2019

DISASTER RISK PROFILE

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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Acknowledgments

This report is the result of extensive research and close collaboration between Zambian governmental institutions, international organizations and scientific research centres. The scientific consortium was led by CIMA Research Foundation in partnership with the UN Office for Disaster Risk Reduction (ROA), and included the VU University of Amsterdam and the Wageningen University & Research.
During the past two years, as the scientific team collected data and conducted the risk assessment process, the vital contributions and continuous feedback provided by the Zambian institutions once again revealed the importance of collaborative, fruitful relationships for knowledge sharing and horizontal learning.

The consortium would like to express its gratitude and acknowledge the valuable support it received from all of its Zambian partners, namely: Disaster Management and Mitigation Unit, Ministry of Lands and Natural Resources, Lusaka City Council, Central Statistics Office, Ministry of Agriculture and Livestock, Ministry of Finance, Ministry of Health, Zambia National Public Health Institute, Ministry of Labour and Social Security, Ministry of Education, National Remote Sensing Centre, Zambia Meteorological Department and Zambezi River Authority.

The present disaster risk profile is not only the synthesis of insights gained during several months collecting data and conducting risk modelling in Zambia, but also the result of having mobilized more than six hundred risk managers from fifteen other African countries during strategic national workshops, consultative meetings and individual interviews. This opportunity, made possible through the implementation of the ACP-EU funded programme "*Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities*", allowed us to listen to the real challenges, perceptions and priorities on risk governance and societal needs. As a result, we believe that we have moved towards a common understanding of risk in each of the countries we have had the privilege to work with.

Aligned to the Sendai Framework for Disaster Risk Reduction, and as representatives of the scientific community, the consortium will always encourage countries to increase research on disaster risk causes and scenarios, supporting local authorities in understanding the value of a systematic interface between policy and science for decision-making. Under this lens, three main groups of stakeholders were identified as key beneficiaries of this report:

- **Policy makers, risk managers and local academia**, who wish to develop their risk knowledge and to apply and promote evidence-informed policy making for good public risk governance.
- **Civil society leaders**, who wish to explore the evolving roles that they may play, through advocacy and awareness, given the foreseen economic, environmental and social changes.
- **International Donors and NGOs** who wish to identify priority sectors and regions for risk mitigation funding and actions.

As science is first and foremost at the service of humankind, we hope that this report facilitates the translation of knowledge into solutions to reduce disaster losses, increase societal resilience and the capacity to create development models able to provide a better future for all of Earth's inhabitants.

The Consortium

Foreword

Zambia has continued to experience extreme weather events, particularly floods, droughts and extreme temperatures due to global climate change. The frequency of occurrence and magnitude of these extreme events have continued to increase over space and time. The Southern region of the country is highly exposed to both flooding and droughts while northern half is more exposed to flooding.

The country has also witnessed a shift in rainfall patterns and growing seasons. Rainfall patterns have become erratic and unpredictable while changes in the growing seasons have become shorter. These extreme weather events have therefore, impacted negatively on rural livelihoods, agriculture and food security, critical infrastructure, health, education, energy, natural resources, housing, productive assets and transport. In spite of various initiatives and adaption projects being implemented by government and stakeholders, the coping capacity of the vulnerable sectors has remained relatively low due structural and chronic vulnerabilities.

The Government of the Republic of Zambia has therefore, been working with CIMA Research Foundation with the support of the United Nations Office for Disaster Risk Reduction to develop country risk profiles and risk management mechanisms. The developed risk profiles are an important component of Disaster Risk Reduction and are based on the four pillars of early warning. The profiles include the estimation of monetary losses, under current and future climate for the different sectors as outline by the Sendai targets. These country risk profiles we go a long way in reducing disaster risk and vulnerability. The Country Risk Profiles will also provide a comprehensive analysis of hazard, risk and uncertainties for floods and droughts in a changing climate and socio-economic situation which is also projected for the next 50 years.

My office will therefore work hard to ensure that policy recommendations are transformed in actionable targets to reduce disaster loss, reduce mortality rates and promote risk awareness for among vulnerable communities. Further, my office wishes to acknowledge that these risk profiles are country owned and will be used by various stakeholders to inform disaster risk planning in all the sectors of the economy. These risk profiles were developed with both global and national datasets making them more accurate due to the integration of local datasets. The risk profiles are complemented by guidelines on the usability of risk profiles in DRR/Climate Change Adaption and sustainable development policies, strategies and planning. The aim of the guidelines is to translate scientific evidence into concrete, applicable development strategies and policy suggestions both for the medium and the long term. It details the advantages of the probabilistic risk assessment methodology employed in the development of the country disaster risk profiles and puts it forward in a language used by decision makers.

Honorable Olipa Phiri Mwansa
MP Minister
OFFICE OF THE VICE-PRESIDENT

Foreword

I wish to take this opportunity to express my gratitude towards the United Nations Office for the financial, logistical and technical support rendered towards the development of the country risk profiles for Zambia. I also wish to acknowledge the relentless efforts that were put on by CIMA Research Foundation towards the successful development of the risk profiles. The CIMA Research Foundation was always in touch with my office organizing capacity building workshops to provide technical capacity and trainings to members of the Zambia Vulnerability Assessment Committee and the high-level people.

Acknowledgements also goes to the institutions and that participated and supported the risk profiling process. I am also highly thankful to all the members of staff from my office that worked with CIMA Research Foundation for the smooth implementation of the "Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities" Programme funded by the European Union. Lastly, special thanks go to the Honourable Minister for the support rendered to the DMMU during the development of the risk profiles.

It my sincere hope that file risk profiles will be used to inform policy in risk financing, budgeting and disaster risk planning.

Chanda Kabwe
National Coordinator
Disaster Management and Mitigation Unit
OFFICE OF THE VICE-PRESIDENT


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Acronyms & Abbreviations

AAL	Annual Average Loss
ACP	African, Caribbean, and Pacific group of states
CCA	Climate Change Adaptation
CIMA	International Centre on Environmental Monitoring
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EU	European Union
GDP	Gross Domestic Product
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
NGO	Non-Governmental Organization
PML	Probable Maximum Loss
PRA	Probabilistic Risk Assessment
RCP	Representative Concentration Pathway
SDGs	Sustainable Development Goals
SSPs	Shared Socio-economic Pathways
STAG	Scientific and Technical Advisory Group (UNDRR)
UN	United Nations
UNDRR	United Nations for Disaster Risk Reduction
USD	United States Dollars

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Risk information for sustainable development

Over the last few decades, disasters resulting from natural hazards have often derailed hard-earned development plans and progress. Disasters damage infrastructure, lifelines and critical facilities and often result in severe human, financial, cultural and environmental losses. While disasters have direct consequences on development efforts, inversely, “bad development” can itself be a driver of risk. Non-planned urbanization and the building of non risk-resilient infrastructure are some examples of unsustainable development. These approaches to development increase the vulnerability of populations and of existing economic systems, while depleting the natural ecosystems, in a vicious cycle.

Over the last four decades, Sub-Saharan Africa has experienced more than 1000 disasters (*World Bank, 2017*), affecting approximately 320 million people (*Preventionweb*). The majority of disasters in Africa are hydro-meteorological in origin, with droughts affecting the largest number of people and floods occurring frequently along major river systems and in many urban areas. Cyclones, geological events, sea level increase, coastal erosion and storm surges also deeply affect the continent. Sub-Saharan Africa’s disaster risk profiles relate information on natural hazards to each countries’ population and economic exposures and vulnerabilities. These exposures and vulnerabilities are exacerbated by countries’ limited coping capacities and resources for investing in disaster risk reduction and recovery measures. In this context, post-disaster rehabilitation often implies the intervention of international aid or the diversion of national funds originally planned for development interventions, resulting in a tremendous setback for societal development as a whole.

Disasters, however, can be significantly minimised with rigorous scientific risk modelling and through effective institutional and community preparedness. Considering that natural hazard events will likely change in frequency and magnitude due to climate change in the near future, it is necessary to ensure that risk assessments be conducted systematically, so as to provide a quantitative basis for disaster risk reduction and climate adaptation measures. Risk reduction processes must also be based on the effective communication and application of **risk information** through the strengthening of institutional and human **capacities**. Risk assessments and the risk information they provide should support risk-informed **decision-making** towards resilience building across all levels and within all socio-economic development sectors.

Risk reduction and resilience building are embedded in the various global frameworks adopted in 2015 and 2016, such as the Addis Ababa Action Agenda, the Paris Agreement, the Agenda for Humanity, the New Urban Agenda, the Sendai Framework for Disaster Risk Reduction and the 2030 Agenda for Sustainable Development. These international frameworks are the result of a long-term process developed by different communities, often from different cultural and scientific backgrounds, but their final aim points towards the same sustainable future. As such, the frameworks are closely intertwined and should be coherently implemented. Challenges such as poverty eradication, economic growth, reduction of inequalities and the creation of sustainable cities and settlements are some examples that require a massive, joint effort to design and apply coherent policies and strategies.

These need to be based on scientific risk information that assesses vulnerability, hazard and exposure to estimate disaster impacts - quantifying population and economic losses across different regions and sectors.

SENDAI / SDG'S INDICATORS

1 NO POVERTY | 2 ZERO HUNGER | 11 SUSTAINABLE CITIES AND COMMUNITIES | 13 CLIMATE ACTION

			Code	INDICATORS	FLOOD C	FLOOD P	FLOOD SEP	DROUGHT C	DROUGHT P	DROUGHT SEP	SDG	SDG INDIC.
SENDAI INDICATORS	B1			Number of directly affected people	•	•	•	•	•	•	1 11 13	1.5.1 11.5.2 13.1.1
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters		C2	Direct agricultural loss (Crops)	•	•		•	•		2	-
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters		C3	Direct economic losses to productive asset (Industrial Buildings + Energy Facilities)	•	•		•	•		1	1.5.2
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters		C3	Direct economic losses in service sector	•	•					1	1.5.2
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters		C4	Direct economic losses in housing sector	•	•					1	1.5.2
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters		C5	Direct economic losses to transportation systems (Roads + Railways)	•	•					1	1.5.2
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters		C5	Direct economic losses to other critical infrastructures (Health + Education Facilities)	•	•					1	1.5.2
SENDAI INDICATORS	D1 Damage to critical infrastructure attributed to disasters		D2	Number of destroyed or damaged health facilities	•	•					11	-
SENDAI INDICATORS	D1 Damage to critical infrastructure attributed to disasters		D3	Number of destroyed or damaged educational facilities	•	•					11	-
SENDAI INDICATORS	D1 Damage to critical infrastructure attributed to disasters		D4	Number of other destroyed or damaged critical infrastructure units and facilities (Transportation systems)	•	•					11	-
* No official Sendai indicators	Agricultural & Economic Indicators			GDP of affected areas*	•	•	•	•	•	•	1	1.5.2
* No official Sendai indicators	Agricultural & Economic Indicators			Number of potentially affected livestock units*				•	•		2	-
* No official Sendai indicators	Agricultural & Economic Indicators			Number of working days lost*				•	•		2	-
* No official Sendai indicators	Agricultural & Economic Indicators			Food Energy Loss				•	•		2	-
* No official Sendai indicators	Agricultural & Economic Indicators			Crop Drought Tolerance				•	•		2	-
* No official Sendai indicators	Hazard Index		SPEI	Standardised Precipitation-Evapotranspiration Index*				•	•			
* No official Sendai indicators	Hazard Index		SSMI	Standardised Soil Moisture Index*				•	•			
* No official Sendai indicators	Hazard Index		SSFI	Standardised StreamFlow Index*				•	•			
* No official Sendai indicators	Hazard Index		SPI	Standardised Precipitation Index*				•	•			
* No official Sendai indicators	Hazard Index		WCI	Water Crowding Index*				•	•			

C Current Climate (1979 - 2018)
P Projected Climate (2051-2100)
SEP Socio-Economic Projection (2051-2100)

Why a probabilistic risk assessment?

The added value of a Probabilistic Risk Assessment (PRA) is often misunderstood, as audiences tend to view it as a highly technical method that is difficult to apply or understand. These difficulties represent a challenge for communicating risk results.
A probabilistic disaster risk profile should be seen as a risk diagnosis instrument, as it provides indications on possible hazardous events and their impact. Both past and probable future events are taken into consideration in a comprehensive risk assessment exercise. In this risk profile two different climate scenarios were considered:

- **under current climate conditions**: with disaster risk assessed using the observed climate conditions in the **1979 - 2018** period;
- **under projected climate conditions**: with disaster risk being assessed under projected climate conditions (projected period **2051 - 2100**), considering the IPCC scenario RCP 8.5 which foresees an increase in the global temperature between 1,5°C and 4°C by 2100, and assuming that further risk mitigation measures will not be put in place.

Probabilistic disaster risk profiles consider all possible risk scenarios in a certain geographical area. This means that both low frequency, high loss impact events, as well as high frequency, lower loss impact events are calculated. Included is their probability of occurrence, and all elements of the risk equation (risk = hazard X exposure X vulnerability / capacity), their variability and uncertainty ranges.

$$\underset{\text{Risk}}{R} = \frac{\underset{\text{Hazard}}{H} \times \underset{\text{Exposure}}{E} \times \underset{\text{Vulnerability}}{V}}{\underset{\text{Capacity}}{C}}$$

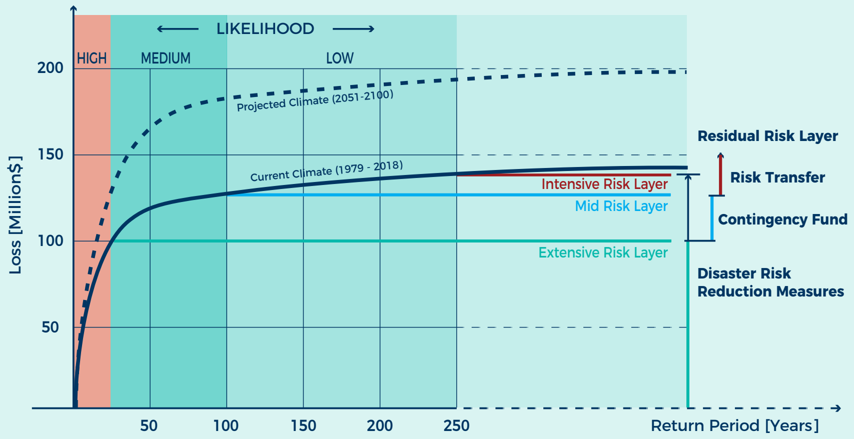
Events which have never been historically recorded but might occur in projected climate conditions are also considered in the risk analysis. This feature is particularly useful in the context of climate change which is dramatically increasing uncertainty about future hazard patterns. Thus, societies need to calculate their "worst" possible impacts in order to be prepared. Under this lens, there is no valid alternative to a probabilistic analysis in order to address this uncertainty in a usable, quantitative way.

By assigning a probability of occurrence to each event magnitude, a probabilistic risk profile quantifies the expected direct impacts of disasters through economic metrics and affected population, both at aggregated and at disaggregated levels (ex. affected children, women and people with disabilities, different regions and development sectors). As this risk information is framed within return periods as a conventional probability measure, a PRA approach provides a clear vision of the risk trends:

This risk information - expressed in an annual average loss curve (AAL) and a probable maximum loss curve (PML) is calculated both at a national scale, as well as by sector and by region, allowing for a geographic and quantitative comparison of disaster losses, as well as within a country and/or between countries. These analyses and comparison exercises are an important step of the risk awareness processes, key in pushing for risk reduction, risk adaptation and risk management mechanisms to be put in place.

PML CURVE INTERPRETATION

Large-scale natural hazards don't necessarily lead to important economic losses. An event that occurs in a desert for example (i.e. no exposure) would not result in any losses. It is therefore important to understand the estimated losses events are likely to produce. The PML curve shows the likelihood of a certain scenario producing an estimated amount of losses. In this example, under current climate conditions, Country X would experience at least one disaster event, leading to losses equal or greater than 50 million dollars, on average every three to five years, and at least one disaster event, leading to losses greater or equal than 130 million dollars, on average every one hundred years. Under projected climate conditions (IPCC RCP 8.5), losses equal or greater than 50 million dollars can be experienced on average every three to five years, while losses equal or greater than 130 million dollars can be experienced on average once every 25 years. In this case, high frequency disasters - within a return period of 10 years and losses of equal or greater than 70 million dollars will keep a constant pattern, both in current and projected climate conditions. Medium and rare frequency loss events (medium and low likelihood) - with a return period ranging from 25 to 250 years are expected to lead to an increase between 30% and 50% in economic losses in future. The PML curve can be subdivided into three main layers: the **Extensive Risk Layer** typically associated with risk reduction measures (e.g. flood defences, vulnerability reduction interventions); the **Mid Risk Layer** that captures higher losses which are commonly mitigated using financial funds at country level, such as the contingency fund; the **Intensive Risk Layer** (severe and infrequent hazard events) that is normally managed trough risk transfer mechanisms such as insurance and reinsurance measures. The remaining Residual Risk (catastrophic events) is the risk that is considered acceptable/tolerable due to the extreme rarity of the events causing such loss levels. Given their rarity, there are no concrete actions to reduce risk beyond preparedness (e.g. civil protection actions, humanitarian aid coordination).



Probabilistic disaster risk profiles are used as the first step in cost-benefit analyses of investments and policies for disaster risk reduction. Cost-benefit analyses show decision-makers the required level of public sector financing and/or insurance mechanisms to support disaster risk management across sectors, an important tool for guiding risk management policies. In the medium and long term, these investments and policies improve social and economic outcomes, as well as institutional coherence and efficiencies. The return on these investments (i.e. from the decrease in disaster losses) will free resources, allowing future budgets to address other development challenges, thus creating a virtuous cycle. The integration of disaster risk profiles developed with a probabilistic approach instils an added value, not only by delivering highly reliable science-based information, but also as a trigger for integrated and resilient development approaches.

Climate Scenarios

Although the international community is consensually aware of the ongoing global warming due to the emission of greenhouse gases and air pollutants in the atmosphere, its main consequences are expected to be observed in the behaviour of projected climate patterns.

Both historical and projected climate patterns cannot be analysed without considering its intrinsic link with socioeconomic development. Factors like population, economic activity, urbanization, social equality and consumption patterns determine the way energy, land and natural resources are used. These in turn determine the emission of greenhouse gases and air pollutants in the atmosphere. Climate change is expected to impact socio-economic activities by, for example, increasing the frequency and severity of extreme weather events with direct impacts in societal well-functioning and development.

The way this climate-social dependency will translate into projected climate patterns is inherently uncertain, as it depends on human decisions, actions and behaviours yet to be made. But the future is not completely unknown: scenarios can be used to explore what could and what should happen in different decision-making contexts, analysing the consequences on the development of the projected climate conditions. With this in mind, in the late 2000s, the international climate community started developing scenarios to explore how the world might change over the next century, looking at possible trajectories of population, economic growth and greenhouse emissions, both through isolated and integrated approaches.

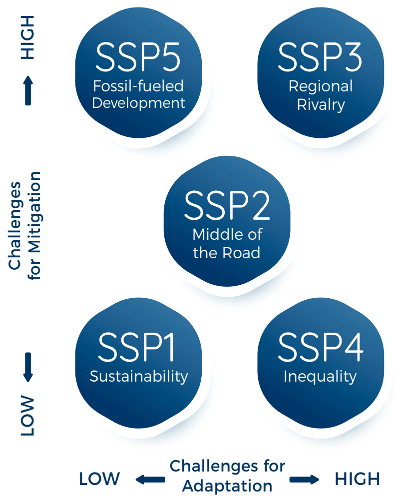
The Representative Concentration Pathways (RCPs) were developed to describe the different levels of greenhouse gases and other radiative forces that might occur by 2100 - not including any socioeconomic narratives - and are represented in four different pathways: 2.6, 4.5, 6.0, 8.5.

SCENARIO NAME	ASSUMES WE REDUCE CO_2 EMISSIONS	PREDICTED TEMPERATURE INCREASE BY 2100	PREDICTED SEA LEVEL RISE BY 2100
RCP 2.6	VERY QUICKLY	(1˚C)	0.44 m
RCP 4.5	SOMEWHAT QUICKLY	(1.8˚C)	0.53 m
RCP 6.0	MORE SLOWLY	(2.4˚C)	0.55 m
RCP 8.5	HARDLY AT ALL	(4.1˚C)	0.74 m

Source table: https://www.exploratorium.edu/climate/looking-ahead

Another set of "pathways" were developed in 2016, by modelling the behaviour of socioeconomic factors such as population, economic growth, education, urbanization and the rate of technological development. They are known as the "*Shared Socioeconomic Pathways*" (SSPs) and are based on five different ways in which the world might evolve:

SSP1 - a world of sustainability focused growth and equality
SSP2 - a “middle of the road” world where trends broadly follow their historical patterns
SSP3 - a fragmented world of “resurgent nationalism”
SSP4 - a world of ever-increasing inequality
SSP5 - a world of rapid and unconstrained growth in economic output, energy use



Source image: https://climatescenarios.org/primer/socioeconomic-development

Each of the SSPs socioeconomic conditions can be related to estimates of future energy use characteristics and greenhouse gas emissions, therefore the connection between SSPs and RCPs is crucial for combined modelling.
In our case the SSP2 - middle of the road pathway has been chosen as one of the most probable scenarios for future development. This choice is based on the fact that no specific information or study was gathered in this direction thus, a “central” scenario was thought to be the most adequate choice. In the “*middle of the road*” SSP2, emissions will continue to increase through the end of the century, reaching between 65GtCO2 and 85GtCO2, resulting in a warming of 3.8-4.2°C. As a result, the combination of the RCP8.5 worst case scenario with SSP2 is a consistent choice that highlights the future risk figures in the absence of a strong, global and coordinated commitment towards a climate change mitigation policy.

Both RCP and SSPs were designed to be complementary: while the RCPs set pathways for greenhouse gas concentrations and the amount of warming that could occur by the end of the century, SSPs set the stage on which reductions in emissions will - or will not - be achieved. Moreover, SSPs are now being used as important inputs for the latest climate models and will be integrated in the Sixth Assessment of the Intergovernmental Panel on Climate Change (to be published in 2020-2021) and to explore how the climate goals of the **Paris Agreement** could be met.

SOCIO-ECONOMIC PROJECTIONS FOR ZAMBIA

This risk profile assumed the SSP2 for its projection analysis: a “middle of the road” scenario world where the world trends broadly follow their historical patterns. According to these conditions, the population of Zambia in 2050 will more than double compared to the 2019 official projection data whereas GDP is expected to increase by eleven times.

POPULATION [Million People]

17.4 2019

38.8 2050 Projection

GDP [Billion$]

21.2 2015

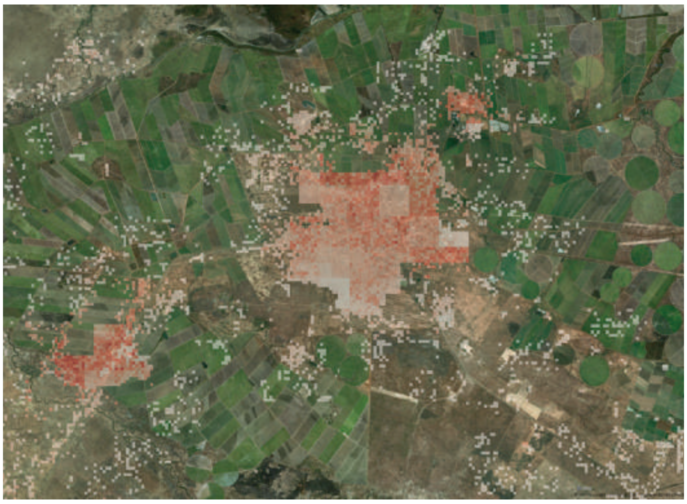
235.8 2050 Projection

PROJECTING POPULATION GROWTH AND URBANIZATION

Population levels are projected to increase in the future, but population distribution is also projected to change dramatically. Urbanization will be a driving force in many African countries in the coming decades. This will affect the riskscape, especially for localized hazard patterns such as the ones on floods. In this profile a model has been used to mimic population growth and urbanization based on a simplified Cellular Automata similar to the one proposed in the literature (i.e. SLEUTH from Clarke and Gaydos, 1998*). Starting from a grid representation of population distribution over the country, the model simulates the evolution of two simultaneous processes triggered by a myriad of seemingly random events: population growth in each location and population migration from one location to another. The evolving population pattern is conditioned by population density, presence of bodies of water, distance that needs to be covered for internal migration and the ability of certain locations/cities to attract populations. The attractiveness of a certain location increases with its vicinity to transport infrastructure and with increasing urban connectivity, so that urbanization is a spontaneous, dynamic evolution of the model. Parameters of the model are calibrated with data and projections of population growth and urbanization from UN-World Population Prospects**.

City of Mazabuka, current population density

0
10
30
100
300
1000
3000
10.000
30.000
[People]



City of Mazabuka, 2050 projection of population density

** Clarke, K.C., and L. Gaydos., 1998. Loose-coupling a cellular automaton model and GIS: Long-term urban growth prediction for San Francisco and Washington/Baltimore, Int J of Geographic Inf Sci. 12, 699–714.*
*** https://population.un.org/wpp/*

Local data collected

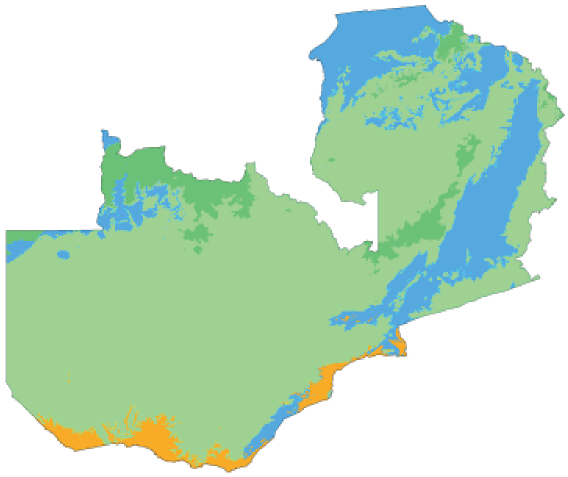
	AREA	DATA TYPE	LEVEL OF DETAILS	SOURCE OF DATA
	Admin. boundaries	National, provincial and district boundaries	National, provincial and district	Ministry of Lands and Natural Resources (MLNR)
EXPOSURE	Built-up	Building footprints Lusaka City	District	Lusaka City Council (LCC)
	Population	Census and housing	Sub-municipal (ward)	Central Statistics Office (CSO)
		Population Statistics (age distribution, gender)	District	
		Minorities	Provincial	
		Population Projections (2011 to 2035)	District	
		Poverty	Sub-municipal (ward)	World Bank
	Agricultural Production	Crop production (small- and large-scale)	District	Ministry of Agriculture and Livestock & Central Statistics Office (CSO)
		Cost of production for different crops	Yearly	Ministry of Agriculture and Livestock
	GDP	Sector-specific GDP for provinces in USD and Zambian Kwacha (2015)	Provincial	Central Statistics Office (CSO) and Ministry of Finance (MoF)
		Provincial GDP in USD and Zambian Kwacha (2015)		
	Inflation	Overall inflation	Provincial	Central Statistics Office (CSO)
	CPI	Consumer Price Index (CPI) for education, food, health, etc.	Provincial	Central Statistics Office (CSO)
	Living Conditions	Average household size, per capita expenditure and income	Provincial	Central Statistics Office (CSO)
	Health	Prevelance of Asthmas, HIV, hypertension and Malaria	Provincial	Central Statistics Office (CSO)
		Malaria - prevalence, mosquito-net ownership, indoor spraying, etc	Provincial	Ministry of Health (MoH)
		Epidemic prone areas	District	Zambia National Public Health Institute (ZNPHI)
	Labour	Employment	Provincial	Central Statistics Office (CSO) and Ministry of Labour and Social Security
		Informal Economy		
		Own use production workers		
		Social protection		
		Unemployment		
		Working age population		
		Working conditions		

	AREA	DATA TYPE	LEVEL OF DETAILS	SOURCE OF DATA
EXPOSURE	Critical Infrastructure	Primary and secondary schools countrywide	-	Ministry of Education and the National Remote Sensing Centre (NRSC)
		Health Facilities including rural health posts, healthcentres and hospitals		MoH and the NRSC
		Power genartion facilities with energy sources		NRSC
		Trunks and main roads, and railways		
HAZARD	Rainfall	Observed rainfall for ~ 10 years	Monthly / 40 stations	Zambia Meteorological Department (ZMD)
		Observed rainfall for ~ 5 years	Daily / 17 stations	Southern African Science Service Centre for Climate Change and Adaptive Landuse (SASSCAL)
	Temperature	Observed minimum and maximum temperature for ~ 10 years	Monthly / 40 stations	Zambia Meteorological Department (ZMD)
		Observed minimum and maximum temperature for ~ 5 years	Daily / 17 stations	Southern African Science Service Centre for Climate Change and Adaptive Landuse (SASSCAL)
	Discharge	Observed water levels and flows (rating formula included) for ~19 years	Daily / Monthly 10 stations for the Zambezi Basin	Zambezi River Authority (ZRA)
	Aquifers, catchments, rivers, etc.	Aquifers, basin blocks, catchments, lakes, rivers and wetlands	-	NRSC
LOSS	Type of event (flash flood, riverine flood, storm event, drought etc...)	Data on flood events and their related impacts countrywide	-	Disaster Management and Mitigation Unit (DMMU)
	Number of people affected/displaced	Event-specific, aggregated at a district level	-	Disaster Management and Mitigation Unit (DMMU)

ZAMBIA CLIMATE TRENDS

Zambia is a landlocked country in southern Africa, with a tropical climate in the Köppen climate classification. Most of the country is classified as humid subtropical or tropical wet and dry, with small stretches of semi-arid steppe climate in the south-west and along the Zambezi valley.
Zambia has a tropical climate where temperatures remain relatively cool throughout the year due to the high altitudes of the East African Plateau.
The highest seasonal temperatures are reached in the hot, dry season, with temperatures between 22 - 27˚C (from September to November), and 15 - 20˚C in the winter months (from June to August).
Similarly to other southern African countries, temperature observations indicate that Zambia has experienced a considerable increase in temperature over recent years. An analysis of climate data from 1970 to 2015 shows an average rise of around 1˚C.

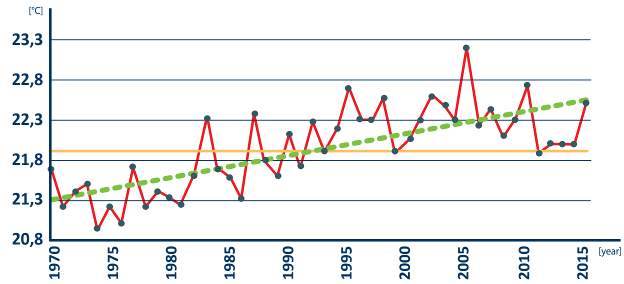
Rainfall in Zambia is strongly influenced by the El Niño Southern Oscillation (ENSO), which causes further inter-annual variability.
El Niño brings drier than average conditions in the wet summer months in the southern half of the country, whilst the north of the country simultaneously experiences significantly wetter-than average conditions.
The country experiences two main seasons, the rainy season (from November to April) and the dry season (May to October/November). The dry season is subdivided into the cool dry season (from May to August), and the hot dry season (from September to October/November).
Rainfall varies over a range of 500 to 1,400 mm (19.7 to 55.1 in) per year, with an average annual precipitation over the entire country of approximately 975 mm.



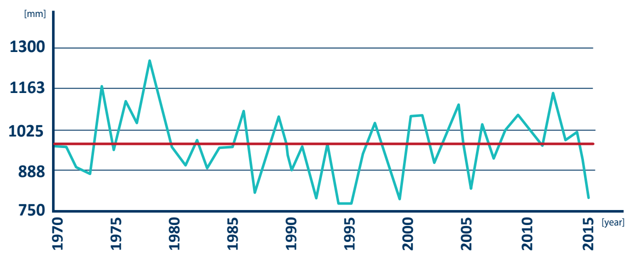
Zambia map of Köppen climate classification

- Tropical savanna (Aw)
- Warm desert climate (BWh)
- Temperate, dry winter, hot summer (Cwa)
- Temperate, dry winter, warm summer (Cwb)

TEMPERATURE AND PRECIPITATION TRENDS (1970 - 2015)



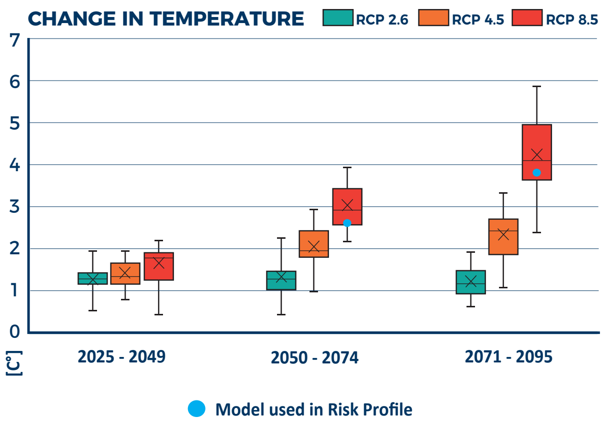
Mean Annual Temperature
Average of Mean Annual Temperature
Trend Mean Annual Temperature

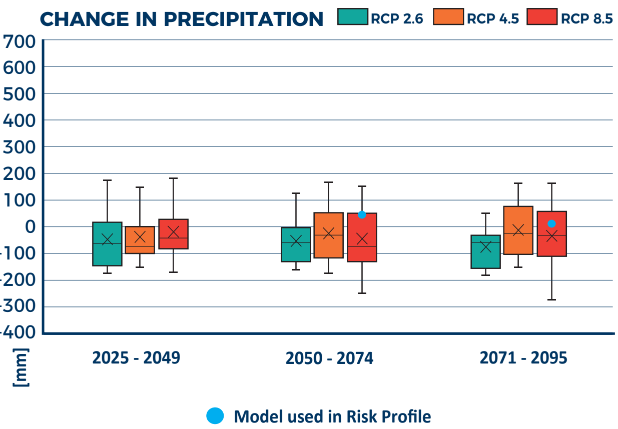


Annual Precipitation
Average of the Annual Precipitation

ZAMBIA CLIMATE PROJECTIONS

In a recent study Alder et al. [1] compared the observed temperature and precipitation values registered in the period 1980-2004 with the estimations of a set of global climate models provided by the Coupled Model Intercomparison Project Phase 5 (CMIP5). Three future periods (2025-2049, 2050-2074 and 2071-2095) were analysed considering the different Representative Concentration Pathways (RCPs) used in the IPCC Fifth Assessment Report for greenhouse emission scenarios [2].
In all future projections, both long term and short term, and for all emission scenarios, model simulations showed an increase in temperature. The increase was more substantial in the high emission scenario (RCP8.5) and for long-term periods projections. Projections in the high emission scenario showed, moreover, an increase in temperature between 2.2°C and 4.2°C for the mid-term period (2050-2074) and an increase of up to 4 °C for the long-term period (2071-2095). Future changes in precipitation were more uncertain, however the models predicted a moderate increase - around 10% - in precipitation for the medium term. Projections for the long-term period show a divergent change.





The climate indicators used in this risk profile have been obtained using a climate projection model based on the RCP 8.5 - high emission scenario for the period 2006-2100 (SMHI-RCA4 model, grid spacing 0.44° about 50 km - driven by the ICHEC-EC-EARTH model). This Regional high-resolution model that is part of the CORDEX Africa project [3] was then accurately calibrated for the African domain, allowing for a better capture of the climate variability and its inherent extremes. Projections deriving from the Regional Model were then checked for consistency against the full ensemble of global models available for the area. Results show that the Regional Model forecasted changes in temperature and annual precipitation which are in line with the range of variability presented by Alder et al.
Within the RCP 8.5 scenario, the Regional Model predicts a moderate temperature rise compared to the Global ensemble. On the contrary, regarding the annual precipitation at the country level, the Regional Model predicts a higher increase in the long-term period than the one predicted on average by the Global ensemble.

REFERENCES

1: Alder, J. R., & Hostetler, S. W. (2015). Web based visualization of large climate data sets. Environmental Modelling & Software, 68, 175-180.
2: https://www.ipcc.ch/assessment-report/ar5/
3: https://www.cordex.org/domains/region-5-africa/

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. 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 in different locations.

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 by 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 by the typology of exposed elements, and also 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 the productive and agricultural sectors). The sectors are created by clustering all of 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 USD) are considered in both current (2016) and future (2050) scenarios. The critical sectors are characterised in terms of their economic value (in USD), using the most updated information available.

FLOOD

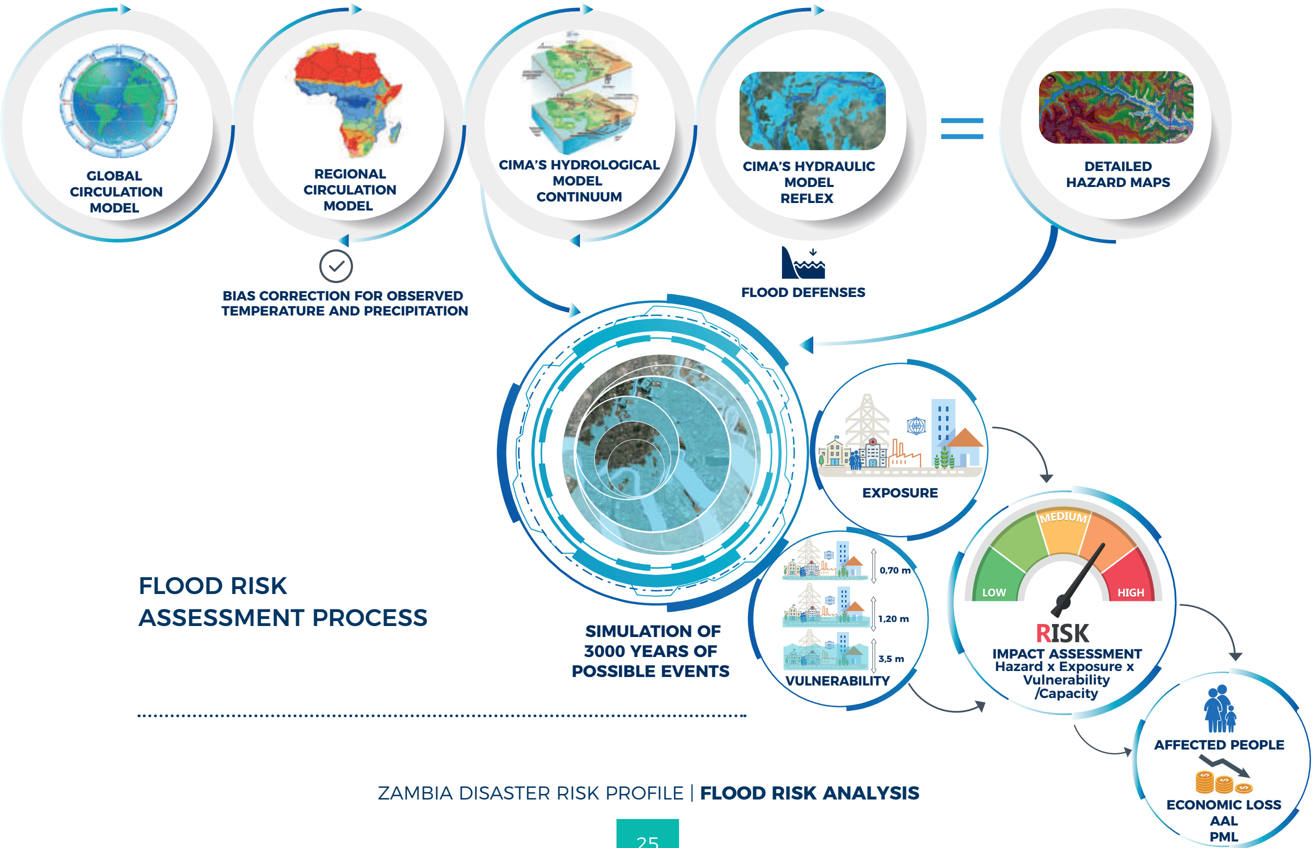
Results (Fig. & Tab.)

Flood Risk Analysis

Flood risk assessment involves four main steps: flood hazard assessment; identification and characterization of exposed elements; vulnerability assessment and capacity / performance of flood protection/structural mitigation measures in lowering flood damaging conditions. From the combination of these four steps into a flood model we are able to determine **risk**.

Different procedures and methodologies to determine risk are used worldwide through a variety of models and approaches. Their common aim is to understand the probability that different magnitudes of damaging flood characteristics - considering flood depth, horizontal flood extent, flood velocity and flood duration - will occur over an extended period of time. These estimates can be calculated both in current and projected climate conditions through a consistent analysis of meteorological, geological, hydrological, hydraulic and topographic properties of the watershed, channels, and floodplains, resulting in detailed hazard maps. Hazard maps are then combined with the reproduction of past events patterns and the modelling of projected future events. Information on the performance capacity of flood protection measures is finally added to the analysis. This workflow allows for the estimation of the "expected" water depth for a certain location and/or individual infrastructures, for a set of reference scenarios. From this step on, it is possible to explore the full frequency distribution of events and the consequent damage to exposed assets, taking into consideration their different levels of vulnerability.

The probability of a given flood magnitude is expressed in terms of the "return period" (or recurrence interval). Return period is the average time interval, in years, separating two consecutive events equal or exceeding the given flood magnitude. The damage assessment is converted into economic metrics through the computation of the average annual loss - the expected loss per year, averaged over many years - and the probable maximum loss - a relationship describing all the potential losses with a certain probability range.



FLOOD RISK ASSESSMENT PROCESS

Within this articulated process, access to data is of vital importance to achieve an accurate risk evaluation. Not only is it necessary to feed information to the modelling chain for the identification of possible hazards in specific locations, such as historical series of observed temperature, rainfall and discharges volumes, it is also crucial to feed the damage models with detailed data on population and assets' levels of exposure and vulnerability. It is only possible to fully understand the economic, social and environmental impacts of past and future possible events with this data. To this end, the present risk profile considers five categories of potentially exposed values. Information about those values were provided by local institutions whenever available. Regional and global datasets were used both as substitutes, when local data was not available, and as data validators, to cross check the consistency of different data sources.

POPULATION

Population estimates were obtained through official censuses at the maximum level of detail available - in the case of Zambia this information was obtained at the ward level. Further information on age, gender, schooling and the presence of vulnerable groups were accessed through official datasets at the local or district level. Global datasets on population were only used in this study to retrieve spatial binary information (population/no-population at any point in space) or information on the relative distribution of population inside a given area. This study considered population according to two different levels of detail:

- the density, meaning the spatial distribution of population across the country;
- the statistical composition, according to the population categories used to identify vulnerable segments (e.g. children, women, people with disabilities).

Projections for future population were produced using the Shared Economic Pathway - SSP2 - "*Middle of the Road*" where global population growth is expected to be moderate in the first half of the century and levels off in the second half.

BUILT-UP

Information on the built-up area refers to two main aspects: to the description of the physical exposure of buildings, in terms of their spatial location inside or outside flood-prone areas; the elements which might influence its vulnerability - such as its occupancy characteristics, the existence of basements, and the typology of its constructive materials;

The built-up data prepared for the present risk profile were obtained from the exposure dataset used in the Global Assessment Report 2015 and in the The Atlas of the Human Planet 2017. They have been divided into three sector classes, according to the exposure categories reported in the Sendai Framework Indicators: housing sector distribution, service sector distribution and productive sector distribution (limited to the industrial sector as the energy production is considered separately).

Whenever possible, local data was also included, regarding:

- Number of storeys of residential buildings in urban and rural areas;
- Number of storeys of non-residential buildings (e.g. business, government etc.) in urban areas;
- Construction materials in urban and rural areas;
- Elevation of the ground floor;
- Average construction cost of residential buildings in urban and rural areas per unit surface area;
- Average construction cost of non-residential buildings (e.g. business, government etc.) in urban areas per unit surface area.

GROSS DOMESTIC PRODUCT (GDP)

Present national GDP data was obtained from the World Bank national studies (*https://data.worldbank.org/indicator/NY.GDP.MKTP.CD*). However, in order to improve the accuracy of the risk results in terms of affected GDP, two increased levels of detail were added from official national data:

• Sub-national gross domestic product (provincial and, if available, municipal level)
• Sector-specific gross domestic product (agriculture, industry, services and commerce (either at national or, if available, at sub-national

Projections of the GDP in 2050 were extracted from the SSP Database from IIASA, using the estimates for the Shared Economic Pathway - SSP2 - '*Middle of the Road*' scenario where income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain.

AGRICULTURAL PRODUCTION

The data on agricultural production refers mainly to the economic value and the vulnerability of the most relevant crop types in the national agricultural production. Estimates of crop distribution, useful to understand production and land use patterns, were obtained through the Spatial Production Allocation Model (MapSpam - September 2019 release) and coupled with national production prices.
The use of local data was useful to identify the most relevant crops and to describe its vegetative/growing cycles, used for vulnerability characterization. Thus, the data analysed included:

• List of crops which account for at least 85% of the Total Gross Production Value of all crops for the country;
• The economic values in terms of production cost and/or wholesale price in USD per ton for each crop;
• Information on the growing cycle of each crop.

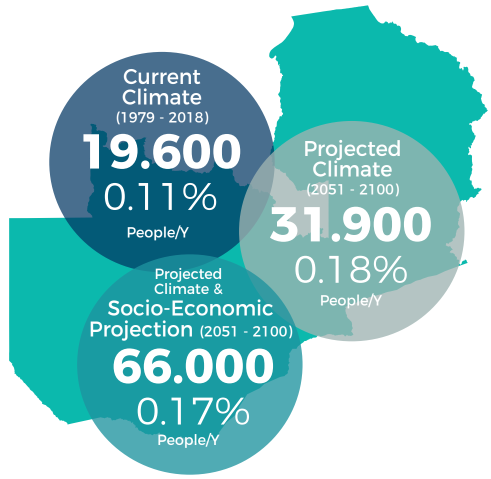
In this risk profile iteration, the selection of crops considered was not only based on their commercial value but also to the role that specific produces play in the average diet of the population. A decrease in the availability of this crops on the national market may result in food insecurity.

CRITICAL INFRASTRUCTURES

Critical infrastructures data refer to the description of the physical exposure in terms of spatial location of school, medical and hospital facilities, energy plants, as well as the transport network combined with their economic values. The main added values of this information rely on knowing the exact location of the infrastructure, the typology of its construction materials, and, in the case of roads, also its elevation and the construction costs per km.
As the available information on critical infrastructures - such as education and health structures was not spatially accurate enough for their direct use in the risk assessment, the scientific team opted to aggregate these data at the ward or district level (depending on the available ancillary information) and then redistribute it in space following the localization of built-up areas. This allowed for the maintenance of the information content of the data on each relevant sector, decreasing potential errors linked to considering a wrong localization of the buildings.

POPULATION

[B1] - ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE



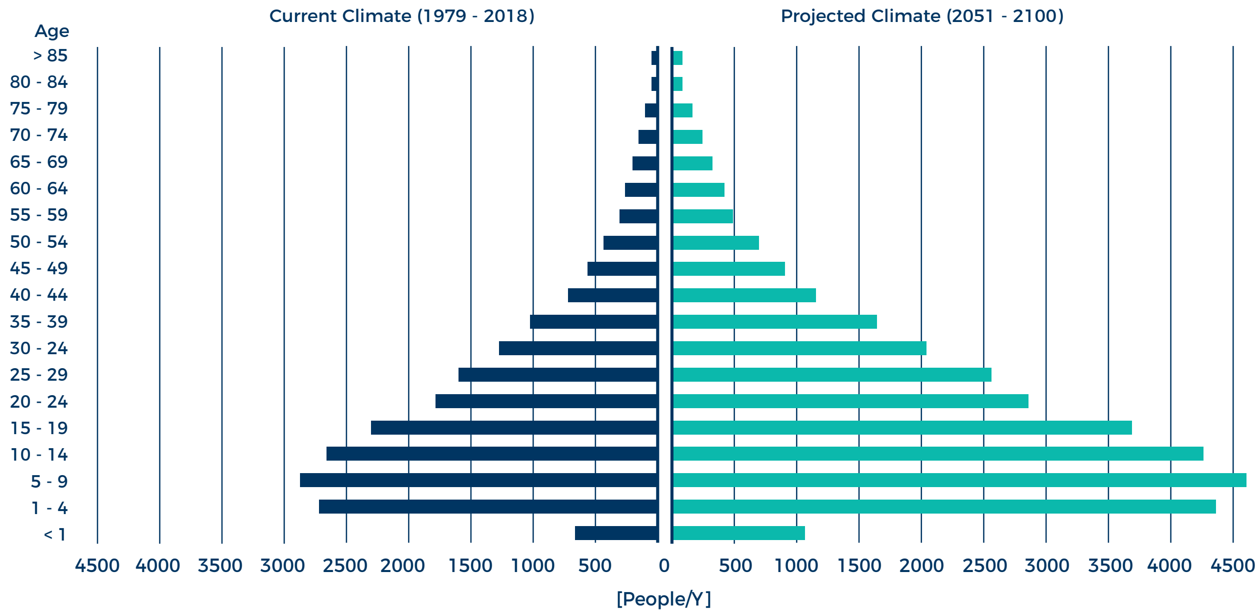
[B1] - Annual Average Number of potentially affected People
Fig. F01

	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)
POTENTIALLY AFFECTED CHILDREN 0-4	3370	5490
POTENTIALLY AFFECTED YOUTH 5-14	5510	7620
POTENTIALLY AFFECTED ELDERLY >65	520	840
	People/Y	People/Y
POTENTIALLY AFFECTED FEMALES	10.000	16.270
POTENTIALLY AFFECTED PEOPLE WITH DISABILITIES	1250	2050

[B1] - Annual Average Number of potentially affected People
Tab. F02

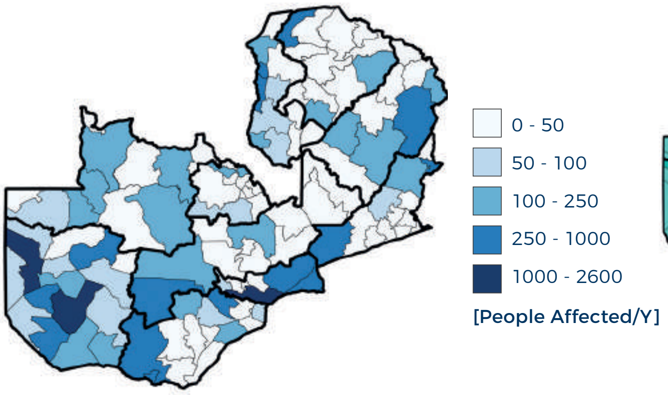
Zambia is highly impacted by severe weather and extreme climate events. Floods represent one of the most prominent issues in Zambia, affecting on average about 20.000 people every year, equivalent to 0.11 % of the total population - ref 2019. These numbers are predicted to change in the future due to two main concurrent factors: on the one hand climate patterns are expected to shift and cause an increase of the flood hazard level while on the other, socio-economic development is predicted to continue at a rapid rate. Considering one possible projected climate scenario (RCP8.5 - worst case scenario), the average number of people affected by floods every year could reach 32.000 (0.18% of the current population), causing an overall increase in the average risk of 60%. On the other hand, if we consider socio-economic development and therefore the possible change in values distribution, concentration and vulnerability, the estimate could increase more than threefold, reaching 66.000 people affected on average every year. This figure, that corresponds to about 0.20% of the total population, is the result of the combined effect of the expected future hazard patterns and the overall increase in population associated with the urbanisation foreseen in many countries in Africa.

Annual Average Number of potentially affected People - Fig. F03

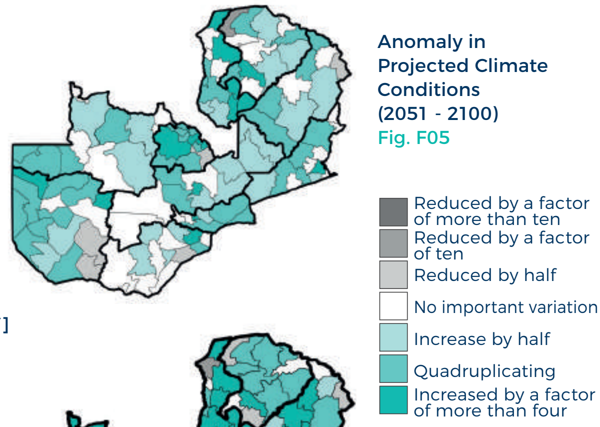


POPULATION

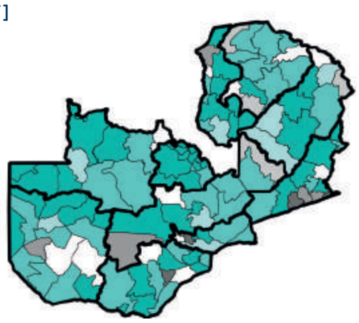
[B1] - ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE



Current Climate Conditions (1979 - 2018) - Fig. F04



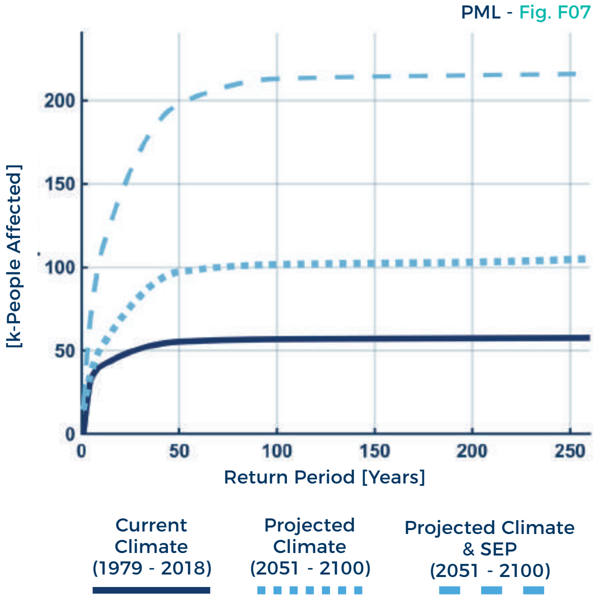
Anomaly in Projected Climate Conditions (2051 - 2100) Fig. F05



Anomaly in Climate and Socio-Economic Projections (2051 - 2100) Fig. F06

In terms of geographical distribution, the majority of the affected population is concentrated in the south-western, southern regions, and the north-eastern regions. In the projected future, this pattern is confirmed and the impact of droughts in the south-western and southern parts of the country are even exacerbated. The age and gender structure of the affected people resembles the overall age and gender structure of the country's demography. Zambia has a young population and, as such, the majority of the affected people are below 30 years of age. However, it is interesting to focus on the most vulnerable categories, such as children in their school age and elderly people, which might suffer serious consequences from floods events. The majority of affected people are women. This is particularly interesting in terms of vulnerability, especially in rural areas where women attend to the majority of the work in agricultural fields and as such are more vulnerable to unexpected flood episodes. Women also play a prominent role in the rural society and their enhanced exposure to floods should be better analyzed from the socio-economic standpoint.

PML - Fig. F07



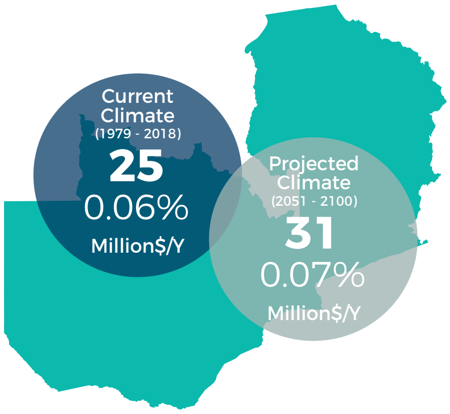
[B1] - PROBABLE MAXIMUM LOSS CURVE OF POTENTIALLY AFFECTED PEOPLE

When the PML curves are analysed, it is interesting to note that a 50-year return period event (i.e. an event that is on average experienced with equal or greater magnitude twice per century) can affect about to 50.000 people, but this figure could increase in the future (considering both climate change and socio-economic development) up to 200.000 people. It is evident that such an event would pose serious civil protection management issues and should be considered when planning emergency resources.

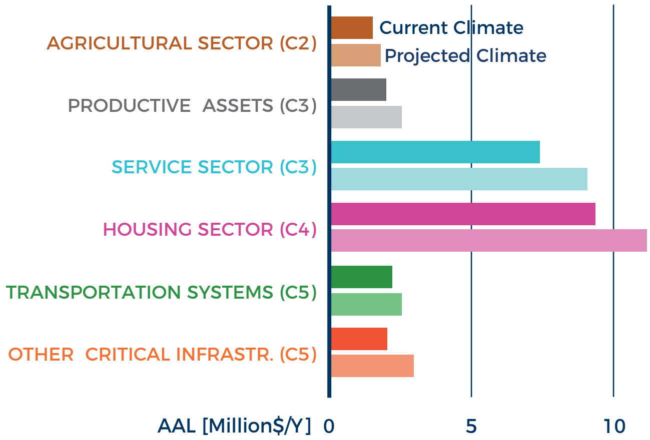
[C1] DIRECT ECONOMIC LOSS

[C1] - AVERAGE ANNUAL LOSS

[C1] - Average Annual Loss - Fig. F08

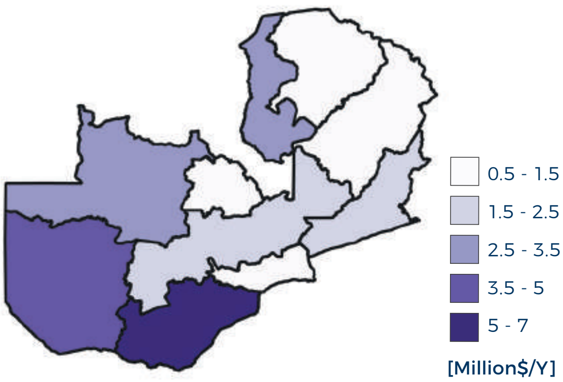


Average Annual Loss per sector - Fig. F09

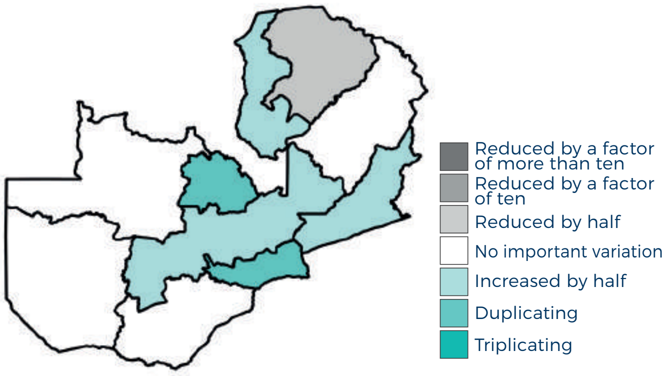


Sendai Target C envisages the substantial reduction of direct economic losses by 2030. It is estimated that Zambia currently loses 25 million USD per year in direct economic losses due to floods, which is roughly 0.06% of the total economic value of the assets considered and 0.12% of the annual GDP. Housing and services (commercial) are the most affected sectors, followed by transportation, critical facilities, productive sectors and agriculture.

Considering the RCP8.5 projected climate scenario (RCP8.5 - worst case scenario), the average direct economic losses will reach 31 million USD per year, about 30% more than the value estimated under current climate conditions. This is a significant increment that should be taken into account in long-term planning and policies even considering the extreme uncertainty associated with such types of estimates.



AAL - Current Climate Conditions (1979 - 2018)
Fig. F10



Anomaly in Projected Climate Conditions (2051 - 2100)
Fig. F11

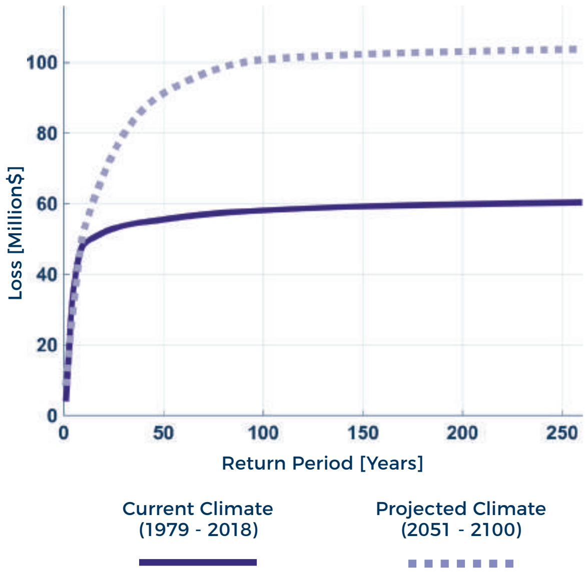
The impact of floods in Zambia has a clear spatial distribution with the majority of economic losses expected to occur in the western and southern provinces. Results for projected climate conditions (RCP8.5 - worst case scenario) do not significantly modify the spatial pattern, but the economic losses are expected to increase in central regions - Copperbelt, Central Province, Eastern Province and Lusaka. Uncertainty in climate predictions and the ongoing evolution of the socio-economic situation of the country could significantly influence these estimates.

[C1] DIRECT ECONOMIC LOSS

[C1] - PROBABLE MAXIMUM LOSS CURVE

The PML curves provide important information on the frequency of floods and associated economic losses. Despite the fact that the average annual losses are of 25 million USD per year, floods with losses of at least 50 million USD are expected to occur very frequently, with a return period of about 10 years (i.e. an event with equal or greater magnitude that is on average experienced every decade). Under projected climate conditions, the frequency of high-impact floods will increase significantly, and it will be very likely (return period of about 25 years) to experience floods with losses of at least 80 million USD.

PML - Fig. F12



GDP

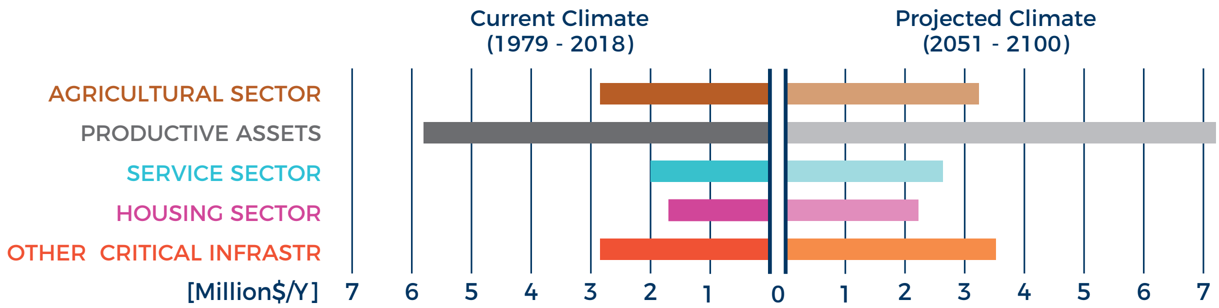
ANNUAL AVERAGE GDP PRODUCED IN POTENTIALLY AFFECTED AREAS

An indication of the risk incidence on the economy can be drawn from the GDP affected (i.e. the GDP produced in areas affected by floods). It is a proxy of direct and indirect potential losses due to floods. Areas subject to flooding over a certain magnitude might suffer indirect losses: assets might be partially or completely damaged and economic activities stopped. In the current climate, the annual GDP produced in areas affected by floods represents on average 0.2% of the total (43 million$/Y). Under projected climate conditions this value is expected to increase to 0.26% (55 million$/Y) and, if socioeconomic projections are taken into consideration, it is expected to reach 0.31% (742 million$/Y). The productive sector is potentially the most affected, followed by the agricultural sector and the critical infrastructure related services. This is due to the GDP accounting not only for the asset values, but also of the value created by the activities linked to those assets. In the projected future, the value of the losses of the productive sector still dominates.

	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)	Projected Climate & SEP (2051 - 2100)
Million$/Y	43	55	742
%	0.20%	0.26%	0.31%

Annual Average GDP Affected - Tab. F13

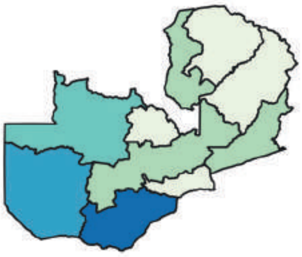
Annual Average GDP produced in potentially affected areas - Fig. F14



DIRECT ECONOMIC
LOSS PER SECTOR

SERVICE SECTOR [C3]

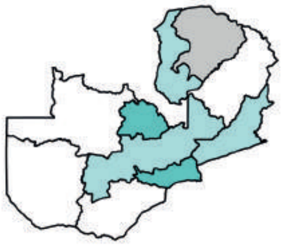
AAL
Current Climate
(1979-2018) - Fig. F15



- 0.2 - 0.5
- 0.5 - 0.7
- 0.7 - 1
- 1 - 2
- 2 - 2.5

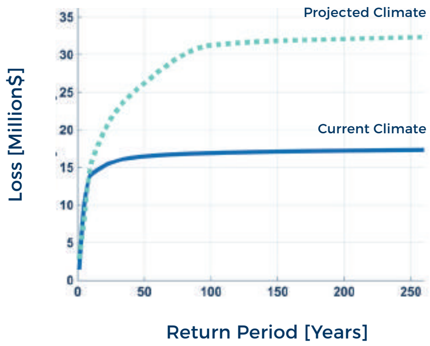
[Million$/Y]

Anomaly in
Projected Climate
(2051 - 2100) - Fig. F16



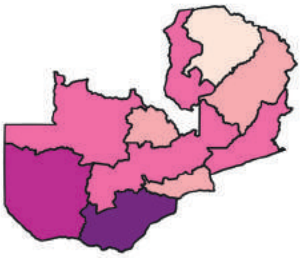
- Reduced by a factor of more than ten
- Reduced by a factor of ten
- Reduced by half
- No important variation
- Increased by half
- Duplicating
- Triplicating

PROBABLE MAXIMUM LOSS CURVE
Fig. F17



HOUSING SECTOR [C3]

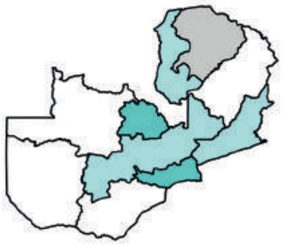
AAL
Current Climate
(1979-2018) - Fig. F18



- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 1
- 1 - 1.5
- 1.5 - 3

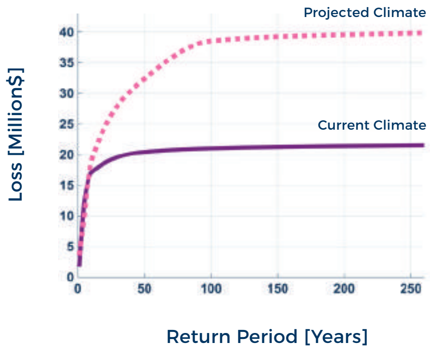
[Million$/Y]

Anomaly in
Projected Climate
(2051 - 2100) - Fig. F19



- Reduced by a factor of more than ten
- Reduced by a factor of ten
- Reduced by half
- No important variation
- Increased by half
- Duplicating
- Triplicating

PROBABLE MAXIMUM LOSS CURVE
Fig. F20



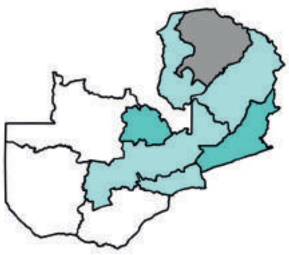
TRANSPORT SECTOR [C5]

AAL
Current Climate
(1979-2018) - Fig. F21

- 0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.35
- 0.35 - 0.5
- 0.5 - 0.75

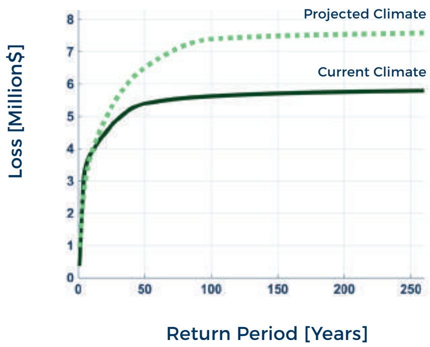
[Million$/Y]

Anomaly in
Projected Climate
(2051 - 2100) - Fig. F22



- Reduced by a factor of more than ten
- Reduced by a factor of ten
- Reduced by half
- No important variation
- Increased by half
- Duplicating
- Triplicating

PROBABLE MAXIMUM LOSS CURVE
Fig. F23



The most affected sectors, in terms of direct economic losses, are housing and services, followed by transportation. The spatial distribution of the annual average losses are very similar for the three sectors and the most affected area are the provinces of the west and the south. High impacts are expected in the central part of the country for the housing sector.

The direct economic losses are estimated to increase for all sectors under projected climate conditions. Specifically, the average annual loss for the housing and service sectors is expected to increase significantly in Lusaka and the Copperbelt Province. Similarly, the losses for the transportation sector in the Central Province are likely to be significantly higher in absolute terms under projected climate conditions while the Copperbelt and Eastern Province are expected to experience the most important relative increases.

The PML curves for the three sectors confirm that Zambia is exposed to very frequent floods and the frequency of high impact floods can increase significantly under projected climate conditions. The impacts of floods with a medium likelihood of occurrence (return period of 50 years) are expected to almost double under projected climate conditions.

Disaster Management and Mitigation Unit

DROUGHT

Results (Fig. & Tab.)

Drought Risk Analysis

Drought risk in this report is assessed in four different ways: the analysis of drought hazard and potentially affected population and livestock; the estimation of drought vulnerability of the human population; the calculation of current and projected losses for hydropower production; the estimation of current and projected damage to crop production.

From the combination of these four assessments, one can get a comprehensive understanding of the drought risk. Droughts can arise from a range of hydro-meteorological processes that reduce water availability. With varying time gaps between the reduction in availability and a potential impact on the system, these processes can create conditions that are "significantly drier than normal", and limit moisture availability to a potentially damaging extent (WMO 2016). A drought hazard, interacting with the vulnerable conditions of the exposed people and assets, becomes a disaster when it causes a serious disruption of the functioning of society, leading to losses. (UNISDR 2015).

The social, economic and environmental impacts of droughts stem from their severity, duration and spatial extent; and from the situation of people, production capacities and other tangible human assets exposed to the drought hazard; it is a combination of the drought hazard, exposure and vulnerability to droughts (UNISDR 2015). In order to align the risk profiles with the Sendai Targets, the approach focuses on the:

- number of affected people B1;
- sections "Drought hazard, exposure and vulnerability";
- agricultural loss (C2; section "Agricultural losses");
- productive assets (C3; section "Hydropower losses");
- and the direct losses (C1) as sum of C2 and C3.

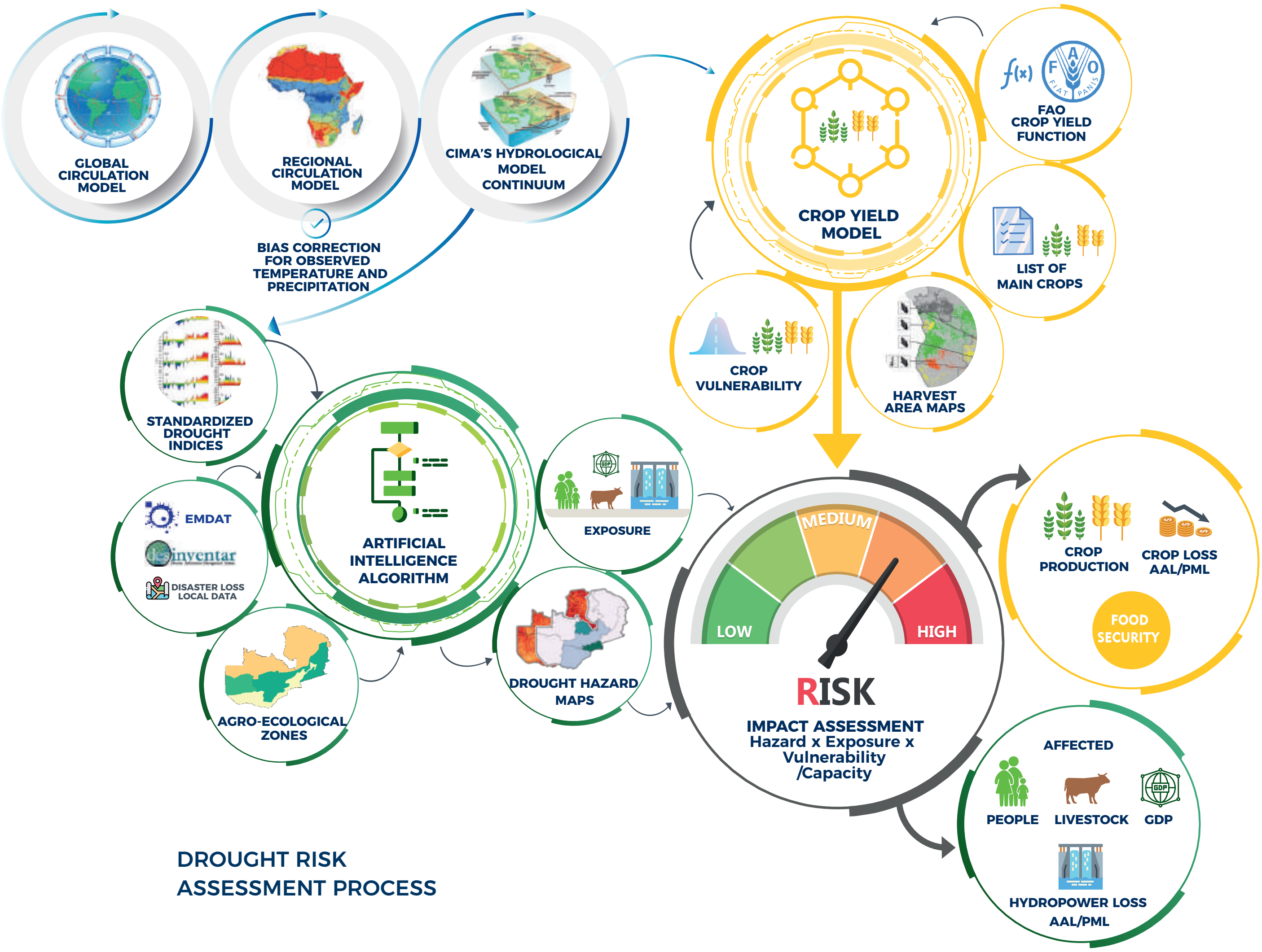
DROUGHT HAZARD, EXPOSURE AND VULNERABILITY

Due to the multi-faceted character of droughts, numerous drought indices exist. One group is the standardized indices, representing anomalies from a normal situation by analysing at least +30 years (preferably 50) in a standardized way. The following five standardized drought indices are used in this risk profile: the Standardized Precipitation Index (SPI), the Standardized Precipitation-Evapotranspiration Index (SPEI), the Standardized Evapotranspiration Index (SEI), the Standardized Soil Moisture Index (SSMI) and the Standardized Stream Flow Index (SSFI). Together, they cover all parts of the hydrological cycle.

Larger, longer and/or more intense droughts are more severe and will result in a larger impact. To include these intensity, duration and spatial extent aspects of drought, the total water deficit (i.e. how much less water than average) is calculated as the cumulative sum of the monthly water deficits. This is done using the different indices and also different deficit intensity thresholds. Then, using an artificial intelligence algorithm applying decision trees, the deficits under different thresholds for different indices are matched with reported drought disaster impacts. This is done for each agro-ecological zone in the country, assuming the vulnerability to droughts is similar under similar agro-ecological conditions. As such, local-tailored indices and thresholds can be used to assess the drought hazard under current and projected climate conditions.

This drought hazard map can be combined with population, GDP and livestock maps so as to calculate how many people or animals are exposed to different drought events. From this, the annual average amount of these potentially affected people and animals can be estimated.

No estimations about mortality and the impact of droughts on livelihoods could be made; nor numbers of how many people would be in need of emergency aid because of the drought impact. While the regional vulnerability is included (droughts are defined based on their effects for each agro-ecological zone), human vulnerability (or livestock vulnerability or GDP sectoral vulnerability) are not accounted for. Quantifying vulnerability to droughts as the relation between severity and the expected impacts requires detailed records on droughts losses and damages which are seldom available. However, one extra proxy for vulnerability was included in the risk profiles: the Water Crowding Index, which quantifies the amount of available water locally available per person.



DROUGHT RISK ASSESSMENT PROCESS

HYDROPOWER LOSSES

Assessing the drought risk for hydropower is possible when given sufficient information on hydropower dams and their reservoirs. Using the GRAND database, all dams with 1st or 2nd use "electricity" were selected and their characteristics (location, height, surface area, capacity) retrieved. Using the coordinates of the dam, corresponding discharge, evaporation, and precipitation were retrieved from the hydro-meteorological data.

For each time step, the influx (discharge and precipitation), as well as the outflux (outflow and evaporation) were estimated. Outflow is a function of the storage capacity (minimal, maximal and current) and long term mean average inflow. Using a reservoir capacity equation, the height of the water level in the reservoir was subsequently determined, which was an important parameter for determining the energy that can be generated. Using a fixed energy price (0.14 USD/kWh) this was translated to a monetary value.

In order to identify losses, a baseline energy production was established. For this, the average annual production over the baseline period (1979-2018) was used. As such, a year with below average production (and thus revenue) was considered a loss (equal to the difference with the baseline average). This way, annual production and loss series were created, allowing to calculate average annual losses and marginal losses for return periods of 5, 10, 25, 50 and 100 years. This was done for current climate conditions, as well as projected climate conditions (keeping the baseline production the same).

AGRICULTURAL LOSSES

When there is insufficient moisture in the soil to meet the needs of a particular crop at a given time and location, drought-induced crop losses can occur. To estimate the risk of droughts on the arable sector and the risk to food security, the major crops for each country were selected based on (1) their contribution to the Gross Production Value of all crops in the country and (2) their importance as food for the population. Data have been acquired from FAOSTAT, MAPSPAM, EARTHSTAT, and supplemented with data derived from Zambia.

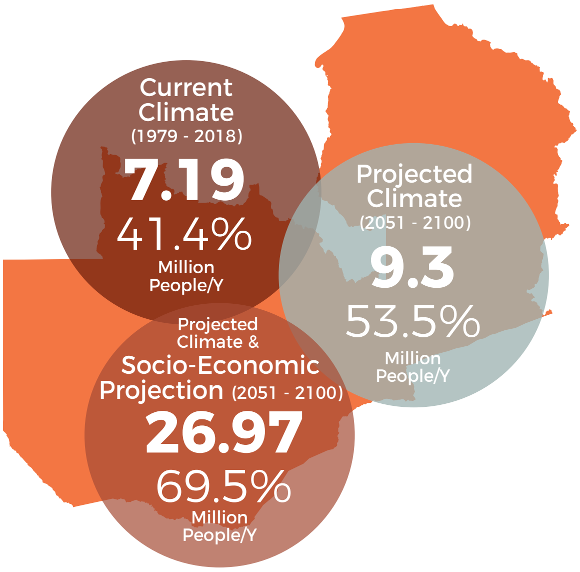
Generally, there is a fairly linear relation between the ratio of actual over potential evapotranspiration and crop yield, as represented by the FAO "water production function". This relation was tailored for all crops by including a local crop drought sensitivity factor - a factor that is also determined by whether the crop is produced under rain fed or irrigated conditions. Further, reference yield values were then defined by matching the calculated crop yields with data from FAOSTAT. Then, the spatially-explicit crop yields' variability as response to changing hydrological conditions could be assessed on a yearly basis, and the annual production could be estimated by multiplying the yields with the harvested areas of the selected crops.

Production losses were calculated as the difference between the production of a year and the 20% lowest value from the current climate. A zero loss was assigned to any year with a production equal or above this 20% threshold. We determined the average annual loss by dividing the summation of these annual losses by the total number of years, including the non-drought years. These calculations can be done in kilograms but also converted to USD by multiplying the production loss with the market price of the evaluated crops .

Additionally, effects of droughts on (1) amount of lost working days (reflecting job opportunities in arable farming), (2) potential loss of food energy supply (in Kcal, calculated as the part of the production which is available for consumption as food for people in Zambia, subtracting the production for export and other uses) and the amount of people who could potentially have been fed by this lost production (assuming Minimum Dietary Energy Requirement of 1730 kcal/cap,day and 10% household waste), and (3) production losses from using drought-adapted varieties (reflecting options for adaptation), have been estimated as well.

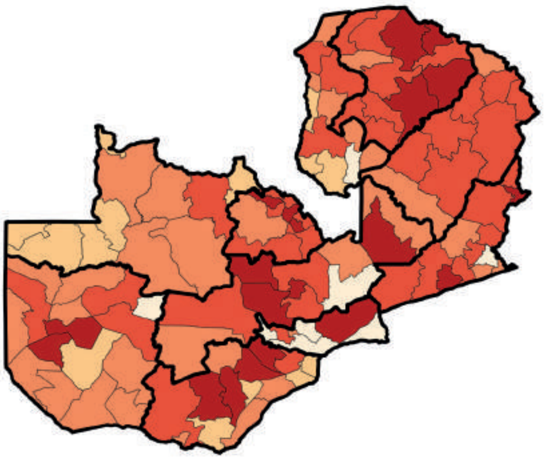
POPULATION

ANNUAL AVERAGE NUMBER OF PEOPLE LIVING IN DROUGHT AFFECTED AREAS



Annual Average Number of People living in drought affected areas
Fig. D01

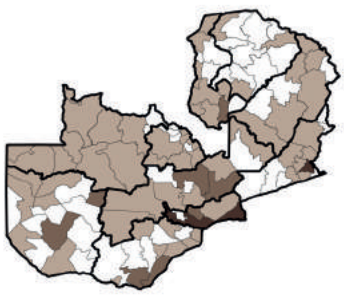
Current Climate Conditions (1979 - 2018) - Fig. D02



0 - 5000
5000 - 20.000
20.000 - 45.000
45.000 - 100.000
100.000 - 400.000
[People/Y]

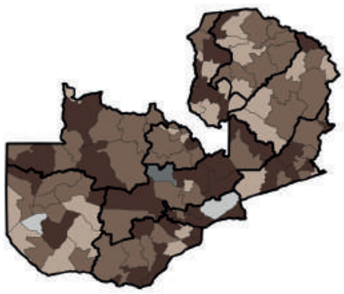
With respect to current climate conditions (1979-2018 climate), the probability of occurrence of soil moisture and meteorological droughts will increase in the projected climate. This is caused by an increase in variability in precipitation and temperature causing more frequent, but shorter drought conditions despite median and average yearly precipitation increases. Streamflow, on the other hand, does reflect the higher average precipitation and displays a decrease in drought probability (-60%) under projected climate conditions (2051-2100).

Under current climate conditions, areas comprising around 7 million people (42% of the total 2019 population) are hit by drought every year, on average. The areas with a high population density such as around Kabwe and Chingola - Kitwe - Ndola have large numbers of people living in areas affected by droughts, but some less populated areas in the semi-arid parts of Zambia, such as Sioma and Mulobezi have high percentages of the population living in the affected area.



Anomaly in Projected Climate Conditions (2051 - 2100)
Fig. D03

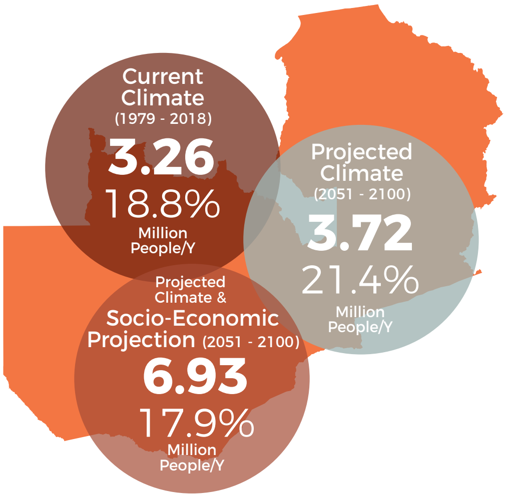
Reduced by a factor of more than ten
Reduced by a factor of ten
Reduced by half
No important variation
Duplicates
Quadruplicates
Increased by a factor of more than four



Anomaly Climate and Socio-Economic Projections (2051 - 2100)
Fig. D04

POPULATION

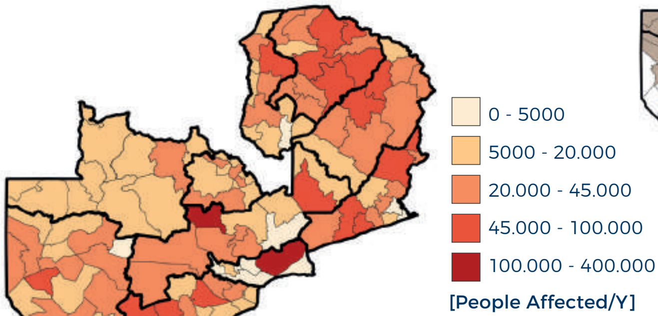
[B1] - ANNUAL AVERAGE NUMBER OF PEOPLE DIRECTLY AFFECTED BY DROUGHT



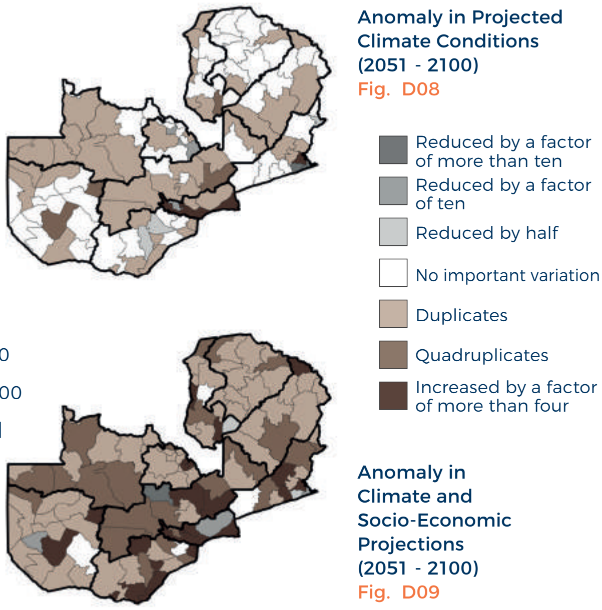
[B1] - Annual Average Number of People directly affected by drought - Fig. D05

	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)
DIRECTLY AFFECTED CHILDREN 0-4	565.200	637.200
DIRECTLY AFFECTED YOUTH 5-14	925.800	1.043.900
DIRECTLY AFFECTED ELDERLY >65	86.800	97.900
	People/Y	People/Y

[B1] - Annual Average Number of People directly affected by drought - Tab. D06



Current Climate Conditions (1979 - 2018) - Fig. D07



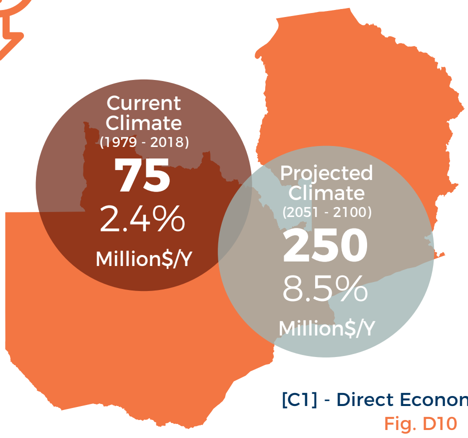
Anomaly in Projected Climate Conditions (2051 - 2100) Fig. D08

Anomaly in Climate and Socio-Economic Projections (2051 - 2100) Fig. D09

Individuals' vulnerabilities and coping capacities to drought conditions depend on their physical, social, economic, and environmental factors or processes. People living in urban environments are usually less vulnerable to drought than those living in rural communities. Rural communities tend to have a limited short-term coping capacity and a limited long-term adaptive capacity. These communities strongly rely on national and more local disaster management authorities' efforts to mitigate such adverse effects and, in extreme cases, are forced to migrate elsewhere to satisfy their subsistence needs. In this sense, transport infrastructure plays a key role in providing access to water during an emergency, as remote unconnected communities are more difficult to reach by external relief resources.

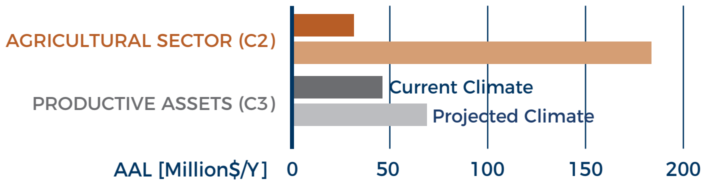
Based on these assumptions, in this risk profile, the combination of people vulnerability and coping capacity to drought was estimated as a function of rural/urban population concentrations within each province. Rural communities with higher levels of isolation were then assumed to suffer wider drought consequences.
Computations show that among 7.2 million people (on average, per year) living in areas affected by drought in current climate conditions, an average of 3.2 million people per year are estimated to be directly affected. This number increases to 3.7 million under projected climate conditions and to 6.9 million if both projected climate conditions and socioeconomic evolution are considered.

[C1] DIRECT ECONOMIC LOSS



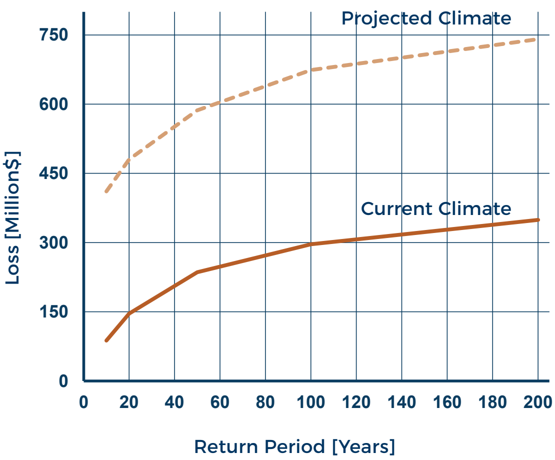
[C1] - Direct Economic Losses
Fig. D10

Direct Economic Losses per sector - Fig. D11



The direct economic losses from agricultural and productive sector (hydropower) are estimated to be 75 million USD on average per year and to increase to 250 million USD under projected climate conditions. The total Average Annual Loss for the agricultural sector (crops) rises greatly under projected climate conditions from 29 to 180 million USD per year, indicating that a substantial part of the annual crop production could be lost due to intensified droughts in the projected climate. Compared to current climate conditions, losses in hydropower generation (C3) resulting from drought will increase by almost 50% under projected climate conditions (for Mulungushi, Itezhi-Tezhi, Kafue Gorge and Kariba dams).

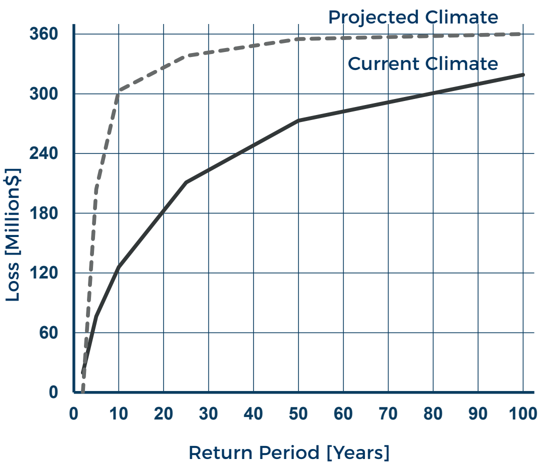
C2 - LOSSES AGRICULTURAL



[C2] - PML - Fig. D12

Under current climate conditions, the probable maximum loss from agriculture increases gradually when return periods go up from 10 to 200 years. It is worth noting that these results become increasingly uncertain as we move into the very rare losses domain. Under projected climate conditions, these losses increase substantially in absolute units, and relative increases range from almost two times, with a 200 year return period, to 4 times, with a 10 year return period. More frequent losses thus become more important under projected climate conditions.

C3 - LOSSES HYDROPOWER

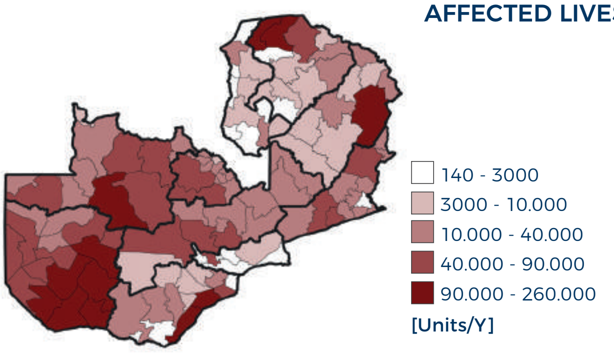


[C3] - PML - Fig. D13

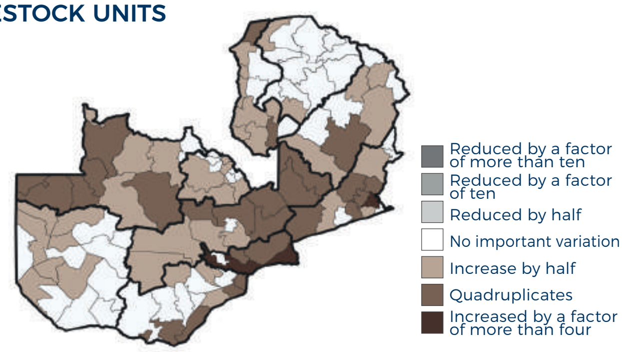
C3 is computed exclusively considering losses in hydropower production. These are defined as production below levels with average reservoir conditions. Under current climate conditions, on average once every 5 years, a loss of about 80 million USD can be expected. Hydropower losses are projected to increase under projected climate conditions reaching at least 200 million USD losses on average once every 5 years. This is a net result of increased losses in the south (Kariba dam), and reduced losses in the other hydropower stations.

LIVESTOCK

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED LIVESTOCK UNITS



Current Climate Conditions (1979 - 2018) - Fig. D14



Anomaly in Projected Climate Conditions (2051 - 2100) - Fig. D15

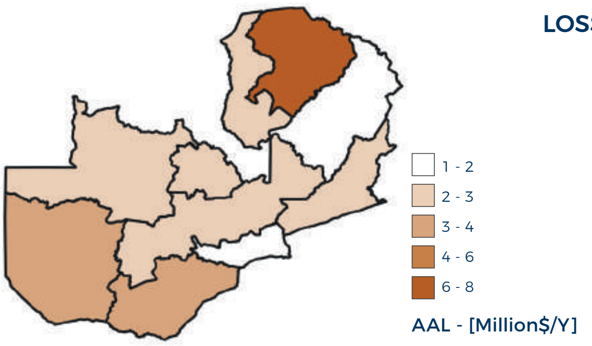
	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)
Million Unit/Y	4.1	5.7
%	38.8%	54.3%

Potentially Affected Livestock - Tab. D16

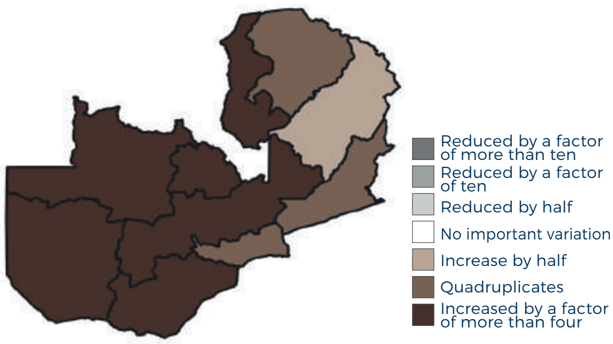
Under current climate conditions, affected livestock (i.e. animals living in areas hit by droughts) amounts to about 4 million units (39%). Livestock units are calculated as the sum of all animals in a certain place, weighed by the water and food needs of the animals (FAO conversion factors). Under projected climate conditions, the number of affected livestock is projected to increase to more than 54% of the total livestock population (with increases in all regions, especially in the central and southern provinces).

AGRICULTURE

C2 - DIRECT AGRICULTURAL LOSS



ALL - Current Climate Conditions (1979 - 2018) - Fig. D17



Anomaly in Projected Climate Conditions (2051 - 2100) - Fig. D18

	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)
Million$/Y	29	180
%	1.9%	11.6%

C2 - Direct Agricultural Loss - Tab. D19

Under current climate conditions direct economic crop losses are around 29 million USD per year. The spatial distribution shows modest variations between different regions, with most of the regions at less than 3 million$/Y, two regions at less than 4 million$/Y and in one region less than 8 million$/Y. These direct economic crop losses are expected to increase to 180 million USD per year under projected climate conditions. This increase is represented by a factor of more than six. The percentage of the average Gross Production Value of the selected crops, on the other hand, rises to almost 12%. Under projected climate conditions, increased droughts cause substantially higher direct economic crop losses in all regions. The western part displays relatively high losses (28 - 38 million $/Y), whereas in the eastern part losses remain relatively low at 3 - 8 million$/Y. The increase in losses between current and projected climates follows the same pattern: highest in the western and lowest in the eastern provinces.

AGRICULTURE

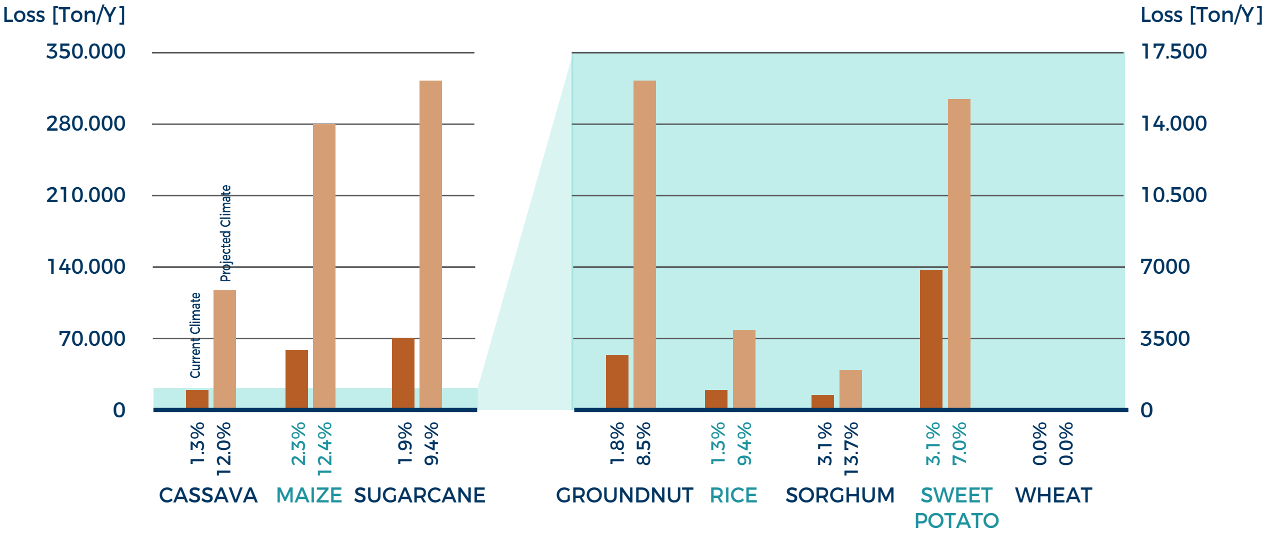
ANNUAL AVERAGE NUMBER OF WORKING DAYS LOST

	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)
k - days / Y	820	4580
%	0.47%	2.62%

Annual Average Number of working days lost Tab. D20

The average number of lost Working Days (WDs) is linked to the crop production losses, because lower crop production is linked to reduced labour requirements, especially during harvest time. This loss has been estimated at roughly 800 k-days/Y under current climate conditions. The increase in the projected climate is more than fivefold. Thus, many more people may have less farmwork employment opportunities. When compared to the total amount of required WDs, the relative value for lost WDs is below 3% under both climates, but increases to 13.5% under projected climate conditions, if compared to the WDs required for harvesting.

AGRICULTURAL PRODUCTION LOSS

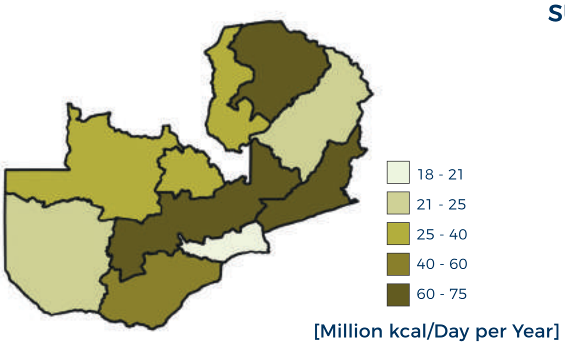


Agricultural Production Loss - Fig. D21

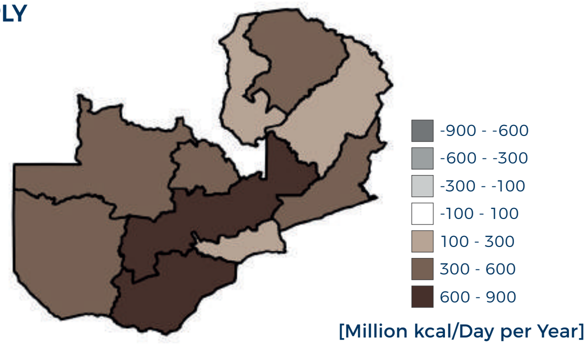
Crop production losses, induced by drought conditions, have been calculated for eight different crops in Zambia. Under current climate conditions, these losses are dominated by cassava, maize and sugarcane (physical units), and if expressed as % of the average crop production, they remain close to or lower than 3%. Under projected climate conditions, large increases in production loss have been calculated for all crops, due to intensification of droughts compared to the current climate. Relative losses range from 7.0 to 13.7%, with increase factors from 2.3 up to 9.2 (excluding wheat). For wheat, no drought effects were calculated because our data assume that most wheat is irrigated.

AGRICULTURE

FOOD ENERGY SUPPLY



Current Climate Conditions (1979 - 2018) - Fig. D22



Projected Climate Conditions (2051 - 2100) - Fig. D23

Several arable crops contribute to the food energy supply of households in Zambia. Droughts could negatively affect the food security situation via lower crop production. To estimate which part of the crop production is, on average, available for direct consumption as vegetal food in Zambia, yearly crop production of selected crops has been computed and expressed in kcal per day. Export and other uses (including feed) are subtracted during the computation. Contribution to food energy supply is expressed in kcal per day for the whole country. The food energy supply is projected to be reduced across the country, especially in the central and south-western provinces.

FOOD SUPPLY CONSEQUENCES

When droughts negatively affect crop production, this may translate into a negative effect on average food energy supply. To illustrate the impact of a lower crop production, the loss of production has been expressed in an equivalent number of people that could have been fed with this lost production (compared to the situation under current climate). To convert food energy supply into number of people potentially fed, we applied the Minimum Dietary Energy Requirement (MDER for Zambia*, 1720 kcal/cap,day) and an assumed household waste of 10%. Below Figure illustrates the results for two periods under the projected climate to emphasize the projected trends (box plot: 25% - 75%; whiskers to indicate extreme values). Our results show that less people can potentially be fed with a diet containing the MDER, as compared to the situation under current climate, and that this effect is stronger in the 2nd half of the projected climate (from an average 1.5 million people to 3 million people). It illustrates a possible negative effect on food security for the people in Zambia due to increased drought conditions under the selected projected climate. The values should be regarded as minimum values, because in reality much more people can be affected in their food security situation (more but less severe), if the conditions for crop growth worsen.

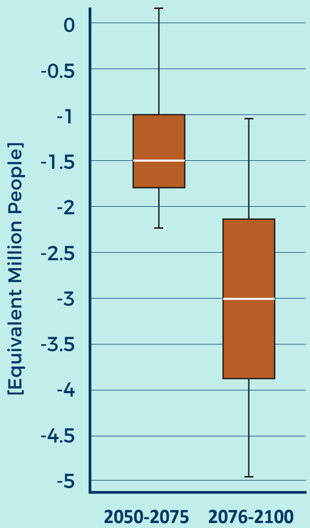


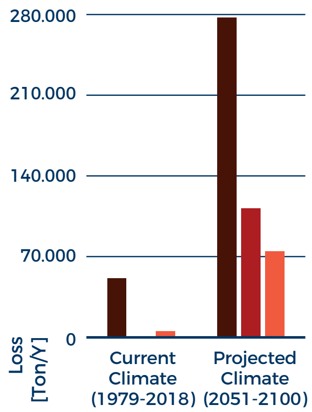
Fig. D24

http://www.fao.org/fileadmin/templates/ess/documents/food_security_statistics/MinimumDietaryEnergyRequirement_en.xls

AGRICULTURE

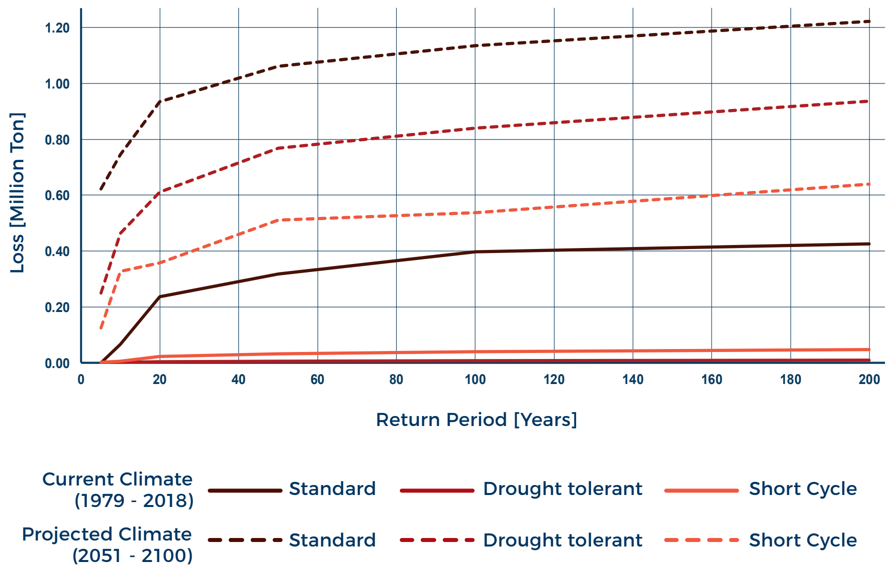
DROUGHT TOLERANT CROPS

MAIZE

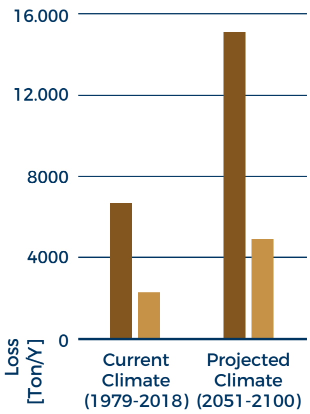


Drought tolerant crops
Fig. D25

Drought tolerant crops - Fig. D26

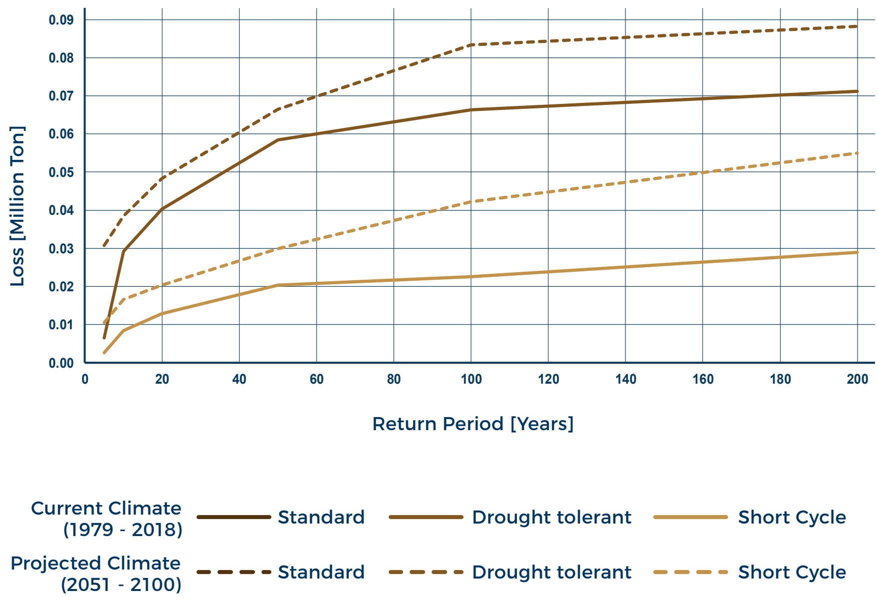


SWEET POTATO



Drought tolerant crops
Fig. D27

Drought tolerant crops - Fig. D28



We estimated the effect of drought-tolerant varieties on crop production for two selected crops: maize and sweet potato in Zambia. For maize we introduced a short-cycle variety to avoid planting too early in the season, and a variety that has better characteristics to tolerate periods of droughts (e.g. via more extensive root system or physiological response to drought conditions). For sweet potato, only the drought-tolerant variety was used.

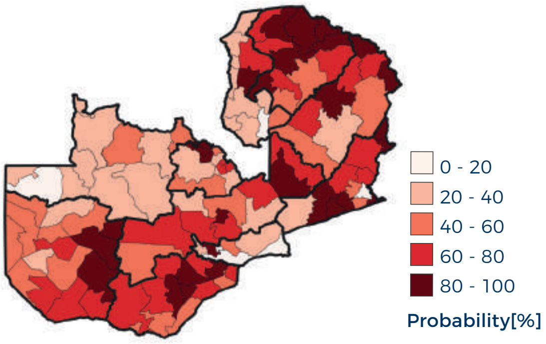
In most cases, the adaptation to drought, gives these varieties an advantage in drier years, but result in lower yields in wetter years. However, the analysis to determine the overall effect with all years in a climate (dry and wet) was not possible within this project. Obviously, this overall effect is strongly influenced by the frequency of occurrence of dry/wet years. In order to reduce the occurrence of lower yields in wet years, an Early Warning System can be used in combination with these varieties: drought monitoring and seasonal outlook can be used to advise a drought-adapted variety when the probability to have droughts in the growing season is high.

A crop production threshold, that is, a level of production under which a loss can be expected, was determined for the standard variety and under current climate conditions. This threshold was used to compute losses in under projected climate conditions and for the two other crop varieties. The results show that for maize, the losses decrease in the current climate, and more substantially so in the projected climate. The two types of adaptation are not very different with respect to this calculated loss. For sweet potato, in both climates, losses are significantly lower than for the standard variety, and more pronounced in the projected climate, due to intensified drought conditions.

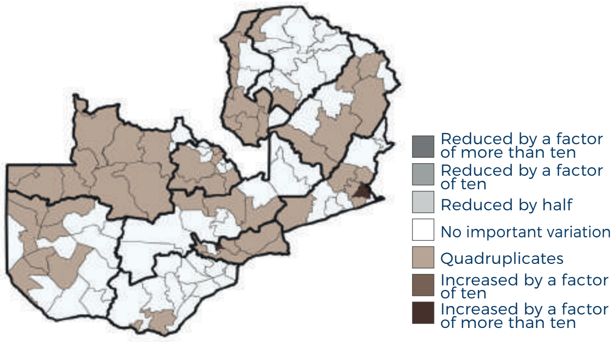
Strong effects are visible in the Probable Maximum Loss estimates for maize: all future losses show much higher values, compared to their counterparts under current climate conditions. Remarkable are the very low losses for the two drought-adapted varieties under current climate conditions, which illustrates their advantage, compared to the standard variety, in the dry years of the current climate. However, under projected climate conditions, PML values increase substantially for these alternative varieties due to the intensification of droughts, though not as much as the increases seen in the standard variety. In the case of sweet potatoes, only the drought tolerant variety was calculated. This variety followed the same trends as for maize: reducing the PML in the current climate and rising in the projected climate, though this projected rise would be far less grave than that seen by the drought tolerant maize.

HAZARD

COMBINED DROUGHT HAZARD



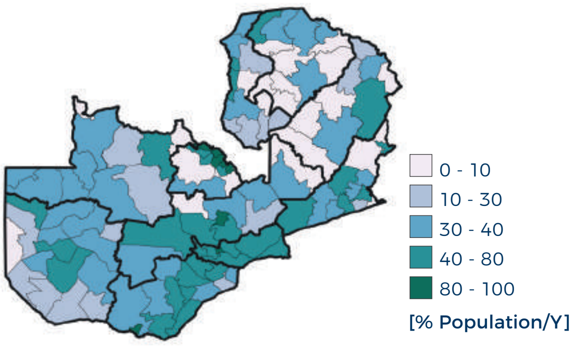
Current Climate Conditions (1979 - 2018) - Fig. D29



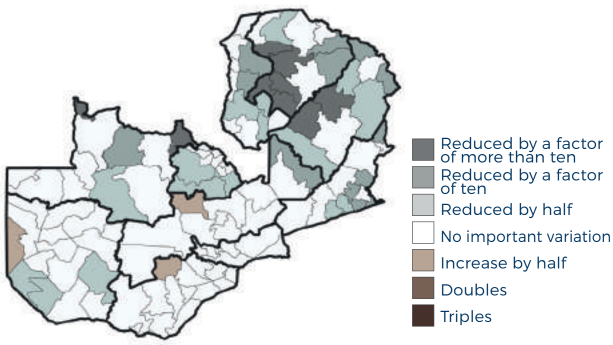
Anomaly in Projected Climate Conditions (2051 - 2100) - Fig. D30

These maps show the average annual chance of experiencing a drought (%). By analysing the deficits in effective rainfall (precipitation minus potential evapotranspiration), in subsurface water (soil moisture), and in the rivers (streamflow), and investigating which deficits caused an impact in the past decades, the vulnerability to water deficits was estimated for different regions in Zambia. Then, the frequency of such meteorological or hydrological deficit under current and projected climate conditions was evaluated. With the combination of the deficit impacts and frequency, we created a drought probability map that showed the annual chance of a harmful drought. Under projected climate conditions, the probability of disastrous droughts will slightly increase in most areas in Zambia, with an estimated significant relative change the western regions. While streamflow and soil moisture indexes will decrease (see pag. 47), the drought hazard will still increase due to the projected higher temperatures and larger rainfall variability.

WCI - WATER CROWDING INDEX



Current Climate Conditions (1979 - 2018) - Fig. D31

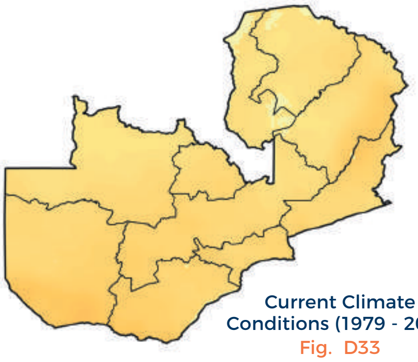


Anomaly in Projected Climate Conditions (2051 - 2100) - Fig. D32

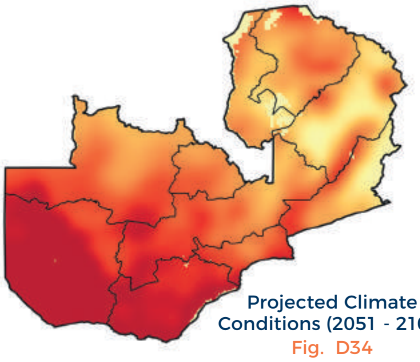
These maps show the percentage of the population per region experiencing water scarcity, based on the water available (precipitation minus actual evapotranspiration) per person per year (<1000 m^3/person/year). Water scarcity indicates that a population depends on water resources from outside of their immediate region (~25 km^2). Currently, the highest percentage of population under water scarcity can be found in the Livingstone region, Copperbelt Province, and around Lusaka, where almost the entire population is not self-sufficient in water from their immediate region. Overall, average water availability changes little under projected climate conditions.

HAZARD INDEX

SPEI
Standardised Precipitation-Evapotranspiration Index



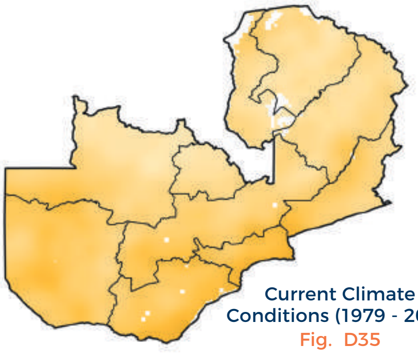
Current Climate Conditions (1979 - 2018)
Fig. D33



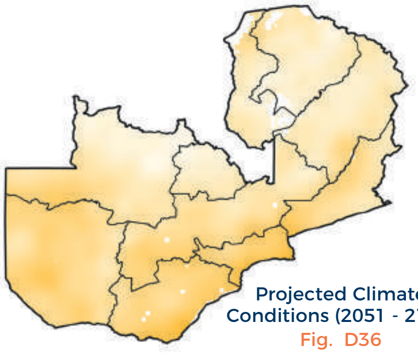
Projected Climate Conditions (2051 - 2100)
Fig. D34

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 – Potential evapotranspiration Index (SPEI). In the south-west of Zambia, the probability of droughts will increase the most. This is particularly important for areas dependent on rainfall for their water resources.

SSMI - Standardised Soil Moisture Index



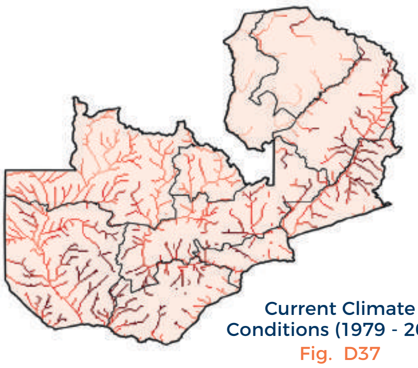
Current Climate Conditions (1979 - 2018)
Fig. D35



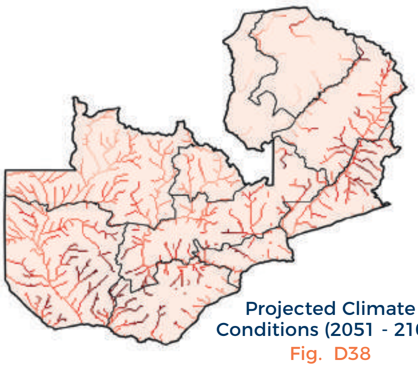
Projected Climate Conditions (2051 - 2100)
Fig. D36

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). It can be noted that the probability of droughts is the highest in the North-Western, Western and Southern provinces of Zambia. There is a decrease in drought probability predicted under projected climate conditions. This is particularly important for agricultural areas and natural ecosystems.

SSFI - Standardised Streamflow Index



Current Climate Conditions (1979 - 2018)
Fig. D37



Projected Climate Conditions (2051 - 2100)
Fig. D38

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 Stream Flow Index (SSFI). 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.

Risk Profile key messages

CLIMATE

The climate projections (2050-2100) considered in this risk profile (RCP 8.5) foresee a marked increase in temperature in Zambia, especially in the final part of the century (2071-2095) when it could reach over four degrees at the country scale. Estimation of precipitations are highly uncertainty and does not have a clear trend.

FLOODS

The average of about 20.000 people affected per year under current climate conditions is projected to increase considerably under projected climate conditions taking into account both climate projections and the population growth, the average affected people per year would increase more than three (above 60,000 people). The south-west provinces contains the most affected provinces, in both present and projected climate conditions. The majority of affected population is under 30 years and there is a significant number of the most vulnerable categories, such as children in their school age, elderly people and women. The majority of affected people are women.

Flood events that are on average experienced with equal or greater magnitude twice per century, can affect about to 50.000 people under current climate conditions and this figure could increase up to 200.000 people under projected climate and socio-economic conditions.

Average Annual Loss due to floods is estimated to be around 25 million USD on average under current climate conditions present, while it is projected to be over 30 million USD under projected climate. The most affected sectors are housing, service and critical infrastructures followed by agriculture. The impact of floods in Zambia has a clear spatial distribution with the majority of economic losses expected to occur in the western and southern provinces.

Though the average annual losses are of 25 million USD per year, floods with losses of at least 50 million USD are expected to occur very frequently, with a return period of about 10 years (i.e. an event with equal or greater magnitude that is on average experienced every decade). Under projected climate conditions, the frequency of high-impact floods will increase significantly, and it will be very likely (return period of about 25 years) to experience floods with losses of at least 80 million USD.

DROUGHTS

On average about 7.2 million people live in areas affected by drought in current climate conditions, and among them, an average of 3.2 million people per year are estimated to be directly affected. This number increases to 3.7 million under projected climate conditions and to 6.9 million if both projected climate conditions and socioeconomic evolution are considered.

More than 39% of livestock is estimated to be exposed to droughts under current climate (i.e. animals living in areas hit by droughts), equivalent to about 4 million units. Under projected climate conditions, the number of affected livestock is projected to increase to more than 54% of the total livestock population (with increases in all regions, especially in the central and southern regions).

The direct economic losses from agricultural and productive sector (hydropower) are estimated to be 75 million USD on average per year and to increase to 250 million USD under projected climate conditions.

The total Average Annual Loss for the agricultural sector (crops), for the whole country, rises greatly under projected climate conditions from 29 to 180 million USD per year, indicating that a substantial part of the annual crop production could be lost due to intensified droughts in the projected climate.

Compared to current climate conditions, losses in hydropower generation (C3) resulting from drought will increase by almost 50% under projected climate conditions (for Mulungushi, Itezhi-Tezhi, Kafue Gorge and Kariba dams).

Policy Recommendations

From 10 to 12 December 2019, at the Hotel Radisson in Lusaka, a National Workshop took place to present the updated flood and drought risk profiles. The Workshop was organized by the Disaster Management and Mitigation Unit in the Office of Vice-President (DMMU), the United Nations Regional Office for Disaster Risk Reduction (UNDRR), and CIMA Research Foundation - International Centre for Environmental Monitoring (Italy).

The workshop was opened by Her Excellency Ms Olipa Phiri Mwanza Minister, Office of the Vice President. Mr. Anderson Banda, Director of Disaster Risk Management, DMMU chaired the opening, with the remarks from the representative of the United Nations Regional Office for Disaster Risk Reduction in Africa, Ms. Katarina Mouakkid Solstesova, Ms. Gift Malunga - UNFPA Country Representative, and the representative of CIMA Research Foundation, Dr. Marco Massabò.

Following working discussions over three days of activities, the workshop's participants proposed the following National Disaster Risk Reduction Policies Recommendations:

1. The results of the risk profile highlight that on average more than 19.600 people per year are potentially affected, including more than 40% of the most vulnerable population (children and elderly). **Zambia needs to develop a land use planning policy that regulates the identification of safe zones for critical infrastructure such as schools and hospitals**. This would reduce the exposure of two traditionally vulnerable groups: children and the ill and, as an added benefit, these could also be used as hubs for safety and coordination during flood events. Using the results provided in the risk profiles, the hotspot areas can be identified, more local risk assessments should be carried out in high-risk areas. The local risk assessment should inform the new land use planning policy.

2. Land use planning policies should emphasize that no major housing or infrastructure developments be built in flood-prone areas, as well as in areas predicted to see major flooding in the future. This measure alone, however, would likely be insufficient as many people currently ignore existing government recommendations and live in catchment areas. **A mechanism to ensure the effective implementation of land use policies**, one that guarantees the resettlement of families elsewhere, should be examined.

3. The government should adapt its building codes according to the evolution of flood risk that is predicted in the projected climate. This would reduce vulnerabilities of buildings and hence reduce the damages of floods to infrastructures. Additionally, the government could use the risk profiles to prioritize the areas of enforcement for current building codes if it lacks the resources for wide-scale implementation at the country level.

4. It is recommended that a **flood and drought insurance mechanism be put in place, using data from the risk profiles as a starting point**. Zambia is already moving in this direction with the support of Africa Risk Capacity. Future discussions should include the adoption of a policy that determines where the line is drawn between an individual and government insurance responsibility.

5. The government should **ensure the existence of emergency and recovery plans for floods and droughts, from the national to the ward level**, taking into consideration the areas that are most disaster-prone as identified in the risk profile.

6. The risk profile shows droughts to have an important impact on livestock and the livelihood of pastoral communities (4 million livestock units per year). It is recommended that the government promote **improved livestock breeds and raising techniques that would help reduce these impacts**. It is also recommended that the government regulate grazing areas to better manage them.

7. Persistent droughts have been depleting groundwater resources in Zambia. In many regions, boreholes are already drying up, with far-reaching impacts on livestock. **It is proposed that the dams used to produce energy be optimized, turning them into livestock rotary points**: a place where all livestock from a determined area could use for drinking water.

8. The risk profile indicates that hydropower losses will increase in the south of the country (Kariba dam) and decrease in the other hydropower stations. As suggested by the workshop participants, it is proposed that the **number of dams be increased in areas where productivity is set to rise in the projected future**.

9. Compared to current climate conditions, losses in hydropower generation are predicted to increase by almost 50% under projected climate conditions. To move away from the country's dependence on hydroelectricity, it is proposed that the **government should look to diversify its energy sources**. Examples of sources discussed included solar, biomass and wind power.

10. It is recommended that **the government invest in using drought-resilient crops and in reducing its dependence on maize**. Subsidies could be used to incentivize farmers to transition. Certain regions less sensitive to drought, once again through the use of subsidies, could be encouraged to grow more sensitive and lucrative cash crops, while others could grow more resistant subsistence crops. A consensus was established that the government should increase its investments in climate-smart techniques in the agricultural sector overall.

11. Many concerns have been raised about the need to **review the country's water policies**. For example, there is an urgent need to better regulate boreholes so that these stop drying up. The risk profiles make one trend obvious: the north-east will continue to become more wet and the south-west will continue to become drier. Water transfer infrastructure at the national scale could be discussed. Generally, more cooperation should take place at the national level around water resources and there should be an increased focus on recharge areas.


wikipedia.org

Glossary

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)
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.

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 represented by a combination of various standardized indices, covering a range of drought types (meteorological, subsurface and surface (hydrological) droughts). In this disaster risk profile, droughts are analysed in terms of hazard, exposed population, GDP and livestock. Drought induced losses are explicitly estimated for crop production and hydropower generation, by linking hazard, exposure and vulnerability (H x E x V)

STANDARDIZED DROUGHT INDICES
Standardized drought indices represent the 'abnormality' of certain water deficits, assessed by analysing the meteorological, sub-surface or surface water balances. Using these indices, drought can be defined as at least three consecutive months with standardised index values below a certain drought threshold, indicating conditions that are significantly dryer than normal for a certain region, given the reference period 1979-2018. On the drought indices maps, the drought probability is calculated using a varying drought threshold [coincidencing with the 5%-25% lowest water availabilities ever recorded]: the dryer the area, the less extreme the water deficit needs to be in order to be considered 'a drought'.

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

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 projected climate. Losses at national level have been estimated as the sum of all Admin 1 losses.

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. Typically, PML is relevant to define the size of reserves which, insurance companies or a government should have available to manage losses.

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.

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.

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

Notes

www.preventionweb.net / resilient-africa

www.undrr.org

RISK PROFILES ARE AVAILABLE AT:

riskprofilesundrr.org

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