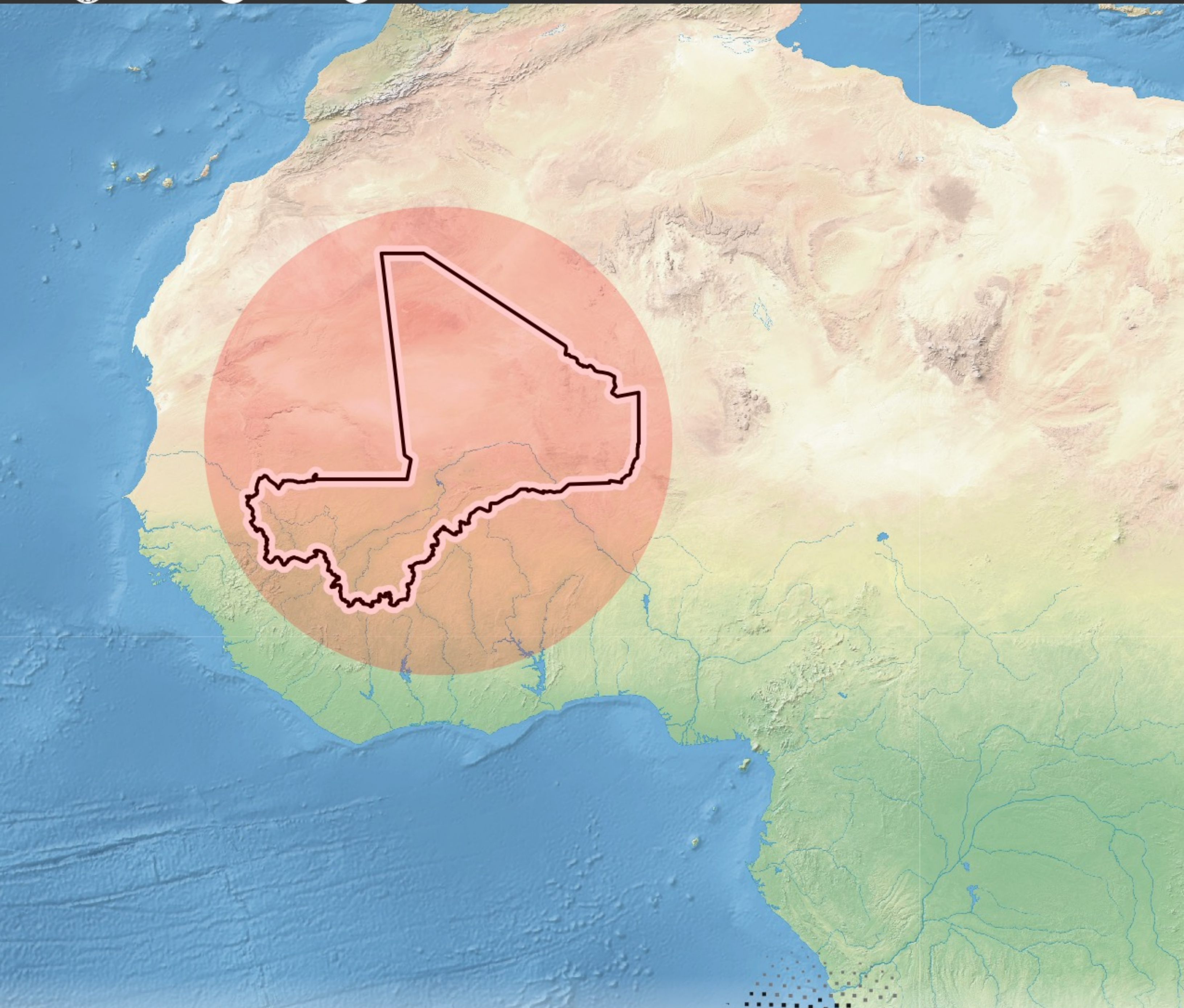
DISASTER RISK PROFILE

Mali

Drought Flood Landslide



Africa Disaster Risk Financing Initiative

Building Disaster Resilience in Sub-Saharan Africa

WORLD BANK GROUP

GFDRR
Global Facility for Disaster Reduction and Recovery

An initiative of the African, Caribbean and Pacific Group of States funded by the European Union

The International Bank for Reconstruction and Development
The World Bank Group
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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.

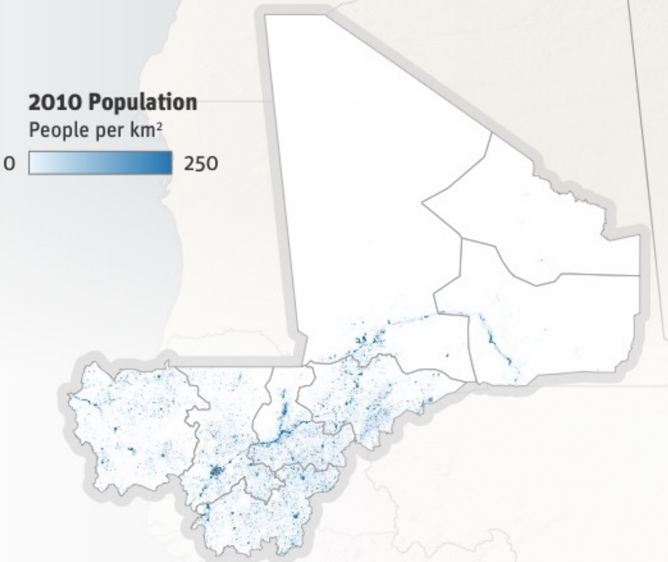
MALI

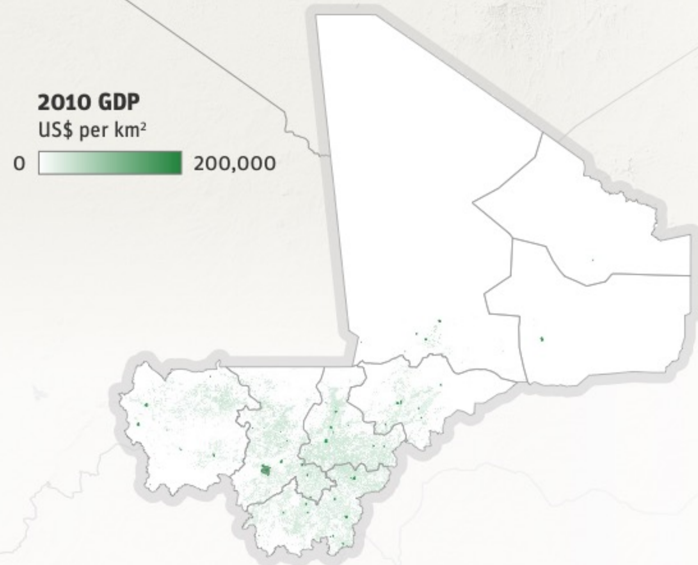
GDP $13 billion* **Population 17.5 million*** ***2015 estimates**

Mali's population stood at 17.5 million in 2015 and its population has a growth rate of 3% each year. It is a sparsely population country with most of the population living in the southern part. Approximately 60% of the population lives in rural areas[1], with the urban population concentrated in the capital city, Bamako (population 1.8 million[2]). The country is one of the least developed countries in the world; 44% of the population lives below the poverty line[3] and Mali's Human Development Index is 0.442[4].

The major agricultural region is southern Mali with most production between Bamako, Mopti and Sikasso along the banks of the Niger River. Mali's agricultural sector accounts for 42% of GDP and 80% of overall employment[5]. Agriculture in Mali is dominated by small-scale traditional rain-fed subsistence agriculture and pastoralism. The industrial sector, largely based on gold and salt mining, accounts for a further 17% of GDP, with the service sector contributing the remaining 38%[6].

The majority of cereal crops in Mali are rain-fed, with harvests vulnerable to rainfall variability. A severe drought can shrink farm production by up to 50% (e.g. 1983-1984). Several million people will face food insecurity during a severe drought.





Low-lying urban development on the banks of the Niger River in Bamako, Mali.

RISK SUMMARY

MALI

All $ amounts are in USD

Drought Flood Landslide

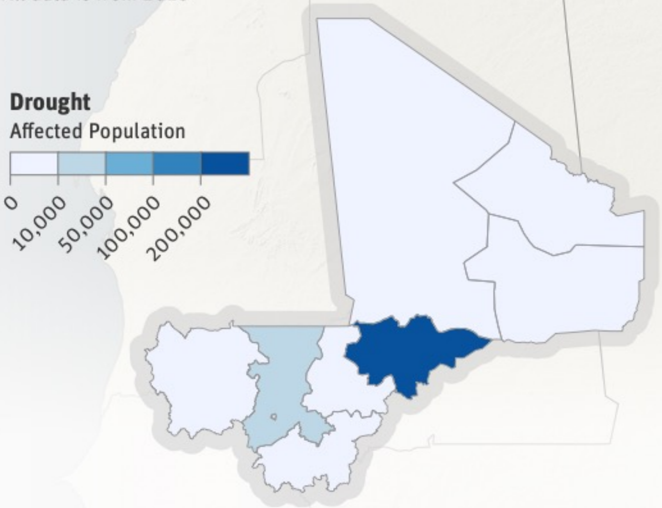
Droughts and floods pose the most significant and recurring risk to Mali, with the highest impacts occurring in the southern region. **Drought is** the greatest hazard due to Mali's climate and uneven distribution of water resources. On average, 0.4 million people are affected by drought every year, but this number can be substantially higher in dry years.

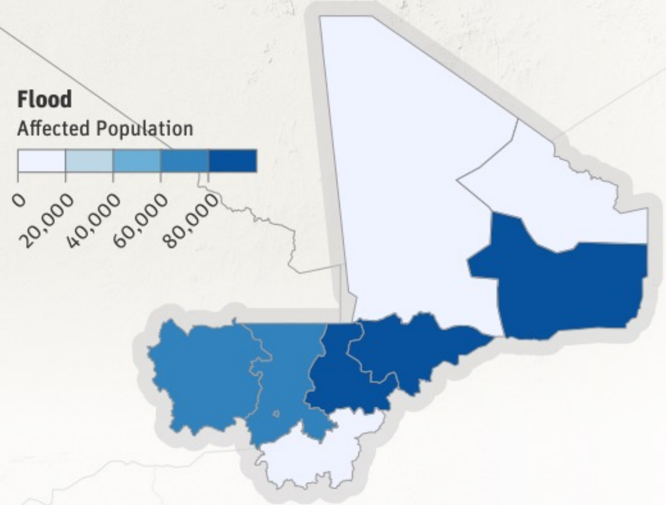
Flooding poses a threat to lowland, highland, and urban areas, with 500,000 people affected by floods each year, on average. A much smaller number of people are at risk from **landslides**.

Future changes in Mali's population and economy, coupled with changes in climate-related hazards, are expected to increase the impacts of droughts and floods.

Modeled Impact on Population*

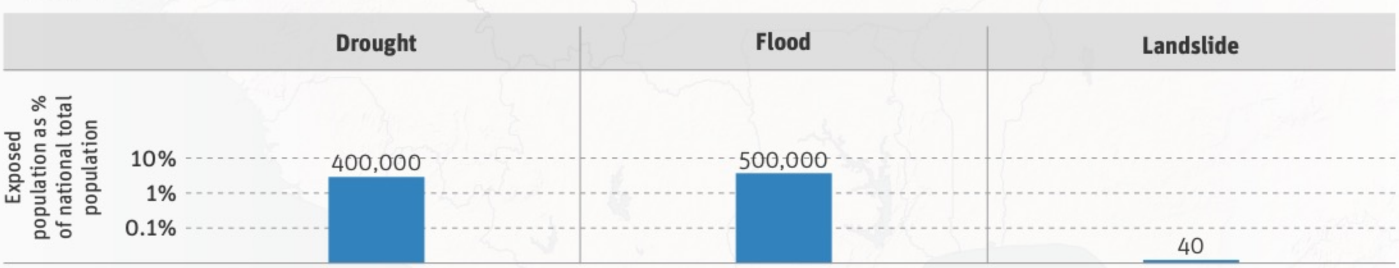
*All data is from 2010





Modeled Impact*

*All data is from 2010



Hazard Summary Table

HAZARD	IMPACT
Drought	On average, around 400,000 people are affected by water scarcity each year, and agricultural income loss of around $10 million is expected annually.
Flood	On average, each year 500,000 people and around 300 education and healthcare facilities nationally are affected by river flooding.
Landslide	Due to its localized nature, the estimated annual average impact of landslides is low (40 people at risk, $80,000 of damage to building stock), though a single large event can exceed the annual average estimation.

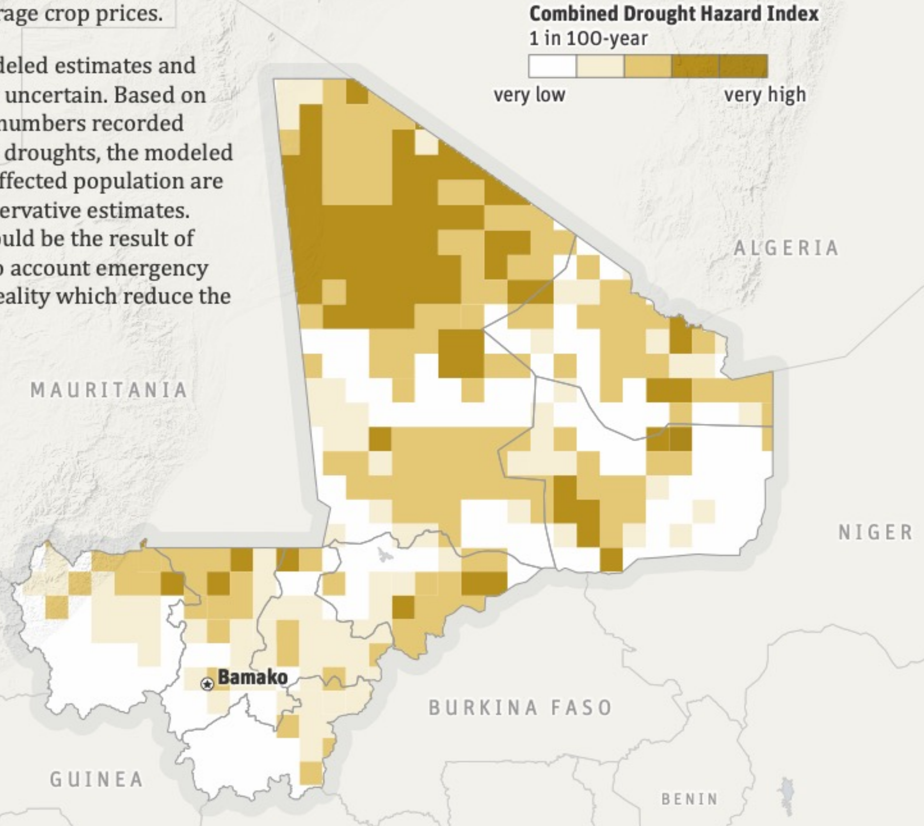
DROUGHT
MALI

Droughts are sustained periods of below-normal water availability. Droughts occur due to natural atmospheric variability (e.g. El Niño conditions), desertification caused by land degradation. Increasing rainfall variability and extremes are increasing drought hazards, already common in the Sahel.

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. **Agricultural drought** is assessed by estimating the potential for lack of rainfall and its impact on rainfed agriculture. The greatest deficits in precipitation and water availability occur in the northern regions of Mali (see main map).

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 drought, with the loss estimated based on long term average crop prices.

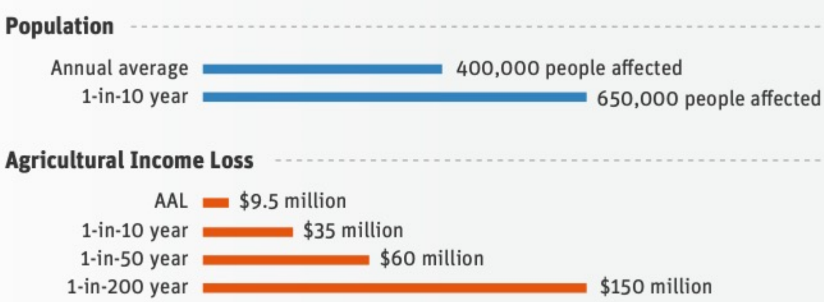
These are modeled estimates and are inherently uncertain. Based on the historical numbers recorded from previous droughts, the modeled numbers for affected population are probably conservative estimates. In part, this could be the result of not taking into account emergency measures in reality which reduce the impact.



Key Facts

- Droughts are a recurrent hazard in Mali, as in the wider Sahel region. They have contributed to severe food crises including those in 1972-1974, 1983-1985, 2002-2003, 2011-2012 and 2015-2018, which was in part due to the 2015/2016 El Niño induced drought.
- The severe 2011-2012 drought resulted in a large and long lasting impact. In 2017, more than 3.5 million people were food insecure and almost 1 million people in need of food assistance.
- Livestock are an important component of the agricultural economy of Mali, and livestock are adversely effected during droughts. Approximately, 40% of livestock was lost during the 1972-1974 drought. However, this analysis does not account for impacts on livestock.

Modeled Impact



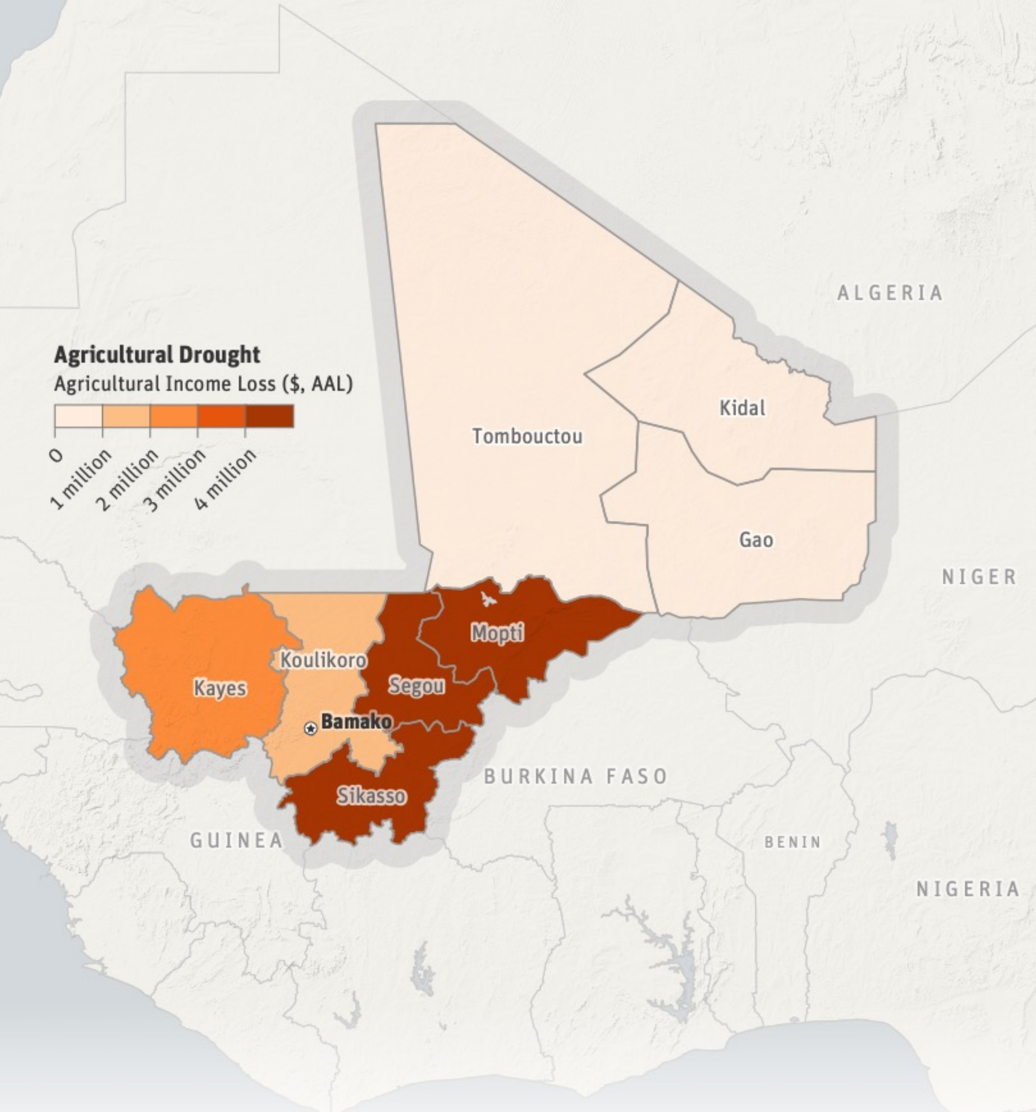
AAL = Average Annual Loss; 1-in-10 year return period equates to a 10% annual probability; 1-in-50 to 2% annual probability; and 1-in-200 to 0.4% annual probability.

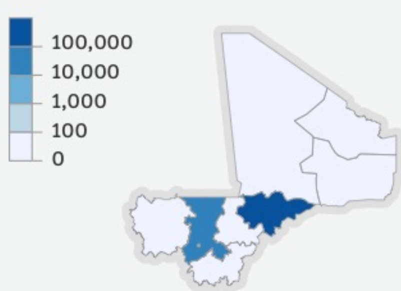
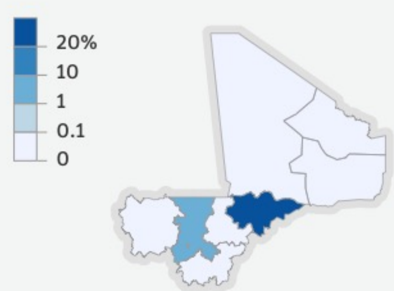
The distribution of drought risk is determined by the occurrence of drought hazard/events, the location where assets intersect with this hazard, and the vulnerability of those assets. For more detail, see the Methodology section.

MALI

In Mali 400,000 people live in areas expected to experience water scarcity each year, predominantly in the southern regions. Despite the relatively high hazard in the northern regions, there is sparse population in this region.

On average, once every 10 years a loss of at least $35 million in agricultural income will occur. Sikasso, Mopti and Segou are the regions that provide the greatest contribution to national crop losses.



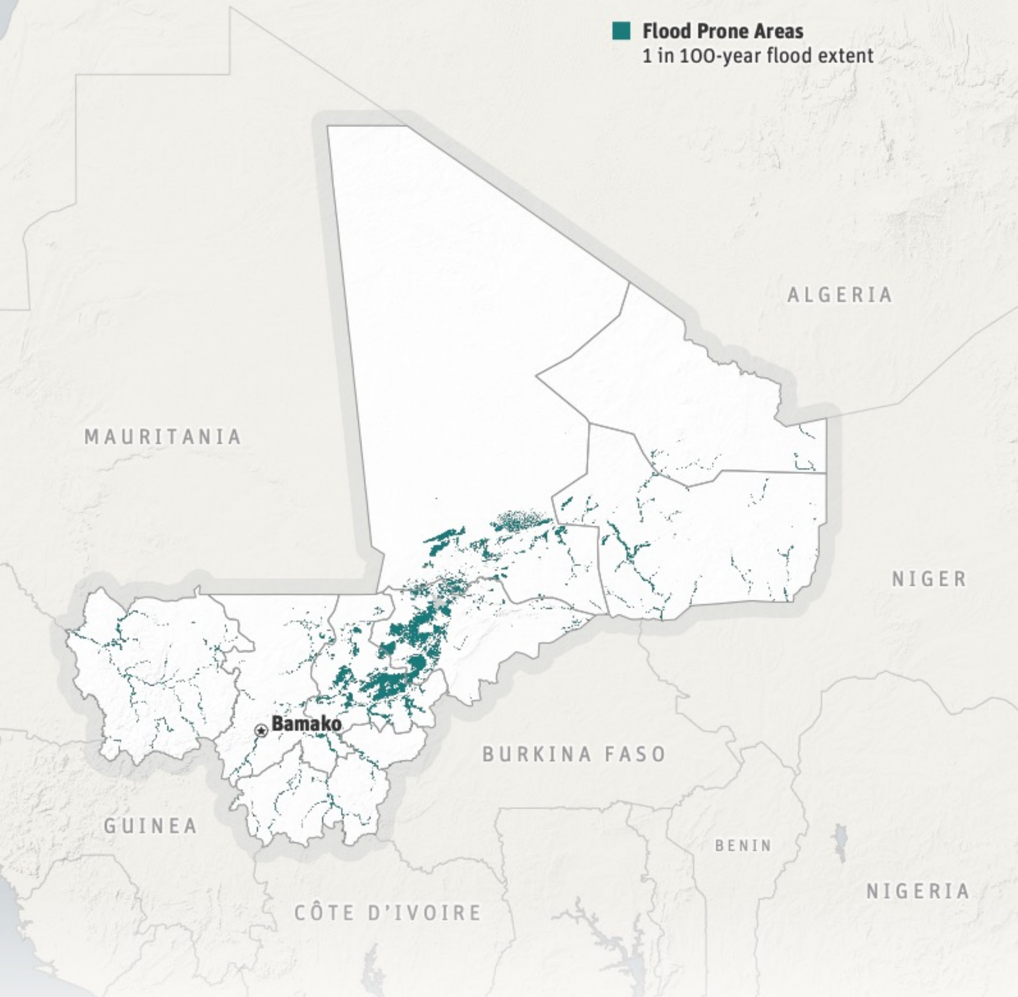
	Asset Distribution	Average annual affected (water scarcity) Per region	Average Annual Loss Contribution to national average loss
Population Pop. exposed to water scarcity			

MALI

The southern part of Mali is part of the Niger River basin. The Niger River in Mali covers 25% surface area of the total basin. Its principal tributary in Mali is the Bani River, which flows into the Niger River at Mopti. The Senegal River flows through western Mali, whereas northern Mali has almost no surface water due to the desert conditions.

The flood potential of Niger and Senegal Rivers can be seen in the main map. In Mali, the greatest flood potential occurs in September until November following the most intense and sustained rainfalls from the July-October rainy season. The Inner Delta in central Mali southwest of Timbuktu is a prominent feature in which the river gradient is low. Seasonal floods in this area provide an excellent area for fishing, agricultural land and grazing area for cattle. Peak river flows upstream of the Inner Delta generally occur in September. The Inner Delta system causes some delay in the peak flows downstream along the Niger River, towards the northeast.

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.



Modeled Impact

Population

Annual average	500,000 people exposed
1-in-10 year	1.5 million people exposed
1-in-50 year	1.5 million people exposed

Buildings

AAL	$250 million damage
1-in-10 year	$750 million damage
1-in-50 year	$1 billion damage

Education and Health Facilities

Annual average	300 facilities exposed
1-in-10 year	850 facilities exposed
1-in-50 year	1,500 facilities exposed

Transport

Annual average	600 kilometers exposed
1-in-10 year	2,000 kilometers exposed
1-in-50 year	2,500 kilometers exposed

Agriculture

AAL	$10 million crop damage
1-in-10 year	$35 million crop damage
1-in-50 year	$60 million crop damage

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

- Mali's vulnerability to flooding has been shown several times in the past decade (e.g. 2012, 2013, 2016). In 2012, more than 60,000 people were affected by floods.
- Based on information from UNDP[7], there have been over 3 million people impacted by floods in Mali in the past 30 years.

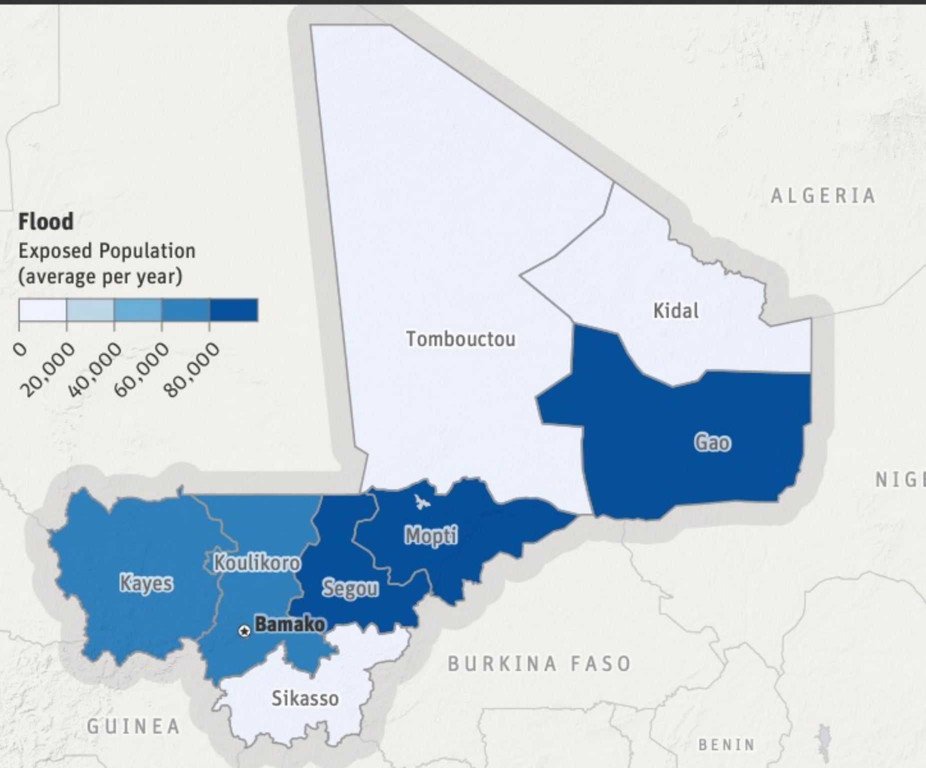
The distribution of flood risk is determined by the occurrence of flood events, the location where assets intersect with these hazards, and the vulnerability of those assets. For more detail, see the Methodology section.

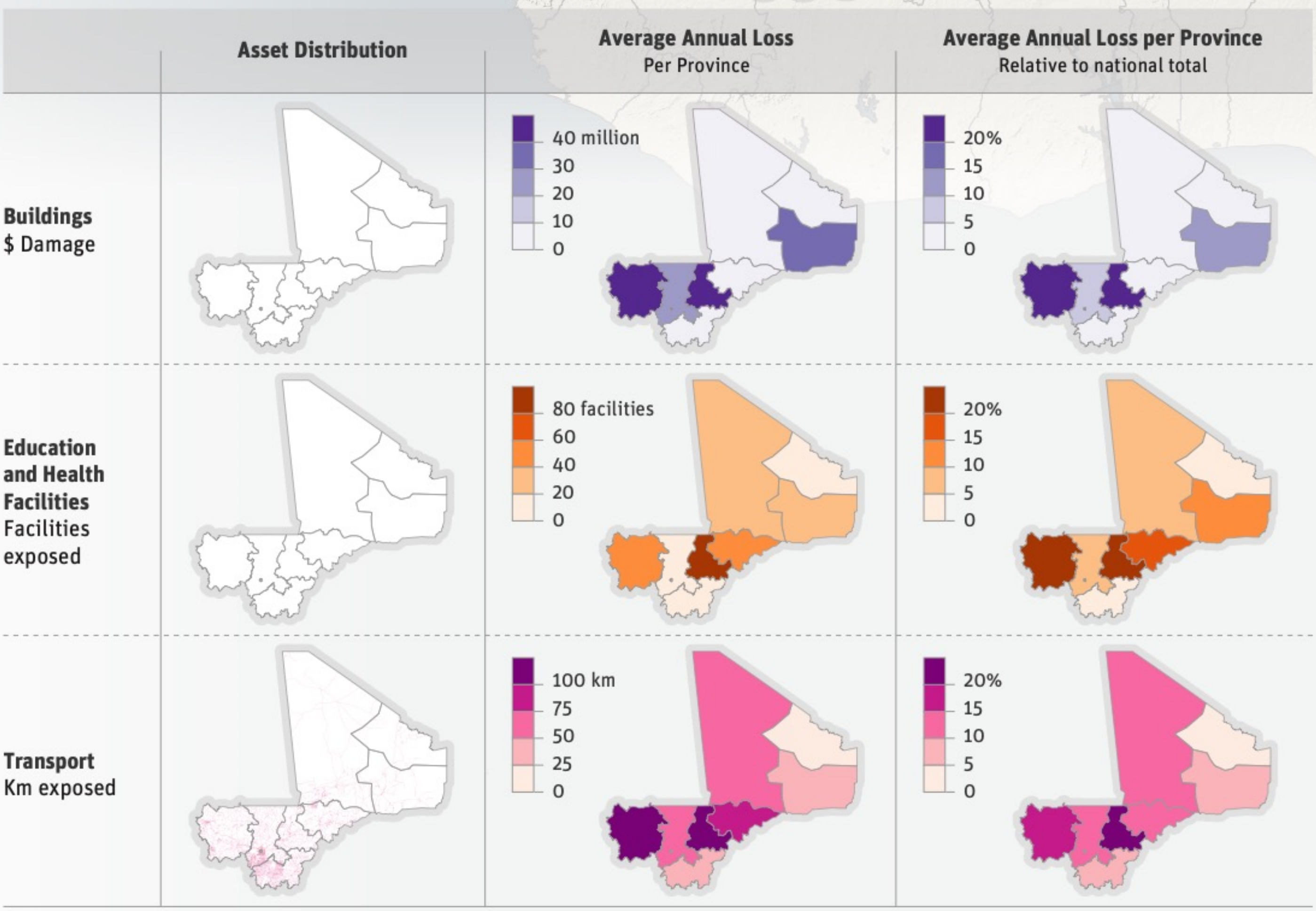
FLOOD
MALI

Mali is vulnerable to flooding predominantly in the southern regions. Damage of $600 million to crops and $1 billion of damage to the building stock may occur in at least one flood in a person's lifetime. It is expected that on average each year, over 500,000 people will be affected by flooding. On average, each year flooding is expected to affect 300 education and health facilities.

It is noted that the estimated number of affected people and the building damage are high compared to (limited) historical records. Uncertainties in the modeling, but also under-recording of historical event impacts may explain this. Further analysis of flood risk to people and assets in Mali is required.

Bamako, Segou and Kayes regions contribute most to the national estimated building damage and affected population. Gao, however, has the highest risk relative to the population and value of building stock within the region.





LANDSLIDE
MALI

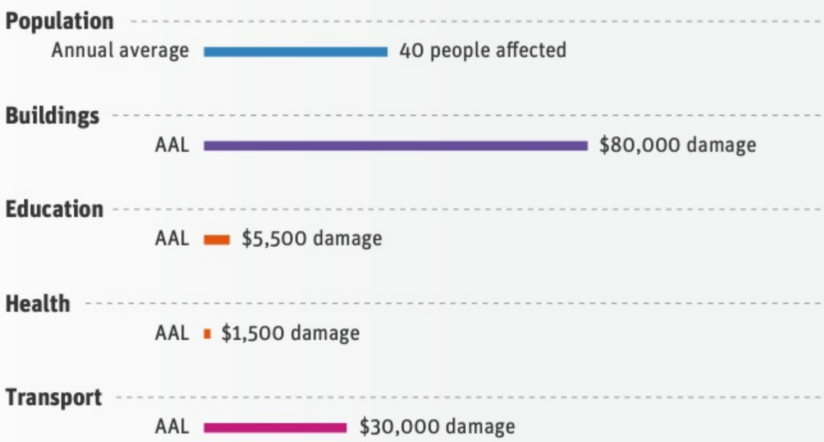
Landslide hazard in Mali is generally very low – large areas of relatively flat topography and arid conditions mean much of the country is not susceptible to landslides. In the south of the country where rainfall is highest there is moderate landslide hazard. These include areas of Kayes region, in Koulikoro region immediately west of the capital city Bamako, and around the edges of the Dogon Plateau east of the city of Mopti, in Mopti region. Here on the Bandigara Escarpment, rockfall poses the greatest risk.

The areas of moderate landslide hazard in the south coincide with the greatest density of population and economic activity in the country. Future land use change close to Bamako and Kayes in particular could coincide with areas of landslide hazard, causing an increase in slope instability and increasing the hazard through activities related to urbanization, such as road cutting, deforestation and construction on slopes.

Key Facts

- Despite the low landslide hazard and absence of reported major landslide events, this profile objectively quantifies the landslide hazard risk across the country for use in disaster risk management.
- 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 rainfall triggers, and the potential impact of different sizes of landslides on the population, buildings, and transport networks.

Modeled Impact



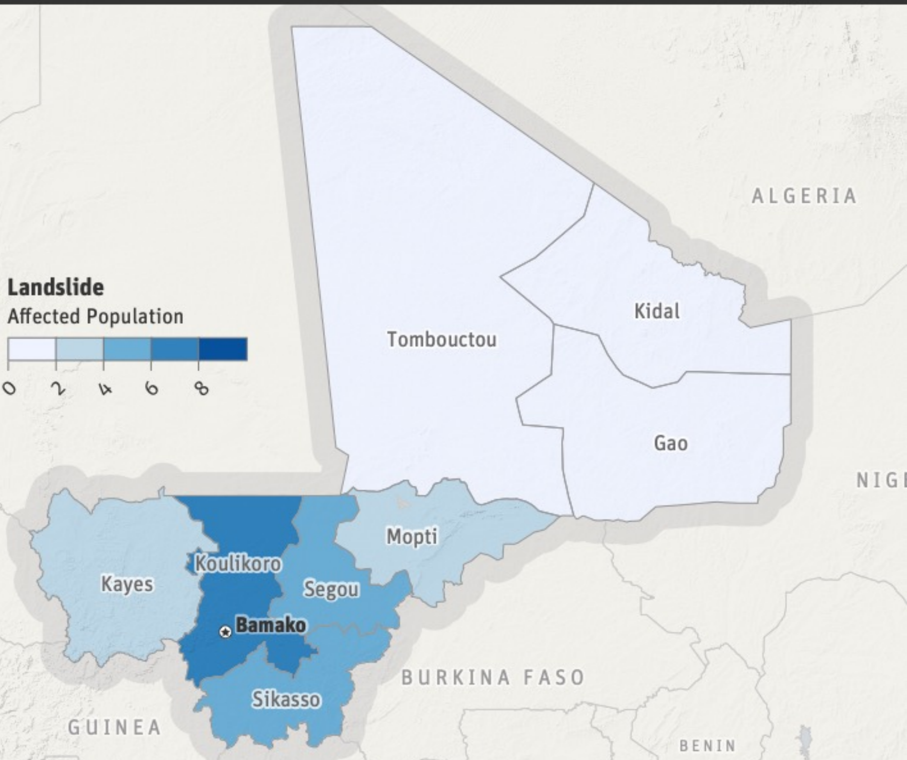
Landslide risk is a function of population and assets being located in areas susceptible to landslides (based on slope angle, vegetation cover and soil type), and the potential for earthquakes and rainfall to trigger landslides there. For more detail, see the Methodology section.

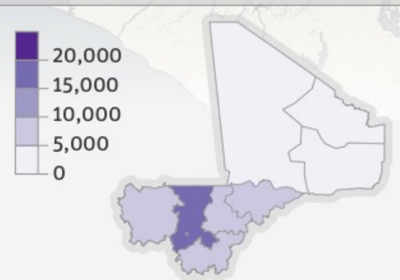
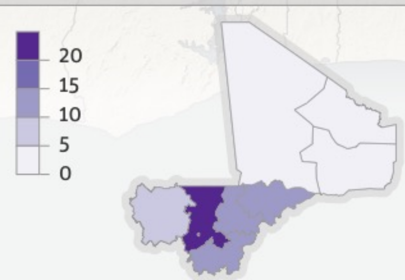
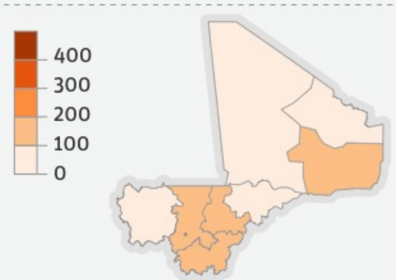
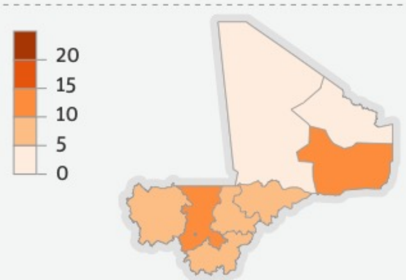
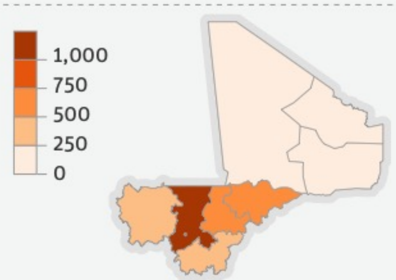
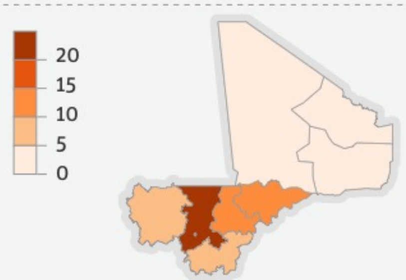
MALI

Due to the low landslide hazard in in most parts of Mali, the risk to population and risk of damage to the building stock, critical facilities and transport networks from landslides is also very limited.

On average, each year around 40 people are at risk of being affected by landslides, which reflects the very localized nature of the hazard. It is expected that per year, damage to road and rail networks could be limited to around $30,000. The regions contributing most to the national risk estimates are Bamako and Koulikoro.

Despite the risk appearing very low, these are long-term averages; a sufficiently intense period of rainfall could have a devastating local effect on unstable slopes, causing higher levels of damage and loss of life in a single event.



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

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/theworldfactbook/.

[2] Ibid.

[3] Ibid.

[4] 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.

[5] Central Intelligence Agency, The World Factbook, 2015, https://www.cia.gov/library/publications/theworldfactbook/.

[6] Ibid.

[7] UNDP, 2017, Project background document 'Programme for the Support of the National Adaptation Strategy to Climate Change in Mali'. https://www.adaptation-undp.org/explore/western-africa/mali

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