Flood   Drought

Zambia

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

Building Disaster Resilience in Sub-Saharan Africa

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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, Ghana, Guinea Bissau, Kenya, Kingdom of Eswatini, 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.

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. A realistic set of all possible hazardous events (scenarios) that may occur in a given region, including very rare, catastrophic events, is simulated. For each event, potential impacts are computed in terms of economic losses or number of people and assets affected, considering publicly available information on Hazard, Exposure, and Vulnerability. Finally, statistics of losses are computed and summarised through proper quantitative economic risk metrics, such as: 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 are explicitly quantified and taken into account: uncertainties in the hazard forcing, uncertainties in the 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, the AAL also accounts for much larger losses that occur less frequently. As such, AAL represents the funds that would be required annually in order to cumulatively cover the average disaster loss over time.

Probable Maximum Loss (PML) describes the maximum loss that could be expected corresponding to a given likelihood, expressed in terms of annual probability of exceedance or its reciprocal, the return period. For example, 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 that, for instance, 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 same 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).
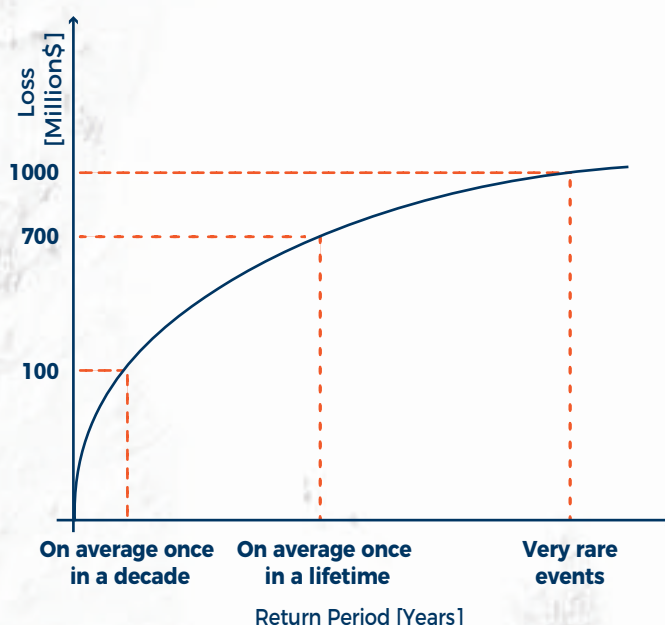
PROBABILISTIC RISK PROFILE: RISK COMPONENTS

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.

A modelling chain composed of climate, hydrological, and hydraulic models using all the available information, in terms of rainfall, temperature, humidity, wind, and solar radiation, 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.
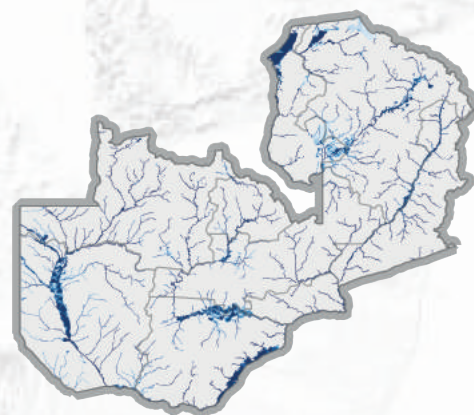
Flood hazard map for 1 in a 100 years probability evaluated under current climate conditions, the scale of blues represents different water depth values.
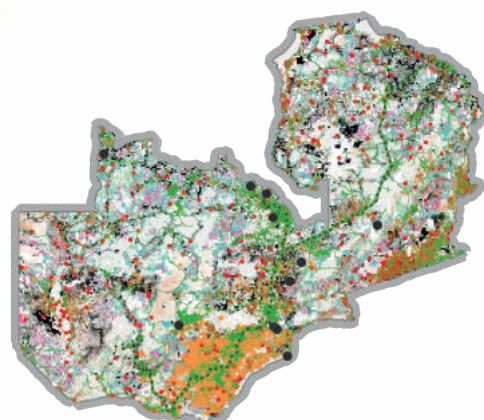
VULNERABILITY

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.

The direct losses on the different elements at risk are evaluated applying vulnerability functions, which link the hazard intensity to the expected loss (economic loss or number of affected people), considering also the associated uncertainty. Vulnerability functions are differentiated for each typology of exposed element and take into account local factors, such as typical constructive typologies for infrastructures or the crop seasonality for the agricultural production. For flood, vulnerability is a function of the water depth. The only exception is represented by agricultural production, for which it is a function of the season in which the flood is occurring. In the case of agricultural drought, the 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, when the loss of hydropower production is evaluated.

EXPOSURE

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

The losses caused by floods and droughts are evaluated on population, GDP and a series of critical sectors (education, health, transport, housing, and productive and agricultural sectors). The critical 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]

COUNTRY CLIMATE OUTLOOK

OVERVIEW

Zambia has a predominantly humid subtropical climate with small patches of semi-arid steppe in the southwest of the country. Three climate regions are recognized based on rainfall dynamics and vegetation:

- Tropical savannas covering the country's major valleys, including the driest areas of Zambia, with annual rainfall below 600 mm. This is Zambia's most arid region.
- Warm semi-arid climates of the Sandveld plateau, the southern provinces of the Kalahari sand plateau and the Zambezi floodplains of the western province; annual rainfall is 800–1000 mm.
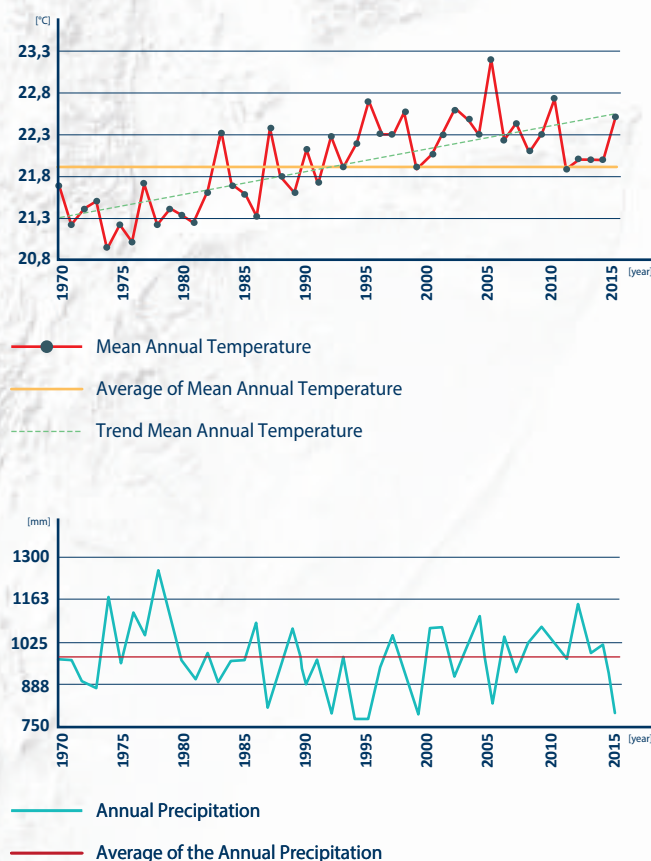- Humid subtropical climates characterized by annual rainfall above 1200 mm and by highly leached soils.

Despite these differences, all regions experience the same seasons: a hot and dry season from August to November, a wet season from November to April and a cool and dry season from May to August [1]. The highest summer rainfall occurs in the north-east parts of the country, and gradually decreases towards the south-west [2].

CLIMATE TRENDS

Similarly to other countries in Southern Africa, temperature observations indicate that Zambia has experienced a considerable increase in temperature over recent years. An analysis of climate data from 1970 to 2015 [3] shows an average rise of temperature of around 1˚C. Trends for precipitation are not as clear as those for air temperature, and are variable in time and space.

Average annual precipitation for Zambia is approximately 975 mm, while the mean number of wet days is around 92.

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 ZAMBIA

Zambia is drained by two major river basins: the Zambezi, flowing in the centre, west and south and covering about three-quarters of the country; the Congo basin in the north, covering the remaining quarter. A very small area in the northeast is part of the internal drainage basin of Lake Rukwa, which is located in Tanzania. The Zambezi River is the fourth-longest river in Africa (2,500 km). The area of its basin is 14 million of km², slightly less than half of the Nile's. In the Zambezi basin, there are a number of major rivers flowing wholly or partially through Zambia: the Kabompo, Lungwebungu, Kafue, Luangwa, and the Zambezi itself, which runs through the country in the west and then forms deep valleys and waterfalls such as Victoria Falls on the southern border with Zimbabwe. The Luapula and the Chambeshi Rivers feed the Congo River in the north. Much of the water flowing into the Congo River is barely utilized, while the Zambezi is highly used for various purposes, including irrigation and hydropower generation [4].

Photo Credits: Brian J. McMorrow - Luangwa River

CLIMATE PROJECTIONS FOR ZAMBIA

There is a wealth of climate projection studies over multiple time spans and multiple scales. Climate models are tools that the scientific community uses to assess the trends of weather conditions over long periods. In a recent study [5], temperature and precipitation changes from global climate models of the Coupled Model Intercomparison Project Phase 5 (CMIP5) were reported. For different greenhouse emission scenarios (see IPCC's Emissions Scenarios), three future periods (2025-2049, 2050-2074 and 2071-2095) were compared against the reference period 1980-2004.

In all periods, models show an increase of temperature from low to high emissions scenarios. This is more evident in long term period projections.

In the high emission scenario (RCP 8.5), model projections show an increase between 2°C and 4°C for the mid term period (2050-2074) and an increase between 2.5°C and 6°C for the long term period (2071-2095).
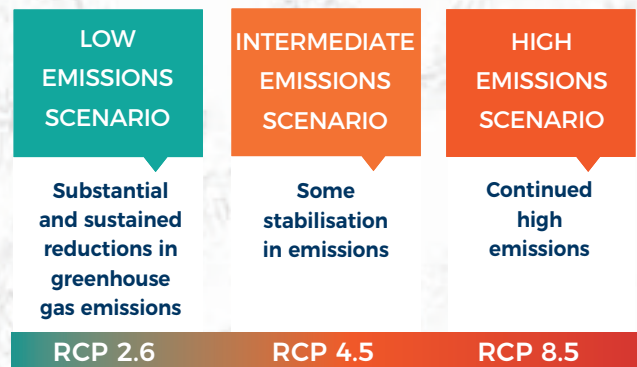
Considering the change in precipitation for all the emission scenarios and all the considered time periods, a clear trend cannot be identified.

Time Frame	Climate Projections (RCP 8.5 - High emission scenario)	
Mid-term Future (2050-2074)	+	Increase in temperature from 2°C to 4°C
		divergent change in precipitation (from -25% to +15%)
Far Future (2071-2095)	+	Increase in temperature from 2.5°C to 6°C
		divergent change in precipitation (from -25% to +20%)

CLIMATE PROJECTIONS USED IN THIS RISK PROFILE

The results of the Risk Profile referring 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) [6, 7, 8].

In this study, it was decided to use a high-resolution model, accurately calibrated on the African domain, to better capture climate variability, important for assessing extremes. Regional model projections were checked for consistency against the full ensemble of available global models in the area. The model forecasted changes in temperature and annual precipitation by the end of the century, in line with the range of variability of the global models analyzed in the study by Alder and Hostetler [5].

LOW EMISSIONS SCENARIO	INTERMEDIATE EMISSIONS SCENARIO	HIGH EMISSIONS SCENARIO
Substantial and sustained reductions in greenhouse gas emissions	Some stabilisation in emissions	Continued high emissions
RCP 2.6	RCP 4.5	RCP 8.5

IPCC's Emissions scenarios for Climate Projections

CHANGE IN TEMPERATURE

Model used in risk profile

CHANGE IN PRECIPITATION

Model used in risk profile
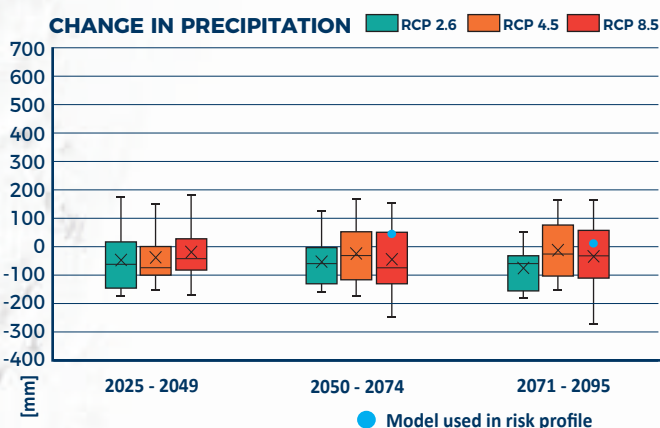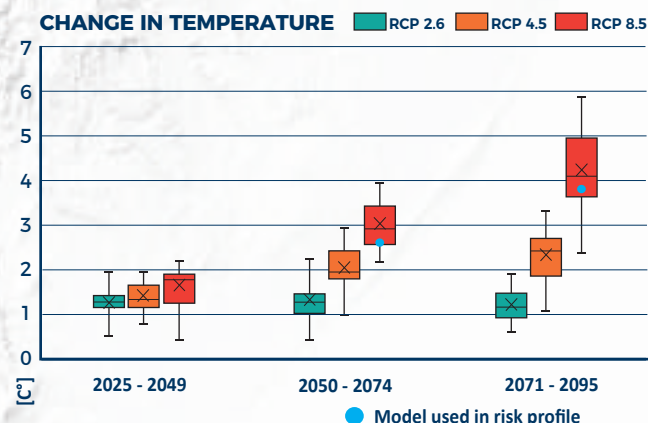
The high emission scenario was maintained as representative of the worst climate change scenario, enabling the analysis of a full range of possible changes. However, in this specific case, the regional model predicts a more moderate increase in temperature (almost 4° C in the long term future), with respect to the global ensemble. As regards to annual precipitation at country level, almost no changes are predicted by the regional model in the far future.

COUNTRY SOCIO-ECONOMIC OUTLOOK

OVERVIEW

Large and landlocked in the center of southern Africa, Zambia population is about 16.6 million (2016). Zambia is one of the largest copper producer in Africa and exports foster a rapid economic growth before 2014[2]. Before 2014, Zambia's real GDP growth was averaging roughly 6.7% per annum, though growth slowed during the period 2015 to 2017, due to falling copper prices, reduced power generation, and depreciation of the kwacha [9]. In 2017, Zambia's economic growth recovered to an estimated 3.9% (from 3.8% in 2016) on the back of a bumper crop harvest and better electricity supply [10]. Anyway Zambia's lack of economic diversification and dependency on copper as its sole major export makes it vulnerable to fluctuations in the world commodities market and prices. Rural poverty and high unemployment levels remain significant problems, although recent strong economic growth bodes well for a general improvement of life conditions [11].

PROJECTIONS

Recently, climate scientists and economists have built 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 [12,13]. The scenarios range from relatively optimistic trends for human development, with "substantial investments in education and health, rapid economic growth and well-functioning institutions" [14], to more pessimistic economic and social development, with little investment in education or health in poorer countries, coupled with a fast-growing population and increasing inequalities.

SOCIO-ECONOMIC PROJECTIONS
USED IN THE RISK PROFILE

The "middle of the road" scenario envisages that historic development patterns will persist throughout the 21st century. The results shown in this report refer to this scenario. According to these conditions, the population of Zambia in 2050 will roughly double compared to 2016 (World Bank Data), whereas GDP is expected to increase by eleven-fold.

POPULATION

2016 Projection
16.591
[Million People]
30.104
2050 Projection

GDP

2016 Projection
20.955
[Billion$]
236.271
2050 Projection

ZAMBIA

AREA : 743.390 km²

POPULATION DENSITY : 24 people/km²

MEDIAN AGE : 17 years

HUMAN DEVELOPMENT INDEX : 0.58

LIFE EXPECTANCY AT BIRTH : 61.9 years

MEAN YEARS OF SCHOOLING : 6.9 years

EMPLOYMENT TO POP. RATIO (AGES > 15) : 69%

EMPLOYMENT IN AGRICULTURE : 53.3%

EMPLOYMENT IN SERVICES : 34.8%

data from:
http://hdr.undp.org/en/countries/profiles/
https://data.worldbank.org/indicator/
http://www.worldometers.info

A "SENDAI DRIVEN" PRESENTATION

The Sendai Framework guides the organisation of the risk profile results.

The first page of results refers to Sendai Framework Target B: "Substantially reduce the number of affected people globally by 2030" and specifically to Sendai indicator B1: "Number of directly affected people attributed to disasters". In the following pages, indicators that contribute to other Sendai Framework Targets are reported.

Indicators that contribute to increasing knowledge of the country on Sendai Framework Target C: "Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030" are considered.
The indicator C1 "Direct economic loss attributed to disasters" is computed as a compound index of several indicators computed in a fully probabilistic manner in this study that can be reconciled to the Sendai indicators.

In the case of flood, Target C is addressed in the second page and the indicators used are:
·C2 Direct agricultural loss attributed to disasters (based on different return periods. the main crops).
·C3 Direct economic loss to all other damaged or destroyed productive assets attributed to disasters. In this risk profile, C3 is split into two components: productive assets (industrial buildings and energy facilities) and service sector (governmental and service buildings).
·C4 Direct economic loss in the housing sector attributed to disasters.
·C5 Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters. In this risk profile C5 is split into two components: transportation systems (roads and railways) and other critical infrastructures (health and education facilities).

Sendai Framework Target D: "Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030" is also addressed. The count of affected critical infrastructures (e.g. health and education facilities and kilometres of transportation network) is provided.

In the third page of results for floods, the most relevant sectors for the country are selected and their AAL distribution is presented in present and future climate conditions in relation to the exposure distribution considered in the study. The results are broken down on the fourth and final page

according to different return periods and presented in terms of PML curve of the total damage across all sectors. The contribution of the different sectors is highlighted in each range of return periods of the total damage.

In the case of drought, the second page reports the spatial distribution of main effects on GDP, livestock units, percentage of population experiencing water scarcity, and agricultural (crop) losses; the latter map can be associated to indicator C2.

In the third page, the following indicators related to Target C are reported:
·C2 Direct agricultural loss attributed to disasters (based on the main crops).
·C3 Direct economic loss to all other damaged or destroyed productive assets attributed to disasters. In these calculations, only hydropower losses are assessed in the context of drought.

In the fourth page the result derived in economic terms for income losses due to lack of agricultural production and loss of Hydropower production are broken down according to different return period.

C1 DIRECT ECONOMIC LOSS
C2 AGRICULTURAL SECTOR
C3 PRODUCTIVE ASSETS
C3 SERVICE SECTOR
C4 HOUSING SECTOR
C5 TRANSPORTATION SYSTEMS
C5 OTHER CRITICAL INFRASTRUCTURES

SENDAI INDICATORS
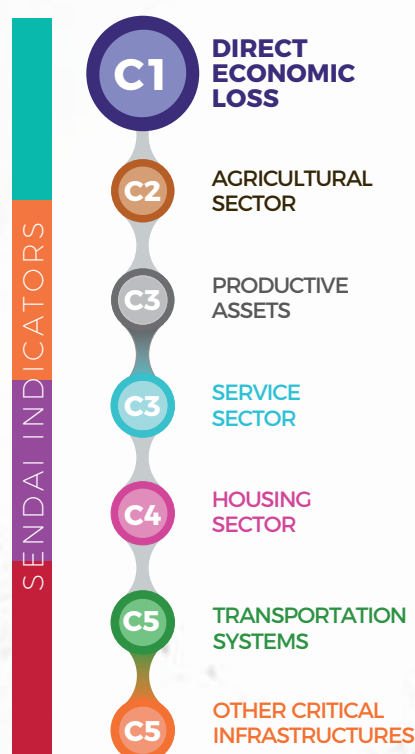
RESULTS | FLOODS

[B1] ANNUAL AVERAGE NUMBER OF AFFECTED PEOPLE

Present Climate

Future Climate

☐	2000 - 3000
☐	3000 - 5000
☐	5000 - 9000
☐	9000 - 14.000
☐	14.000 - 20.000
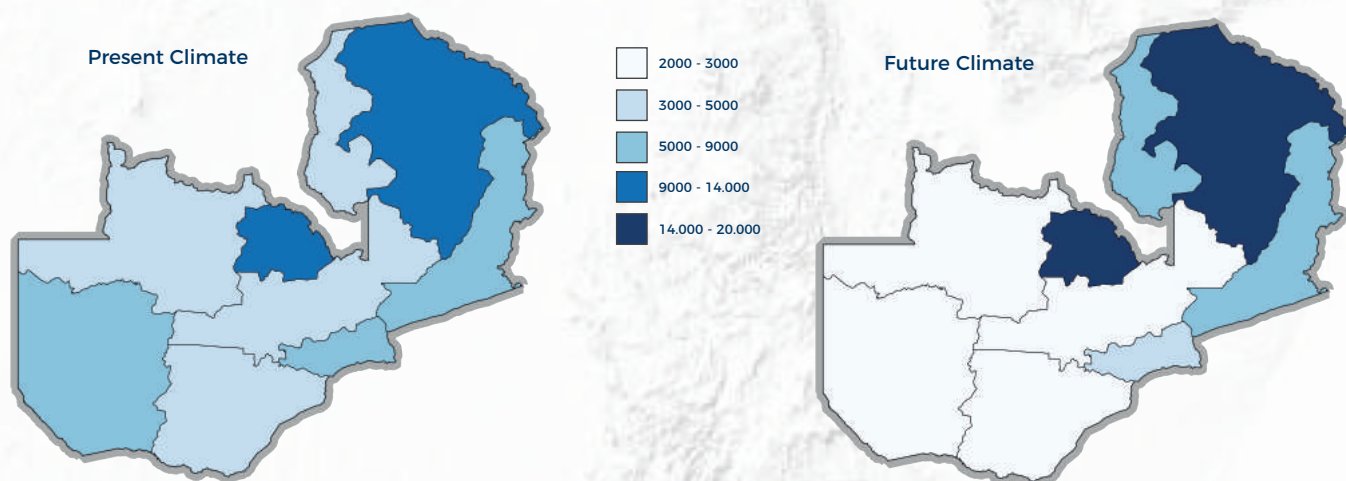
KEY MESSAGES

● Floods are relevant natural hazards in Zambia, affecting on average about 67,000 people every year, almost 0.40% of the country's total population.

● Affected populations are geographically concentrated in the Provinces of Copperbelt and Northern (Muchinga and North Zambia).

● The potentially affected GDP in flooded areas is also high, amounting to almost 0.8% of total national GDP .

● Future climatic conditions paired with projections of future population show an increase in potentially affected population of about twice the estimated value for present conditions.

● The potentially affected GDP is expected to increase by almost 14 times by 2100 if future climatic conditions are paired with projections of future GDP growth.

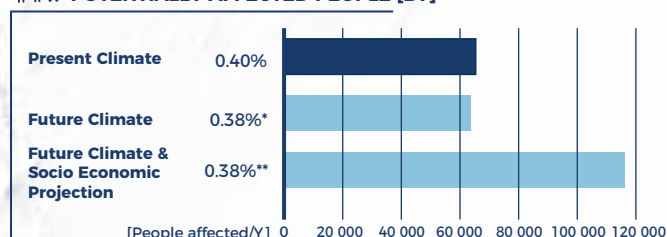● Future climatic conditions alone, due to high uncertainty in precipitation projections (see Climate Session of the risk profile), does not show a distinctive increasing or decreasing trend in population and GDP potentially affected because of climate change.

● Taking into consideration the above-mentioned circumstances, risk-informed decision-making for sustainable development is crucial.

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE [B1]

Present Climate	0.40%
Future Climate	0.38%*
Future Climate & Socio Economic Projection	0.38%**

[People affected/Y] 0   20 000   40 000   60 000   80 000 100 000 120 000
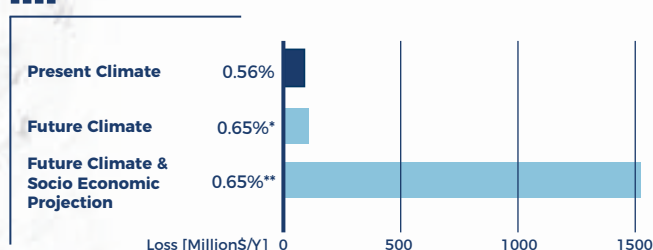
* % computed with reference to the total 2016 Population / GDP
** % computed with reference to the total 2050 Population / GDP
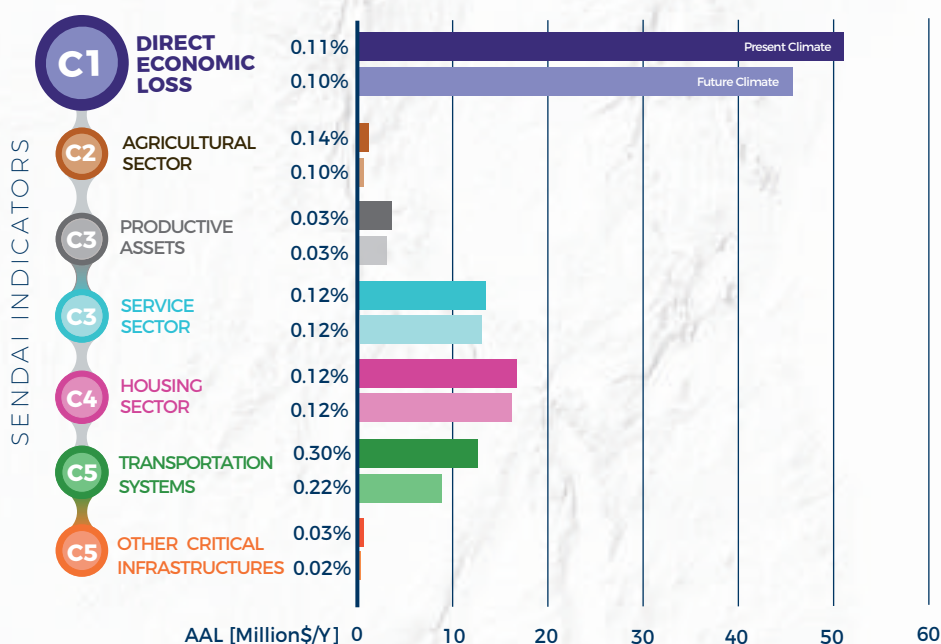
ANNUAL AVERAGE POTENTIALLY AFFECTED GDP

Present Climate	0.56%
Future Climate	0.65%*
Future Climate & Socio Economic Projection	0.65%**

Loss [Million$/Y] 0   500   1000   1500

RESULTS | FLOODS

[C1] DIRECT ECONOMIC LOSS

1.5 – 4
4 – 6
6 – 9
9 – 10
10 – 15.5

AAL
[Million$/Y]

AAL
Present Climate

AAL
Future Climate
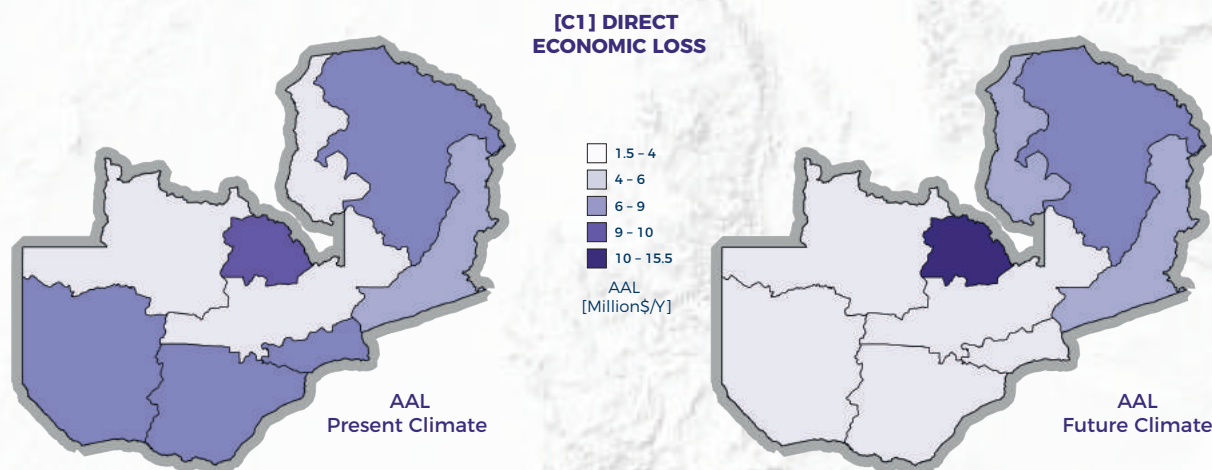
KEY MESSAGES

● The direct economic loss in Zambia is geographically distributed in line with exposure concentration, with the highest values in the Copperbelt province.

● The value of direct economic losses in terms of AAL amounts to 51 million US$, or roughly 0.11% of the total exposure value in the current climate. The largest portion of losses is due to housing, service sector (commercial) and critical infrastructures (i.e. transportation systems), accounting for almost 44 million US$ equivalent to about 85% of total loss.

● The proportion of different sectors in overall loss does not significantly change in future climate conditions.

● Considering the present exposed assets, the estimates of average annual losses under future climate conditions show different geographical trends. In future climate conditions, the AAL for the Copperbelt province is expected to increase while a slight decrease is expected for the other provinces. Uncertainty in climate predictions and the ongoing evolution of socio-economic situation of the country might significantly influence these estimates.

SENDAI INDICATORS

C1	DIRECT ECONOMIC LOSS	0.11% Present Climate
		0.10% Future Climate
C2	AGRICULTURAL SECTOR	0.14%
		0.10%
C3	PRODUCTIVE ASSETS	0.03%
		0.03%
C3	SERVICE SECTOR	0.12%
		0.12%
C4	HOUSING SECTOR	0.12%
		0.12%
C5	TRANSPORTATION SYSTEMS	0.30%
		0.22%
C5	OTHER CRITICAL INFRASTRUCTURES	0.03%
		0.02%

AAL [Million$/Y]   0   10   20   30   40   50   60

AFFECTED INFRASTRUCTURES [D]

[D8] Transportation System [km/Y]

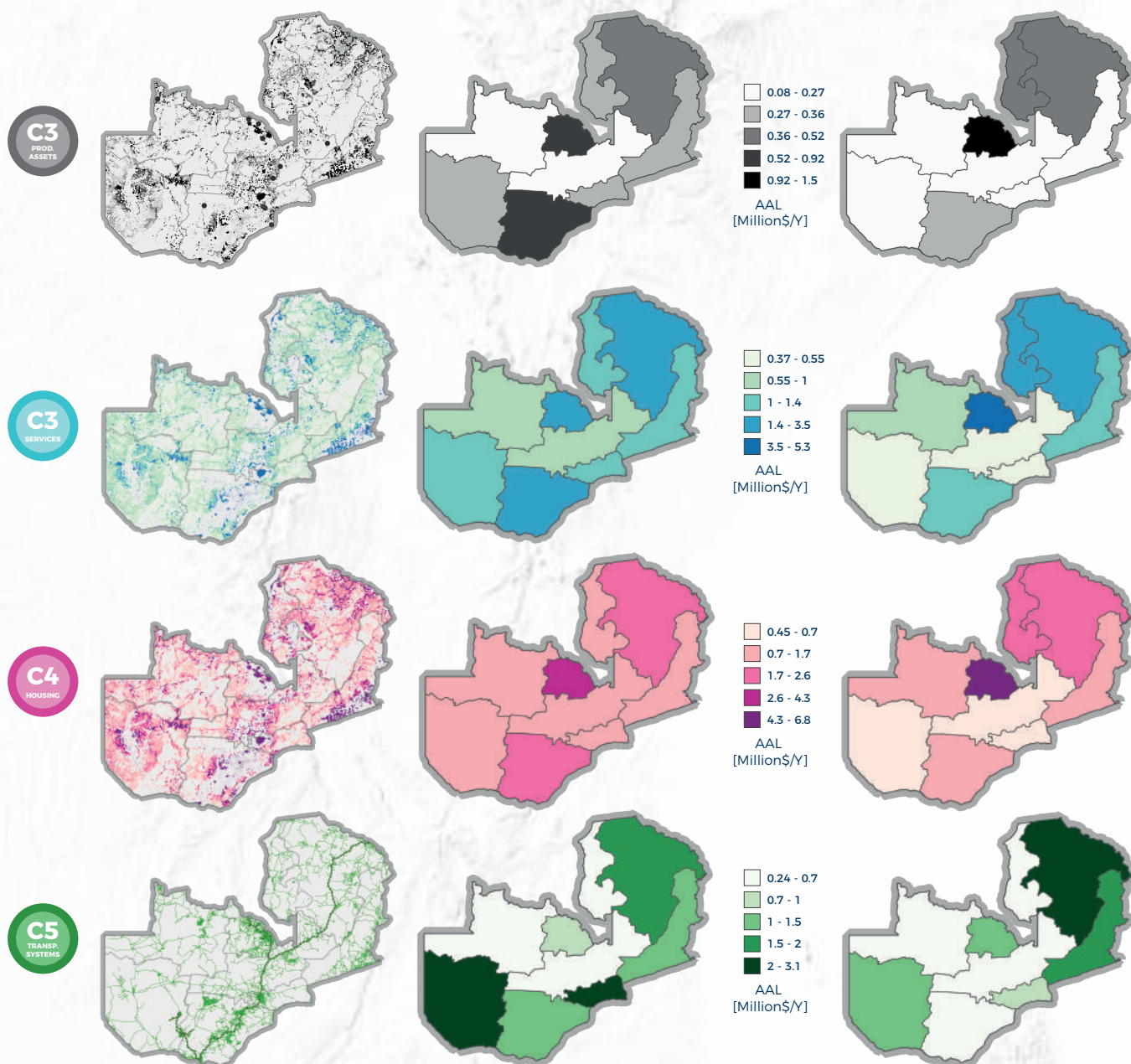245 Present climate
210 Future climate

RESULTS | FLOODS

KEY MESSAGES

● Comparison between present and future climate AALs shows a consistent pattern across all regions and sectors, with Copperbelt and Northern (Muchinga and North Zambia) provinces with the highest value of expected economic losses.

● The expected impact to the different sector varies in the provinces: housing and service sectors are predominant in Copperbelt, Luapula and South Zambia, transport systems are very relevant for Western Zambia, Lusaka and Northern (Muchinga and North Zambia), while productive sectors are potentially highly impacted in Copperbelt and Western Zambia.

EXPOSURE DISTRIBUTION   AAL - Present Climate   AAL - Future Climate

C3 PROD. ASSETS

0.08 - 0.27
0.27 - 0.36
0.36 - 0.52
0.52 - 0.92
0.92 - 1.5
AAL [Million$/Y]

C3 SERVICES

0.37 - 0.55
0.55 - 1
1 - 1.4
1.4 - 3.5
3.5 - 5.3
AAL [Million$/Y]

C4 HOUSING

0.45 - 0.7
0.7 - 1.7
1.7 - 2.6
2.6 - 4.3
4.3 - 6.8
AAL [Million$/Y]

C5 TRANSP. SYSTEMS

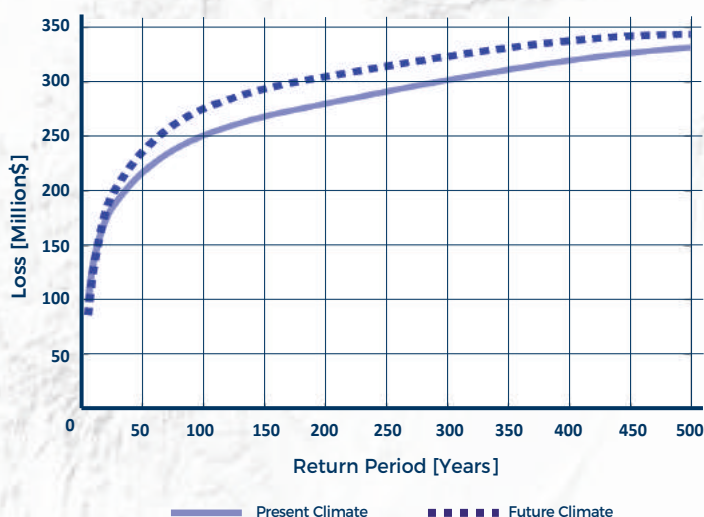0.24 - 0.7
0.7 - 1
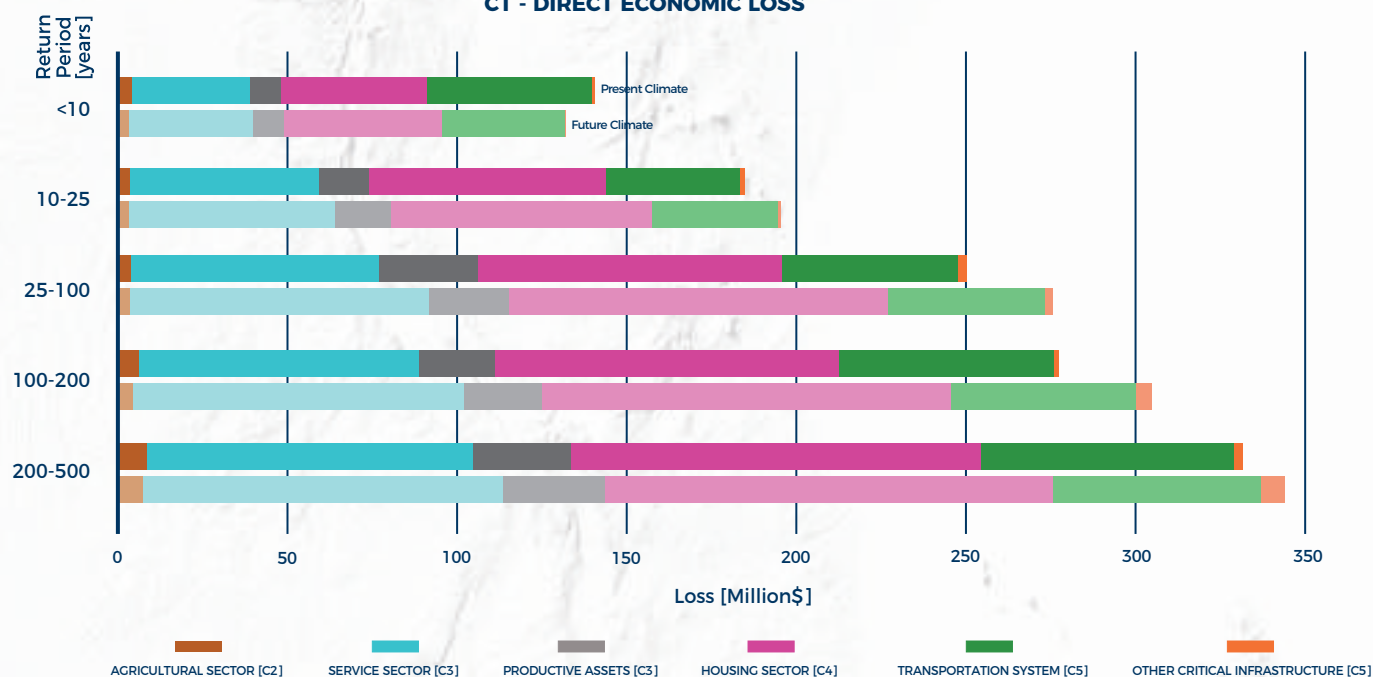1 - 1.5
1.5 - 2
2 - 3.1
AAL [Million$/Y]

RESULTS | FLOODS

KEY MESSAGES

● In both present and future climate, the PML curves rise steeply up to the 10-year loss, meaning that considerable losses may be experienced relatively frequently.

● For scenarios with return period larger than 10 years, the losses estimated under future climate condition tends to increase with respect of estimates under current climate conditions. Uncertainty in climate predictions and in the ongoing evolution of socio-economic situation of the country might significantly influence these estimates.

● The share of losses across sectors and for the different return periods does not consistently change under future conditions

● The PML curve rises steep till the 50 year loss and flattens after that. This sets an unfavourable condition for risk transfer contracts, the first part of the curve should be strategically modified with risk reduction measures before designing a risk transfer option.

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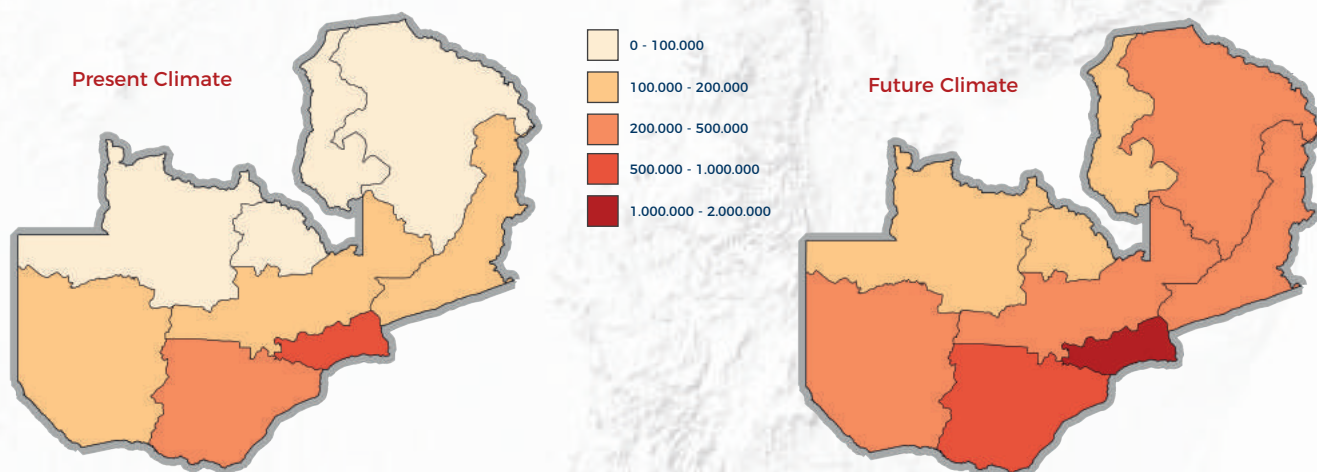

PROBABLE MAXIMUM LOSS CURVE (PML) ACROSS ALL SECTORS
C1 - DIRECT ECONOMIC LOSS

AGRICULTURAL SECTOR [C2] SERVICE SECTOR [C3] PRODUCTIVE ASSETS [C3] HOUSING SECTOR [C4] TRANSPORTATION SYSTEM [C5] OTHER CRITICAL INFRASTRUCTURE [C5]

RESULTS | DROUGHTS

[B1] ANNUAL AVERAGE NUMBER OF AFFECTED PEOPLE

Present Climate

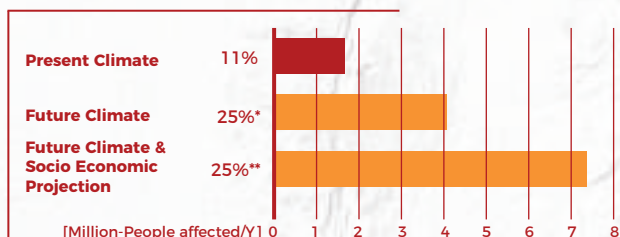|	
	0 - 100.000
	100.000 - 200.000
	200.000 - 500.000
	500.000 - 1.000.000
	1.000.000 - 2.000.000

Future Climate

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

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.

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE [B1]

Present Climate	11%
Future Climate	25%*
Future Climate & Socio Economic Projection	25%**

[Million-People affected/Y] 0 1 2 3 4 5 6 7 8

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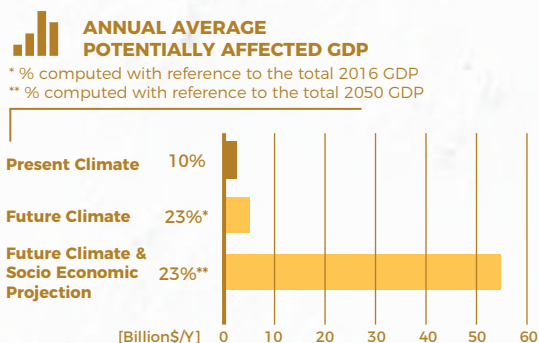** % computed with reference to the total 2050 Population

KEY MESSAGES

● With respect to present conditions (1951-2000 climate), the probability of occurrence of severe effective precipitation deficiency (precipitation – evapotranspiration) will increase by 11.5% in the future (2050-2100 climate). A larger share of Zambia will become drought-prone.

● Currently, on average 1.73 million people (11% of the total 2016 Population) are annually potentially affected by droughts. In the future, this number is expected to increase to 25% (on average 7.3 million people if population growth is accounted for).

KEY MESSAGES (P.16)

● The GDP potentially affected by droughts is expected to increase with a factor 2.3. While currently, annually on average 10% of the GDP (2 billion USD) is potentially affected, this is expected to rise to 23% of the GDP.

● In the future almost 60% more livestock is expected to be annually affected by droughts. The percentage of affected livestock will rise from 21% (550 thousand livestock units) to 34%. While now, only livestock in the southern part of Zambia is potentially affected, the amount of livestock units affected by droughts will increase over the whole country due to climate change. (No changes in livestock population are included).
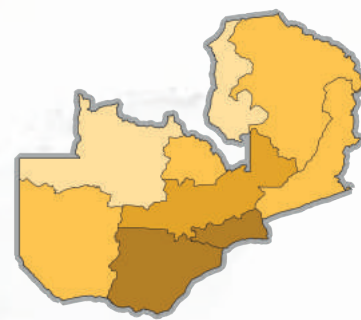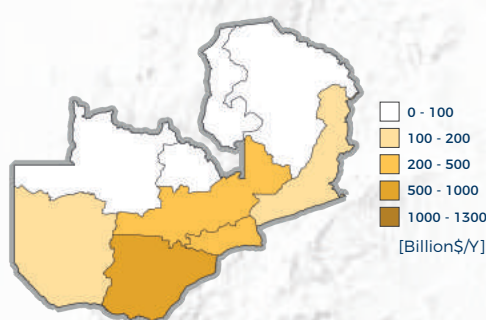
RESULTS | DROUGHTS

Annual average GDP / Livestock units potentially affected by at least 3 months of effective precipitation deficiencies, as calculated through the standardized precipitation-evapotranspiration index (SPEI) using a 3-month accumulation period.
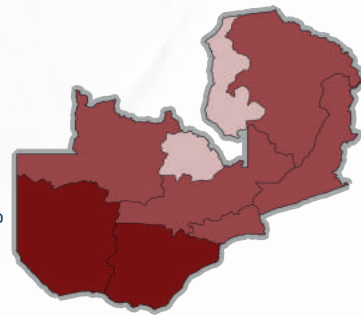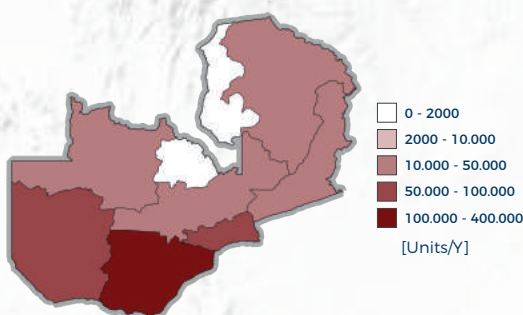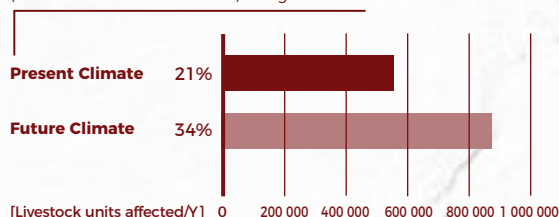
Present Climate　　　　**Future Climate**

ANNUAL AVERAGE POTENTIALLY AFFECTED GDP
* % computed with reference to the total 2016 GDP
** % computed with reference to the total 2050 GDP

Present Climate	10%	
Future Climate	23%*	
Future Climate & Socio Economic Projection	23%**	

[Billion$/Y]　0　10　20　30　40　50　60

0 - 100
100 - 200
200 - 500
500 - 1000
1000 - 1300
[Billion$/Y]

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED LIVESTOCK UNITS*
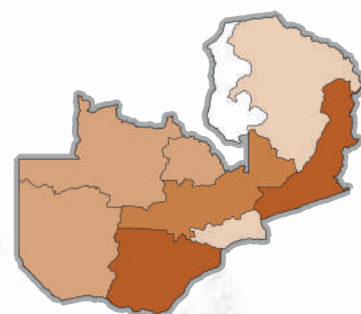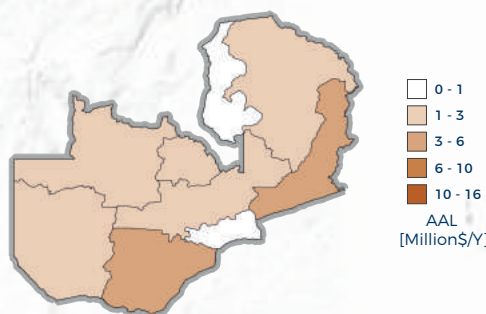*Livestock is a summation of all livestock animals (referred to as livestock units) using FAO conversion factors

Present Climate	21%
Future Climate	34%

[Livestock units affected/Y]　0　200 000　400 000　600 000　800 000　1 000 000

0 - 2000
2000 - 10.000
10.000 - 50.000
50.000 - 100.000
100.000 - 400.000
[Units/Y]

WCI
Water Crowding Index

These maps show the percentage of the population experiencing water scarcity, based on local (83 km²) average water available per person per year. People living with less than 1000 m³/person/year, are in water scarcity. Specifically, areas with high concentrations of people are dependent on outside water resources (such as Lusaka). With climate change and population growth, more provinces are expect to have over 10% of their population in water scarcity. Overall, average water availability changes little under future climate conditions, but we see a slight increase in central Zambia in people under water scarcity.

0 -10
10 -20
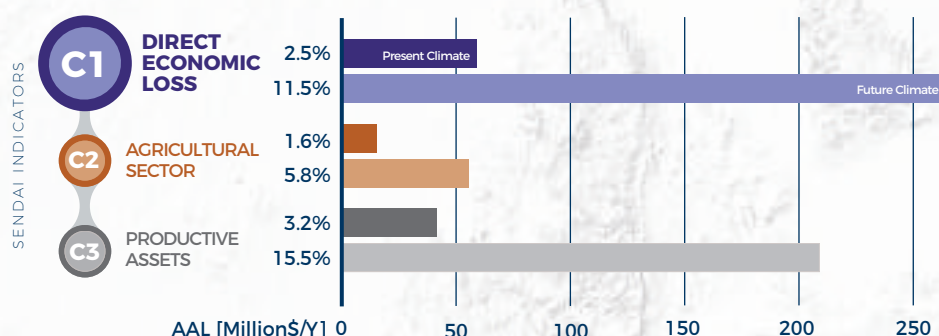20 - 40
40 - 60
60 - 100
[Pop%/Y]
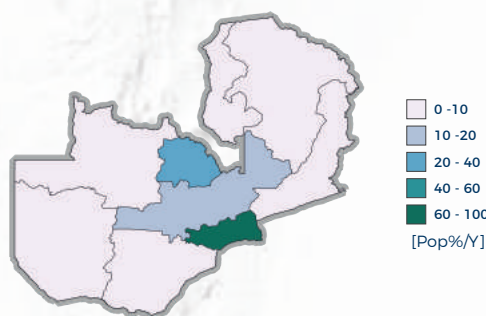
C2 AGRICULTURAL SECTOR

The distribution of agricultural (crop) losses shows a concentration of losses in three provinces of the country (south, central and east). Under future climate conditions, increases in losses have been estimated throughout the entire country, except in the northern part of Zambia.

0 - 1
1 - 3
3 - 6
6 - 10
10 - 16
AAL [Million$/Y]

RESULTS | DROUGHTS

SENDAI INDICATORS

C1 DIRECT ECONOMIC LOSS
2.5% Present Climate
11.5% Future Climate

C2 AGRICULTURAL SECTOR
1.6%
5.8%

C3 PRODUCTIVE ASSETS
3.2%
15.5%

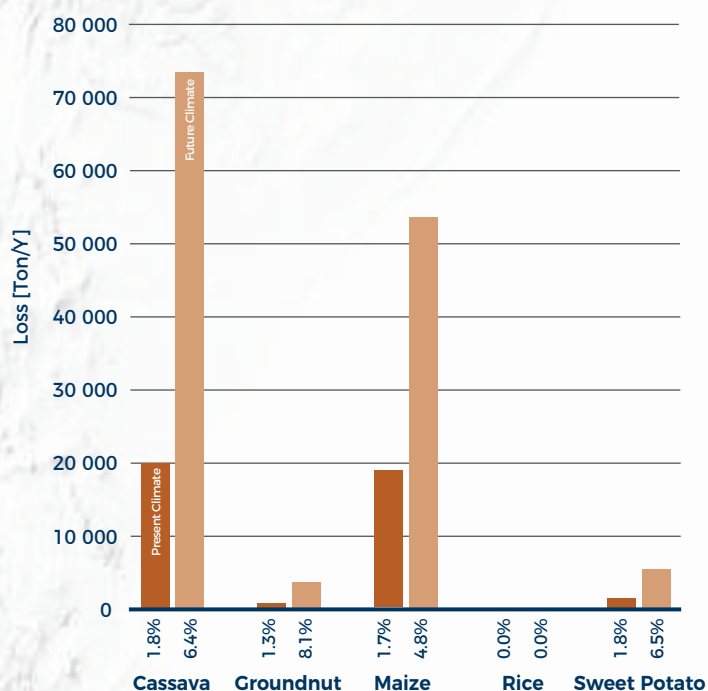AAL [Million$/Y] 0   50   100   150   200   250

C2 is computed considering only the direct loss suffered because of a loss of agricultural (crop) production with respect to a reference production in the present climate. The crops considered in the analysis are the ones that contribute at country level to at least 85% of the total gross crop production value. It might therefore happen that crops that have an important role in the local agriculture (commercial or for subsistence) might be neglected in the overall analysis. C3 is computed considering only the loss in hydropower production as compared to a nominal production in present climate.
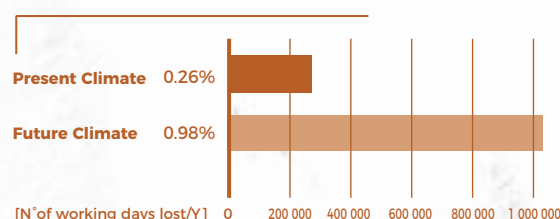
KEY MESSAGES

● Losses in agricultural (crop) production (C2) are projected to increase substantially (almost 4 times), but still remain moderate compared to total income from crops (<6%).

● Losses in hydropower generation (C3) due to drought are set to increase almost 5 times under future climate conditions, compared to present conditions (for Mulungushi, Itezhi-Tezhi, Kafue Gorge and Kariba dams).

● Total direct economic losses (C1) due to drought is for the most part attributable to the loss of hydropower (C3), and to a lesser extent due to the agricultural sector (C2).

● Agricultural losses are dominated by cassava and maize. In relative terms, groundnut production is affected most under future conditions (from 1.3% to 8.1%). Rice production is not affected, because it is predominately irrigated and due to our assumption that irrigation water is ample available, both under present and future climate conditions.

● Approximately a 4-fold increase in lost working days is expected under future climate conditions. The loss of working days is estimated at less than 1% for both present and future conditions. However, the number of working days lost, expressed as a percentage of the average amount of days required for harvesting, is approximately 7 times higher.

AGRICULTURAL PRODUCTION LOSS

Loss [Ton/Y]

80 000
70 000
60 000
50 000
40 000
30 000
20 000
10 000
0

	Cassava	Groundnut	Maize	Rice	Sweet Potato
Present	1.8%	1.3%	1.7%	0.0%	1.8%
Future	6.4%	8.1%	4.8%	0.0%	6.5%

ANNUAL AVERAGE NUMBER OF WORKING DAYS LOST

Present Climate   0.26%
Future Climate   0.98%

[N°of working days lost/Y] 0   200 000 400 000 600 000 800 000 1 000 000

RESULTS | DROUGHTS

SSFI
Standardized Streamflow Index

Present Climate

Future Climate

1
2
3
4
5
6
[Months/Y]

This map denotes the average amount of months per year with low stream flow conditions for a return period of 1 in 10 years. The standardized stream flow index is used to define low flows (lowest 6% per month in the reference climate of 1950-2000). In the current climate, some small upstream parts of rivers are sensitive to droughts. However, under climate change this extends also to some of the main channels, particularly in the south of Zambia (Zambezi river).

KEY MESSAGES

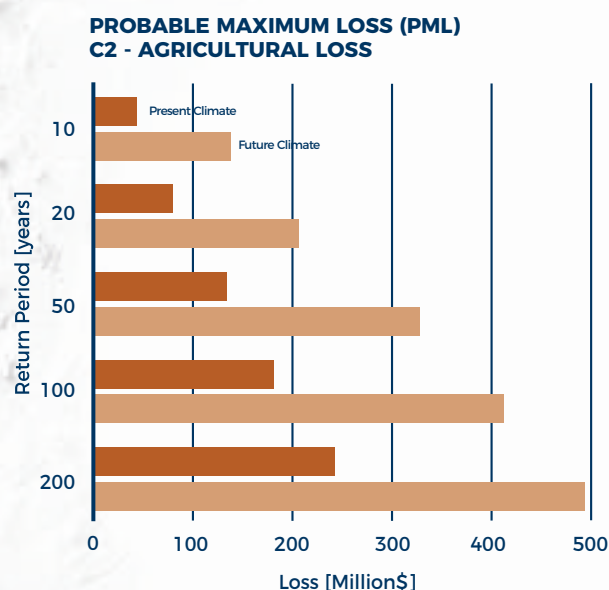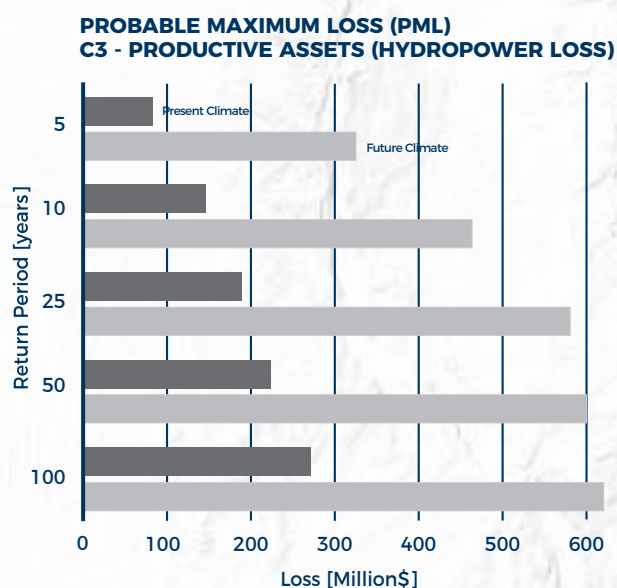● For hydropower losses (defined as the production below production with average reservoir conditions under the present climate), losses increase substantially for all return periods. Relatively speaking, particularly the increases for low return periods (1-in-5 years) are large (3.5 times increase).

● In the case of agricultural (crop) income losses (see Glossary), current climate conditions present a gradual increase in expected losses when return periods go up from 10 to 200 years. It is worth noting that these results might be affected by a high level of uncertainty as we move into the very rare losses domain.

● Under future climate conditions, agricultural income losses increase significantly in absolute units, compared to present climate conditions, and relative increases range from almost 2 times (200 year return period) to approximately 3 times (10 year return period).

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

Present Climate
Future Climate

Return Period [years]: 5, 10, 25, 50, 100

Loss [Million$]: 0, 100, 200, 300, 400, 500, 600

PROBABLE MAXIMUM LOSS (PML)
C2 - AGRICULTURAL LOSS

Present Climate
Future Climate

Return Period [years]: 10, 20, 50, 100, 200

Loss [Million$]: 0, 100, 200, 300, 400, 500

HYDROPOWER PLANTS

With the completion of the upgraded Lunzua station (14.8 MW) in November 2014, Zambia reached 2,257 MW of installed hydropower capacity, which represents 94 % of the nation's total energy mix [15]. Currently there are five mini hydropower plants and five large hydropower plants working (in addition to the already mentioned Lunzua): Kafue Gorge (990 MW), Kariba North (720 MW), Lusiwasi (12 MW), Victoria Falls B (60 MW), Victoria Falls C (40 MW). To increase the generation capacity and to mitigate the growing energy demand, cascaded generation is going to be implemented. This method is based on the principle that river water is not consumed in the generation process but it is necessary a number of rivers with sufficient or good amount of water running throughout the year[16].

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, from improving building codes and designing risk reduction measures, to carrying out macro-level assessments of the risks to prioritise investments. Risk metrics can help discern the contributions of different external factors (such as demographic growth, climate change, urbanization expansion, etc.) and provide a net measure of progress of disaster risk reduction policies implementation.

AAL can be interpreted as an opportunity cost, given that resources set aside to cover disaster losses could be used for development. Monitoring AAL in relation to other country economic indicators, such as GDP, capital stock, capital investment, reserves, and social expenditure, would provide indications of country 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 layers. Extensive Risk Layer: this layer is typically the one associated with risk reduction measures (e.g. flood defences, local vulnerability reduction interventions). Immediately after this extensive layer is the Mid Risk Layer, which builds up cumulative losses from higher impact events. The losses of this layer are normally mitigated using financial funds, like a contingency fund, that are normally put in place and managed by the country itself.

The losses that compose the Intensive Risk Layer (severe, infrequent hazard events) are difficult to finance on the

country level, and a mechanism of risk transfer has to be put in place (e.g. insurance and reinsurance measures). The remaining layer of the curve determines the Residual Risk (catastrophic events), which is the risk that is considered acceptable/tolerable due to the extreme rarity of the events able to determine such loss levels. Due to this rarity, there are no concrete actions to reduce risk beyond preparedness actions that tend to ease the conditions determined by the event (e.g. civil protection actions, humanitarian aid coordination).
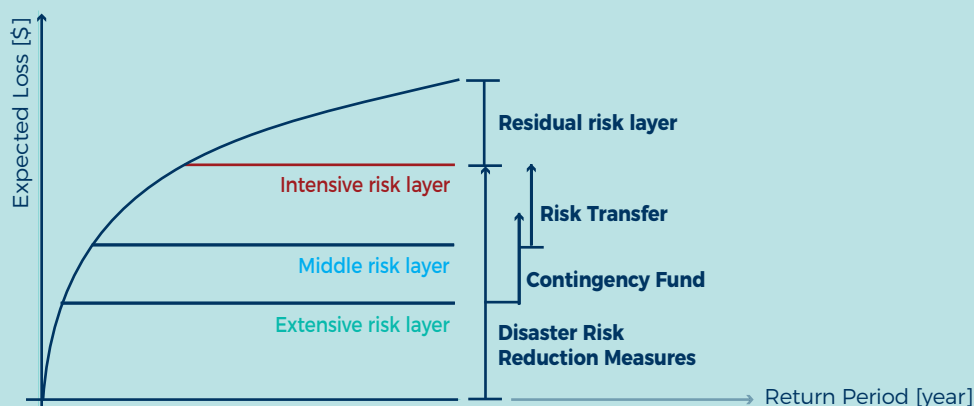
GLOSSARY & REFERENCES

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
Drought refers to dryer than normal conditions of a specific area (i.e. variability). Not to be confused with aridity, which refers to a lack of water resources in absolute terms. In this profile, drought hazard is denoted by various indicators, covering a range of the drought types. Both hydrological and agricultural droughts are explicitly addressed, both in terms of hazard, exposed population and GDP, and corresponding losses related to crop production and hydropower generation. Drought hazard and risk are modelled based on distributed rainfall and a hydrological model solving the water balance (same one as used for the flood risk assessment). 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, assessed for January, February, March, etc. separately. (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).

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

[1] Climate Change Risk Profile, Zambia, USAID
https://www.climatelinks.org/sites/default/files/asset/document/2016%20CRM%20Fact%20Sheet%20-%20Zambia.pdf

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[4] Ngoma et al. (2017). Irrigation Development for Climate Resilience in Zambia: The Known Knowns and Known Unknowns.
https://www.researchgate.net/publication/322436256_Irrigation_Development_for_Climate_Resilience_in_Zambia_The_Known_Knowns_and_Known_Unknowns

[5] Alder, J. R., & Hostetler, S. W. (2015). Web based visualization of large climate data sets. Environmental Modelling & Software, 68, 175-180.

[6] Abba Omar, S. & Abiodun, B.J., How well do CORDEX models simulate extreme rainfall events over the East Coast of South Africa? Theor Appl Climatol (2017) 128: 453. https://doi.org/10.1007/s00704-015-1714-5

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[9] http://www.worldometers.info/world-population/zambia-population/

[10] Zambia overview, WorldBank, https://www.worldbank.org/en/country/zambia/overview

[11] https://www.indexmundi.com/zambia/economy_profile.html

[12] Keywan Riahi et al., The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview, Global Environmental Change, Volume 42, January 2017, Pages 153-168

[13] Richard H. Moss et al., The next generation of scenarios for climate change research and assessment, Nature volume 463, pages 747–756 (11 February 2010)

[14] Brian C. O'Neill et al., The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6, Geosci. Model Dev., 9, 3461–3482, 2016, doi:10.5194/gmd-9-3461-2016

[15] https://www.hydropower.org/country-profiles/zambia

[16] http://www.zesco.co.zm/projects/generation

The results presented in this report have been elaborated to the best of our ability, optimising the publicly data and information available. All geographic information has limitations due to scale, resolution, data and interpretation of the original sources.

www.preventionweb.net/resilient-africa

www.unisdr.org

RISK PROFILES ARE AVAILABLE AT:

africa.cimafoundation.org