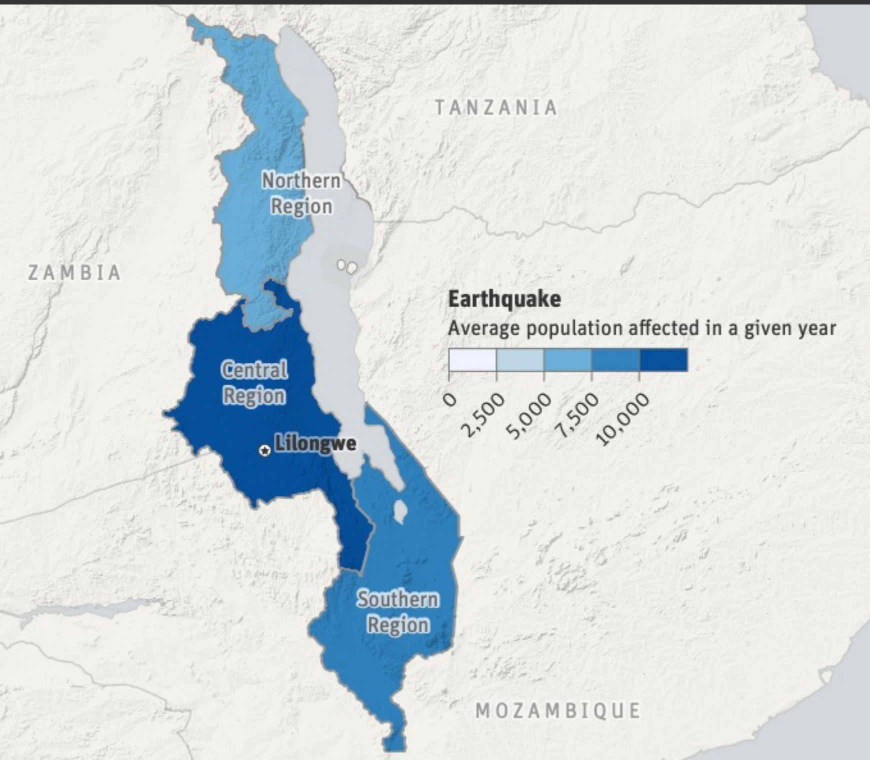
Key Facts

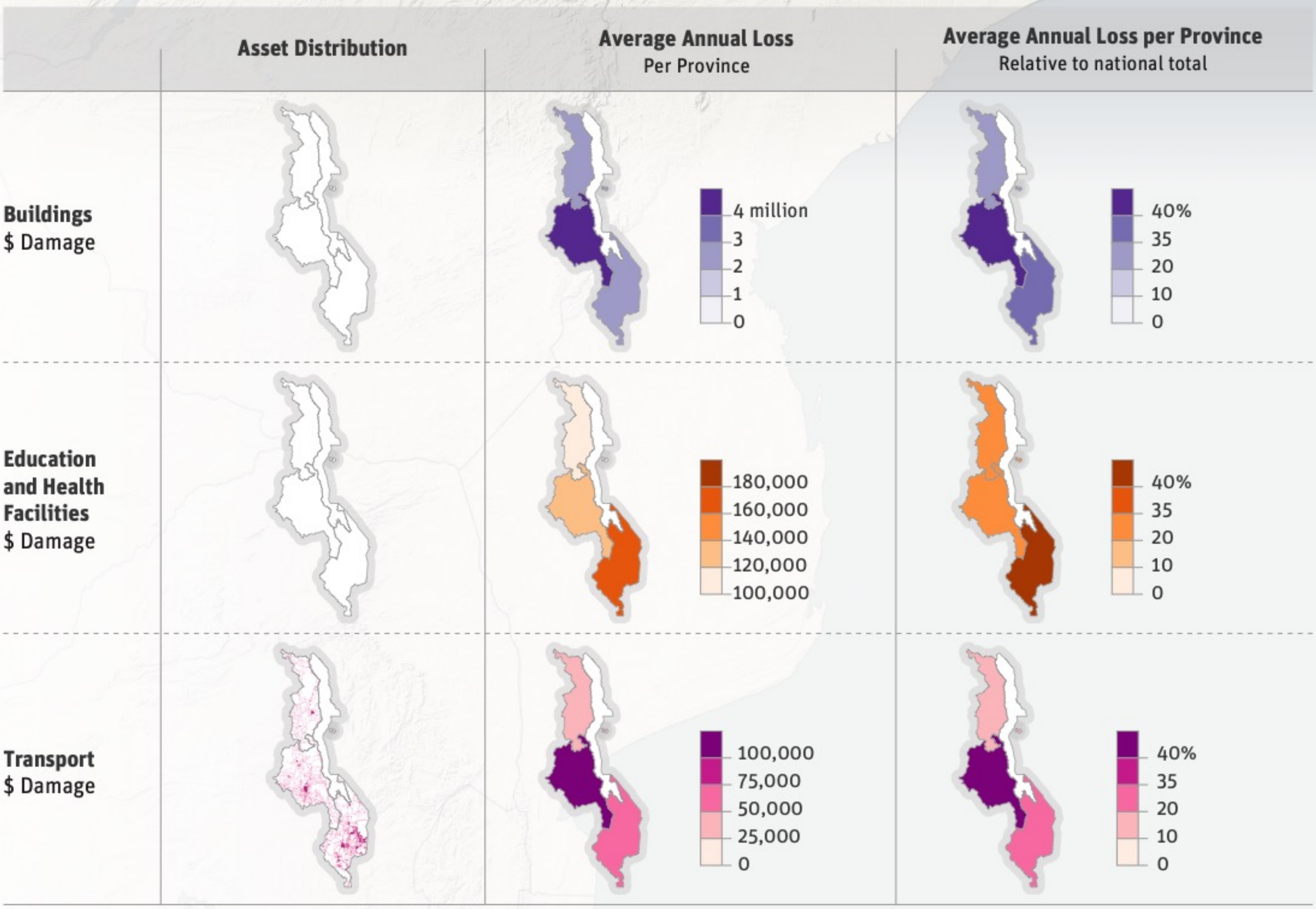
- The M_W6.3 and M_W5.6 Salima earthquakes in March 1989 are the largest earthquakes to have been recorded in Malawi. The larger event killed eight people and made thousands of people homeless, but damage could have been much worse if it had occurred closer to an urban areas. Rural bamboo, straw and timber dwellings sustained limited damage but more permanent unreinforced masonry building would be expected to sustain much more damage.
- This study includes losses to due to damage from earthquake ground shaking only. Secondary hazards (liquefaction and fire following an earthquake) are not accounted for. Landslide hazard is considered under the separate landslide section, where ground shaking is considered as a potential trigger of landslides.

The distribution of earthquake risk is determined by modeled earthquake hazard events, the location where assets intersect with these hazards, and the vulnerability of those assets. For more detail, see the Methodology section.

It is possible that, at least once in a person's lifetime, an earthquake could occur that affects 70,000 people with at least light ground shaking (see bars, opposite). In such an earthquake, there is likely to be at least light to moderate building damage in some areas. The cost of this would be approximately $200 million, with potential for $3 million of damage to education and health facilities.

The Central region experiences the greatest seismic risk in terms of total people affected in the region (see main map). This region faces also the highest seismic risk for its building stock and transport network both in absolute and relative terms.





DISASTER RISK PROFILES

GLOSSARY AND NOTES

Glossary

Average annual loss

Average annual loss (AAL) is the estimated impact (in monetary terms or number of people) that a specific hazard is likely to cause, on average, in any given year. It is calculated based on losses (including zero losses) produced by all hazard occurrences over many years.

Exposure

Exposure refers to the location, characteristics, and value of assets such as people, buildings, critical facilities, and transport networks located in an area that may be subject to a hazard event.

Hazard

Hazard refers to the damaging forces produced by a peril, such as ground shaking induced by an earthquake or water inundation associated with flooding.

Risk

Disaster risk is a function of hazard, exposure, and vulnerability. It is quantified in probabilistic terms (e.g., Average Damage Per Year, and return period losses) using the impacts of all events produced by a model.

Vulnerability

Vulnerability is the susceptibility of assets to the forces of a hazard event. For example, the seismic vulnerability of a building depends on a variety of factors, including its structural material, quality of construction, and height.

Notes

[1] Central Intelligence Agency, The World Factbook, 2015, https://www.cia.gov/library/publications/the-world-factbook/.

[2] United Nations Development Programme, Human Development Report 2015: Work for Human Development (New York: United Nations Development Programme, 2015), http://hdr.undp.org/en/data.

[3] GFDRR, European Union, World Bank, 2015. Malawi 2015 Floods Post Disaster Needs Assessment Report, https://www.gfdrr.org/sites/default/files/publication/pda-2015-malawi.pdf.

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