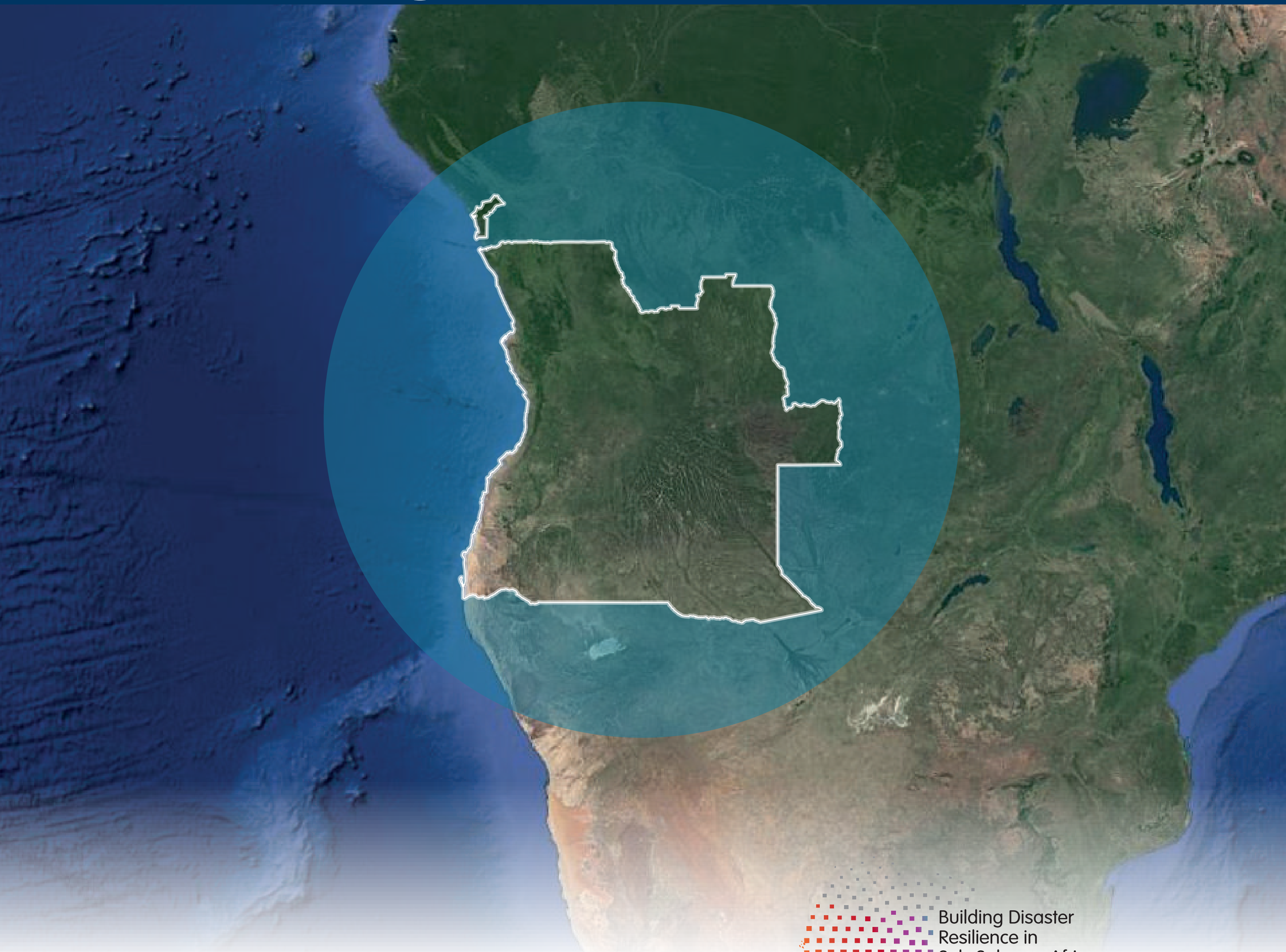
2019

DISASTER RISK PROFILE

Flood Drought

Angola



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

Building Disaster Resilience in Sub-Saharan Africa

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

This project is funded by the European Union

UNDRR
UN Office for Disaster Risk Reduction

cima RESEARCH FOUNDATION

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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 Angolan 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 Angolan partners, namely: the Civil Protection and Fire Service of Angola, the National Institute of Statistics, the Ministry of Agriculture and Forestry, the Ministry of Environment, the Ministry of Education, the Ministry of Health, the Ministry of Energy and Water, the National Institute of Water Resources, the National Institute of Meteorology and Geophysics, the Ministry of Construction and Public Works, the National Road Institute and PRODEL - Public Electricity Company.

The present disaster risk profile is not only the synthesis of insights gained during several months collecting data and conducting risk modelling in Angola, 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

Angola has been mostly affected by disasters of hydrometeorological and meteorological origin and in some cases by man-made disasters. About 80% of disasters in Angola are related to water, either due to its excess or its lack.

Floods have been the catastrophic events causing the most casualties and material damage, especially in social infrastructure.

Improving the quality of information on disaster risks in order to facilitate its use in national and cross-border disaster risk management strategies is fundamental for Angola, especially in a context where we expect to see changes in the frequency and magnitude of natural events. It is, therefore, our common responsibility to ensure that such events do not turn into disasters.

Through Angola's disaster risk profile, an important instrument for the management of flood and drought risk in the country, the National Civil Protection Commission demonstrates its commitment to fulfill the priority of the Sendai Framework for Disaster Risk Reduction: to know the risk of disasters in all its dimensions, namely hazards, exposure, vulnerabilities and the capacities to deal with it.

Under this lens, this Risk Profile will allow us to target investments aimed at disaster risk reduction in the most affected areas, with a cost-benefit perspective and, consequently, to estimate the positive effects for the protection of the population and Angola's sustainable development.

This important instrument also obliges us to assume a more interventionist and proactive stance with regard to prevention, mitigation and preparation of disasters in our country.

Eugénio César Laborinho
Ministry of the Interior
Coordinator of the National Civil
Protection Commission of Angola


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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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Table of Contents

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 2019*). 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

	INDICATORS			FLOOD			DROUGHT			SDG	SDG INDIC.
				C	P	SEP	C	P	SEP		
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.

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

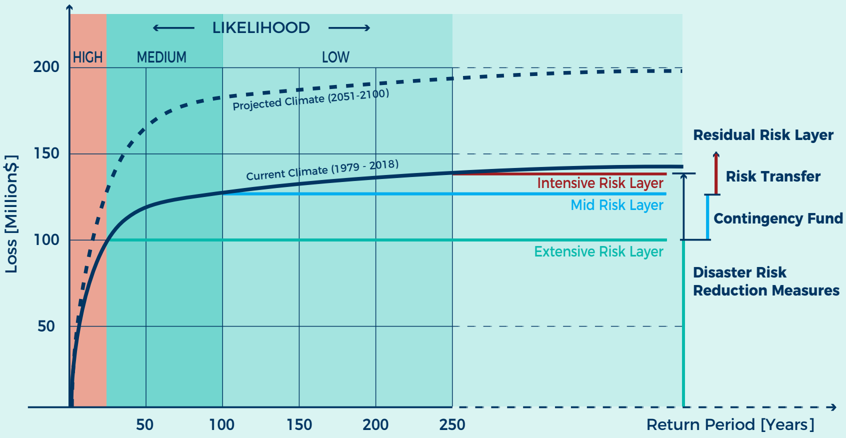
Events which have never been historically recorded but might occur in projected climate conditions are also considered in the risk analysis. This feature is particularly useful in the context of climate change which is dramatically increasing uncertainty about future hazard patterns. Thus, societies 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.

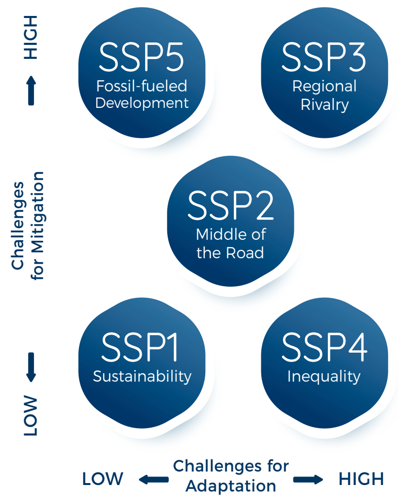
The Representative Concentration Pathways (RCPs) were developed to describe the different levels of greenhouse gases and other radiative forces that might occur by 2100 - not including any socioeconomic narratives - and are represented in four different pathways: 2.6, 4.5, 6.0, 8.5.

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 ANGOLA

This risk profile assumed the SSP2 for its projection analysis: a "*middle of the road*" world where trends broadly follow their historical patterns. According to these conditions, by 2050, both GDP and population in Angola will triple when compared to 2014 (Local Data and World Bank).

POPULATION [Million People]	**25.8** 2014 / **77.4** 2050 Projection	GDP [Billion$]	**122.5** 2017 / **324.7** 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**.

Southern suburbs of Luanda, current population density

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

Southern suburbs of Luanda, projection for 2050 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
EXPOSURE	Population	Population Statistics (age distribution, gender, minorities at national or sub-national scale). Characterization of dwellings. Population projection by 2024 for the municipalities and 2050 for the provinces. Limites of the new administrative division	Commune level or sub municipality level.	National Institute of Angola Statistics (INE)
EXPOSURE	GDP	Sector-specific Gross Domestic Product (GDP) Local Gross Domestic Product (e.g., Regional)	Sector Specific at national level	National Institute of Angola Statistics (INE)
EXPOSURE	AGRICULTURE	Livelihood zones Market prices and agricultural information bulletim(2010 to 2019). Vegetative cycle of the main crops. Report of the agricultural year 2018-2019.	Thirteen spatial zones of the country. Prices of agricultural products in Angola´s main markets. Data on family and business agricultural production for the agricultural year 2018-2019 national and provincial level.	Ministry of Agriculture and Foresty
EXPOSURE	CRITICAL INFRASTRUCTURES	Location of Critical Infrastructure (e.g., health, education, energy production) possibly with attributes information. Linear critical infrastructure (e.g., railways, roads, etc)	Primary and Secondary Schools Countrywide	President's Office – egional Administrations and Local Government (PO-RALG) – schools and Health facilities information
			Health Facilities including dispesaries, Healthcentres and Hospitals	Ministry of Health
			Electroproductive Centers Hydrometric network Main river network Angola's hydrographic network	Ministry of Energy and Water Public electricity generation company-Prodel National Institute of Water Resources (INRH)
			National and Complementary Roads of Angola	Ministry of Construction and Public Works / National Road Institute of Angola (INEA)
HAZARD	HAZARD	Temperature variation (minimum, maximum and average)	Daily and monthly temperature variation in 11 stations in the country,(1971 to 2018)	National Institute of Meteorology and Geophysics de Angola (INAMET)
		Average rainfall	Daily and monthly rainfall variation of 11 stations per country (1971 to 2018)	
		Annual summary of the daily average flow rates.	31 stations (1951-1974)	
LOSS	LOSS DATA	Flooding Zones	Data on flood events countrywide (observations from 1976 to 2013).	Ministry of Energy and Water National Institute of Water Resources-INRH

ANGOLA CLIMATE TRENDS

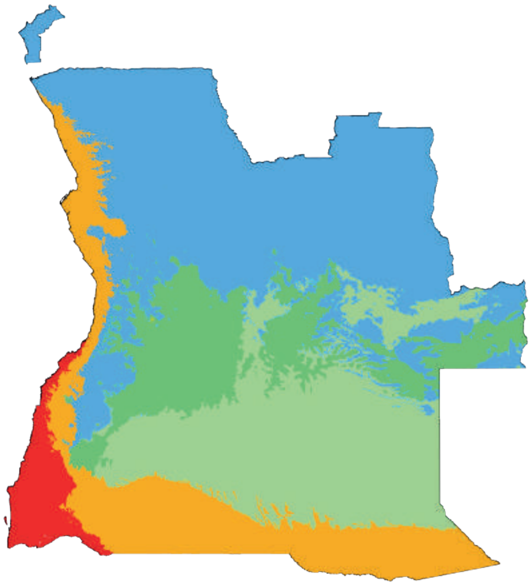
Angola is composed of three natural regions: the coastal lowland, characterized by low plains and terraces; an area of hills and mountains, rising inland from the coast into a great escarpment; an area of high plains, called the high plateau (planalto), which extends eastward from the escarpment.[1]

The dominant climate in Angola varies from humid tropical to dry tropical and is strongly influenced by the country's geographic position, near to the Atlantic Ocean, its topography, the Benguela cold water current, and the movement of the Intertropical Convergence Zone (ITCZ) where the northern and southern air masses converge. In the Köppen climate classification, the northern part of the country is classified as tropical, while the southern part is temperate with dry winters and stretches of semi-arid and arid desert climates.

Temperatures fall according to the distance from the equator and altitude, and tend to rise closer to the Atlantic Ocean. Thus, at the mouth of the Congo River, the average annual temperature is about 26°C, while on the temperate central plateau the average temperature is 16°C.

The country has two distinct seasons: a cool dry Cacimbo season from June to September and a warm, humid, rainy season from October to May. Similarly, to other central-southern African countries, temperature observations indicate that Angola has experienced considerable temperature increases in recent years. An analysis of climate data from 1970 to 2015 shows an average temperature rise of just under 1°C. This increase is particularly noticeable from the 1980s onwards.

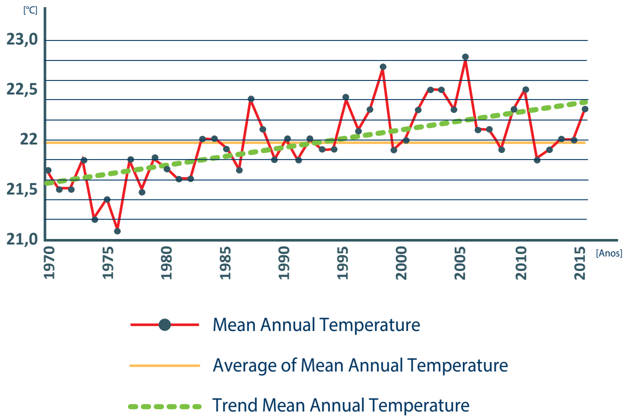
Precipitation trends are not as clear as those for air temperature and are variable in time and space. Over the last 40 years, rainfall has marginally increased in Angola, with a large difference between very wet and dry years. The average annual precipitation for Angola is about 970 mm. The semiarid, narrow coastal region has an average annual rainfall of 600 mm, with higher rainfall in the north and lower rainfall in the south.

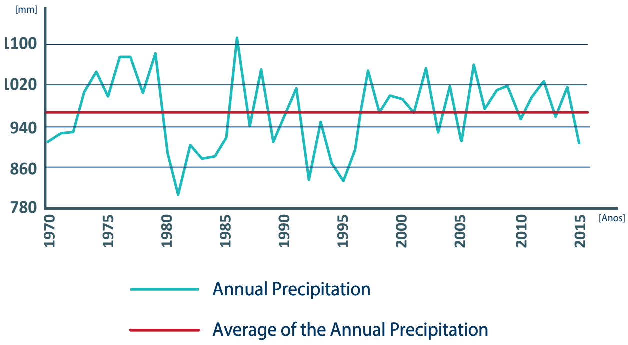


Angola map of Köppen climate classification

- Tropical savanna (Aw)
- Arid, desert, hot (BWh)
- Arid, steppe, hot (BSh)
- Temperate, dry winter, hot summer (Cwa)
- Temperate, dry winter, warm summer (Cwb)

TEMPERATURE AND PRECIPITATION TRENDS (1970 - 2015)

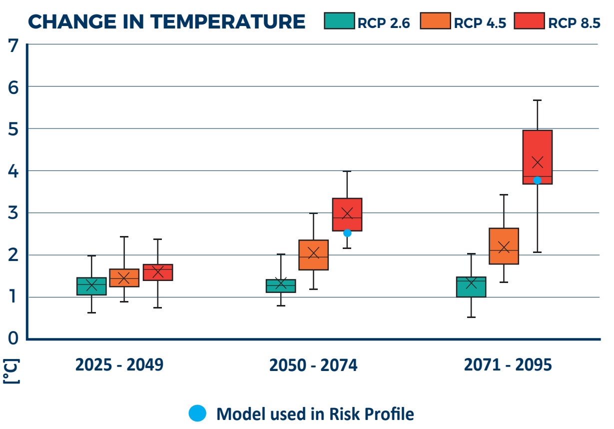


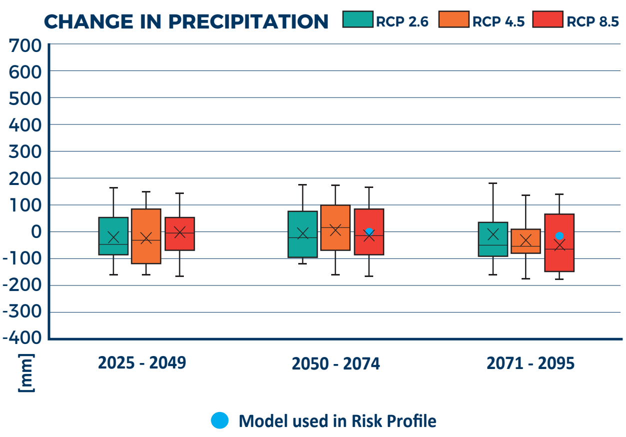


ANGOLA CLIMATE PROJECTIONS

In a recent study Alder et al. [2] 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 [3].

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 [4] 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: http://worldfacts.us/Angola-geography.htm
2: Alder, J. R., & Hostetler, S. W. (2015). Web based visualization of large climate data sets. Environmental Modelling & Software, 68, 175-180.
3: https://www.ipcc.ch/assessment-report/ar5/
4: 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.

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FLOOD

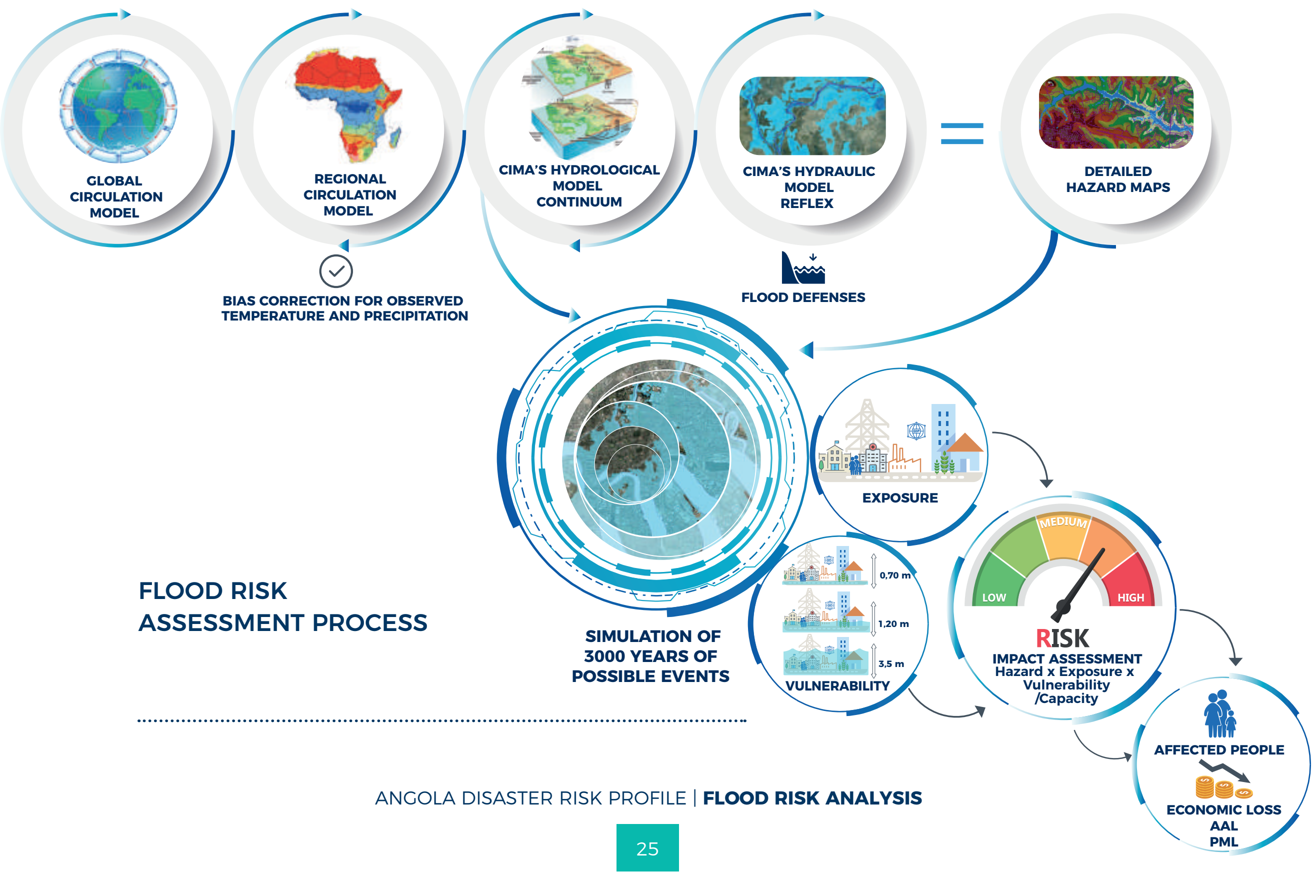
Results (Fig. & Tab.)

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 Angola this information was obtained at the *comuna* 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.

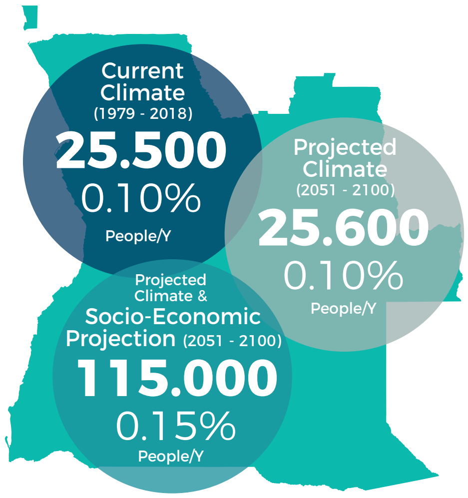
In this risk profile iteration, the selection of crops considered was not only based on their commercial value but also to the role that specific produces play in the average diet of the population. A decrease in the availability of this crops on the national market may result in food insecurity.

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



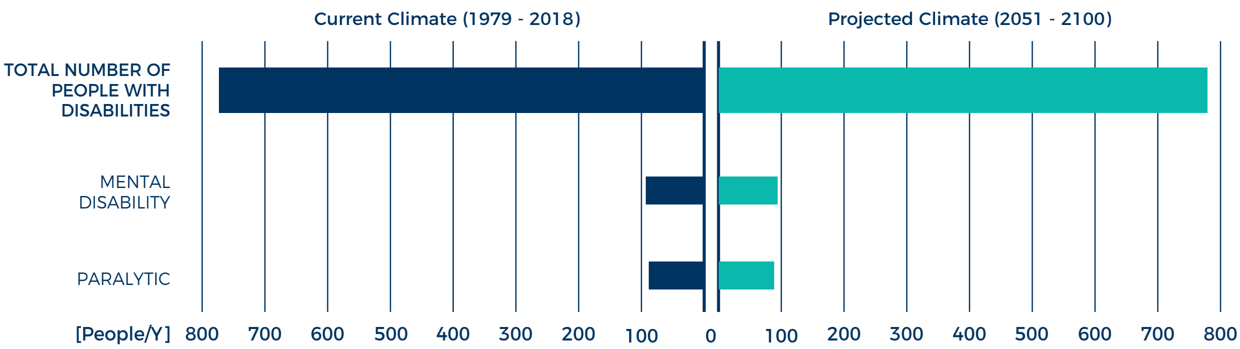
[B1] - Annual Average Number of potentially affected People
Fig. F01

	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)
POTENTIALLY AFFECTED CHILDREN 0-4	5230	5210
POTENTIALLY AFFECTED YOUTH 5-14	7100	7040
POTENTIALLY AFFECTED TEENAGERS 15-24	4610	4590
POTENTIALLY AFFECTED ADULTS 25-65	7950	7840
POTENTIALLY AFFECTED ELDERLY >65	830	840
	People/Y	People/Y
POTENTIALLY AFFECTED FEMALES	13.310	13.380

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

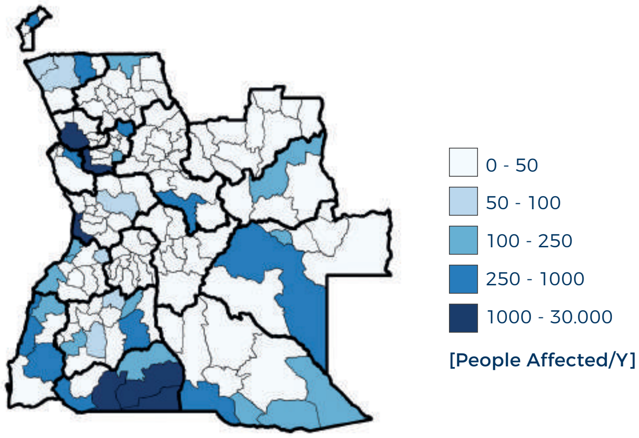
Angola is highly impacted by severe weather and extreme climate events. Floods represent one of the most prominent issues in Angola, affecting on average more than 25.000 people every year (0.10% of the total Angolan population). These numbers also hold under projected climate conditions (considering one possible projected climate scenario - RCP8.5, worst case scenario) and the hypothesis of unchanged socio-economic patterns. If we consider, however, the socio-economic development and therefore the possible changes in values distribution and population concentration, this number could increase more than fourfold, reaching 115.000 people affected on average every year. This figure, which represents 0.15% of the total population, is the result of the combined effect of the expected projected 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 with disabilities
Fig. F03

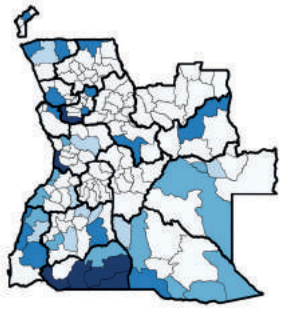


POPULATION

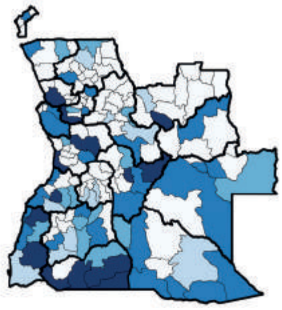
[B1] - ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE



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



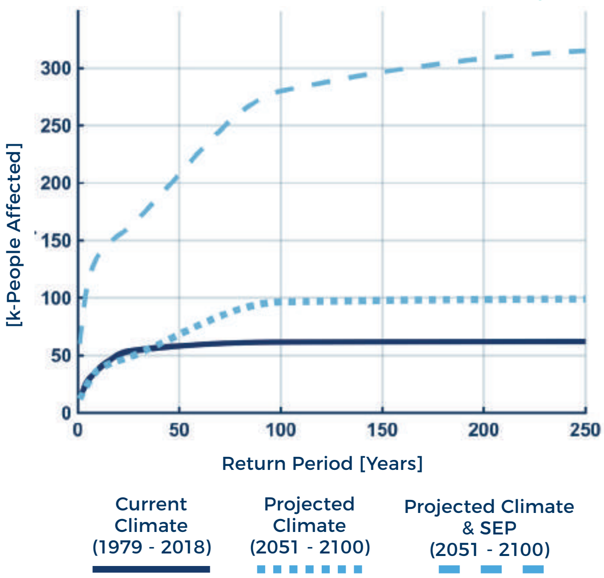
Projected Climate Conditions (2051 - 2100) Fig. F05



Climate & Socio-Economic Projections (2051 - 2100) Fig. F06

In terms of geographical distribution, the pattern is rather disperse, with the majority of the population affected concentrated along the coastal areas and southern regions, but also some concentration in the eastern regions. In the projected future, the general pattern is confirmed with a marked increase in the whole country if socio-economic development is considered.
The age and gender structure of the affected people resembles the overall age and gender structure of the country's demography. Angola is a country with a young population and, as such, the majority of the affected people are below 24 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 more serious consequences from the flood event. 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



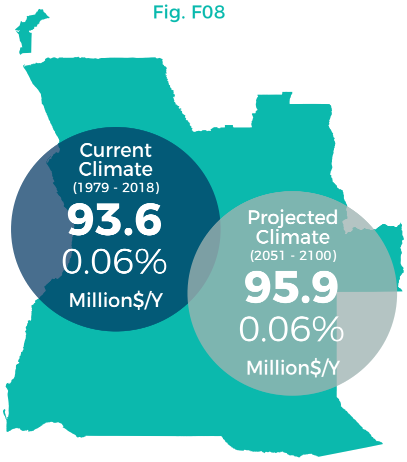
[B1] - PROBABLE MAXIMUM LOSS CURVE OF POTENTIALLY AFFECTED PEOPLE

When the PML curves are analysed it is interesting to note that, for more frequent events (below 40-year return period), the curves of present conditions and projected climate conditions with unchanged socio-economic pattern have the same trends, but differ for rarer values.
When considering both climate change and socio-economic development, losses dramatically increase for both frequent and rare events. It is evident that adaptation to this scenario should consider all kind of DRR measures, spanning from structural interventions, to risk transfer, to Early Warning.

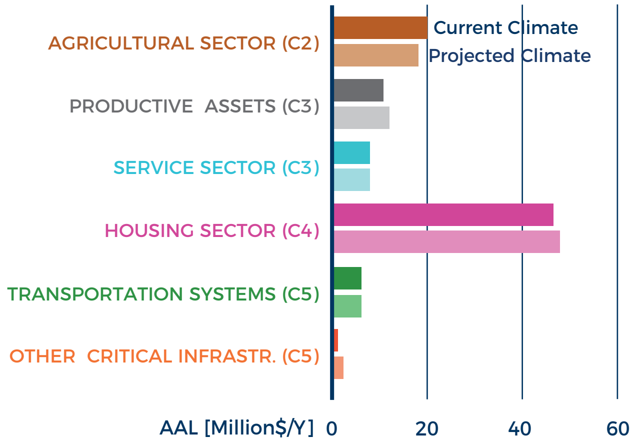
[C1] DIRECT ECONOMIC LOSS

[C1] - AVERAGE ANNUAL LOSS

[C1] - Average Annual Loss
Fig. F08



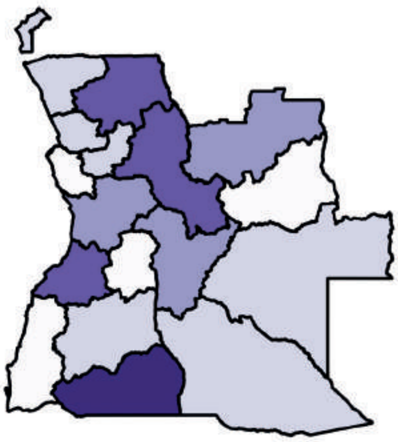
Average Annual Loss per sector - Fig. F09

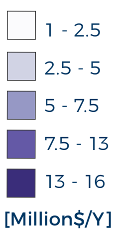


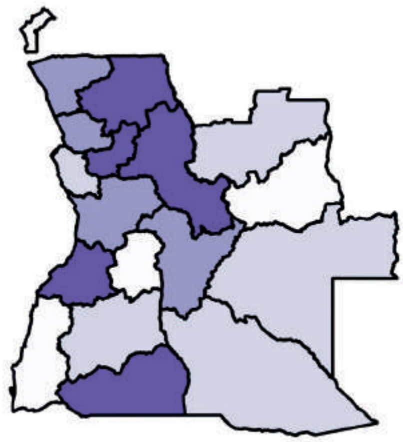
Sendai Target C envisages the substantial reduction of direct economic losses by 2030. The estimated direct economic losses from floods in Angola is of about 94 million USD per year, which is roughly 0.06% of the total economic value of the assets considered and 0.08% of the annual GDP. Housing and agriculture are the most affected sectors, followed by the productive sector, services, transportation and critical facilities. The same values of average direct economic losses will be maintained also under the projected climate conditions.
The annual number of currently affected health centers and educational centers averages around 20 and 5 respectively, while the kilometres of affected roads averages 170 annually. A slight increase in these numbers is expected under projected climate conditions.

	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)
D4 - AFFECTED [KM/Y] INFRASTRUCTURES	171	195
D3 - AFFECTED [UNITS/Y] SCHOOLS	19	22
D2 - AFFECTED [UNITS/Y] HOSPITALS	5	7

Damage to critical infrastructures - Tab. F10







AAL - Current Climate Conditions (1979 - 2018)
Fig. F11

AAL - Projected Climate Conditions (2051 - 2100)
Fig. F12

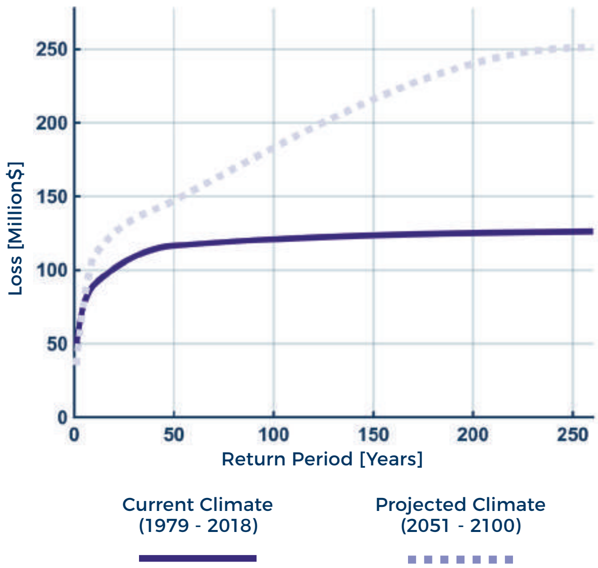
The impact of floods in Angola has a sparse spatial distribution with the majority of economic losses expected to occur in Uige, Cuanza Norte, Benguela and Cunene. Results for projected climate conditions (RCP8.5 - worst case scenario) foresee a general slight increase except for the provinces of Cunene and Lunda Norte. Uncertainty in climate predictions and the ongoing evolution of the country's socio-economic situation 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 current average annual losses are 94 million USD per year, floods with losses of at least 100 million USD are expected to occur frequently, with a return period of about 25 years (i.e. on average experienced every 25 years). Under projected climate conditions, the same loss becomes more frequent: on average once in 10 years. Rare flood events would generate a significant increase in losses: +50% for a return period of about 100 years and +100% for a return period of about 250 years.

PML - Fig. F13



GDP

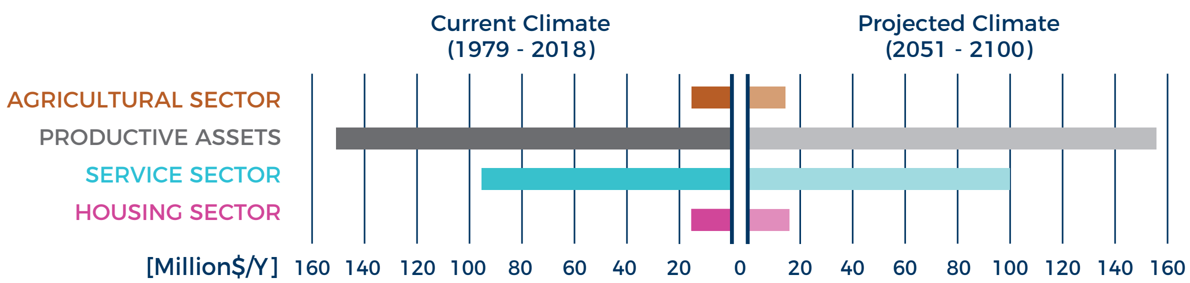
ANNUAL AVERAGE GDP PRODUCED IN POTENTIALLY AFFECTED AREAS

An indication of the risk incidence on the economy can be drawn from the portion of 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 0.23% of the total (281 million$/Y). In the projected future, the proportion relative to the total GDP remains almost the same, around 0.24%, even when considering socio-economic projections (912 million$/Y).

GDP generated by the productive sector is the most affected, followed by the service sector. GDP generated by agricultural and housing sectors in potentially affected areas is less. In the projected future, affected GDP of the productive sector and service sector increase slightly.

	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)	Projected Climate & SEP (2051 - 2100)
Million$/Y	281	292	912
%	0.23%	0.24%	0.24%

Annual Average GDP Affected - Tab. F14

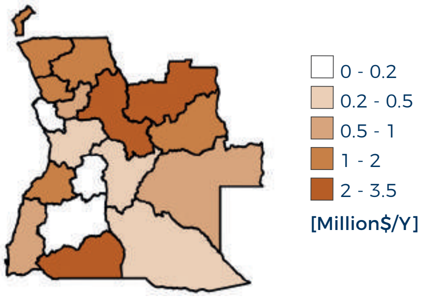


Annual Average GDP produced in potentially affected areas - Fig. F15

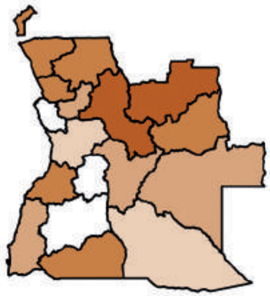
DIRECT ECONOMIC
LOSS PER SECTOR

AGRICULTURAL SECTOR [C2]

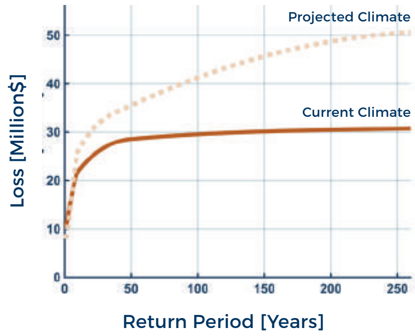
AAL
Current Climate Conditions
(1979-2018) - Fig. F16



AAL
Projected Climate Conditions
(2051 - 2100) - Fig. F17

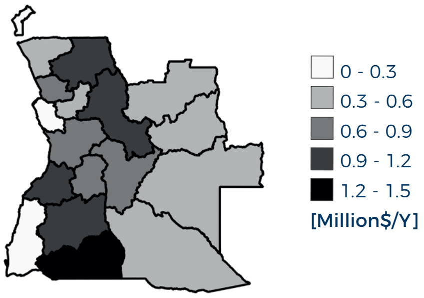


PROBABLE MAXIMUM LOSS CURVE
Fig. F18

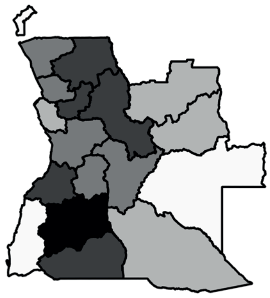


PRODUCTIVE ASSETS [C3]

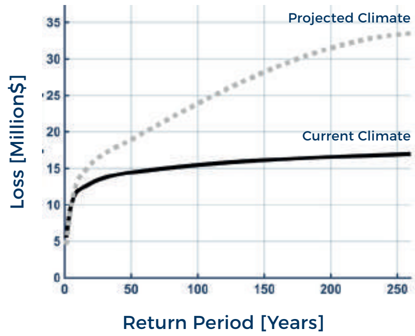
AAL
Current Climate Conditions
(1979-2018) - Fig. F19



AAL
Projected Climate Conditions
(2051 - 2100) - Fig. F20

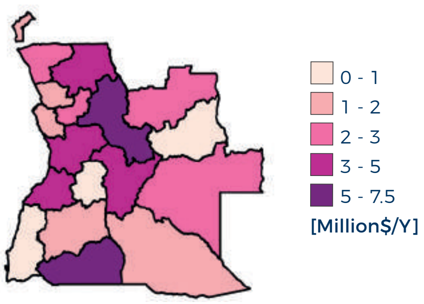


PROBABLE MAXIMUM LOSS CURVE
Fig. F21

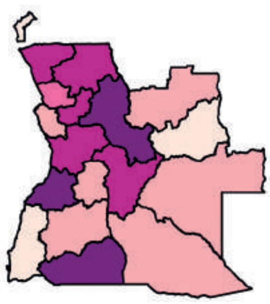


HOUSING SECTOR [C4]

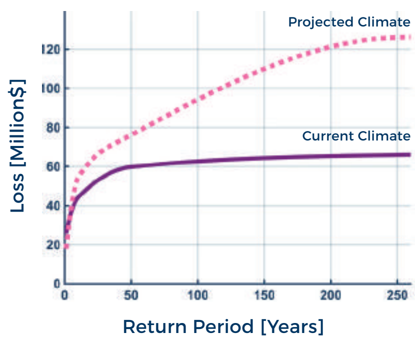
AAL
Current Climate Conditions
(1979-2018) - Fig. F22



AAL
Projected Climate Conditions
(2051 - 2100) - Fig. F23



PROBABLE MAXIMUM LOSS CURVE
Fig. F24



The most affected sectors, in terms of direct economic losses, are housing and agriculture, followed by the productive sector. Under current climate conditions, the spatial distribution of the annual average losses differs per sector, except for the provinces of Cunene and Malanje, where high losses are experienced for all three sectors.

Under projected climate conditions, direct economic losses would keep the same pattern or slightly increase for all sectors except in Cunene and Moxico for the productive sector, and Moxico, Cabinda and Lunda Norte for the agricultural sector. Losses in the productive sector seem to increase in the Huíla, Luanda, Cuanza Norte and Zaire. For housing the increase is expected in the north-western regions and Benguela, Huambo, Bengo, Cuanza Norte and Zaire.

The PML curves for the three sectors confirm that Angola 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 low likelihood of occurrence (return period of 200 years) are expected to almost double under projected climate conditions for the housing and productive sectors.

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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.

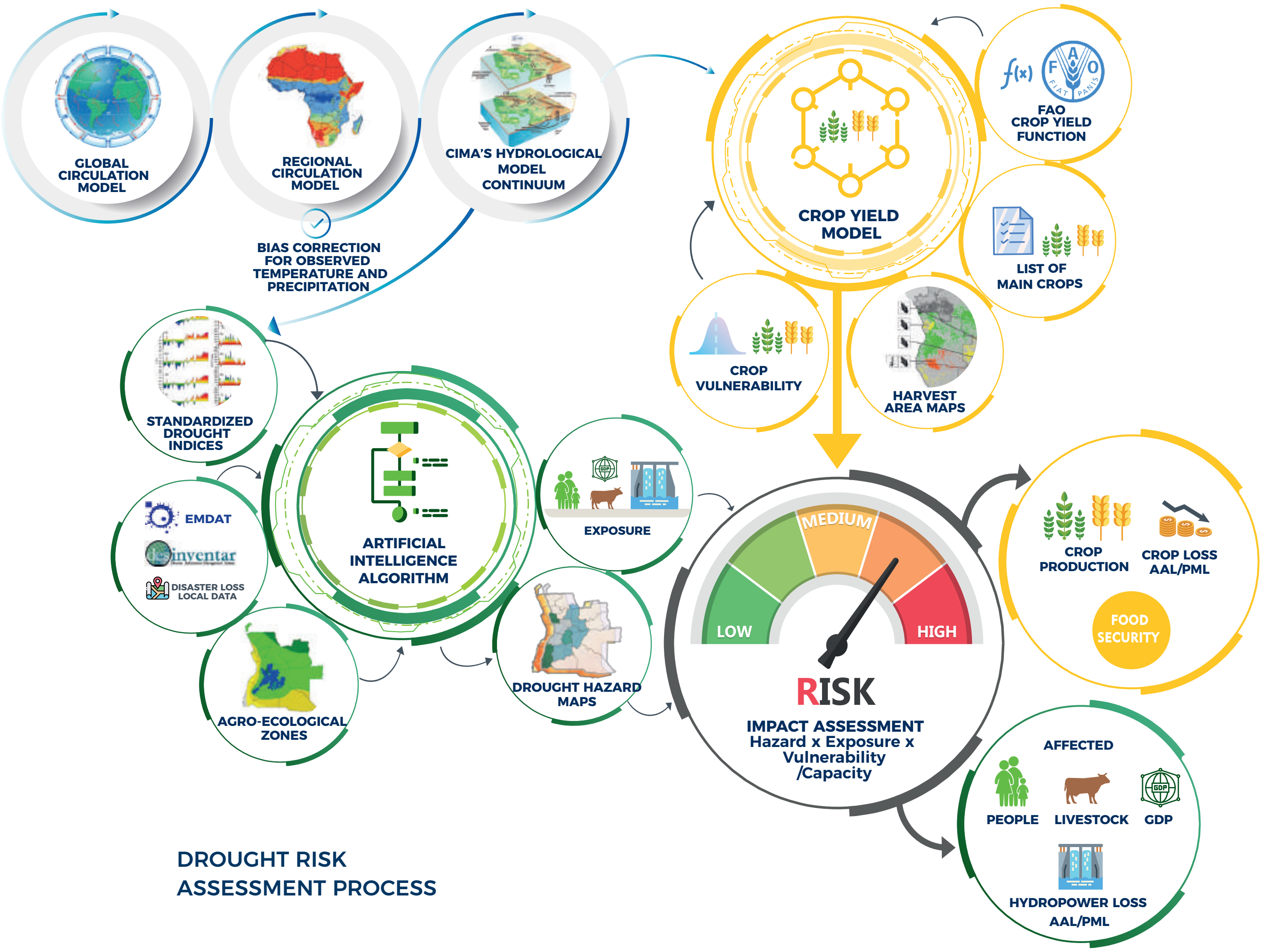
DROUGHT HAZARD, EXPOSURE AND VULNERABILITY

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 Angola.

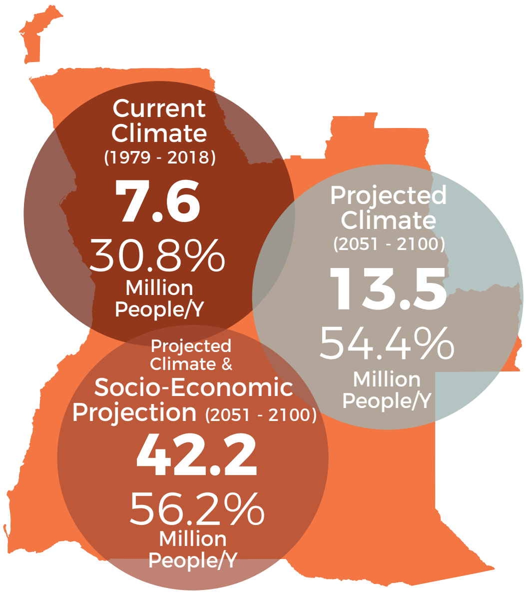
Generally, there is a fairly linear relation between the ratio of actual over potential evapotranspiration and crop yield, as represented by the FAO "water production function". This relation was tailored for all crops by including a local crop drought sensitivity factor - a factor that is also determined 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 Angola, 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.

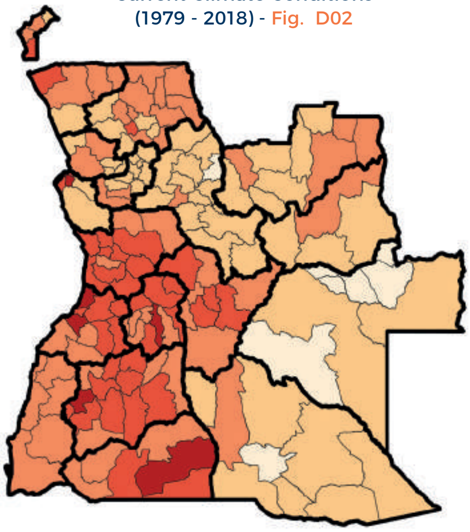
POPULATION

ANNUAL AVERAGE NUMBER OF PEOPLE LIVING IN DROUGHT AFFECTED AREAS



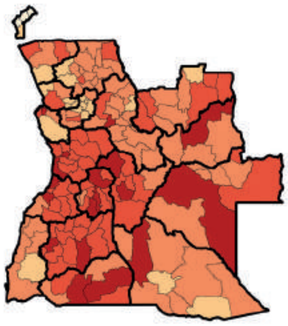
Annual Average Number of People living in drought affected areas
Fig. D01

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

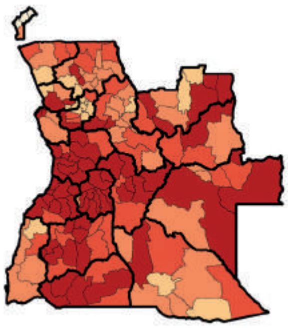


- 0 - 1000
- 1000 - 10.000
- 10.000 - 50.000
- 50.000 - 200.000
- 200.000 - 1.710.000

[People/Y]



Projected Climate Conditions (2051 - 2100)
Fig. D03



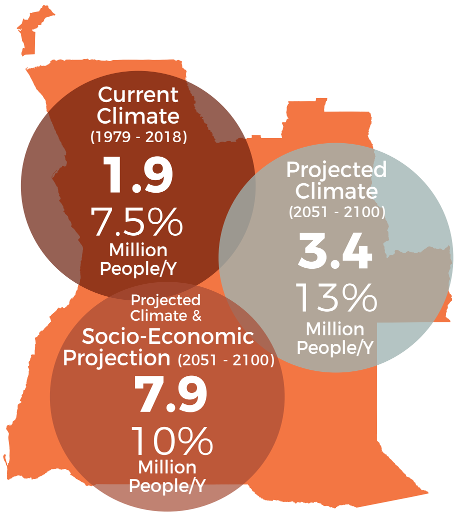
Climate & Socio-Economic Projections (2051 - 2100)
Fig. D04

With respect to observed conditions (1979-2018 climate), the probability of occurrence of soil moisture and meteorological droughts will increase under projected conditions (2051-2100 climate). While with the average annual precipitation, its variability also increases. This, together with an increased temperature, thus higher potential evapotranspiration, results in longer, more intense and more frequent meteorological, hydrological and agricultural droughts.

Under current climate conditions, central-southern regions have the largest number of potentially affected people, while the eastern regions have less population exposed to droughts. Throughout the country, on average 7.6 million people (around 30% of the total population of 2014) are annually exposed to droughts. Under projected climate conditions, this number is expected to increase to over 50%. Overall, the amount of people exposed to droughts is expected to increase in Angola, with some significant increases in the east (Moxico area).

POPULATION

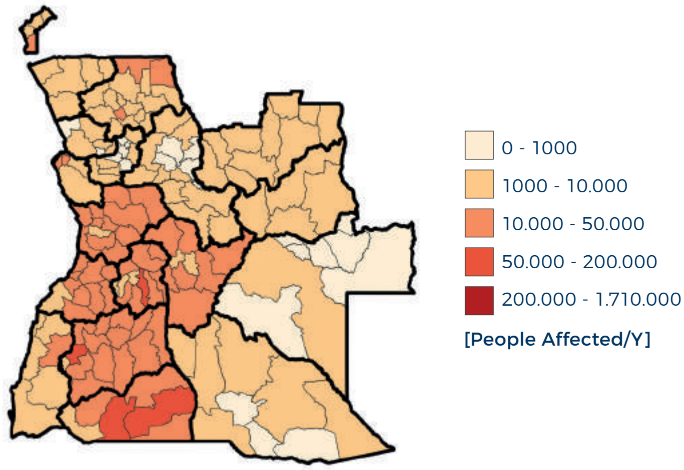
[B1] - ANNUAL AVERAGE NUMBER OF PEOPLE DIRECTLY AFFECTED BY DROUGHT



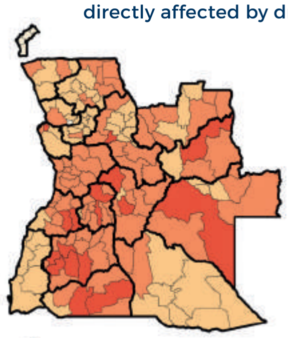
[B1] - Annual Average Number of People directly affected by drought - Fig. D05

	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)
POTENTIALLY AFFECTED CHILDREN 0-4	0.39	0.71
POTENTIALLY AFFECTED YOUTH 5-14	0.53	0.96
POTENTIALLY AFFECTED TEENAGERS 15-24	0.35	0.63
POTENTIALLY AFFECTED ADULTS 25-65	0.60	1.07
POTENTIALLY AFFECTED ELDERLY >65	0.06	0.11
	Million People/Y	Million People/Y

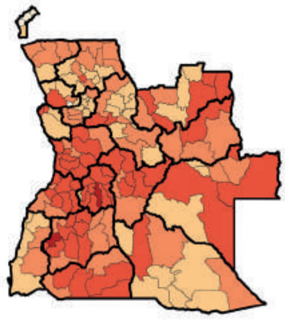
[B1] - Annual Average Number of People directly affected by drought - Tab. D06



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



Projected Climate Conditions (2051 - 2100) Fig. D08



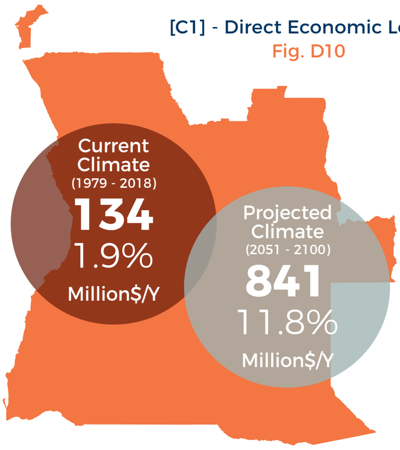
Climate & Socio-Economic Projections (2051 - 2100) Fig. D09

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 provincial 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.

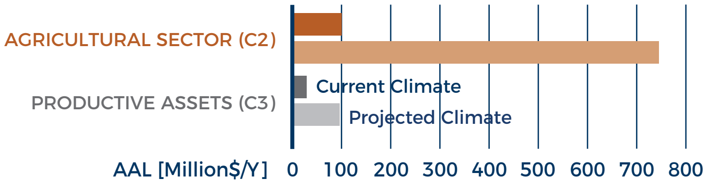
Based on these assumptions, in this risk profile, the combination of people vulnerability and coping capacity to drought was estimated as a function of rural/urban population concentrations within each province. Rural communities with higher levels of isolation were then assumed to suffer wider drought consequences. Computations show that among 7.6 million people (on average, per year) living in areas affected by drought in the current climate, an average of 1.9 million people per year are estimated to be directly affected. This number increases to 3.4 million under projected climate conditions and to 7.9 million if both projected climate conditions and socioeconomic evolution are considered. Cunene is clearly the most affected province.

[C1] DIRECT ECONOMIC LOSS

[C1] - Direct Economic Losses
Fig. D10

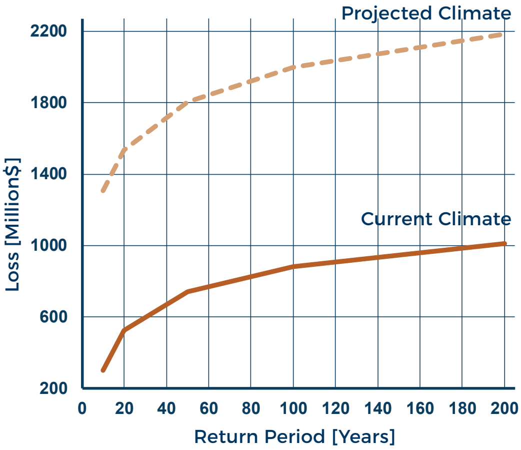


Direct Economic Losses per sector - Fig. D11



The Average Annual Loss (direct economic from crops), as a total for the whole country, is much higher under the projected climate then it is in the current climate (from 100 to 744 million USD per year). This represents a more than sevenfold absolute increase. The relative increase, represented by the values expressed as a percentage of the average Gross Production Value of the selected crops, rises from about 1.7% to almost 12.3% (see table D19). This indicates that a substantial part of the annual crop production might be lost due to intensified droughts under the projected climate. Compared to current climate conditions, losses in hydropower generation (C3) resulting from drought will increase three times, from over 30 to almost 100 million USD per year (for Mabubas, Cambambe, Capanda, Gove and Matala dams).

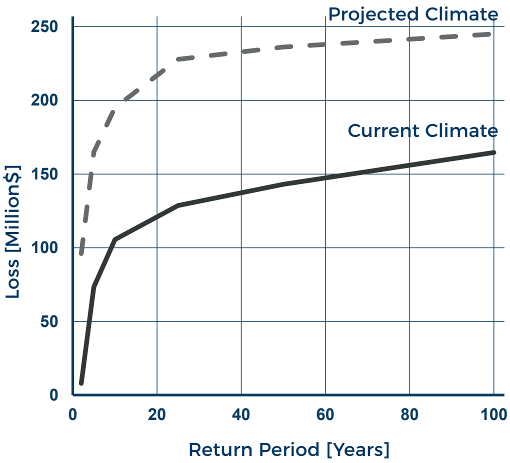
C2 - LOSSES AGRICULTURAL



[C2] - PML - Fig. D12

Under current climate conditions, direct economic crop losses increase gradually in expected maximum loss when return periods rise from 10 to 200 years. It is worth noting that these results' uncertainty becomes higher as we move into the very rare losses domain. Under the projected climate, these losses increase substantially in absolute units, compared to the situation in the current climate, and relative increases range from more than two times with a 200 year return period to circa five times with a ten year return period. More frequent losses are thus projected to become more important in the future.

C3 - LOSSES HYDROPOWER

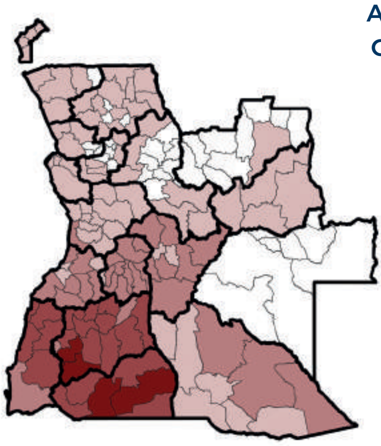


[C3] - PML - Fig. D13

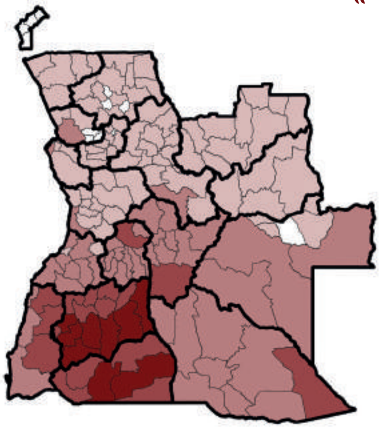
C3 is computed by exclusively considering losses in hydropower production. These are defined as production levels below average reservoir conditions. Under current climate conditions, frequent losses of once in ten years (on average) are expected to exceed 100 million USD. Hydropower losses are projected to increase in Angola's projected climate. Losses of just over 160 million, which in current climate conditions are expected once in every 100 years, would be experienced once every five years on average under projected climate conditions. This is a net result of the increase of annual losses in all hydropower stations. Strikingly, this increase in annual losses is mainly due to very frequent (once every one or two years) events, meaning that many years will have below (current) average production in the projected climate conditions.

LIVESTOCK

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED LIVESTOCK UNITS



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



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

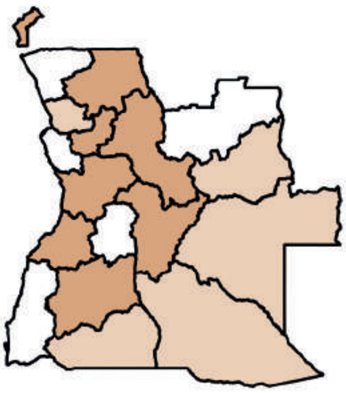
	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)
Million Unit/Y	7.2	10.3
%	47.6%	68.5%

Potentially Affected Livestock - Tab. D16

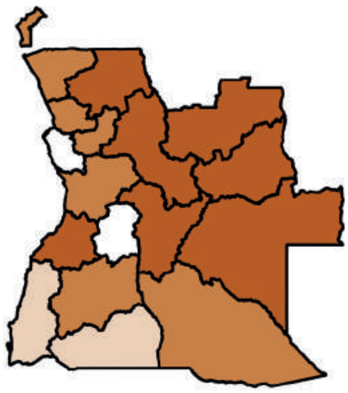
Under current climate conditions, affected livestock (i.e. animals living in areas hit by droughts) amounts to 7.2 million units (48% of the total value). Livestock units are calculated as the sum of all animals in a certain place, weighed by the water and food needs of the animals following FAO conversion factors. Under projected climate conditions, the number of affected livestock is projected to increase to more than 68% of the total livestock population. Major losses, which are concentrated in the southern regions under current climate conditions, would extend to central and eastern regions in the future.

AGRICULTURE

C2 - DIRECT AGRICULTURAL LOSS



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



AAL - Projected Climate Conditions (2051 - 2100) - Fig. D18

	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)
Million$/Y	100	745
%	1.66%	12.28%

C2 - Direct Agricultural Loss - Tab. D19

Under current climate conditions, direct economic crop losses are concentrated in eight provinces (Benguela, Huila, Bié and Cuanza Sul, Cuanza Norte, Malanje, Cabinda, Uíge), which contribute to almost ¾ of the total losses. Under the future climate projections and considering the same crop distribution, increased droughts would cause substantially higher direct economic crop losses in nearly all provinces (except Luanda, Huambo, Cunene). Particularly, the north-eastern regions would experience high losses (up to 45 - 100 million dollars/Y).

AGRICULTURE

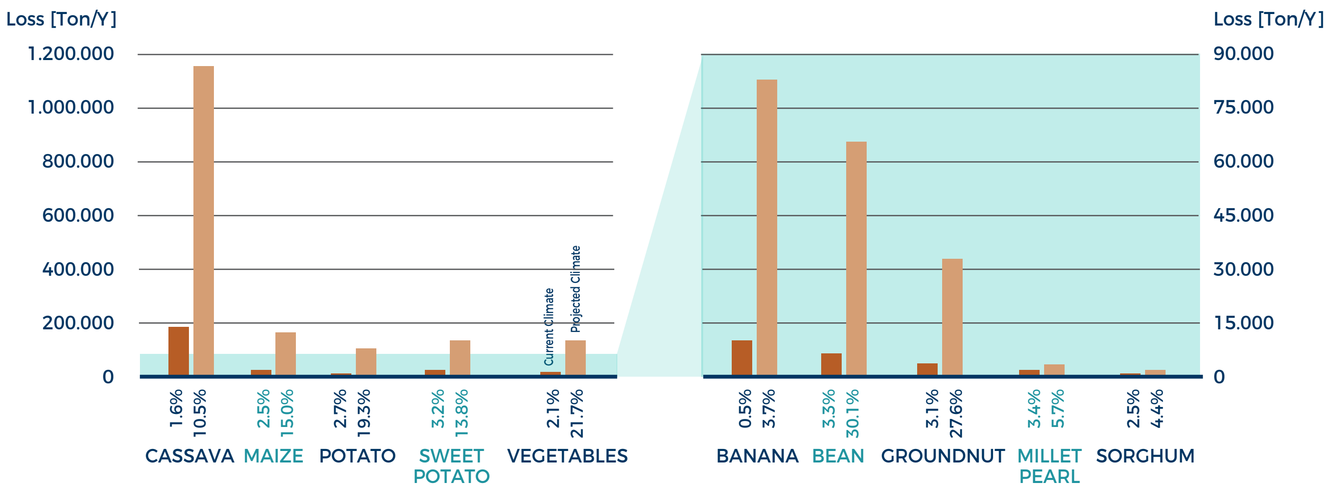
ANNUAL AVERAGE NUMBER OF WORKING DAYS LOST

	Current Climate (1979 - 2018)	Projected Climate (2051 - 2100)
k - days / Y	1730	12.120
%	0.31%	2.17%

Annual Average Number of working days lost
Tab. D20

The estimated average number of lost working days 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 1.7 million working days per year due to droughts under current climate conditions. The increase resulting from increased droughts under the projected climate conditions is sevenfold: up to 12 million days per year. Thus, many more people may have less farmwork employment opportunities under this projected climate scenario. Compared to the average amount of working days required for land preparation, sowing and harvesting, the relative values for lost working days is 0.3% under current climate climate conditions and increases to around 2% under projected climate conditions.

AGRICULTURAL PRODUCTION LOSS

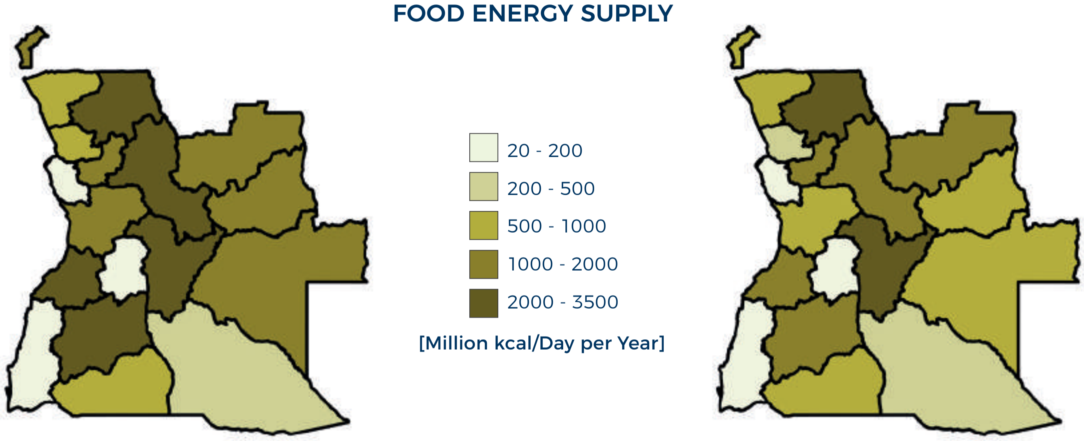


Agricultural Production Loss - Fig. D21

Crop production losses, induced by drought conditions, have been calculated for ten different crops in Angola. Under current climate conditions, these losses are dominated by cassava (physical units), and if expressed as a percentage of the average crop production, crop losses remain close to or lower than 3.5%. Under the projected climate, large increases in production loss have been calculated for all crops, due to the intensification of droughts compared to the current climate. Relative losses range from 3.7 to 30%, with an increase in factors from 1.7 (millet) to up to 10 (vegetables).

AGRICULTURE

FOOD ENERGY SUPPLY



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

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

Arable crops contribute to Angola's food energy supply. Droughts potentially diminish food security situation via lower crop production. This analysis has estimated which part of the crop production is, on average, available for direct consumption as vegetal food in Angola, therefore excluding crops used for export or other purposes (including feed). Contribution to food energy supply is expressed in kcal per day for the whole country. The crops included in this analysis are the same as those considered for Agricultural Production Loss. The highest values of energy supply under current climate conditions are found in the central part from the north to the south, except Huambo. Due to increased drought conditions under the projected climate conditions, food energy supply should decreases in most provinces (except Luanda and Cunene), but would be most severe in the central and eastern parts of the country. An evaluation of the economic loss and energy supply maps shows that the distribution of loss increases in both of these are very similar.

FOOD SUPPLY CONSEQUENCES

When droughts diminish crop production, they also diminish the 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 conditions). To convert food energy supply into number of people potentially fed, we applied the Minimum Dietary Energy Requirement (MDER for Angola is 1750 kcal/cap,day*) and an assumed a household waste of 10%. The Figure below 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 conditions, and that this effect is stronger in the 2nd half of the projected climate (from an average 2.25 million people to 3.25 million people). It illustrates a possible negative effect on food security for the people in Angola due to increased drought conditions in the selected projected climate. The values should be regarded as minimum values, because in reality many more people could be affected in their food security situation (more but less severe), when conditions for crop growth worsen.

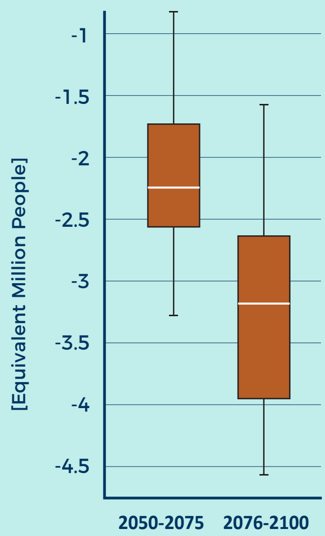


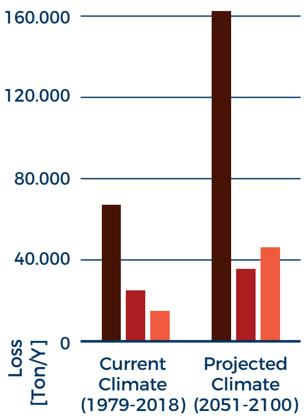
Fig. D24

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

AGRICULTURE

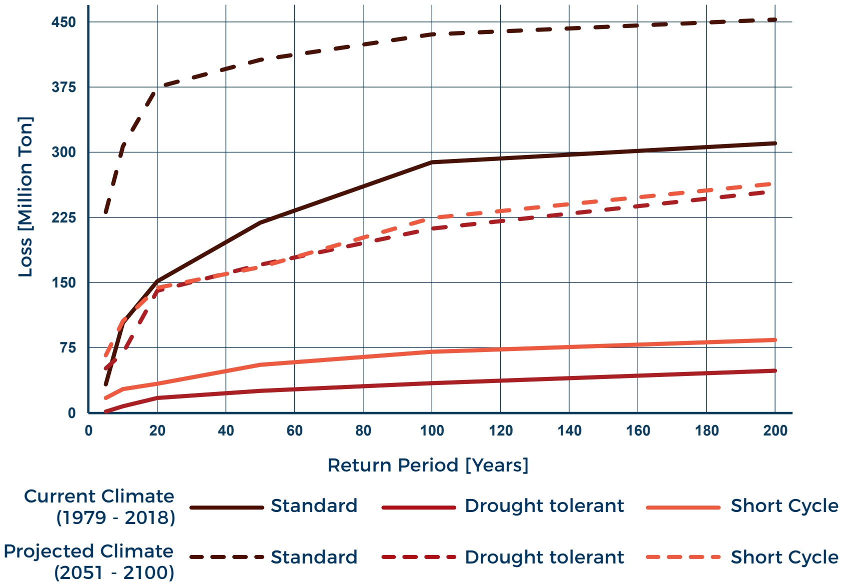
DROUGHT TOLERANT CROPS

MAIZE

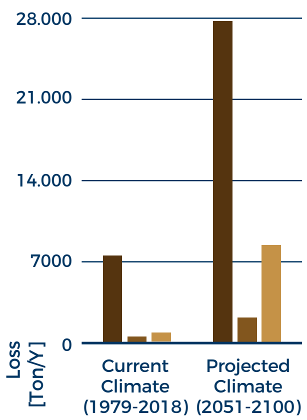


Drought tolerant crops
Fig. D25

Drought tolerant crops - Fig. D26

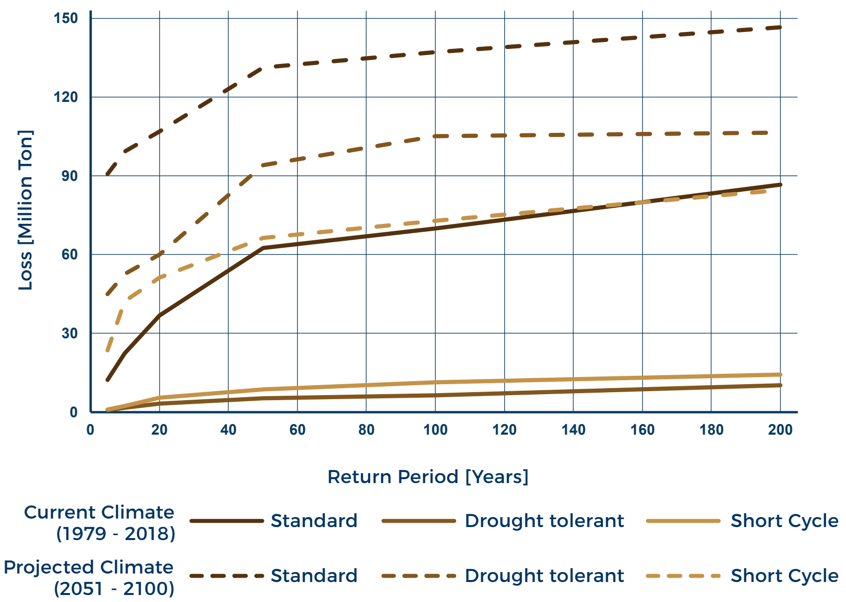


BEAN



Drought tolerant crops
Fig. D27

Drought tolerant crops - Fig. D28



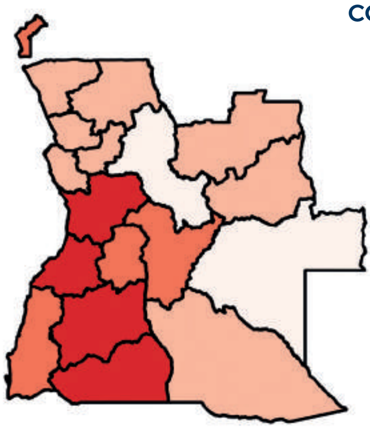
We estimated the effect of drought-adapted varieties on crop production for two selected crops: maize (staple crop) and beans (protein crop). For both crops we introduced a short-cycle variety to avoid planting too early in the season, and a variety that has better characteristics to tolerate periods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

In most cases, the adaptation to drought, gives these varieties an advantage in drier years, but results in lower yields if conditions are good (i.e. in wet 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 using a drought-adapted variety when the probability of 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 under projected climate conditions and for the two other crop varieties. The results show that for maize, losses should decrease substantially in both climates. The two types of adaptation are not very different with respect to this calculated loss. For beans, losses diminish for the current climate as well as under projected climate conditions, compared to the standard variety, due to intensified drought conditions. Our results show a slightly larger beneficial impact for the drought-tolerant varieties compared to the short-cycle varieties. The only exception is in the case of maize in current climate conditions, where the short-cycle variety seems more beneficial.

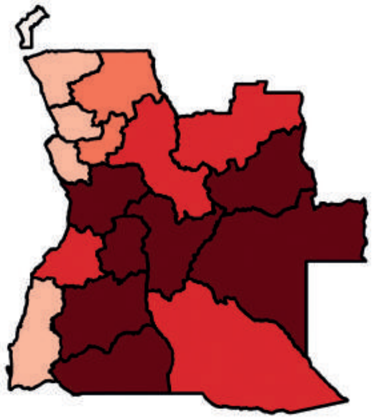
Strong effects are visible in the Probable Maximum Loss estimates for maize: all losses in the projected climate conditions show much higher values, compared to their counterparts in the current climate. However, the losses of the two drought-adapted varieties under projected climate conditions remain lower than the standard variety in the current climate. This suggests that the adaptation would be able to compensate for the increased drought situation of this projected climate. The situation is less pronounced for beans, where only the short-cycle variety under projected climate is similar to the standard variety in current climate. The graphs illustrate for both crops the potential advantage of using adapted varieties in the dry years of the two climates, compared to the standard variety.

HAZARD



COMBINED DROUGHT HAZARD

0 - 10
10 - 30
30 - 50
50 - 70
70 - 100
Probability[%]

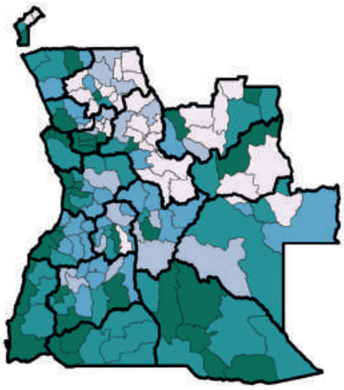


Current Climate Conditions (1979 - 2018) - Fig. D29

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

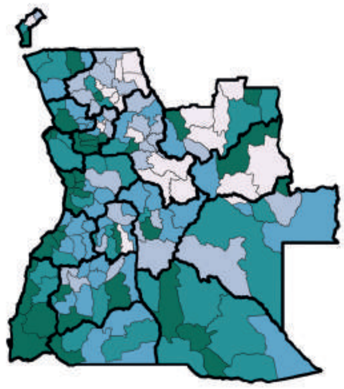
These maps show the annual average chance of experiencing a drought (%). By analysing the deficits in effective rainfall (precipitation minus potential evapotranspiration), in subsurface water (soil moisture), and in the rivers (streamflow), and investigating which deficits caused an impact in the past decades, the vulnerability to water deficits was estimated per agro-ecological zone of Angola. Then, it was evaluated how often such meteorological or hydrological deficit occurs under current climate conditions and how often it is expected to occur under projected climate conditions. This results in a drought probability map, showing the annual chance that a drought - of a severity which resulted in a harmful impact in the past - will hit. The results show the highest probability to experience drought is found in the southern and the central-western regions, under current climate conditions. Under projected climate conditions, the probability of droughts would strongly increase towards the east, Moxico and Lunda Sul being the two provinces where major increases are expected. The projected increase in drought risk can be assigned to higher temperatures and larger rainfall variability in a projected climate, and to the close link between drought disasters and evaporation deficits in Angola.

WCI



WATER CROWDING INDEX

0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
[% Population/Y]



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

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

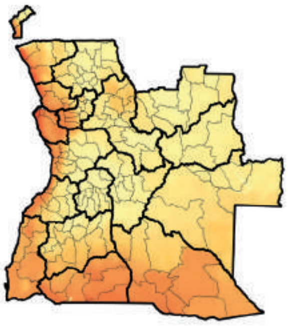
These maps show the percentage of the population per region experiencing water scarcity, based on the water available (precipitation minus actual evapotranspiration) per person per year (<1000 m^3/person/year). Water scarcity indicates that a population depends on water resources from outside their immediate region (~25 km^2). Currently, the highest percentage of population in water scarcity can be found in and around the capital (Luanda, Cazenga Cacuaco) and in the south-east (Benguela, Catumbela, Namibe), where almost the entire population is not self-sufficient in water resources coming from their immediate region. Overall, average water availability will decrease under projected climate conditions. With a growing population, large increases in water scarcity are projected in, among others, Dala, Luacano and Tchikala Tcholohanga.

HAZARD INDEX

SPEI - Standardized Precipitation-Evapotranspiration Index

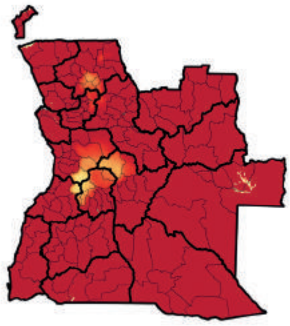
These maps denote the average annual chance of a meteorological drought occurring (%). Droughts are defined as 3 consecutive months of precipitation minus evapotranspiration values considerably below normal conditions; calculated through the Standardized Precipitation – Potential Evapotranspiration Index (SPEI). Due to temperature increases, this indicator projects a major increase in drought frequency throughout the country. This is particularly important for areas dependent on rainfall for their water resources.

Current Climate Conditions (1979 - 2018) - Fig. D33



0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Probability [%] of 3-months Drought

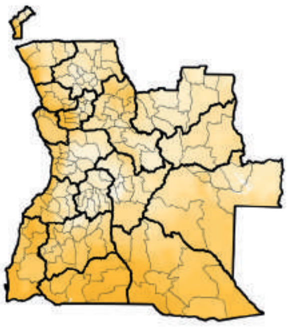
Projected Climate Conditions (2051 - 2100) - Fig. D34



SSMI - Standardized Soil Moisture Index

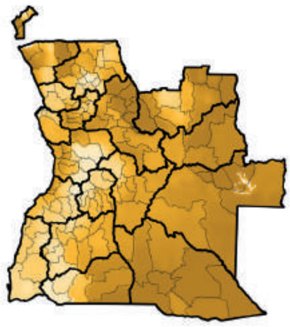
These maps denote the average annual chance of a subsurface drought occurring (%). Droughts are defined as 3 consecutive months of soil moisture conditions considerably below normal conditions; calculated through the Standardized Soil Moisture Index (SSMI). It can be noted that the probability of droughts is the highest along the coast and in the south of the country. In the projected climate, there is a general increase in drought probability. Eastern regions in particular might see a sharp increase. This is important for agricultural areas and natural ecosystems.

Current Climate Conditions (1979 - 2018) - Fig. D35



0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Probability [%] of 3-months Drought

Projected Climate Conditions (2051 - 2100) - Fig. D36



SSFI - Standardized Streamflow Index

These maps denote the average annual chance of a hydrological drought occurring (%). Droughts are defined as 3 consecutive months of stream flow levels considerably below normal conditions; calculated through the Standardized StreamFlow Index (SSFI). This indicator is particularly important for areas dependent on rivers for their water resources. The probability of droughts is expected to generally increase, particularly in the eastern regions.

Current Climate Conditions (1979 - 2018) - Fig. D37

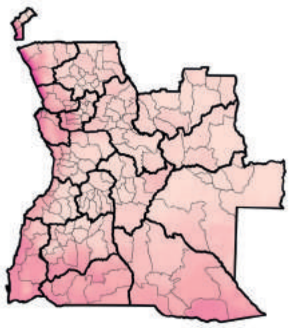
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Probability [%] of 3-months Drought

Projected Climate Conditions (2051 - 2100) - Fig. D38

SPI - Standardized Precipitation Index

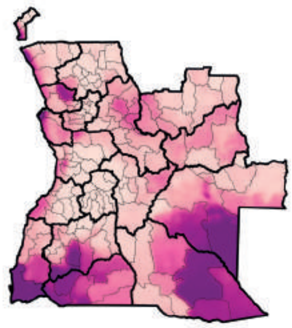
These maps denote the average annual chance of a meteorological drought occurring (%). Droughts are defined as three consecutive months of precipitation considerably below normal conditions; calculated through the Standardized Precipitation Index (SPI). In Angola, the likelihood of drought is higher in the south, southeast, and in coastal areas. These areas will also see the largest increase in droughts, according to future climate projections. This is particularly important for areas dependent on rainfall for their water resources.

Current Climate Conditions (1979 - 2018) - Fig. D39



0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Probability [%] of 3-months Drought

Projected Climate Conditions (2051 - 2100) - Fig. D40



Risk Profile key messages

CLIMATE

The climate projections (2050-2100) considered in this risk profile (RCP 8.5) foresee a huge increase in temperature in Angola: especially in the final part of the century (2071-2095), when it would reach 4 degrees at the country scale. No significant changes in rainfall totals are foreseen at the country level.

FLOODS

The average value of 25,000 people affected per year in the current climate conditions does not vary if only the climate variations are considered. Taking into account both climate projections and the population increase, however, the average affected people per year would increase more than 4 times (above 100,000 people). Cunene is one of the most affected provinces, in both present and projected climate conditions.

Average Annual Loss due to floods is estimated on average to be just under 100 million USD in the present and projected climate. Most affected sectors are housing and agriculture.*

The increased frequency of extreme events under projected climate conditions: a loss of 125 million USD occurs on average every 200 years in current climate conditions, while in future the same loss would occur on average every 20 years.

DROUGHTS

On average almost 1.9 million people are estimated to be directly affected by drought per year. Cunene Province is a hotspot. The situation would worsen significantly under projected climate conditions, where 7.9 million people are estimated to be directly affected if population growth is also accounted for.

Drought risk would increase across the country, including eastern and northern regions.

More than 40% of livestock is currently exposed to risk and would be close to 70% under projected climate conditions. Drought risk for livestock is also expanding eastward and northward.

Average annual economic losses in agriculture due to drought is estimated to be about 100 million USD under current climate conditions. These and would increase 7 times under projected climate conditions, if no adaptation measures are implemented.*

Agriculture production losses would cause a decrease in available food energy supply equivalent to around 3 million potentially fed people.

*Hydroelectric losses (deficit compared to current average production) would increase threefold under projected conditions: respectively from above 30 to almost 100 million USD.**

** This risk profile considers prices and exchange rate USD/AOA (United States Dollar / Angolan Kwanza) of 2015.*

Policy Recommendations

From 16 to 18 December 2019, at the Hotel Trópico in Luanda, a National Workshop took place to present the updated flood and drought risk profiles, organized by the National Civil Protection Commission (CNPC), the United Nations Regional Office for Disaster Risk Reduction (UNDRR), and CIMA Research Foundation - International Centre for Environmental Monitoring (Italy).

The opening session was led by His Excellency the Chief Commissioner Salvador José Rodrigues, the Interior Secretary of State for Technical Assurance, representing the Minister of the Interior, who was flanked by the Ambassador of the European Union, Mr. Tomas Ulicny, by Mr. Abubakar Sutan Rcai, representing the UN Resident Coordinator in Angola, by the representative of the CIMA Research Foundation, Mr. Lauro Rossi and the representative of the United Nations Regional Office for Disaster Risk Reduction in Africa, Mr. Roberto Schiano Lomoriello.

THE WORKSHOP HAD THE FOLLOWING OBJECTIVES:

• To present and evaluate the results of the updated flood and drought risk profile, the data sources used, and the new risk metrics applied to affected people and in different sectors.

• To improve the interpretation of the basic key risk metrics, including Average Annual Loss (AAL), Probable Maximum Loss (PML) and Loss Exceedance Curve (LEC) for floods and droughts;

• To promote the nationwide adoption of the risk profile, including developing policy recommendations based on the results of the risk profile and on the local knowledge and experience.

• To increase the national capacity to incorporate disaster risk reduction into investment planning and public economic development systems, in accordance with the Sendai Framework and the 2030 Agenda.

• To understand the budget level for national disaster risk reduction investments and to discuss methodologies to identify public investments and spending in those areas, as well as to understand the direct and indirect economic benefits of investment in Disaster Risk Reduction.

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

INSTITUTIONAL AND LEGAL FRAMEWORK

1. Having realised the importance of a scientific approach for effective risk management, the participants proposed incorporating the academic sector's studies and research of climate change phenomena into the design processes for national disaster risk reduction projects and programmes.

2. Considering future projections regarding flood and drought risk, participants proposed that the Angolan Executive consider the risk profile results in budget forecasts and strategic investments, so that the expected impacts can be anticipated and minimized.

3. Similarly, participants proposed the drawing up of a strategic document on the National Policy on Civil Protection and Integral Risk Management, which would result in creating new regulations and procedures.

4. Based on the worsening of the expected impacts in all sectors of development, as described in the risk profile, participants recommended strengthening the multi-sectoral monitoring and coordination National Platform for risk reduction, based on Decree 229/10.

5. Considering the difficulty of sharing data between institutions and the need to respond collectively and promptly to risk, participants proposed developing a National Platform for Disaster Risk Reduction, including the public sector, the private sector, the academic community, traditional authorities, students, UN agencies, NGOs and representatives of civil society. The main objective of this action should be to increase the network of partnerships, cooperation and exchange of ideas both nationally and internationally, in order to improve knowledge, technical skills and technological development for risk management.

6. Considering the need to effectively predict and manage risk at various levels (national, provincial and municipal), participants suggested that Provincial and Municipal Civil Protection Commissions should be considered as budgetary units, with the autonomy to manage their resources.

7. To foster continuous dialogue between political interlocutors and the technical-scientific community, a fundamental step for effective risk management, participants proposed creating a thematic technical group in the National Assembly dedicated to Disaster Risk Reduction.

8. Given the need to increase risk awareness and resilience in communities, participants suggested implementing local participatory strategies through the Local Disaster Risk Management Committees.

9. Considering the impacts of climate change predicted for Angola, especially in relation to drought, participants suggested implementing mitigation actions in line with international Framework Agreements, like the Sendai Framework for Disaster Risk Reduction, the Paris Agreement and the 2030 Agenda for Sustainable Development.

STRUCTURAL RISK REDUCTION MEASURES

10. Considering that, according to the risk profile, the risk of drought will increase significantly in the future and the risk of flooding will not decrease, participants proposed setting up mechanisms for diverting, retaining and exploiting rain and river water, based on cost-benefit analyses.

11. Taking into account the provinces and municipalities identified in the risk profile that may suffer the greatest impacts, participants suggested creating safe resettlement zones for people living in risk zones (properly catalogued).

12. Taking into account the provinces identified as being most prone to drought and considering the impact on the population's food security, participants suggested building silos to store cereals, as well as implementing projects to promote local production through rural commerce.

13. Considering the projected future increase in drought risk nationwide, participants proposed research be undertaken on the diversification of agricultural crops/seeds, in order to provide food alternatives for the population. Usage of drought tolerant varieties should be further explored, as they can significantly reduce production losses (reduction of 60% in current climate conditions and 70% in projected climate conditions, for maize).

14. Considering the expected impacts arising from flood risks, participants proposed building and maintaining macro drainage and flood mitigation infrastructures, giving priority to the provinces and municipalities highlighted by the risk profile.

NON-STRUCTURAL RISK REDUCTION MEASURES

15. Based on the results presented in the 2019 risk profile, participants proposed updating the National Plans and the Provincial Plans for Preparation, Response, Contingency and Recovery (2015-2017).

16. Similarly, participants suggested accelerating the process of implementing the 2018 – 2022 Drought Recovery Framework.

17. Considering the need to access information that allows a continuous analysis of risk and its associated factors, participants proposed creating a common platform for hazard, exposure and vulnerability data storage, with shared access between various entities and sectors.

18. To improve responsiveness to natural events which, according to the risk profile, will be reflected in increased economic losses in various sectors and in the increased number of people affected, participants suggested investing in an early warning system based on detailed risk maps for each province, integrating local knowledge.

19. Considering the overall results of the risk profile, participants suggested that urban plans take into account extreme weather events and be designed based on sustainability criteria and disaster resilience.

RISK AWARENESS AND KNOWLEDGE

20. After analysing the risk profile, participants proposed carrying out information, education, awareness and mobilisation actions, as well as training to communities and professionals on the results contained therein and on topics related to disaster prevention and risk reduction. Likewise, they suggested including subjects related to Disaster Prevention in Schools and Communities on the curriculum for primary and secondary education.

21. In order to make the results of the risk profile known and shared by Angolan society, participants suggested that the different ministerial bodies duly share and communicate results to the various development sectors (agricultural sector, production sector, housing sector, transport sector, services sector, critical infrastructure sector, among others).

22. Based on the results of the risk profile, participants proposed developing and maintaining a Risk Atlas at the national, provincial and municipal levels, which would include a vulnerability assessment to various threats.

Luanda, 18 December 2019

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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