2019

DISASTER RISK PROFILE

Flood Drought

Côte d'Ivoire (République de)

Building Disaster Resilience in Sub-Saharan Africa

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

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

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INTRODUCTION

Disasters are on the rise, both in terms of frequency and magnitude. From 2005-2015, more than 700.000 people worldwide lost their lives due to disasters that affected over 1.5 billion people, with women, children and people in vulnerable situations disproportionately affected. The total economic loss amounted to more than US$ 1.3 trillion. Disasters inordinately affect lower-income countries. Sub-Saharan Africa, where two-thirds of the world's least developed countries are located, is prone to recurrent disasters, largely due to natural hazards and climate change.

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

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

As part of the "Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities" programme, UNDRR hired CIMA Research Foundation for the preparation of 16 Country Risk Profiles for floods and droughts for the following countries: Angola, Botswana, Cameroon, Equatorial Guinea, Gabon, Gambia (Republic of The), Ghana, Guinea Bissau, Kenya, Eswatini (Kingdom of), Côte d'Ivoire, Namibia, Rwanda, São Tomé and Príncipe, Tanzania (United Republic of), and Zambia.

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

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

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

PROBABILISTIC RISK PROFILE: METHODOLOGY

PROBABILISTIC RISK ASSESSMENT

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

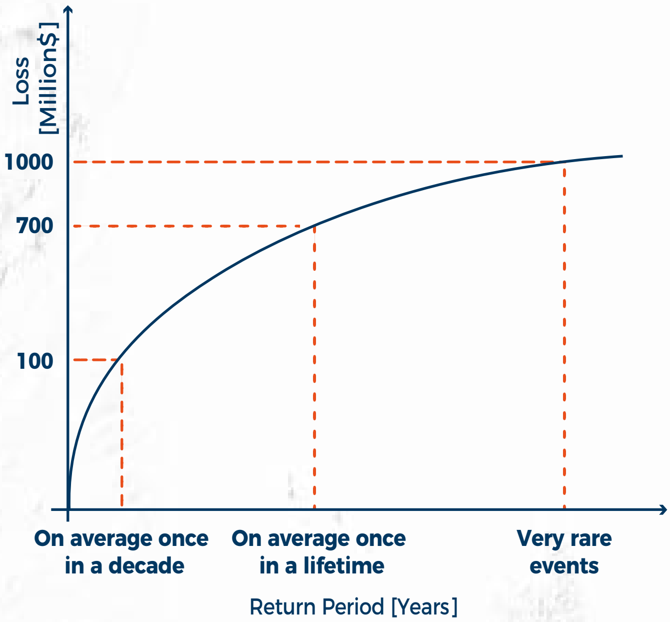
This disaster risk profile for floods and droughts is based on probabilistic risk assessment. Awareness of possible perils that may threaten human lives primarily derives from experience of past events. In theory, series of historical loss data long enough to be representative of all possible disastrous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

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

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

Probable Maximum Loss (PML) describes the loss which could be expected corresponding to a given likelihood. It is expressed in terms of annual probability of exceedance or its reciprocal, the return period. For instance, in the figure below, the likelihood of a US$ 100 million loss is on average once in a decade, a loss of US$ 1 billion is considered a very rare event. Typically, PML is relevant to define the size of reserves which, insurance companies or a government should have available to manage losses.

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



PROBABILISTIC RISK PROFILE: RISK COMPONENTS

HAZARD

process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.

In order to best predict possible flood and drought scenarios, a modelling chain composed of climate, hydrological, and hydraulic models combined with available information on rainfall, temperature, humidity, wind and solar radiation, has been used. 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.

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

VULNERABILITY

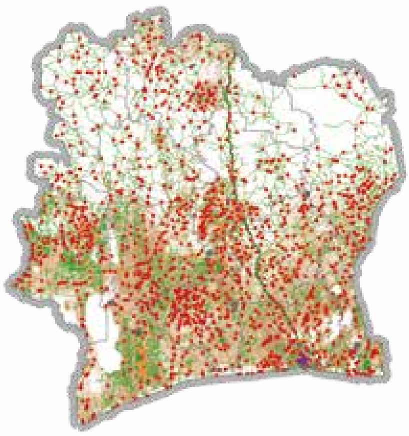
conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

Direct losses on different elements at risk are evaluated 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 US$) are considered in both current (2016) and future (2050) scenarios. The critical sectors are characterised in terms of their economic value (in US$), using the most updated information available.



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

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

CÔTE D'IVOIRE DISASTER RISK PROFILE

A SENDAI ORIENTED RISK PROFILE

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

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

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

COUNTRY SOCIO-ECONOMIC OUTLOOK

OVERVIEW

Situated in Western Africa, Côte d'Ivoire is a young and rapidly growing country and economy. Urbanizing at a rate of 3.4% per annum, the country's demographic and economic expansion has shown no sign of slowing down.[1] In 2017 for example, Côte d'Ivoire registered an impressive GDP increase of almost 8%, making it one of the fastest growing countries in the world, and this rate is expected to be maintained in years to come. Most of this economic development has been attributed to the agricultural sector, which has been aided by recent positive climate conditions, showing climate to have an important impact on the economy [2]. The country has also experienced a considerable increase in poverty in recent decades, which jumped from 10% to 51% between 1985 and 2011.[3] Such inequalities make economic stability even more crucial to social and political stability. The risk calculations presented in this report offer some light on to what economic sectors are most at risk of being impacted by droughts and flooding caused by a changing climate. It argues that risk mitigation must be used as an essential tool to ensuring continued economic development and political stability.

SOCIO-ECONOMIC PROJECTIONS

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

PROJECTIONS USED IN THE RISK PROFILE

The "middle of the road" scenario used in this risk profile envisages that the historical patterns of development are continued throughout the 21st century. Following this projection, Côte d'Ivoire's population will increase by 29% between 2016 and 2050 (World Bank Data), whereas GDP is expected to increase more than twelvefold.

POPULATION

2016 Projection
23.7
[Million People]
30.6
2050 Projection

GDP

2016 Projection
36.4
[Billion$]
462.1
2050 Projection

CÔTE D'IVOIRE

AREA : 322.462 km² *(INS.CI)*

POPULATION DENSITY : 78 people/km²

MEDIAN AGE : 18.4 years *(WORLDOMETERS - 2017)*

HUMAN DEVELOPMENT INDEX : 0.492 *(UNDP - 2017)*

LIFE EXPECTANCY AT BIRTH : 54.1 years *(UNDP - 2017)*

MEAN YEARS OF SCHOOLING : 5.2 years *(UNDP - 2017)*

EMPLOYMENT TO POP. RATIO (AGES > 15) : 55.8% *(WB - 2017)*

EMPLOYMENT IN AGRICULTURE : 48.3% *(WB - 2017)*

EMPLOYMENT IN SERVICES : 45.3% *(WB - 2017)*

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

COUNTRY CLIMATE OUTLOOK

OVERVIEW

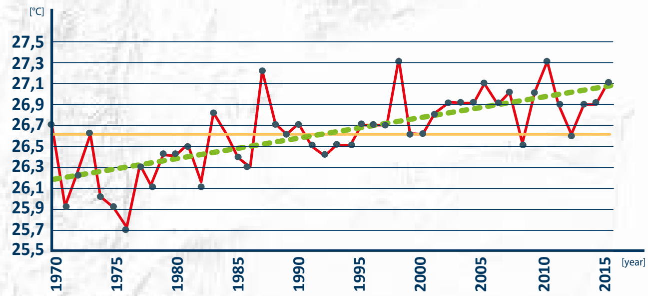
Côte d'Ivoire's climate is generally warm and humid, ranging from equatorial in the southern coasts to tropical in the centre and semi-arid in the far north [7]. Seasons are more clearly distinguishable by rainfall and wind direction than by temperature. Two climatic zones are created by the alternating wind patterns. In the north, tropical conditions delineate two major seasons. Heavy rains fall between June and October, averaging 1100mm annually. Along the coast, equatorial conditions prevail and four seasons are generally distinguishable. Some rain falls in most months, with an average of 2000mm annually. Heavy rains fall between May and July in most years, and shorter rains during August and September. The minor dry season still brings sparse rainfall during October and November, followed by the major dry season from December to April [8].

CLIMATE TRENDS

Similarly to other Western African countries, temperature observations indicate that the Côte d'Ivoire has experienced a considerable increase in temperature in recent years. An analysis of climate data from 1970 to 2015 [9] shows an average rise of a little more than 1˚C. Trends for precipitation are not as clear as those for air temperatures, and are variable in time and space.

Average annual precipitation for Côte d'Ivoire is approximately 1300 mm, while the mean number of wet days per year is of around 122.

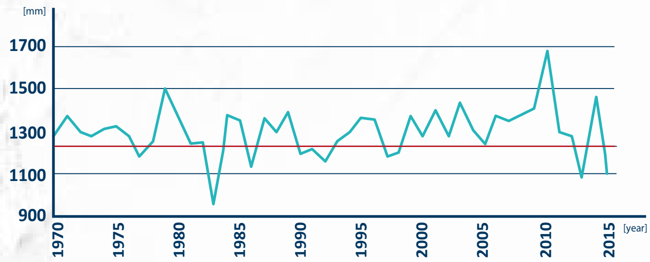
TEMPERATURE AND PRECIPITATION TRENDS IN CURRENT CLIMATE



Mean Annual Temperature

Average of Mean Annual Temperature

Trend Mean Annual Temperature



Annual Precipitation

Average of the Annual Precipitation

RIVERS OF CÔTE D'IVOIRE

There are four main rivers in Côte d'Ivoire, all flowing from north to south, into the Atlantic Ocean: the Komoé, the Bandama, the Sassandra and the Cavally rivers. The Komoé is the easternmost of the main rivers and it flows within a narrow 700 km basin before emptying into the Ebrié Lagoon. The Bandama River is the longest in the country (800 km) and it drains most of central Côte d'Ivoire before it flows into the Tagba Lagoon. The Bandama flows through Lake Kossou, a large artificial lake created in 1973 by the construction of the Kossou Dam at Koosou. The Sassandra River has its source in the high ground of the north, and winds through shifting sandbars to form a narrow estuary, which is navigable for about eighty kilometers inland from the port of Sassandra. Finally the Cavally River (500 km) has its headwaters in the Nimba Mountains in Guinea and forms the border between Côte d'Ivoire and Liberia for over half of its length. It crosses rolling land and rapids and is navigable for about 50 km inland from its exit to the sea. In addition to these four main rivers, there are also several smaller coastal rivers, which also generally flow from north to south into the Atlantic, creating in some cases lagoons at the river delta. In the north, there are several tributaries of the Niger and the Black Volta rivers. The Niger tributaries flow northwards towards Mali [10].

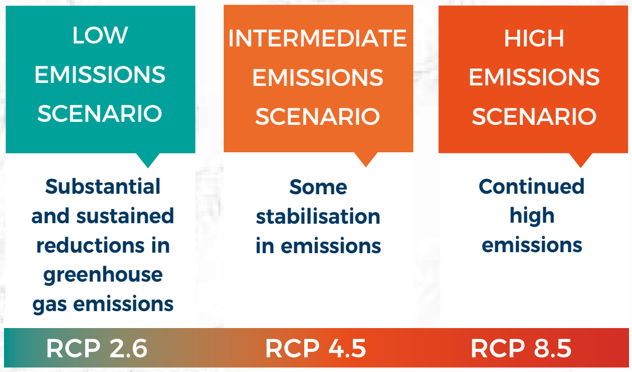
Photo Credits: Lone fisherman on Sassandra river, Ivory Coast - https://commons.wikimedia.org/wiki/File:Lone_fishermin_Ivory_Coast.jpg

CLIMATE PROJECTIONS FOR CÔTE D'IVOIRE

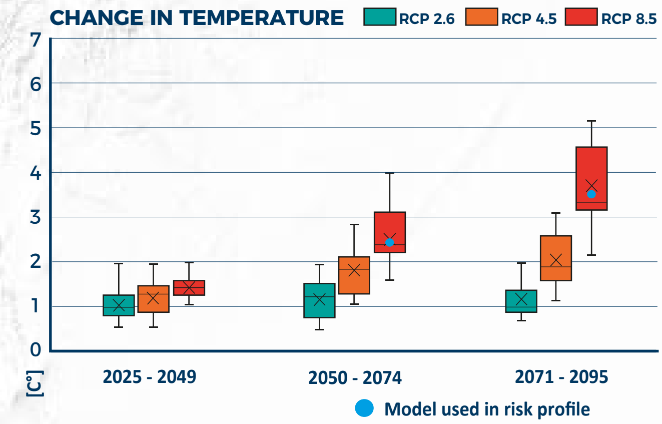
Climate projection studies are abundant for multiple different time spans and with various scales. Climate models are tools that the scientific community uses to assess trends in weather conditions over long periods. In a recent study [11] Alder, et al., compared the observed temperature and precipitations of the 1980-2004 period 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 then analyzed for different greenhouse emission scenarios (see IPCC's Emissions Scenarios).

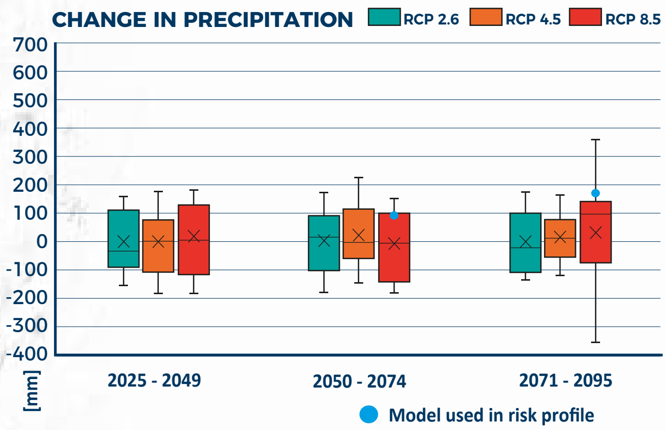
In all periods, models showed an increase in temperature. This was more evident in long term period projections. In high emission scenarios (RCP 8.5), model projections show an increase of between about 1.5˚C and 4˚C for the mid term period (2050-2074) and an increase of between about 2˚C and 5˚C for the long term period (2071-2095). Future changes in precipitation seem to be less predictable in the three periods, where the variability is large for all considered emission scenarios (containing both negative and positive changes).

Time Frame	Climate Projections (RCP 8.5 - High emission scenario)
Mid-term Future (2050-2074)	Increase in temperature from 1.5˚C to 4˚C divergent change in precipitation (from -15% to +15%)
Far Future (2071-2095)	Increase in temperature from 2˚C to 5˚C divergent change in precipitation (from -30% to +30%)



IPCC's Emissions scenarios for Climate Projections





CLIMATE PROJECTIONS USED IN THIS RISK PROFILE

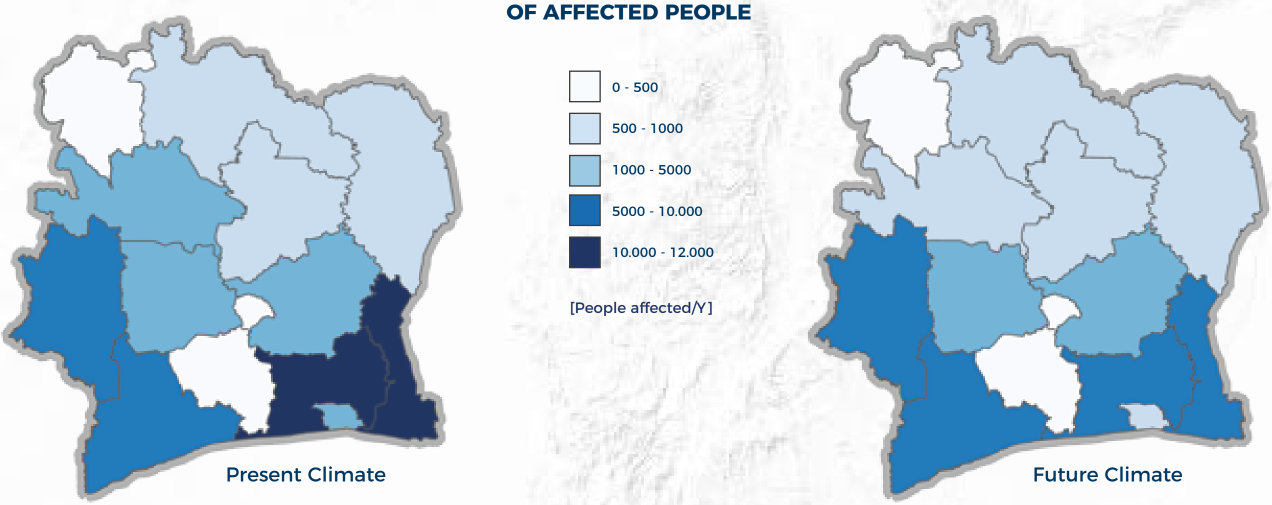
Results presented in the Risk Profile which refer to climate change have been obtained using a climate projection model based on a high emission scenario (SMHI-RCA4 model, grid spacing 0.44˚ about 50 km- driven by the ICHEC-EC-EARTH model, RCP 8.5, 2006-2100). [12, 13, 14]

This study uses a high-resolution model which has been accurately calibrated for the African domain. This allows for a better capture of climate variability which is key in assessing extremes. Regional model projections were checked for consistency against the full ensemble of available global models in the area. The model forecasts changes in temperature and annual precipitation by the end of the century, in line with the range of variability of the global models analyzed in the study by Alder and Hostetler [11].

The high emission scenario was maintained as representative of the worst climate change scenario, enabling the analysis of a full range of possible changes. In this specific case, the regional model predicts an increase in temperature of around 3.5˚C in the long term future, in line with the global ensemble. As regards to annual precipitation at the country level, an increase of between 10% and 15% is predicted by the regional model in the far future, while the average variation from global models is much closer to zero.

RESULTS | FLOODS

[B1] ANNUAL AVERAGE NUMBER OF AFFECTED PEOPLE



KEY MESSAGES

- Floods affect on average 45.000 people every year, about 0.2% of the country's total population*.

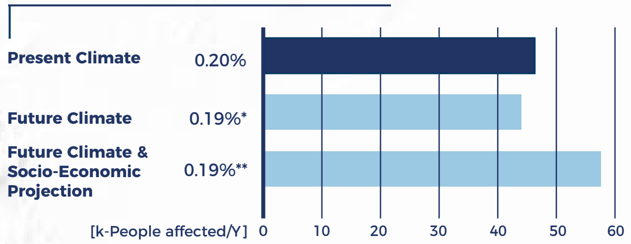
- The affected people are geographically concentrated in the coastal provinces in both present and future climate conditions, but with a pattern that seems more severe in the eastern part in the present climate, and western coastal provinces most affected under future climate conditions.

- The GDP percentage in areas affected by floods amounts on average to more than 0.3% of the total national GDP*.

- Côte d'Ivoire's future climate projections do not predict substantial changes in terms of annual average losses as a consequence of the very uncertain trend in precipitation predicted by climate models in the last part of the century: similar risk figures are computed using weather forcing that considers climate change. However, when the future climatic conditions are paired with the projection of future growth in population and GDP**, the risk grows. In particular, affected GDP figures are expected to increase by a factor of ten (or more).

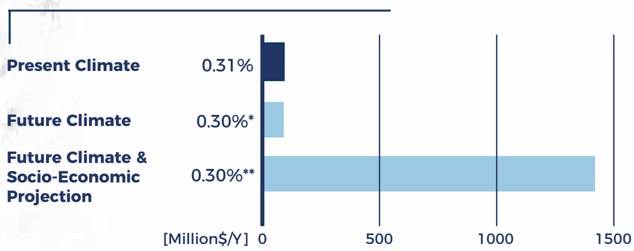
- Taking into consideration the above statements the importance of a risk informed development in the future becomes undeniable, especially where computations highlight the importance of future developments of the country with respect to the climate change forcing.

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE [B1]



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

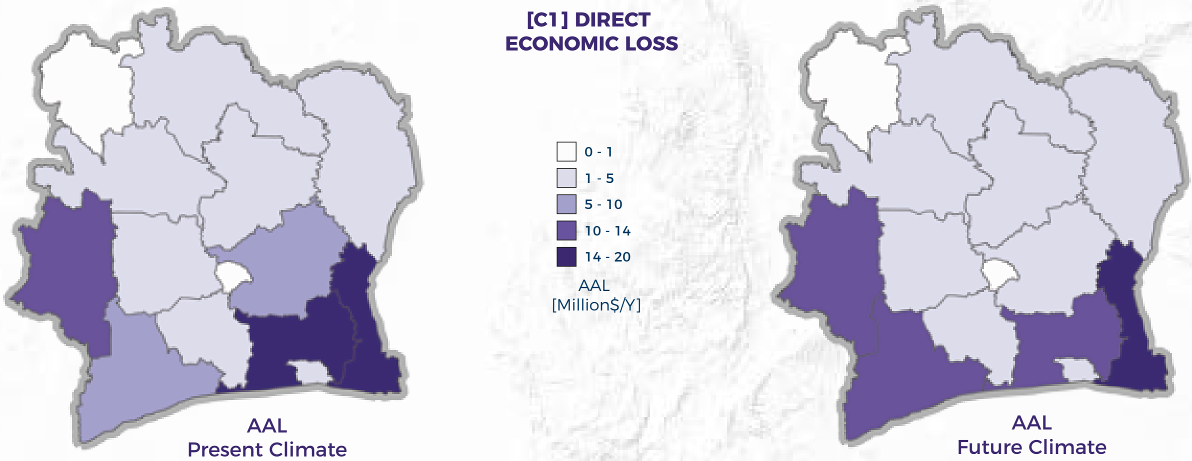
ANNUAL AVERAGE POTENTIALLY AFFECTED GDP



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

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

RESULTS | FLOODS



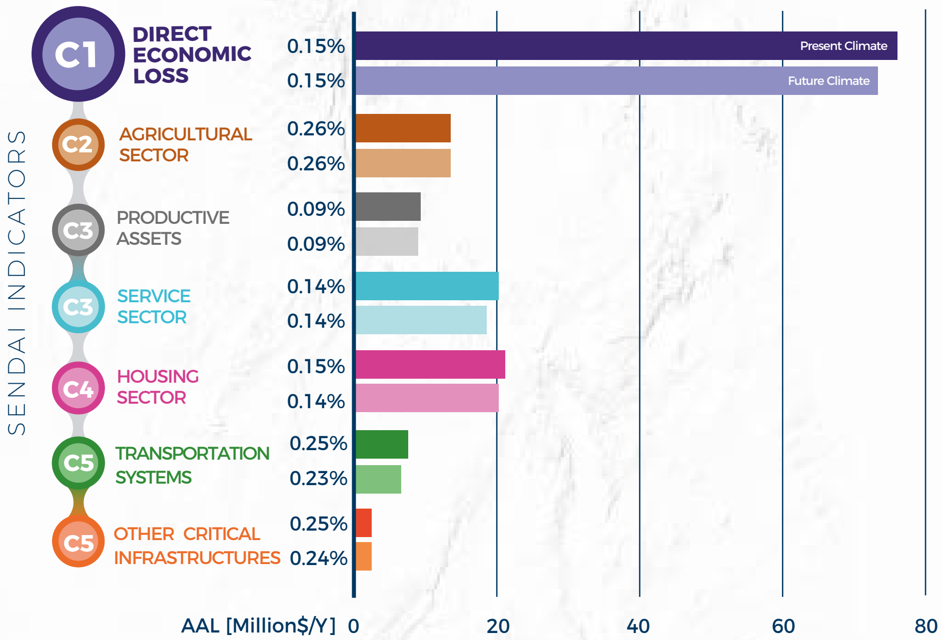
KEY MESSAGES

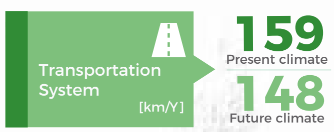
- Coastal areas show the largest direct economic loss. The pattern changes under future climate conditions, where a marked increase in risk can be detected in the district of Bas-Sassandra.

- The value of direct economic losses in terms of AAL in the present climate amounts to about 77 million USD, which accounts for 0.15% of the total stock value. The housing, service and agricultural sectors dominate the total direct economic loss. Schools and health facilities are the sector with the smallest economic loss in absolute terms, but one of the highest in relative ones.

- The proportion of the different sectors to the overall loss does not change in the future in relative values. A very limited variation of losses in sectoral AAL is predicted.

- The annual average number of kilometers of roads and railways affected by floods slightly decreases under future climate conditions. This result is obtained under the assumption that the road and railway network will not change significantly in future. However, as already discussed for GDP and population the increase in the risk figures is dominated by future changes in exposure. This calls for specific attention in planning future investments in infrastructures so that the risk figures do not increase significantly.

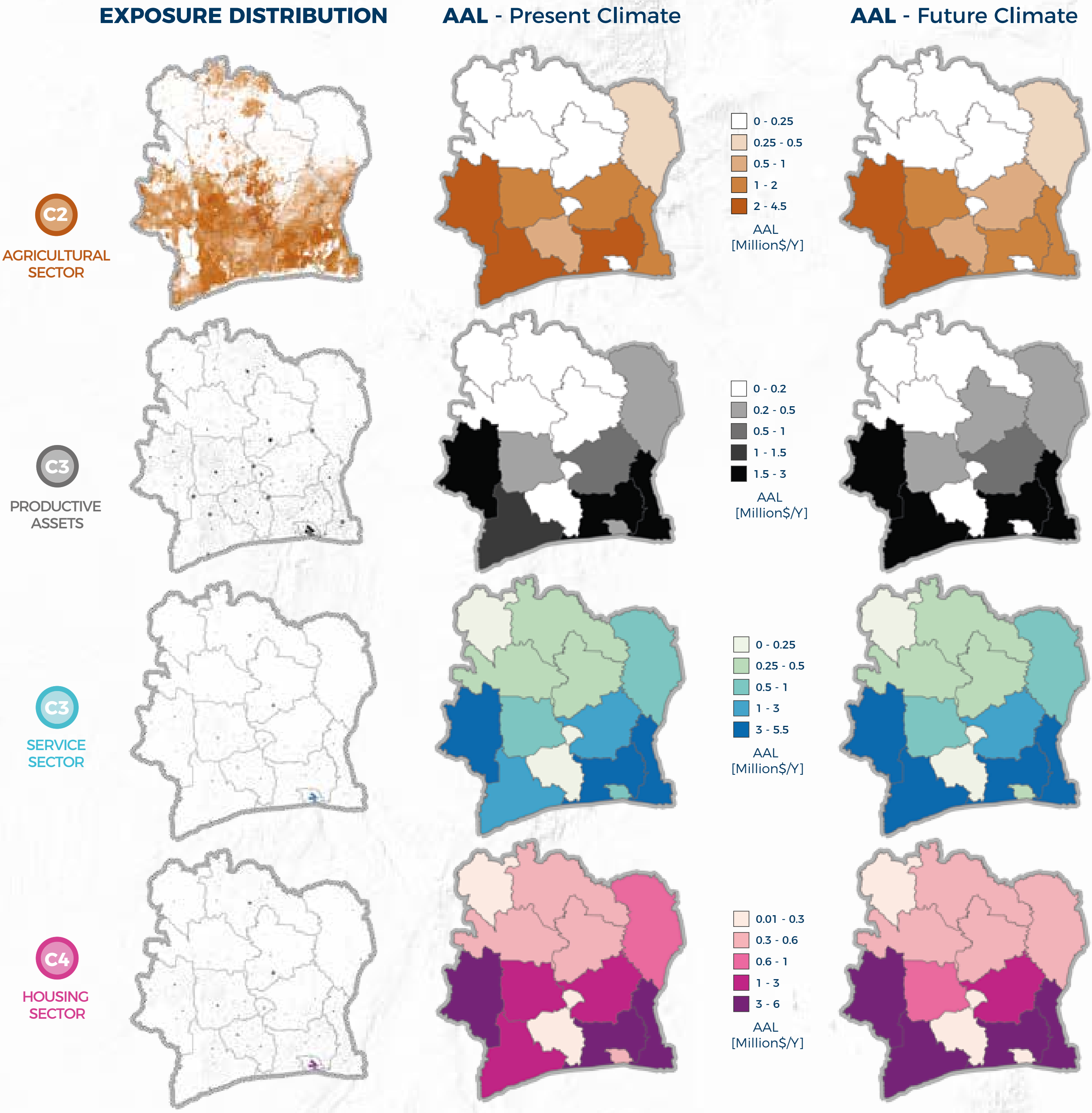




RESULTS | FLOODS

KEY MESSAGES

- The AAL distribution for all sectors show a similar pattern, with the coastal, and partly the central areas, withstanding the majority of the losses.
- The pattern changes in the future in a similar way for the different sectors with an increase of risk in the western parts of the country.



RESULTS | FLOODS

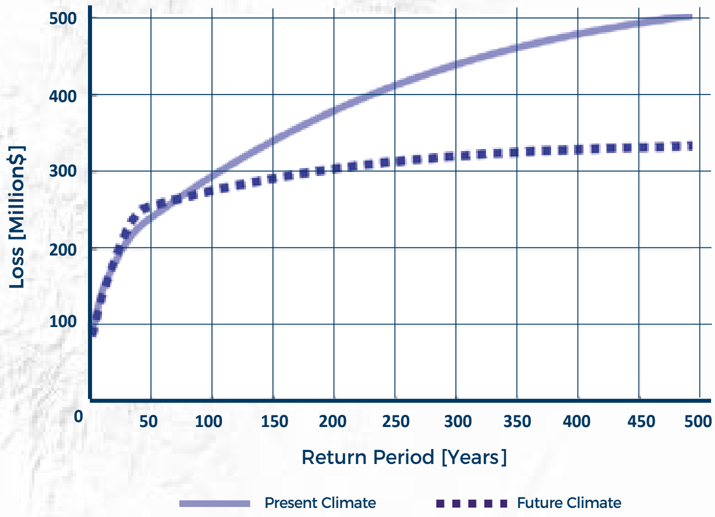
KEY MESSAGES

- The PML curve rises steeply in the first part, characterised by the high frequency losses. The curves for present and future conditions do not differ significantly in this first part, but the curves depart from each other for medium and heavy losses.

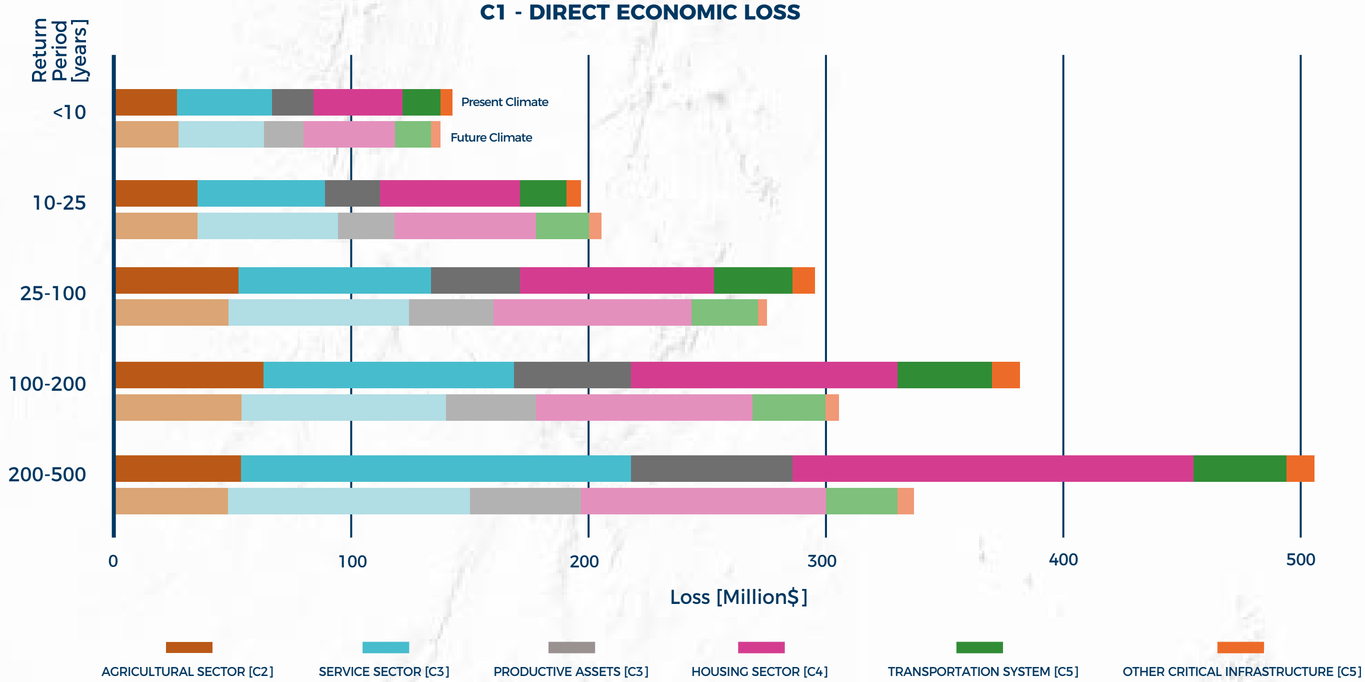
- The share of losses between the sectors for the different return periods do not change significantly, even though it is possible to notice a stronger contribution to the losses from the industry sector as we move to more important losses.

- The PML curve rises steeply until the 30 year loss, and then the slope changes. This sets an unfavourable condition for risk transfer contracts. The first part of the curve should be strategically modified with risk reduction measures before designing a risk transfer option.

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

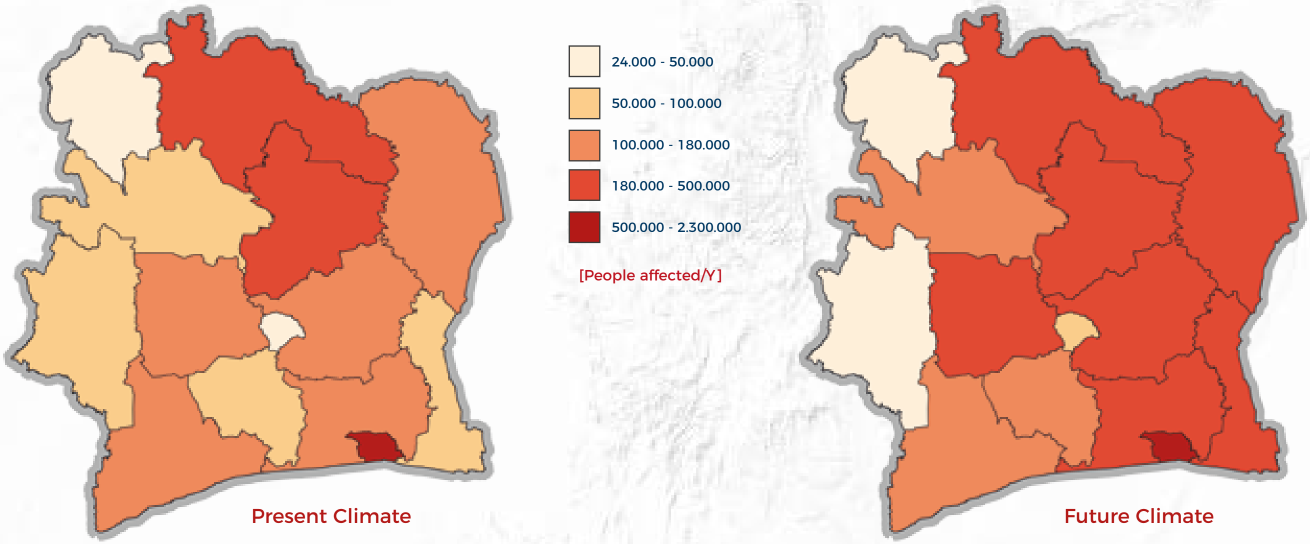


PROBABLE MAXIMUM LOSS CURVE (PML) ACROSS ALL SECTORS
C1 - DIRECT ECONOMIC LOSS



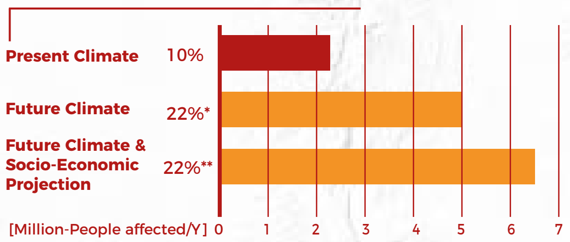
RESULTS | DROUGHTS

[B1] ANNUAL AVERAGE NUMBER OF AFFECTED PEOPLE



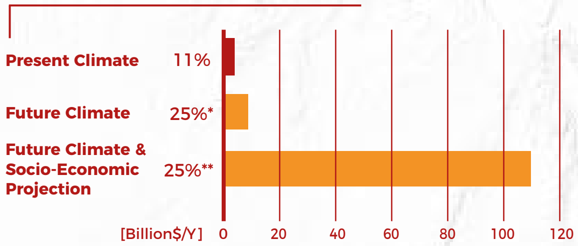
Annual average of population potentially affected by at least three months of drought conditions, as calculated using the standardized precipitation-evapotranspiration index (SPEI) and using a 3-month accumulation period.

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE [B1]



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

ANNUAL AVERAGE POTENTIALLY AFFECTED GDP



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

KEY MESSAGES

- With respect to present conditions (1951-2000 climate), the probability of occurrence of droughts, calculated through the standardized precipitation – evapotranspiration index, will increase by 7.5% in the future (2051-2100 climate).

- Currently, an annual average of 2.3 million people (10%) are potentially affected by droughts. In the future, this number is expected to increase to 22% (6.6 million people exposed every year - if population growth is accounted for), with the east of the country experiencing the largest increase.

- The GDP potentially affected by droughts is expected to increase from almost 4 billion to more than 8 billion USD annually - excluding expected economic development. While currently, on average 11% of the GDP is exposed, this is expected to rise to 25%.

RESULTS | DROUGHTS

KEY MESSAGES

- In the future more livestock is expected to be annually exposed to droughts. The percentage of potentially affected livestock will rise from 11% to 24%. The spatial distribution of livestock units under future climate conditions do not change significantly when compared with the present situation: the increase is gradual in all provinces.

- Agricultural losses in absolute terms are mainly due to yams. In relative terms, almost all crops are less affected under future conditions, except maize and yams.

- The distribution of agricultural (crop) losses shows a concentration of losses in the central, southern and western parts of the country. Under future climate conditions, estimated losses decrease in most provinces except in the northern part of Côte d'Ivoire.

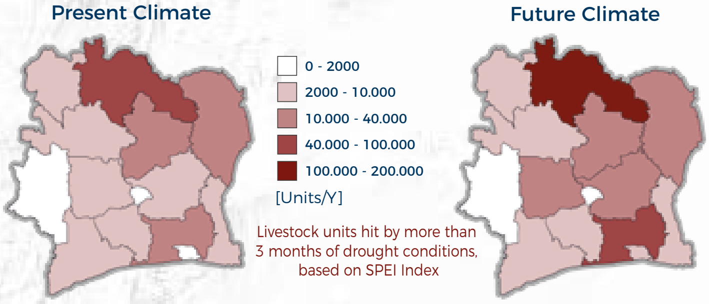
- An approximate, 50% decrease in lost working days is expected under future climate conditions. The loss of working days is estimated at less than 0.5% for both present and future conditions. However, the number of working days lost, expressed as a percentage of the average amount of days required for harvesting, will be approximately five times higher.

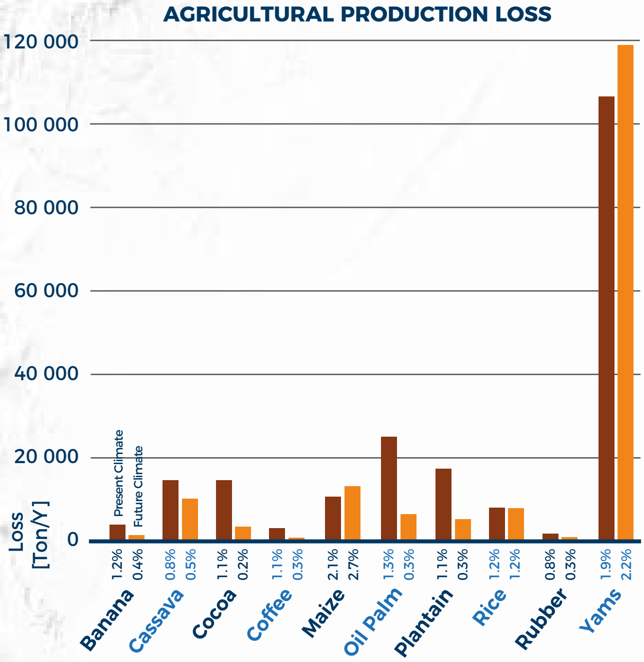
ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED LIVESTOCK UNITS* [k-Livestock units]

185 | **11%** Present climate

405 | **24%** Future climate

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

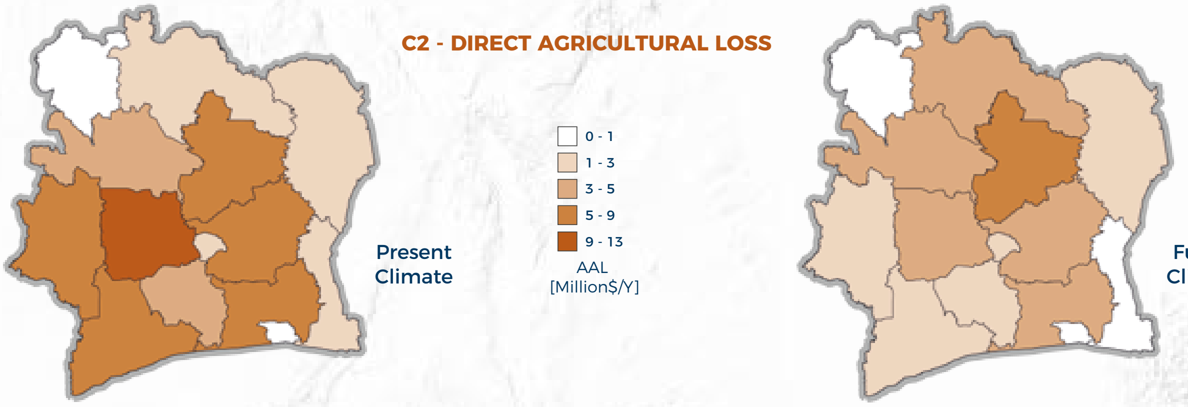




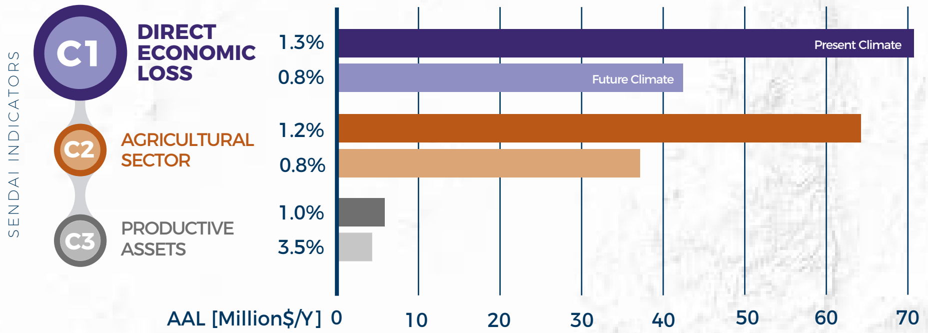
ANNUAL AVERAGE NUMBER OF WORKING DAYS LOST [k-Days]

1090 | **0.1%** Present climate

545 | **0.2%** Future climate



RESULTS | DROUGHTS



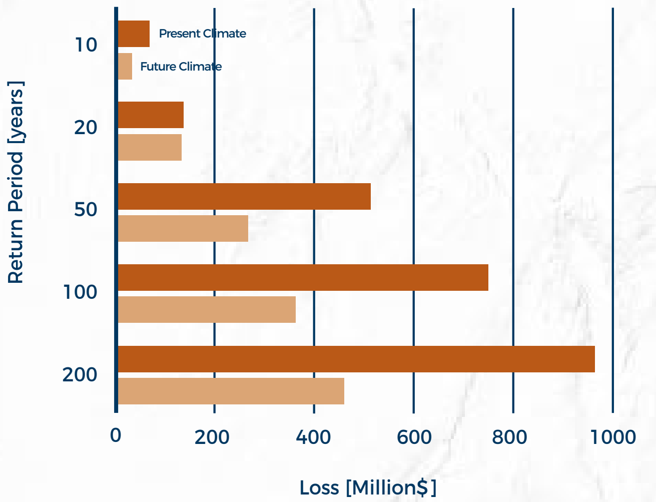
C2 is computed considering only direct loss associated with reference agricultural (crop) production. Reference crops considered in the analysis are the ones which contribute to at least 85% of the total country-level gross crop production value. It might therefore happen that crops which have an important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

KEY MESSAGES

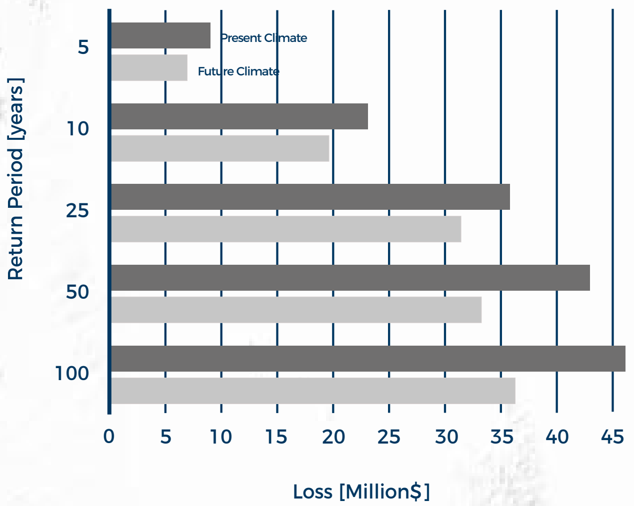
- Total direct economic losses (C1) due to drought are for the most part attributable to the agricultural sector (C2).
- Losses in agricultural production (C2) are projected to decrease substantially from 1.2% to 0.8% compared to the total income from crops.
- Losses in hydropower generation (C3) due to droughts are expected to decrease slightly, due to an increase in river flow under future climate conditions (dams considered: Kossou, Buyo, Taabo, Ayame1+2).

- In the case of agricultural income losses (see Glossary), losses are estimated to decrease for all return periods from 5 to 100 years. Under future climate conditions, both for absolute and relative units, highest decreases are found with the higher return periods.
- Hydropower losses are projected to decrease for most return periods under future climate conditions. Overall, changes are small, which is the net result of increased losses at Kossou, but reduced losses at Buyo.

PROBABLE MAXIMUM LOSS (PML) C2 - AGRICULTURAL LOSS



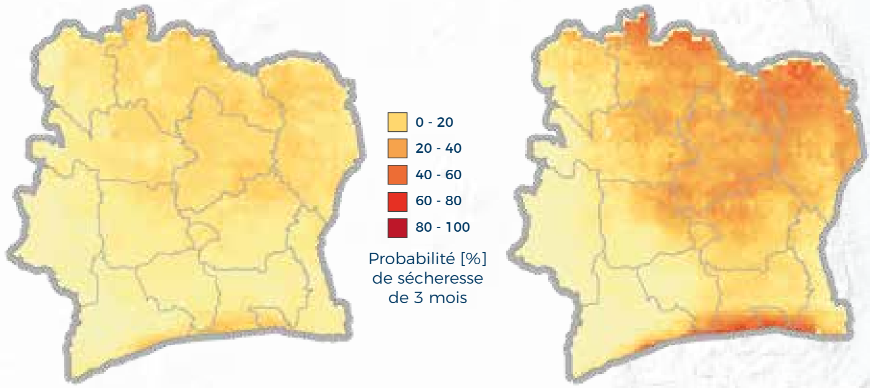
PROBABLE MAXIMUM LOSS (PML) C3 - PRODUCTIVE ASSETS (HYDROPOWER LOSS)



RESULTS | DROUGHTS

Present Climate

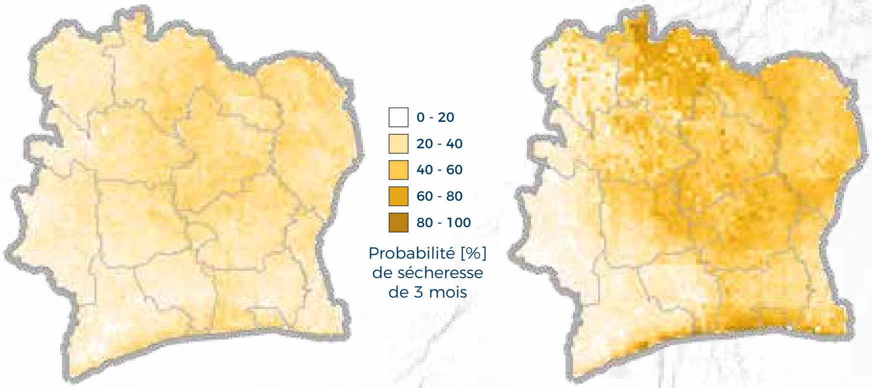
Future Climate



SPEI

Standardised Precipitation-Evapotranspiration Index

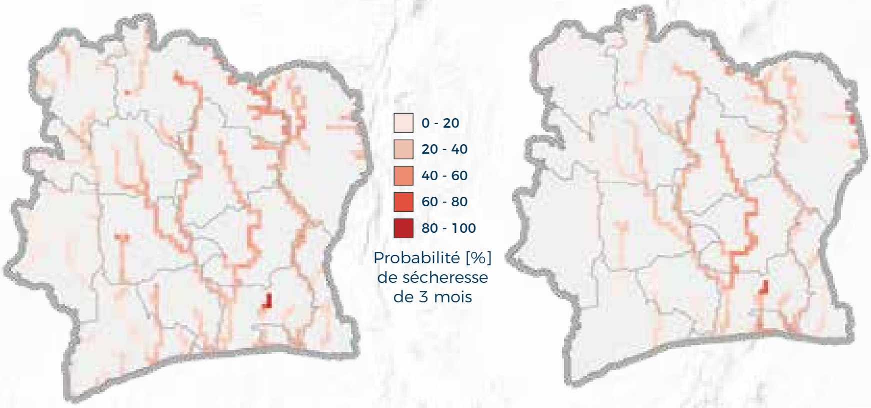
These maps denote the average annual chance of a meteorological drought occurring (%). Droughts are defined as 3 months of precipitation minus evapotranspiration values considerably below normal conditions; calculated through the Standardized Precipitation - Evapotranspiration Index (SPEI; see 'Drought' in Glossary). It can be noted that currently, the probability of droughts is the highest in the south of the country, while climate change will increase the drought frequency in the north-east. This is particularly important for areas dependent on rainfall for their water resources.



SSMI - Standardised Soil Moisture Index

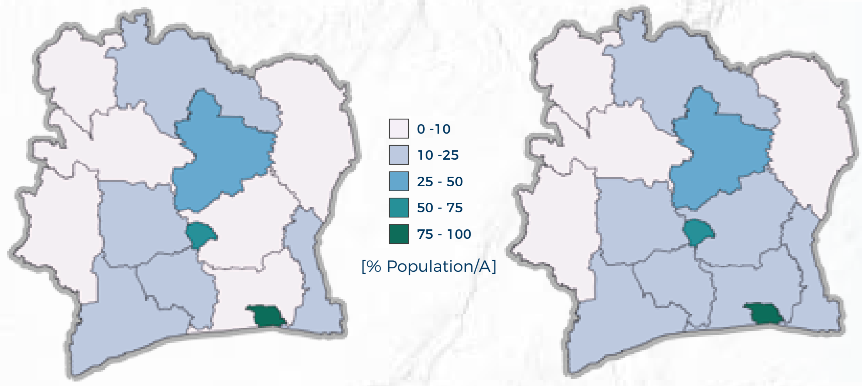
These maps denote the average annual chance of a subsurface drought occurring (%). Droughts are defined as 3 months of soil moisture conditions considerably below normal conditions; calculated through the Standardized Soil Moisture Index (SSMI; see 'Drought' in Glossary).

In a future climate, only the provinces of Bas-Sassandra, Montagnes and Goh-Djiboua will be spared of soil moisture droughts. This is particularly important for agricultural and natural areas.



SSFI - Standardised Streamflow Index

These maps denote the average annual chance of a hydrological drought occurring (%). Droughts are defined as 3 months of stream flow levels considerably below normal conditions; calculated through the Standardized StreamFlow Index (SSFI; see 'Drought' in Glossary). In Côte d'Ivoire, mainly the headwaters of the rivers experience a high flow variability, while rivers like the Nzi and Red and White Bandama are not very drought prone. In the future climate, less droughts are expected in the larger rivers (mainly in the Komoë and headwaters of the Iringou). This is particularly important for areas dependent on rivers for their water supply, navigation and electricity generation.



WCI - Water Crowding Index

These maps show the percentage of the population per region experiencing water scarcity, based on the water available (precipitation minus evapotranspiration) per person per year (<1000 m^3/person/year). Water scarcity indicates that a population depends on water resources from outside their immediate region (~85 km^2). Specifically, areas with high concentrations of people are dependent on outside water resources (primarily around Abidjan Yamoussoukro). With climate change, the proportion of the population dependent on water from elsewhere in the Lacs and Lagunas provinces will increase.

PROBABILISTIC RISK ASSESSMENT FOR RISK MANAGEMENT

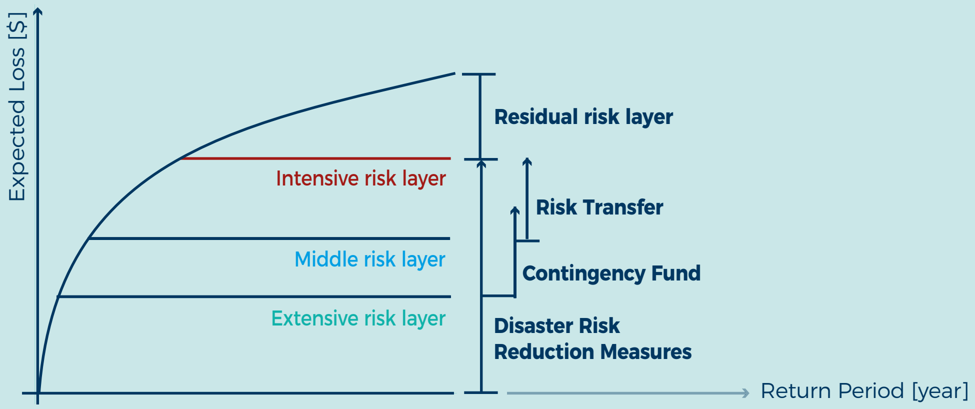
METRICS FOR RISK MANAGEMENT

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

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

PML CURVE

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



GLOSSARY & REFERENCES

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

CLIMATE MODEL*
A numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for some of its known properties. Climate models are applied as a research tool to study and simulate the climate, and for operational purposes, including monthly, seasonal, and interannual climate predictions.

DISASTER RISK*
The potential loss of life, injury, or destroyed, or damaged assets which could occur to a system, society, or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability, and capacity.

DROUGHT
Droughts, defined as unusual and temporary deficits in water supply, are a persistent hazard, potentially impacting human and environment systems. Droughts, which can occur everywhere, should not be confused with aridity, a permanent climate condition. in this profile drought hazard is denoted by various indices, covering a range of drought types (meteorological, hydrological and soil moisture droughts) and standardised using seasonal data (i.e. values accumulated over 90 days). A drought is defined as at least three consecutive months with standardised index values below a certain drought threshold, indicating conditions that are significantly dryer than normal given the reference period 1951-2000.
This drought threshold varies between -0.5 and -2, according to the aridity index of that area: the dryer the area, the less extreme the water deficit needs to be be in order to be considered 'a drought'. droughts are analysed in terms of hazard, exposed population, livestock, and GDP. drought induced losses are explicitly estimated for crop production and hydropower generation.

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

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

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.

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

GLOSSARY & REFERENCES

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

RISK TRANSFER*
The process of formally or informally shifting the financial consequences of particular risks from one party to another, whereby a household, community, enterprise, or State authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party.

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

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

www.preventionweb.net/resilient-africa

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