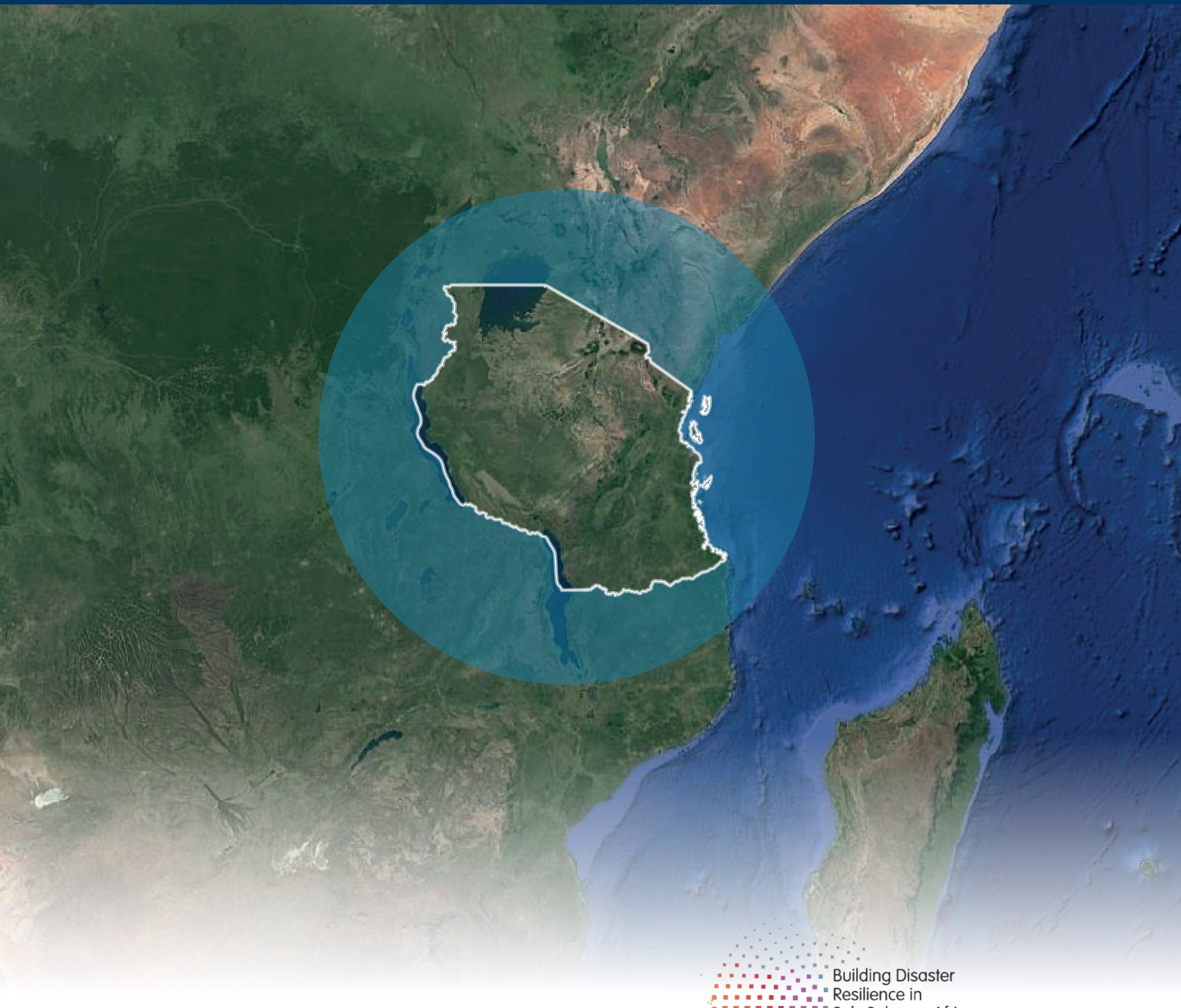
DISASTER RISK PROFILE

Flood Drought

Tanzania (United Republic of)



Building Disaster Resilience in Sub-Saharan Africa

Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities

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

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UNISDR The United Nations Office for Disaster Risk Reduction

cima RESEARCH FOUNDATION

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INTRODUCTION

Disasters are on the rise, both in terms of frequency and magnitude. From 2005-2015, more than 700 thousand people worldwide have lost their lives due to disasters that have affected over 1.5 billion people, with women, children and people in vulnerable situations disproportionately affected. The total economic loss was more than US$ 1.3 trillion. Disasters inordinately affect lower-income countries. Sub-Saharan Africa, where two-thirds of the world's Least Developed Countries are located, is prone to recurrent disasters, largely due to natural hazards and climate change.

The Sendai Framework for Disaster Risk Reduction 2015 – 2030 emphasises the need to manage risk rather than disasters, a theme already present in its predecessors, the Yokohama Strategy and the Hyogo Framework for Disaster Risk Reduction. Specifically, the Sendai Framework calls for strong political leadership, commitment, and involvement of all stakeholders at all levels from local to national and international, with a view to *"prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political, and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience"*.

Understanding disaster risk is the Sendai Framework's first priority for action: *"policies and practices for disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment"*. The outputs of disaster risk assessment should be the main drivers of the disaster risk management cycle, including sustainable development strategies, climate change adaptation planning, national disaster risk reduction across all sectors, as well as emergency preparedness and response.

As part of the programme "Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities", UNISDR engaged CIMA Research Foundation for the preparation of 16 Country Risk Profiles for Floods and Droughts for the following countries: Angola, Botswana, Cameroon, Equatorial Guinea, Gabon, Gambia (Republic of The), Ghana, Guinea Bissau, Kenya, Eswatini (Kingdom of), Ivory Coast, Namibia, Rwanda, São Tomé and Príncipe, Tanzania, and Zambia.

The Country Risk Profiles provide a comprehensive view of hazard, risk and uncertainties for floods and droughts in a changing climate, with projections for the period 2050-2100. The risk assessment considers a large number of possible scenarios, their likelihood, and associated impacts. A significant amount of scientific information on hazard, exposure, and vulnerabilities has been used to simulate disaster risk.

The EU PROGRAMME "Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities"

In 2013, the European Union approved 80 million EUR financing for the programme *"Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities"*. The programme is being implemented in Africa by four partners: the African Union Commission, the United Nations Office for Disaster Risk Reduction (UNISDR), the World Bank's Global Facility for Disaster Reduction and Recovery (WB/GFDRR), and the African Development Bank's ClimDev Special Fund (AfDB/CDSF). The programme provides analytical basis, tools and capacity, and accelerates the effective implementation of an African comprehensive disaster risk reduction and risk management framework.

PROBABILISTIC RISK PROFILE: METHODOLOGY

PROBABILISTIC RISK ASSESSMENT

Understanding disaster risk is essential for sustainable development. Many different and complementary methods and tools are available for analysing risk. These range from qualitative to semi-quantitative and quantitative methods: probabilistic risk analysis, deterministic or scenario analysis, historical analysis, and expert elicitation.

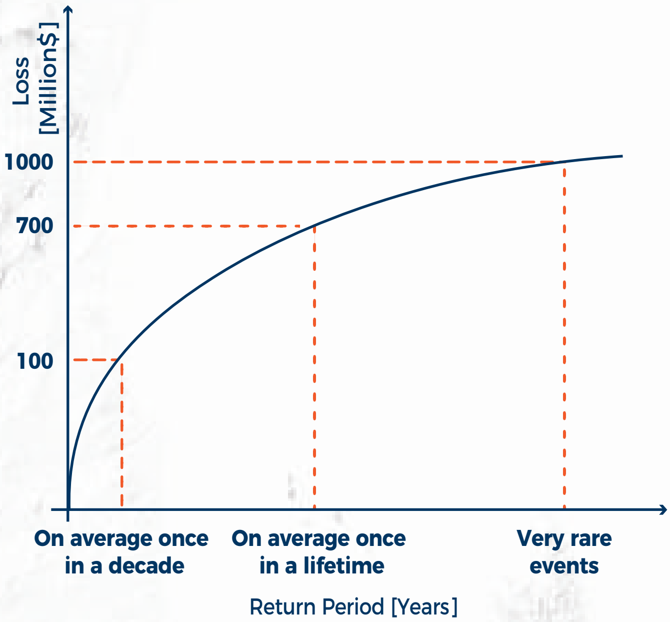
This disaster risk profile for floods and droughts is based on probabilistic risk assessment. Awareness of possible perils that may threaten human lives primarily derives from experience of past events. In theory, series of historical loss data long enough to be representative of all possible disastrous events that occurred in a portion of territory would provide all necessary information for assessing future loss potential. Unfortunately, the availability of national historical information on catastrophic natural hazard events is limited, and data on the economic consequences is even less common.

In the absence of extensive historical data, a modelling approach is needed to best predict possible present and future scenarios, taking into consideration the spatial and temporal uncertainties involved in the analysed process. This profile simulates a realistic set of all possible hazardous events (scenarios) that may occur in a given region, including very rare, catastrophic events. Potential impacts were computed for each event, taking into consideration associated economic losses or number of people and assets affected. Publicly available information on hazard, exposure, and vulnerability was used in the analysis. Finally, statistics of losses were computed and summarised through proper quantitative economic risk metrics, namely Annual Average Loss (AAL) and Probable Maximum Loss (PML).
In computing the final metrics (PML, AAL), the uncertainties that permeate the different steps of the computations have been explicitly quantified and taken into account: uncertainties in hazard forcing, uncertainties in exposure values and their vulnerabilities.

Average Annual Loss (AAL) is the expected loss per year, averaged over many years. While there may actually be little or no loss over a short period of time, AAL also accounts for much larger losses that occur less frequently. As such, AAL represents the funds which are required annually in order to cumulatively cover the average disaster loss over time.

Probable Maximum Loss (PML) describes the 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. For instance, in the figure below, the likelihood of a US$ 100 million loss is on average once in a decade, a loss of US$ 1 billion is considered a very rare event. Typically, PML is relevant to define the size of reserves which, insurance companies or a government should have available to manage losses.

The methodology is also used to simulate the impact of climate change [SMHI-RCA4 model, grid spacing 0.44° - about 50 km - driven by ICHEC-EC-EARTH model, RCP 8.5, 2006-2100 and, future projections of population and GDP growth (SSP2, OECD Env-Growth model from IIASA SSP Database)].
Results are disaggregated by different sectors, using the categories of Sendai Framework indicators: direct economic loss (C1), agricultural sector (C2), productive asset and service sector (C3), housing sector (C4), critical infrastructures and transportation (C5).



PROBABILISTIC RISK PROFILE: RISK COMPONENTS

HAZARD

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.

In order to best predict possible flood and drought scenarios, a modelling chain composed of climate, hydrological, and hydraulic models combined with available information on rainfall, temperature, humidity, wind and solar radiation, has been used to best predict possible flood and drought scenarios. A set of mutually exclusive and collectively exhaustive possible hazard scenarios that may occur in a given region or country, including the most catastrophic ones, is generated and expressed in terms of frequency, extension of the affected area and intensity at different locations.

Flood hazard map for 1 in a 100 years probability evaluated under current climate conditions, the scale of blues represents different water depth values.

VULNERABILITY

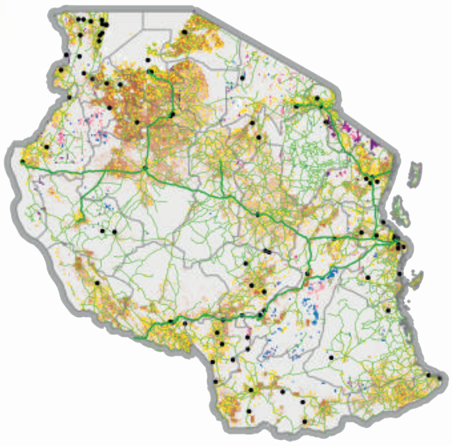
conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

Direct losses on different elements at risk are evaluated applying vulnerability functions. This links hazard intensity to the expected loss (economic loss or number of affected people) while counting for associated uncertainty. Vulnerability functions are differentiated for each typology of exposed elements and take into account local factors, such as typical constructive typologies for infrastructures or crop seasonality for agricultural production. In the case of floods, vulnerability is a function of water depth. For agricultural production, the vulnerability is a function of the season in which a flood occurs. In the case of agricultural drought, losses are computed in terms of lack of production for different crops from a nominal expected production. A similar approach is used for hydrological drought, the evaluation of which focuses on loss of hydropower production.

EXPOSURE

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

Losses caused by floods and droughts are assessed in relation to population, GDP and a series of critical sectors (education, health, transport, housing, and productive and agricultural sectors). The sectors are created clustering all the different components, which contribute to a specific function (e.g. the health sector is comprised of hospitals, clinics and dispensaries). Publicly available global and national data, properly generated, enables the location of these elements at high resolution, e.g. 90 metres or lower, for the whole country. The total number of people and the National GDP (in US$) are considered in both current (2016) and future (2050) scenarios. The critical sectors are characterised in terms of their economic value (in US$), using the most updated information available.



Exposure distribution, the different colors represent different types of assets.

AGRICULTURAL SECTOR [C2] | SERVICE SECTOR [C3] | PRODUCTIVE ASSETS [C3]

HOUSING SECTOR [C4] | TRANSPORTATION SYSTEM [C5] | OTHER CRITICAL INFRASTR.[C5]

UNISDR terminology on Disaster Risk Reduction: https://www.unisdr.org/we/inform/publications/7817

A SENDAI ORIENTED RISK PROFILE

The Sendai Framework guides the organisation of the results of the risk profile. Sendai introduced seven global targets and several indicators for monitoring their achievements. The indicators are common standards for a consistent measurement of progress towards the global targets across countries and over the duration of the Sendai Framework and Sustainable Development Goals. The Risk Profile presents the results of the assessment mostly referring to indicators for the Target B on the affected people, Target C on direct economic losses and Target D on damage and disruption of basic service. Seven additional indicators are included into the risk profile in order to obtain a more comprehensive understanding of risk from floods and droughts. The table below summarises the indicators used in the risk profiles as well the climate and socio-economic conditions considered in the estimation of the different risk metrics.

	INDICATORS			FLOOD			DROUGHT			
				P	F	SEp	P	F	SEp	RISK METRICS
SENDAI INDICATORS	B1		Number of directly affected people attributed to disasters - AAL	Y	Y	Y	Y	Y	Y	Annual Average
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters	C2	Direct agricultural loss attributed to disasters (Crops)	Y	Y		Y	Y		AAL (Average Annual Loss) PML (Probable Maximum Loss)
		C3	Direct economic losses to productive asset (Industrial Buildings + Energy Facilities)	Y	Y		Y	Y		
		C3	Direct economic losses in service sector	Y	Y					
		C4	Direct economic losses in housing sector	Y	Y					
		C5	Direct economic losses to transportation systems (Roads + Railways)	Y	Y					
		C5	Direct economic losses to other critical infrastructures (Health + Education Facilities)	Y	Y					
SENDAI INDICATORS	D1 Damage to critical infrastructure attributed to disasters	D2	Number of destroyed or damaged health facilities	Y	Y					Annual Average
		D3	Number of destroyed or damaged educational facilities	Y	Y					
		D4	Number of other destroyed or damaged critical infrastructure units and facilities (Transportation systems)	Y	Y					
* No official Sendai indicators	Agricultural & Economic Indicators		GDP of affected areas*	Y	Y	Y	Y	Y	Y	Annual Average
			Number of potentially affected livestock units*				Y	Y		
			Number of working days lost*				Y	Y		
	Hazard Index	SPEI	Standardised Precipitation-Evapotranspiration Index*				Y	Y		
		SSMI	Standardised Soil Moisture Index*				Y	Y		
		SSFI	Standardised StreamFlow Index*				Y	Y		
		WCI	Water Crowding Index*				Y	Y		

P Present Climate | **F** Future Climate | **SEp** Socio Economic projection

COUNTRY SOCIO-ECONOMIC OUTLOOK

OVERVIEW

UR of Tanzania is sparsely populated with a density of 59 persons per Km^2 and variations across regions both in Tanzania Mainland and Tanzania Zanzibar [1]. It has a young population with a high growth rate. The median age is 17.9 years [2]. The economy depends on agriculture, which accounts for slightly less than one-quarter of GDP and employs more than 65% of the workforce, although gold production in recent years has increased to about 35% of exports [2]. Tanzania has sustained relatively high economic growth over the last decade, averaging 6 – 7% a year [3]. Its real GDP grew by 7.1% in 2017 according to official statistics. As this report is being drafted, official release of quarterly 2018 growth data is pending due to an on-going GDP rebasing exercise. Growth in 2017 was supported by expansion in both the industrial and agricultural sectors; due to lower food prices, the inflation rate has continued to decline, reaching 3.3% by the end of July 2018 [3]. Poverty has declined since 2007 and continues at a modest pace, with a fall in the poverty rate from 28.2% in 2012 to 26.9% in 2016. This decline has been accompanied by improvements in human development outcomes and living conditions [3].

SOCIO-ECONOMIC PROJECTIONS

Recently, climate scientists and economists have formulated a range of new "pathways" that examine how national and global societies, demographics and economics might lead to different plausible future development scenarios over the next hundred years [4,5]. The scenarios range from relatively optimistic trends for human development, with "substantial investments in education and health, rapid economic growth and well-functioning institutions" [6], to more pessimistic economic and social stagnation, with little investment in education or health in poorer countries, coupled with a fast-growing population and increasing inequalities.

PROJECTIONS USED IN THE RISK PROFILE

The "middle of the road" scenario envisages that recent development patterns will persist throughout the 21st century. The results of this risk profile refer to this intermediate scenario. According to these conditions, the population of Tanzania in 2050 will roughly increase of about 85% compared to 2016 (World Bank Data), whereas GDP is expected to increase of almost fifteen-fold.

POPULATION

2016 Projection
55.4
[Million People]
102
2050 Projection

GDP

2016 Projection
47.4
[Billion$]
702.1
2050 Projection

TANZANIA

AREA : 947,300 km^2

POPULATION DENSITY : 59 people/km^2

MEDIAN AGE : 17.9 years

HDI - HUMAN DEVELOPMENT INDEX : 0.538

LIFE EXPECTANCY AT BIRTH : 66.3 years

MEAN YEARS OF SCHOOLING : 5.8 years

EMPLOYMENT TO POP. RATIO (AGES > 15) : 81.5%

EMPLOYMENT IN AGRICULTURE : 66.7%

EMPLOYMENT IN SERVICES : 27.3%

data from:
http://hdr.undp.org/en/countries/profiles/
https://data.worldbank.org/indicator/
https://www.nbs.go.tz

COUNTRY CLIMATE OUTLOOK

OVERVIEW

The climate varies from tropical along the coast to temperate in the highlands. There are two types of seasonal rainfall distributions [7]:

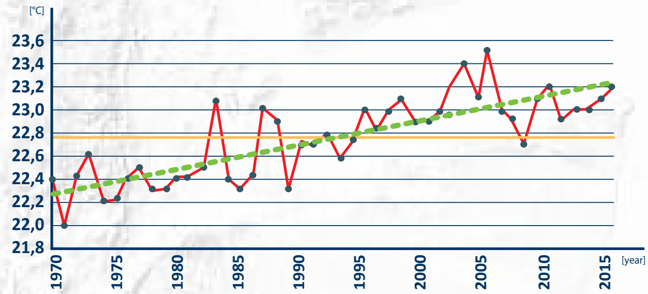
- The unimodal type, where rainfall is usually from October/November to April, found in the central, southern and southwestern highlands;
- The bimodal type, comprising two seasons: the short rains (Vuli) fall from October to December, while the long rains (Masika) fall from March to June. This type occurs in the coastal belt, the north-eastern highlands and the Lake Victoria Basin.

Average annual precipitation for Tanzania is slightly above 1000 mm, while the mean number of wet days is 128.

CLIMATE TRENDS

Similarly to other Eastern Africa countries, temperature observations indicate that Tanzania has experienced a considerable increase in temperature over recent years. An analysis of climate data from 1970 to 2015 [8] shows an average rise of temperature of around 1°C. Trends for precipitation are not as clear as those for air temperatures, and are variable in time and space.

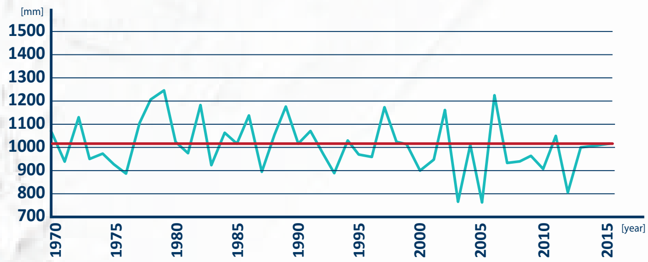
TEMPERATURE AND PRECIPITATION TRENDS IN CURRENT CLIMATE



Mean Annual Temperature

Average of Mean Annual Temperature

Trend Mean Annual Temperature



Annual Precipitation

Average of the Annual Precipitation

RIVERS OF TANZANIA

The United Republic of Tanzania has nine major drainage basins that are the basis for water resources management through nine corresponding basin water boards [7]: Lake Victoria (part of the Nile river basin), Pangani river, Ruvu/Wami river, Rufiji river, Ruvuma river, Lake Nyasa (also called Lake Malawi, part of the Zambezi river basin), Lake Tanganyika (part of the Congo river basin), Lake Rukwa, internal drainage (including lake Natron, Eyasi and Manyara). River discharge and lake levels start rising in November-December and generally reach their maximum in March-April, with a recession period from May to October/November. Many of the larger rivers have flood plains, which extend far inland with grassy marshes, flooded forests and ox-bow lakes [7].

Photo Credit: Rufiji River - Rob from United Kingdom [CC BY 2.0], via Wikimedia Commons

CLIMATE PROJECTIONS FOR TANZANIA

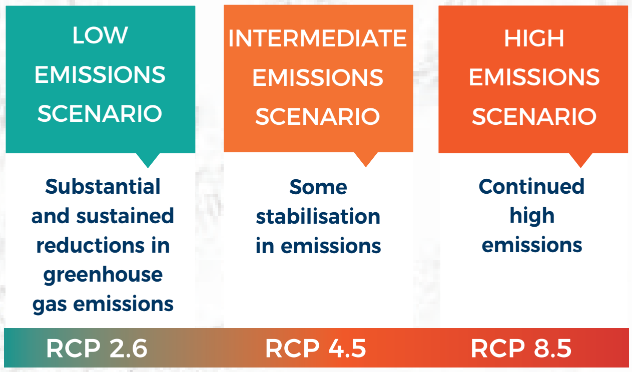
Climate projection studies are abundant for multiple time spans and multiple scales. Climate models are tools that the scientific community uses to assess trends in weather conditions over long periods. In a recent study [9] Alder, et al. have compared the observed temperature and precipitations of the period 1980-2004 with the estimations of a set of global climate models provide by the Coupled Model Intercomparison Project Phase 5 (CMIP5). Three future periods (2025-2049, 2050-2074 and 2071-2095) have been analyzed for different greenhouse emission scenarios (see IPCC's Emissions Scenarios). Model simulations show an increase in temperature in all future projections and emission scenarios, for both short and long term periods. The increase of temperature is more evident in high emissions scenarios and long term period projections. In high emission scenarios (RCP8.5), model projections show an increase between about 2.2˚C and 3˚C for the mid term period (2050-2074) and an increase between about 3˚C and 4.5˚C for the long term period (2071-2095). Future changes in precipitation are much more uncertain, however the models predict a moderate increase in precipitation for both medium and long term periods.

Time Frame	Climate Projections (RCP 8.5 - High emission scenario)
Mid-term Future (2050-2074)	Increase in temperature from 2.2˚C to 3˚C Likely precipitation increase (up to 10%)
Far Future (2071-2095)	Increase in temperature from 3˚C to 4.5˚C Likely precipitation increase (up to 18%)

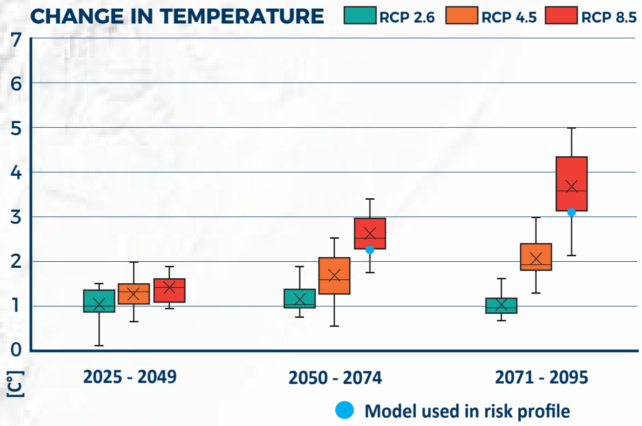
CLIMATE PROJECTIONS USED IN THIS RISK PROFILE

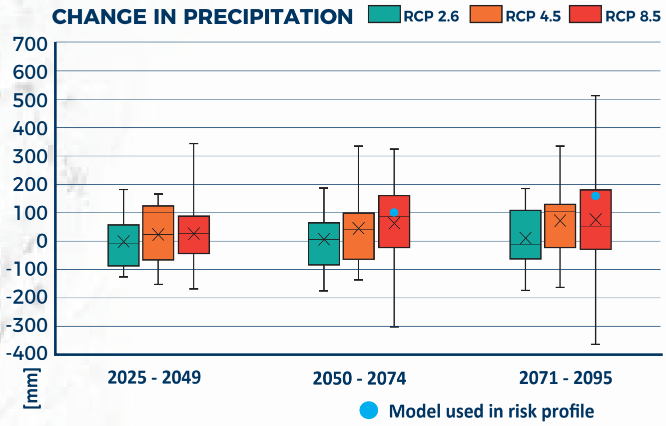
Results presented in the Risk Profile which refer to climate change have been obtained using a climate projection model based on a high emission scenario (SMHI-RCA4 model, grid spacing 0.44˚ about 50 km - driven by the ICHEC-EC-EARTH model, RCP 8.5, 2006-2100). [10, 11, 12]

This study uses a high-resolution model which has been accurately calibrated for the African domain. This allows for a better capture of climate variability which is key in assessing extremes. Regional model projections were checked for consistency against a full ensemble of global models available for the area. The Regional model forecasts changes in temperature and annual precipitation that are in line with the range of variability of global models analyzed in the study by Alder et al.[9].



IPCC's Emissions scenarios for Climate Projections

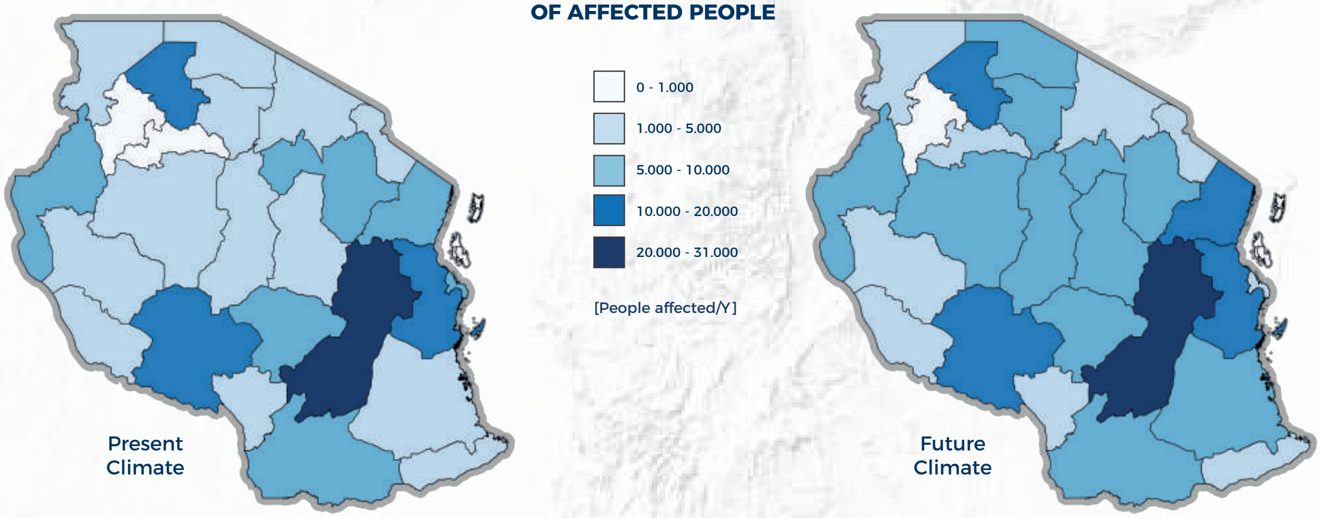




In the specific case of high emission scenario, the Regional model predicts a more moderate temperature rise compared to the global ensemble. On the contrary, as regards to annual precipitation at country level, the Regional model predicts an increase in the long-term period higher than the one predicted on average by the global ensemble.

RESULTS | FLOODS

[B1] ANNUAL AVERAGE NUMBER OF AFFECTED PEOPLE



KEY MESSAGES

● Floods are an extremely impacting natural hazard in UR Tanzania affecting on average almost 150,000 people, about 0.26% of the total population of the Country.

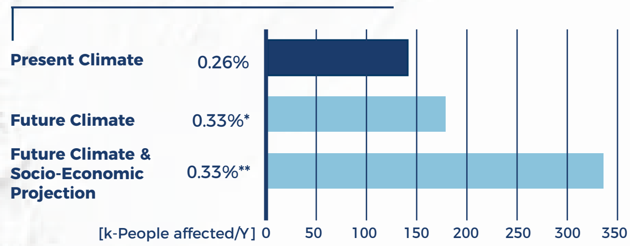
● The distribution of the people potentially affected is rather uniform with one hotspot in the eastern part of the country and specifically in the province Morogoro. This pattern is confirmed in future climate and likely to be even more marked.

● The local economy is heavily exposed to flood. On a yearly average, the areas that are affected by floods produce about 0.45% of the national GDP which corresponds to about 215 Millions USD per year.

● It is likely that, in future climate conditions, the population affected will slightly increase compared to the value evaluated under current climate conditions. However, as shown in the climate section, climate projections are inherently uncertain and this should be considered when using these estimations in policy development. Similar behavior is expected for the potentially affected GDP.

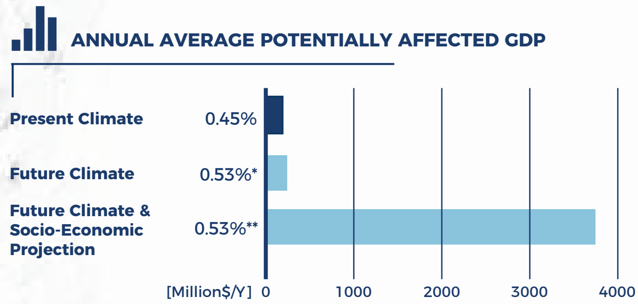
● When population and GDP potentially affected for current climate conditions are compared with estimates under future climate conditions paired with the projected socio-economic situation (*), they show a likely significant increase. Specifically, affected population likely increases up to 2 times and potentially affected GDP increases more than 15 times with respect to estimates in the present climate. The future prediction is affected by uncertainty, however this behaviour calls for a careful planning of the near future development of UR Tanzania that limits the creation of new risk in the country.

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE [B1]



* % computed with reference to the total 2016 Population
** % computed with reference to the total 2050 Population

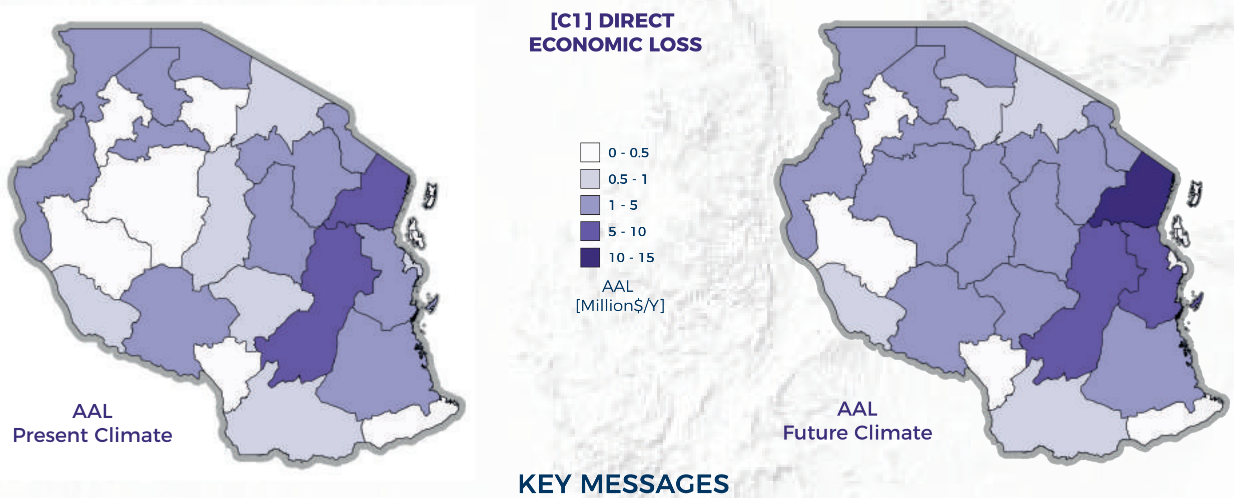
ANNUAL AVERAGE POTENTIALLY AFFECTED GDP



* % computed with reference to the total 2016 GDP
** % computed with reference to the total 2050 GDP

*2016 was taken as a reference year both for GDP and population.
**the Shared Socioeconomic Pathway (SSP) - 2 "mid of the road" (Medium challenges to mitigation and adaptation) has been used to project population and GDP distributions.

RESULTS | FLOODS



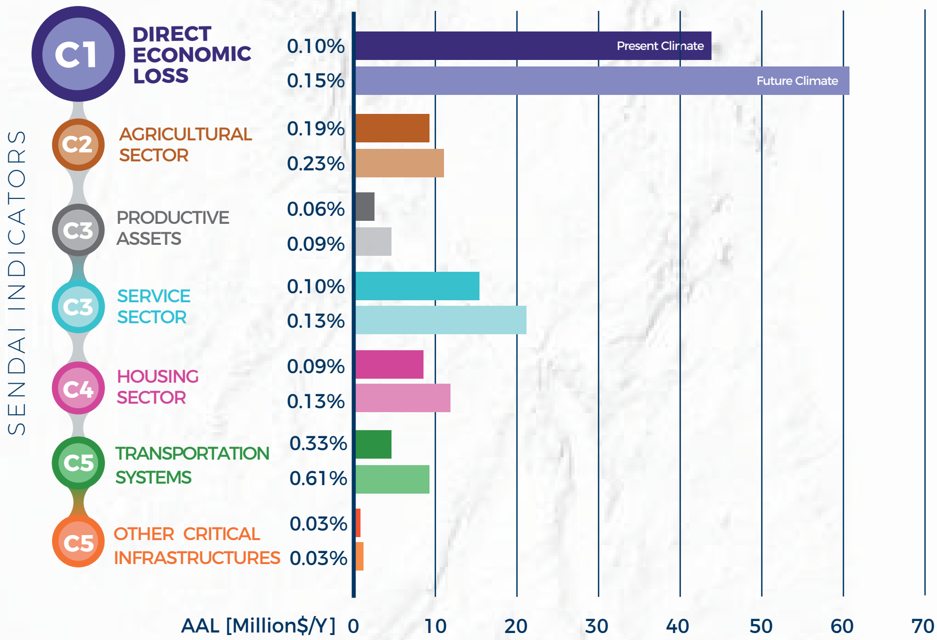
KEY MESSAGES

● The direct economic losses in UR Tanzania result from a complex combination of hazard and exposure geographical distribution. The regions more significantly affected by floods are concentrated in the eastern part. The pattern is substantially confirmed under future climate conditions with three provinces that stem out clearly: Morogoro, Pwani and Tanga provinces.

● The value of direct economic losses in terms of AAL sums up to almost 44 millions of USD that roughly accounts to 0.10 % of the total capital stock value in present climate. The larger portion of losses is due to the housing, service and agricultural sectors.

● In relative terms, the most affected sectors are the transport and the agricultural sector.

● Even considering the present exposed assets, without socio-economic development, the direct economic loss shows a significant increase when climate change is considered, this increase is evenly observable in all sectors. The socio-economic projections are likely to increase this figure, even more, depicting a strongly enhanced risk scape for UR Tanzania in the near future.

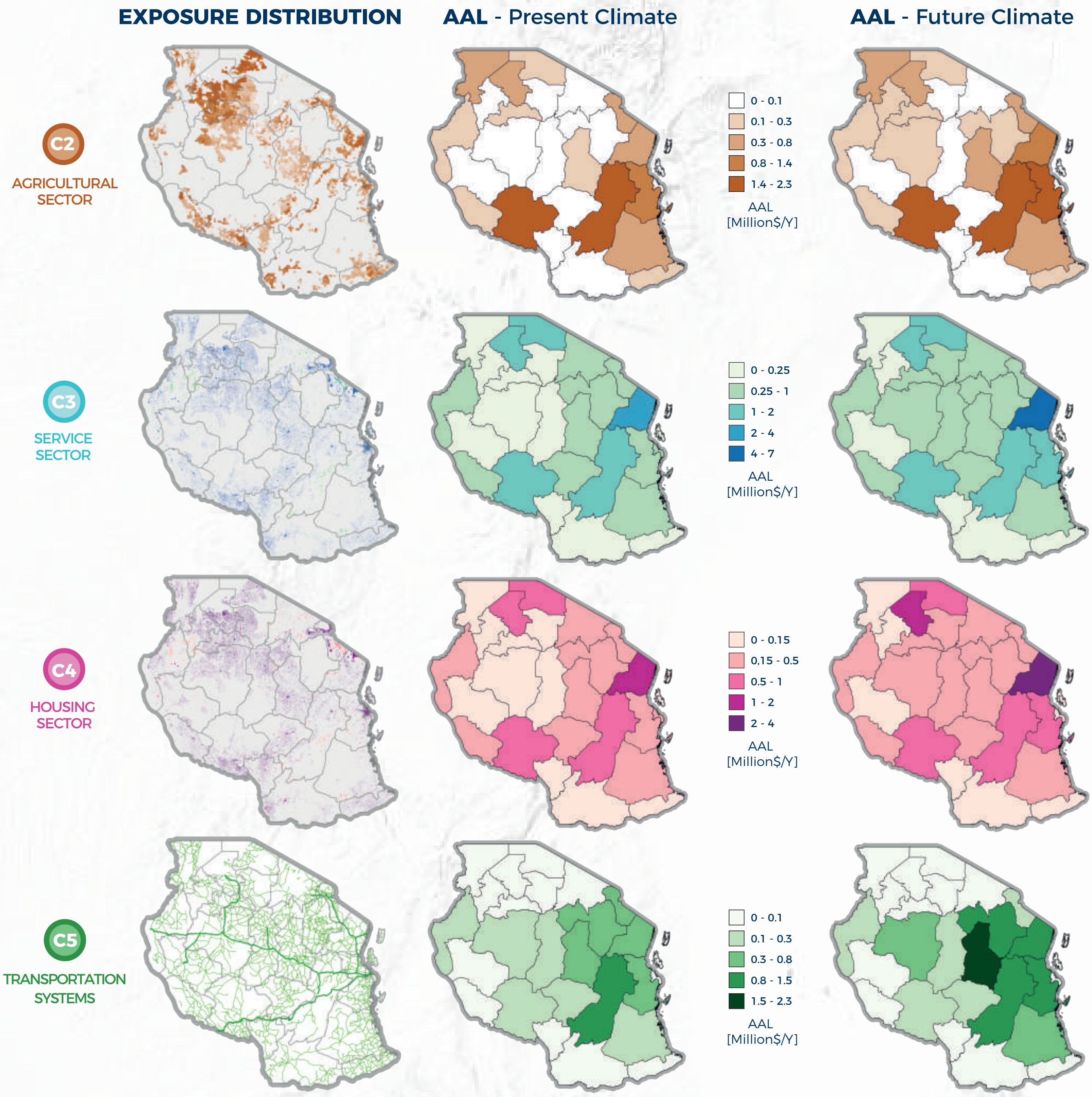


AFFECTED INFRASTRUCTURES [D4]

RESULTS | FLOODS

KEY MESSAGES

- The AAL distribution shows minor differences across the sectors considered depending on the exposure distribution. While Morogoro always remains the most impacted province, the pattern of risk for the other provinces depends more on the sector considered.
- Comparison of AALs for all sectors between present and future climate shows that a significant increase is to be expected in all provinces especially in the central part of the country.



RESULTS | FLOODS

KEY MESSAGES

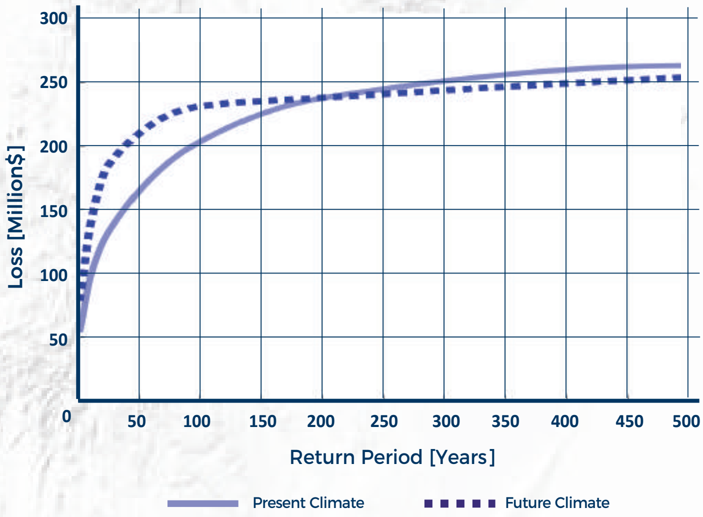
- Although Average Annual Loss is about 44 million USD, the likelihood of a 70 million loss from floods is on average once every 5 years. This means that considerable losses may be experienced frequently. The likelihood of disaster losses of about 200 USD is on average once in 100 years.

- The sectors that are most affected by frequent, very frequent and extreme losses are housing, service and agriculture. The share for transportation system is also significant throughout the different frequencies.

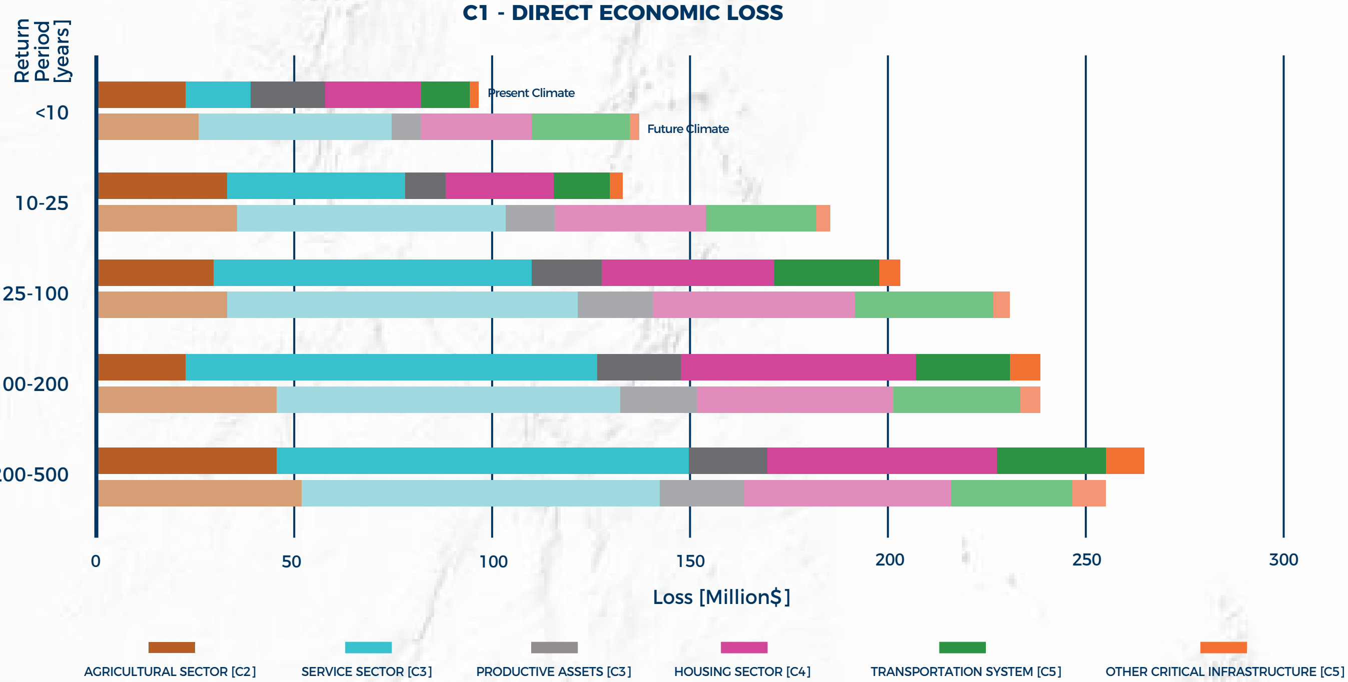
- It is likely that very frequent and frequent flood-related losses will heavily increase under future climate conditions while the extreme losses seem to have a smaller impact in future. Given the high level of uncertainty in future climate prediction, worse scenarios may also be possible (compare climate section on p.8).

- The specific shape of the PML curve, especially the one in present climate, shows that flood risk can be considerably reduced by strategically minimizing the impact of very frequent and frequent disaster events, hence by investing in disaster risk reduction.

PROBABLE MAXIMUM LOSS CURVE (PML)
C1 - DIRECT ECONOMIC LOSS

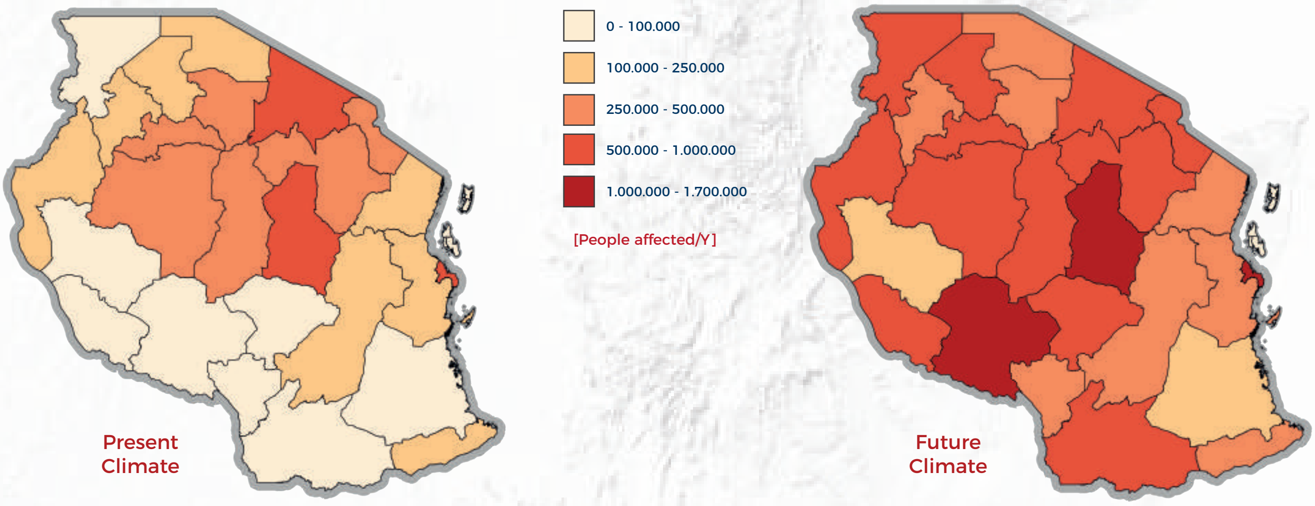


PROBABLE MAXIMUM LOSS CURVE (PML) ACROSS ALL SECTORS
C1 - DIRECT ECONOMIC LOSS



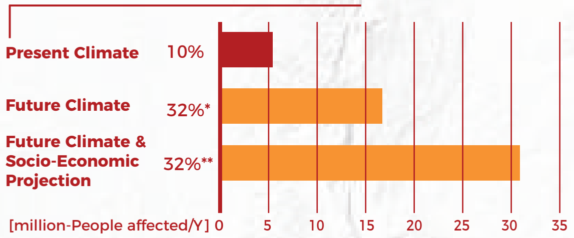
RESULTS | DROUGHTS

[B1] ANNUAL AVERAGE NUMBER OF AFFECTED PEOPLE



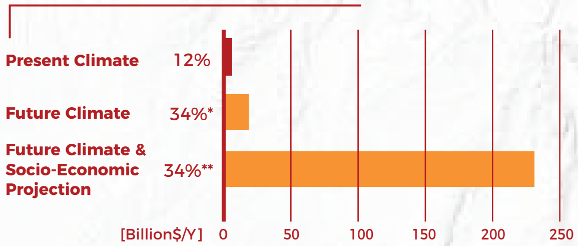
Annually average of population potentially affected by at least three months of drought conditions, as calculated using the standardized precipitation-evapotranspiration index (SPEI) and using a 3-month accumulation period.

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE [B1]



* % computed with reference to the total 2016 Population
** % computed with reference to the total 2050 Population

ANNUAL AVERAGE POTENTIALLY AFFECTED GDP



* % computed with reference to the total 2016 GDP
** % computed with reference to the total 2050 GDP

KEY MESSAGES

- With respect to present conditions (1951-2000 climate), the probability of occurrence of severe drought (precipitation – evapotranspiration deficiency) will increase (+50%) under future climate (2050-2100 climate). This increased drought hazard is country-wide but will mainly occur in areas which are currently already hard hit.

- Under present climate, on average some 5.5 million people (10% of the total 2016 Population) are annually affected by droughts. Under future climate conditions, this number is expected to increase up to 32% (on average 31 million people if population growth is accounted for).

- Under present climate, the average annual percentage of drought-affected GDP (i.e. the economic value produced in areas hit by droughts) is about 12% of the total GDP. This is equivalent to about 5.6 billion USD per year which could be impacted by droughts. Under future climate conditions, drought-related losses may rise to 34% of the GDP, which could mount to 15 billion or even more than 230 billion USD per year, if socio-economic projections are included.

RESULTS | DROUGHTS

KEY MESSAGES

- Under present climate conditions, affected livestock (i.e. animals living in areas hit by droughts) counts 1.5 million units (11%). Under future climate conditions (but keeping the current amount of livestock), the number of affected livestock is projected to increase to more than 4 million livestock units (33% of the total). At present, most of the livestock in areas affected by drought is situated in the northeast region of Tanzania, whereas under future climate conditions, the rest of the country is also likely to see large numbers of livestock being affected by drought.

- Under present climate, agricultural crop losses are dominated by two crops (cassava and maize). The losses of eight crops will decrease under the future climate compared to the present climate, whereas only for banana it will increase. Highest relative loss amounts to 3.4% of the average crop production (bean under present climate). Relative losses of maize, rice and sorghum will decrease most compared to the other crops to less than one third of their values under present climate.

- Economic crop production losses are concentrated in 16 regions in the north eastern part of Tanzania under present climate conditions. Under future climate conditions, this spatial pattern changes completely. Most losses under future climate are found in seven regions near the border in the west, south and east, while in the centre of Tanzania losses are very low.

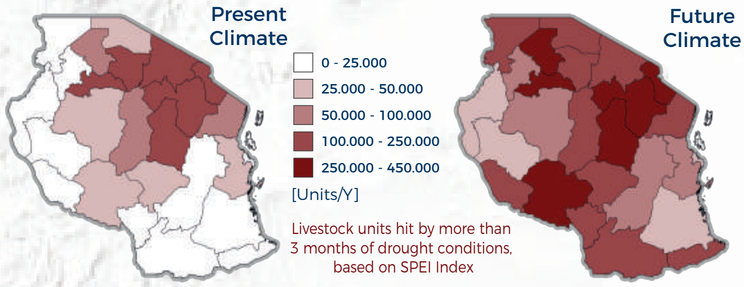
- Consistent with the decreases in crop production losses, the amount of lost working days also decreases between present and future climate. In total about 3.2 million (present) and 1.3 million (future) working days are lost, which is only 0.36% and 0.14% of the average number of working days. However, the number of working days lost, expressed as a percentage of the average amount of days required for harvesting, is approximately 6 times higher.

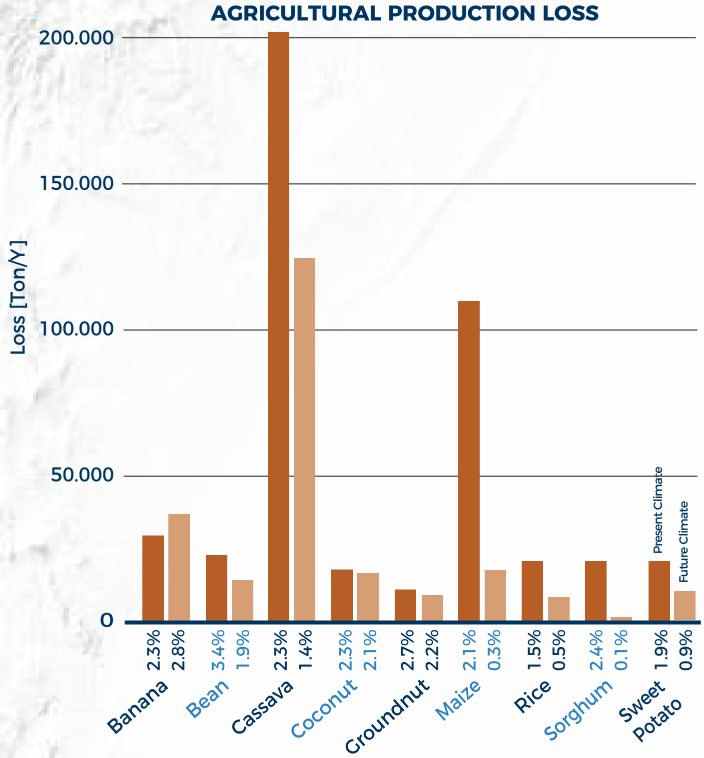
ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED LIVESTOCK UNITS* [k-Livestock units]

1470 | 11% — Present climate

4340 | 33% — Future climate

*Livestock is a summation of all livestock animals (referred to as livestock units) using FAO conversion factors



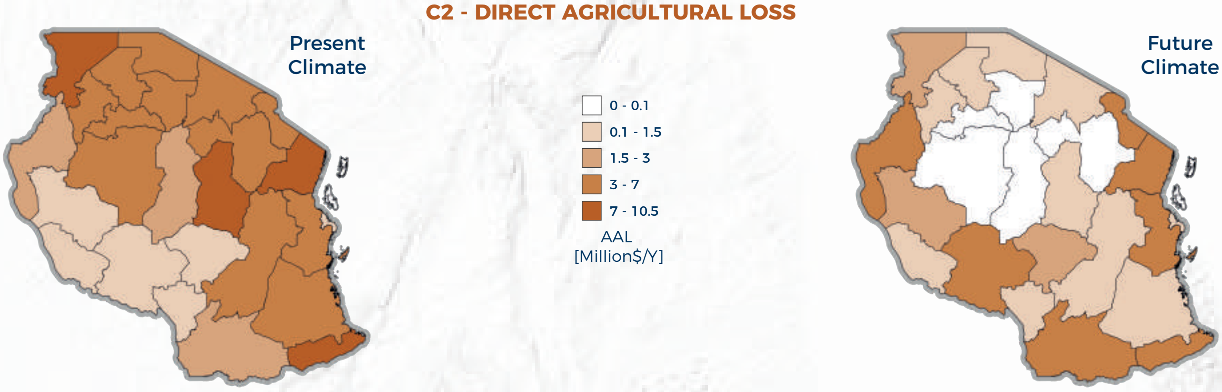


ANNUAL AVERAGE NUMBER OF WORKING DAYS LOST [k-Days]

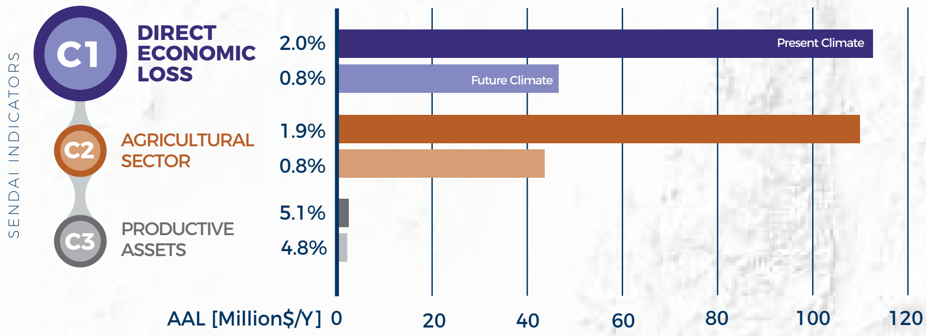
3165 | 0.36% — Present climate

1250 | 0.14% — Future climate

C2 - DIRECT AGRICULTURAL LOSS



RESULTS | DROUGHTS



C2 is computed considering only direct loss associated with reference agricultural (crop) production. Reference crops considered in the analysis are the ones which contribute to at least 85% of the total country-level gross crop production value. It might therefore happen that crops which have an important role in local commercial or substitance agriculture can be neglected in the overall analysis.
C3 is computed considering exclusively losses in hydropower production. These are defined as production below levels with average reservoir conditions.

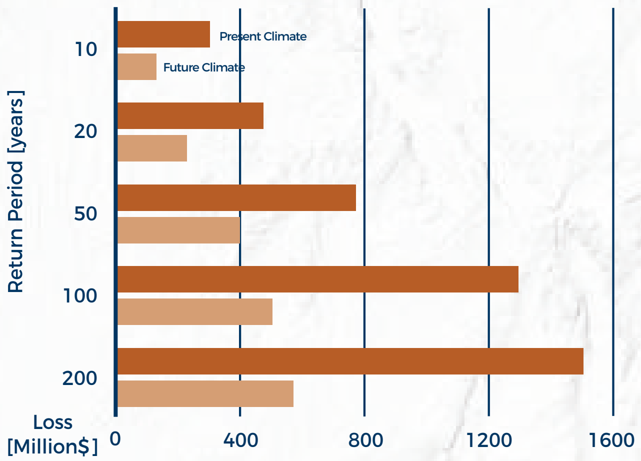
KEY MESSAGES

Average annual economic crop production loss (C2) is more than halved from circa 110 million USD under present climate conditions to circa 45 million USD under future climate conditions. These losses represent 1.9% and 0.8% of the average economic value of crop production, respectively for present and future climate conditions.
The direct economic loss (C1), expressed as average annual value, is dominated by the loss in the agricultural sector (C2), and therefore also decreases under the future climate conditions compared to the present climate conditions.

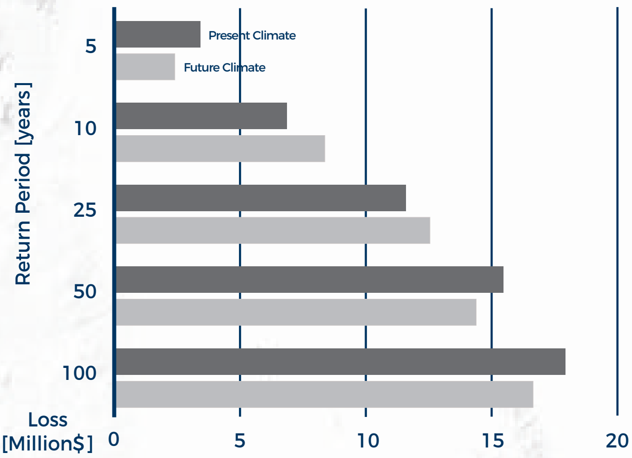
- Under current climate conditions, a gradual increase in agricultural (crop) income loss is expected when return periods go up from 10 to 200 years. Under future climate conditions, significant lower losses are calculated for all return periods, with decreases of almost 50% and more.

- Hydropower losses are projected to change little overall in the future for Tanzania. This is a net result of increased losses in the north (Nyumba ya Mungu dam), and slightly reduced losses in the Great Ruaha river (Mtera and Kidatu dams).

PROBABLE MAXIMUM LOSS (PML)
C2 - AGRICULTURAL LOSS

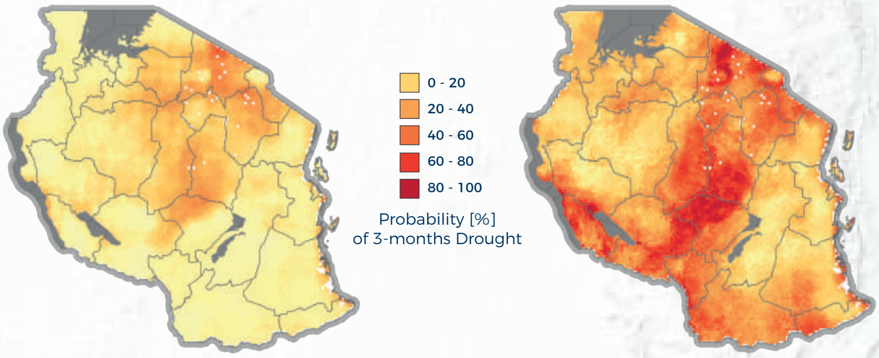


PROBABLE MAXIMUM LOSS (PML)
C3 - PRODUCTIVE ASSETS (HYDROPOWER LOSS)



RESULTS | DROUGHTS

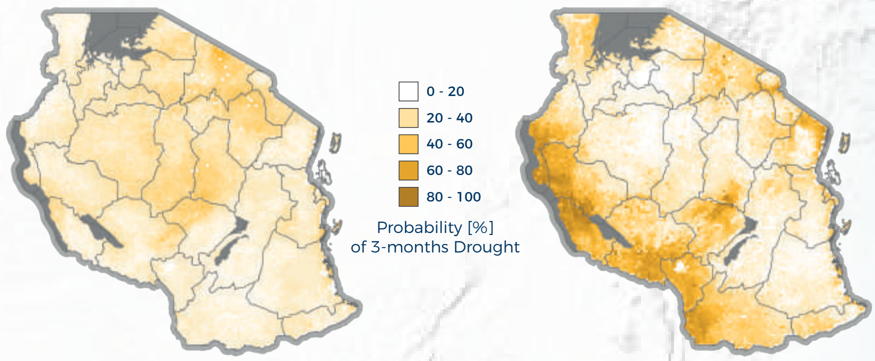
Present Climate **Future Climate**



SPEI

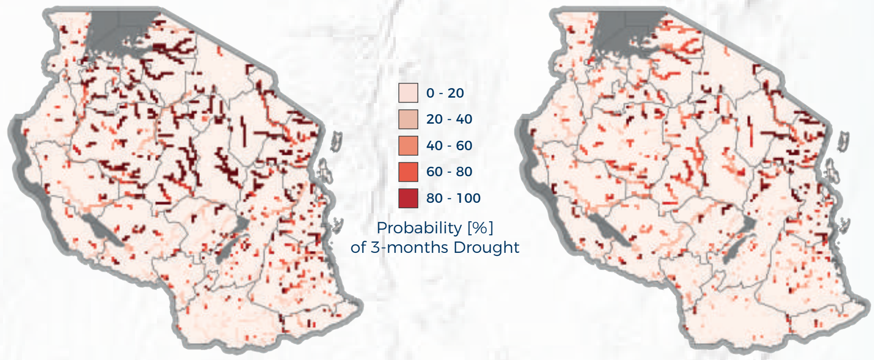
Standardised Precipitation-Evapotranspiration Index

These maps denote the average annual chance of a meteorological drought occurring (%). Droughts are defined as 3 months of precipitation minus evapotranspiration values considerably below normal conditions; calculated through the Standardized Precipitation - Evapotranspiration Index (SPEI; see 'Drought' in Glossary). It can be noted that the probability of droughts is the highest in the semi-arid great rift valley of Tanzania. This is particularly important for areas dependent on rainfall for their water resources.



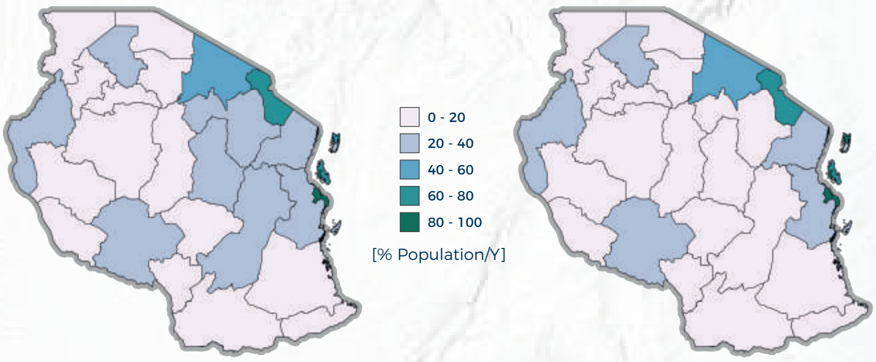
SSMI - Standardised Soil Moisture Index

These maps denote the average annual chance of a subsurface drought occurring (%). Droughts are defined as 3 months of soil moisture conditions considerably below normal conditions; calculated through the Standardized Soil Moisture Index (SSMI; see 'Drought' in Glossary). In the central and south western regions, the probability of droughts will increase the most. This is particularly important for agricultural areas and nature.



SSFI - Standardised Streamflow Index

These maps denote the average annual chance of a hydrological drought occurring (%). Droughts are defined as 3 months of stream flow levels considerably below normal conditions; calculated through the Standardized StreamFlow Index (SSFI; see 'Drought' in Glossary). The probability of droughts in the upstream reaches of rivers is expected to lower. This is particularly important for areas dependent on rivers for their water resources.



WCI - Water Crowding Index

These maps show the percentage of the population per province experiencing water scarcity, based on the water available (precipitation minus evapotranspiration) per person per year (<1000 m^3/person/year). Water scarcity indicates that a population depends on water resources from outside their immediate region (~85 km^2). The highest percentage of population under water scarcity is in the warm and (semi-)arid and highly populated Arusha and Kilimanjaro regions, and around Dar Es Salaam, where more than half of the population unable to be self-sufficient in water.

PROBABILISTIC RISK ASSESSMENT FOR RISK MANAGEMENT

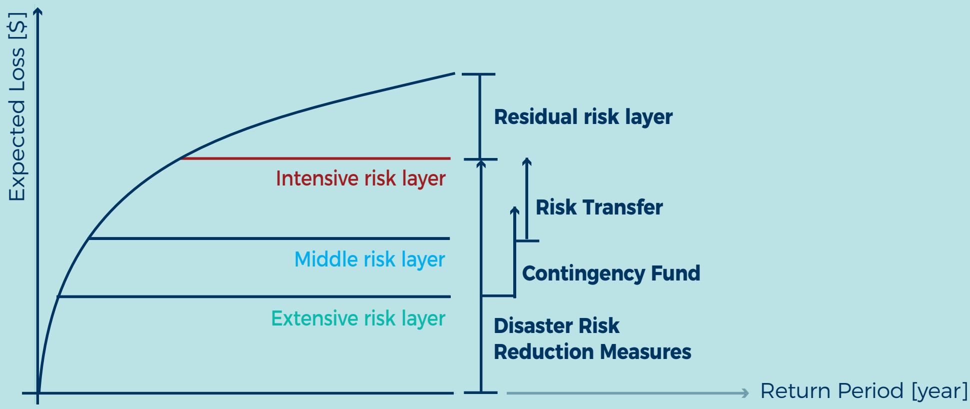
METRICS FOR RISK MANAGEMENT

Risk information may be used to put in place a broad range of activities to reduce risk. Such measures range from improving building codes and designing risk reduction measures, to undertaking macro-level risk assessments used to prioritise investments. Risk metrics help discern the risk contribution of different external factors (such as demographic growth, climate change, urbanization expansion, etc.). They also provide a net measure of progress in the implementation of disaster risk reduction policies. Average Annual Loss (AAL) can be interpreted as an opportunity cost. This is because resources set aside to cover disaster losses could be used for development. Monitoring AAL in relation to other country economic indicators – such as the GDP, capital stock, capital investment, reserves, and social expenditure – provides an indication of a country's fiscal resilience, broadly defined as comprising internal and external savings to buffer against disaster shocks. Economies can be severely disrupted if there is a high ratio of AAL to the value of capital stock. Similarly, future economic growth can be compromised if there is a high ratio of AAL to capital investment and reserves. Social development will be challenged if there is a high ratio of AAL to social expenditure. Moreover, limited ability to recover quickly may significantly increase indirect disaster losses. Countries that already have compensatory mechanisms such as effective insurance in place and that can rapidly compensate for losses will recover far more quickly than those that do not. Such mechanisms may include insurance and reinsurance, catastrophe funds, contingency financing arrangements with multilateral finance institutions, and market-based solutions such as catastrophe bonds (UNISDR, 2011 and 2013).

The PML curve is particularly useful in order to articulate a full DRR strategy. The PML curve describes the loss that can be experienced for a given return period. Knowing the different level of losses expected on a certain frequency can help to understand how to organise a strategy combining different risk reduction, mitigation, or avoidance actions.

PML CURVE

The PML curve can be subdivided into three main layers. The Extensive Risk Layer is typically associated with risk reduction measures (e.g. flood defences, local vulnerability reduction interventions). The Mid Risk Layer captures cumulative losses from higher impact events. Losses within this layer are commonly mitigated using financial funds which are managed at country level, such as the contingency fund. Losses which constitute the Intensive Risk Layer (severe and infrequent hazard events) are difficult to finance at country level. Mechanisms of risk transfer are therefore required to address losses associated with this Intensive Risk layer (e.g. insurance and reinsurance measures). The remaining layer of the curve is Residual Risk (catastrophic events). It is the risk that is considered acceptable/tolerable due to the extreme rarity of such events and associated loss levels. Given its rarity, there are no concrete actions to reduce risk beyond preparedness (e.g. civil protection actions, humanitarian aid coordination).



GLOSSARY & REFERENCES

AFFECTED PEOPLE and GDP
Affected people are the ones that may experience short-term or long-term consequences to their lives, livelihoods or health and in the economic, physical, social, cultural and environmental assets. In the case of this report "affected people from Floods" are the people living in areas experiencing a flood intensity (i.e. a flood water level) above a certain threshold. Analogously, in this report "affected people from Droughts" are the people living in areas experiencing a drought intensity (i.e. a SPEI value) below a certain threshold. The GDP affected has been methodologically defined using the same thresholds both for floods and droughts.

AVERAGE ANNUAL LOSS (AAL)*
Average Annual Loss (also Average Damage per year) 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.

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. Climate models are applied as a research tool to study and simulate the climate, and for operational purposes, including monthly, seasonal, and interannual climate predictions.

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. Droughts, which can occur everywhere, should not be confused with aridity, a permanent climate condition.
In this profile drought hazard is denoted by various indicators, covering a range of drought types. Drought conditions are defined as months with standardised index values below a threshold varying between -0.5 and -2, according to the aridity index of that area. Humid areas have low thresholds, corresponding with the driest 2% of months as found in the period 1951-2000, while semi-arid and arid areas have thresholds linked to respectively the driest 6% and 15% of this reference period (assessed for each month separately).
Droughts are analysed in terms of hazard, exposed population, livestock and GDP, and losses are explicitly estimated for crop production and hydropower generation.

FLOOD*
Flood hazard in the risk assessment includes river (fluvial) flooding and flash flooding. This risk profile document considers mainly fluvial flooding and flash floods in the main urban centres. Fluvial flooding is estimated at a resolution of 90 m using global meteorological datasets, a global hydrological model, a global flood-routing model, and an inundation downscaling routine. Flash flooding is estimated by deriving susceptibility indicators based on topographic and land use maps. Flood loss curves are developed to define the potential damage to the various assets based on the modelled inundation depth at each specific location.

LOSS DUE TO DROUGHT (CROPS)
Economic losses from selected crops result from multiplying gross production in physical terms by output prices at farm gate. Losses in working days have been estimated as function of crop-specific labour requirements for the cultivation of selected crops. Annual losses have been computed at Admin 1 level as the difference relative to a threshold, when an annual value is below this threshold. The threshold equals the 20% lowest value from the period 1951-2000 and has also been applied for the future climate. Losses at national level have been estimated as the sum of all Admin 1 losses.

PROBABLE MAXIMUM LOSS (PML)*
PML is the value of the largest loss that could result from a disaster in a defined return period such as 1 in 100 years. The term PML is always accompanied by the return period associated with the loss.

RESIDUAL RISK*
The 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.

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.

RETURN PERIOD*
Average frequency with which a particular event is expected to occur. It is usually expressed in years, such as 1 in X number of years. This does not mean that an event will occur once every X numbers of years, but is another way of expressing the exceedance probability: a 1 in 200 years event has 0.5% chance to occur or be exceeded every year.

**UNISDR terminology on Disaster Risk Reduction: https://www.unisdr.org/we/inform/publications/7817*

GLOSSARY & REFERENCES

RISK*
The combination of the probability of an event and its negative consequences. While in popular usage the emphasis is usually placed on the concept of chance or possibility, in technical terms the emphasis is on consequences, calculated in terms of "potential losses" for some particular cause, place, and period. It can be noted that people do not necessarily share the same perception of the significance and underlying causes of different risks.

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.

**UNISDR terminology on Disaster Risk Reduction: https://www.unisdr.org/we/inform/publications/7817*

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www.preventionweb.net/resilient-africa

www.unisdr.org

RISK PROFILES ARE AVAILABLE AT:

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