2019

DISASTER RISK PROFILE

Flood Drought

Eswatini (Kingdom of)

Building Disaster Resilience in Sub-Saharan Africa

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

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

This project is funded by the European Union

UNDRR
UN Office for Disaster Risk Reduction

cima RESEARCH FOUNDATION

International Centre on Environmental Monitoring
Via Magliotto 2. 17100 Savona. Italy
2019 - Review

Africa Disaster Risk Profiles are co-financed by the EU-funded ACP-EU Natural Disaster Risk Reduction Program and the ACP-EU Africa Disaster Risk Financing Program, managed by UNDRR.

DISCLAIMER

RIGHTS AND PERMISSIONS

Design and layout: CIMA Research Foundation
Video Production: Don't Movie, Italy

In collaboration with:

PROJECT TEAM

Authors
Roberto Rudari [1]
Amjad Abbashar [2]
Sjaak Conijn [4]
Silvia De Angeli [1]
Hans de Moel [3]
Auriane Denis-Loupot [2]
Luca Ferraris [1;5]
Tatiana Ghizzoni [1]
Isabel Gomes [1]
Diana Mosquera Calle [2]
Katarina Mouakkid Soltesova [2]
Marco Massabò [1]
Julius Njoroge Kabubi [2]
Lauro Rossi [1]
Luca Rossi [2]
Roberto Schiano Lomoriello [2]
Eva Trasforini [1]

Scientific Team
Nazan An [7]
Chiara Arrighi [1;6]
Valerio Basso [1]
Guido Biondi [1]
Alessandro Burastero [1]
Lorenzo Campo [1]
Fabio Castelli [1;6]
Mirko D'Andrea [1]
Fabio Delogu [1]
Giulia Ercolani [1;6]
Elisabetta Fiori [1]
Simone Gabellani [1]
Alessandro Masoero [1]
Enrico Ponte [1]
Ben Rutgers [4]
Franco Siccardi [1]
Francesco Silvestro [1]
Andrea Tessore [1]
Tufan Turp [7]
Marthe Wens [3]

Editing and Graphics
Adrien Gignac-Eddy [1]
Rita Visigalli [1]

Supporting Team
Simona Pozzati [1]
Luisa Colla [1]
Monica Corvarola [1]
Anduela Kaja [1]
Iain Logan [8]
Rich Parker [9]
Tatiana Perrone [1]
Elisa Poggi [1]
Martino Prestini [1]
Maria Ravera [1]

With the support of the UNDRR Regional Office for Africa

CIMA Research Foundation [1] UNDRR [2]
Vrije Universiteit Amsterdam [3] Wageningen University & Research [4]
Università di Genova [5] Università di Firenze [6]
Bogazici University [7] GEG [8] Training in Aid [9]

INDEX

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.

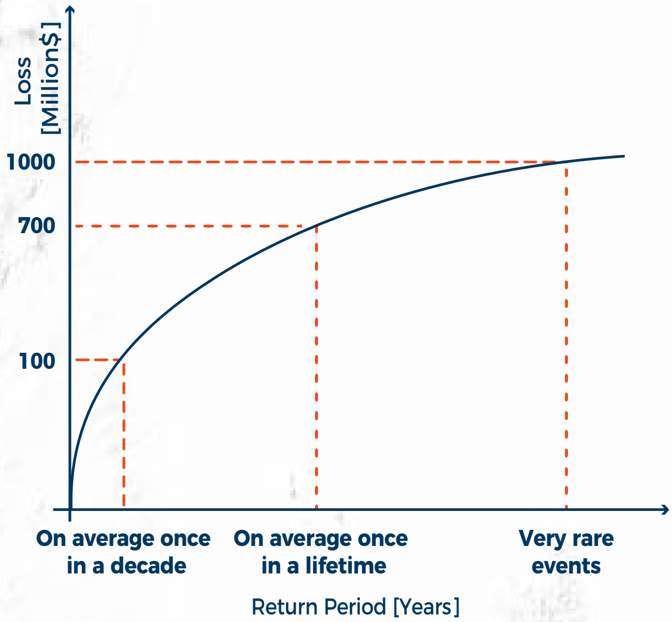
This disaster risk profile for floods and droughts is based on probabilistic risk assessment. Awareness of possible perils that may threaten human lives primarily derives from experience of past events. In theory, series of historical loss data long enough to be representative of all possible disastrous 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

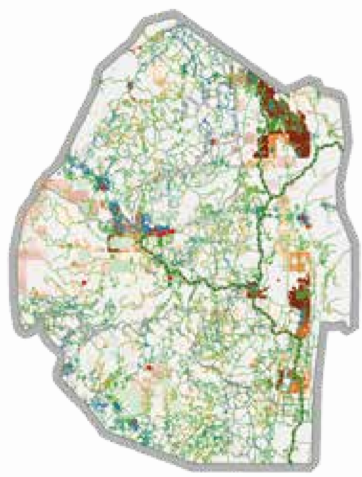
conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

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.

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

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

A SENDAI ORIENTED RISK PROFILE

The Sendai Framework guides the organisation of the results of the risk profile. Sendai introduced seven global targets and several indicators for monitoring their achievements. The indicators are common standards for a consistent measurement of progress towards the global targets across countries and over the duration of the Sendai Framework and Sustainable Development Goals. The Risk Profile presents the results of the assessment, mostly referring to indicators for the Target B on the affected people, Target C on direct economic losses and Target D on damage and disruption of basic service. Seven additional indicators are included 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)
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters	C3	Direct economic losses to productive asset (Industrial Buildings + Energy Facilities)	Y	Y		Y	Y		AAL (Average Annual Loss) / PML (Probable Maximum Loss)
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters	C3	Direct economic losses in service sector	Y	Y					AAL (Average Annual Loss) / PML (Probable Maximum Loss)
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters	C4	Direct economic losses in housing sector	Y	Y					AAL (Average Annual Loss) / PML (Probable Maximum Loss)
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters	C5	Direct economic losses to transportation systems (Roads + Railways)	Y	Y					AAL (Average Annual Loss) / PML (Probable Maximum Loss)
SENDAI INDICATORS	C1 Direct economic loss attributed to disasters	C5	Direct economic losses to other critical infrastructures (Health + Education Facilities)	Y	Y					AAL (Average Annual Loss) / PML (Probable Maximum Loss)
SENDAI INDICATORS	D1 Damage to critical infrastructure attributed to disasters	D2	Number of destroyed or damaged health facilities	Y	Y					Annual Average
SENDAI INDICATORS	D1 Damage to critical infrastructure attributed to disasters	D3	Number of destroyed or damaged educational facilities	Y	Y					Annual Average
SENDAI INDICATORS	D1 Damage to critical infrastructure attributed to disasters	D4	Number of other destroyed or damaged critical infrastructure units and facilities (Transportation systems)	Y	Y					Annual Average
* No official Sendai indicators	Agricultural & Economic Indicators		GDP of affected areas*	Y	Y	Y	Y	Y	Y	Annual Average
* No official Sendai indicators	Agricultural & Economic Indicators		Number of potentially affected livestock units*				Y	Y		Annual Average
* No official Sendai indicators	Agricultural & Economic Indicators		Number of working days lost*				Y	Y		Annual Average
* No official Sendai indicators	Hazard Index	SPEI	Standardised Precipitation-Evapotranspiration Index*				Y	Y		
* No official Sendai indicators	Hazard Index	SSMI	Standardised Soil Moisture Index*				Y	Y		
* No official Sendai indicators	Hazard Index	SSFI	Standardised StreamFlow Index*				Y	Y		
* No official Sendai indicators	Hazard Index	WCI	Water Crowding Index*				Y	Y		

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

COUNTRY SOCIO-ECONOMIC OUTLOOK

OVERVIEW

The Kingdom of Eswatini is a landlocked country that borders South Africa and Mozambique. Its economy is closely linked to the former, on which it relies for approximately 85% of its imports and 60% of its exports. Sugar and soft drink concentrates are the largest foreign exchange earners, but these have been affected by drought in recent years. Overgrazing, soil depletion, drought, and floods are continuous problems for the country.This is made particularly troublesome by the fact that 70% of the population depends on subsistence agriculture [1,2].

The flooding and drought risk assessments presented in this report show the impacts that these will continue to have on the economy. The economic impacts are made even more important for social stability by the very unequal distribution of wealth. In a country where an estimated 20% of the population control 80% of the wealth [3], the large quantity of financially poor individuals are the most vulnerable to potential disasters. Thus, a thorough understanding of risk is essential to the healthy future development of the country.

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 predictions of 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 envisages that the historical patterns of development are continued throughout the 21st century. Following this projection, the Kingdom of Eswatini's population will increase by 15% between 2016 and 2050 (World Bank Data), whereas GDP is expected to more than triple.

POPULATION	GDP
2016 Projection	2016 Projection
1.3	3.7
[Million People]	[Billion$]
1.5	17.5
2050 Projection	2050 Projection

ESWATINI

TOTAL AREA : 17.363 km² *(UN)*

POPULATION DENSITY : 81 people/km²

MEDIAN AGE : 20.4 years *(UNDP - 2017)*

HUMAN DEVELOPMENT INDEX : 0.54 *(UNDP - 2017)*

LIFE EXPECTANCY AT BIRTH : 48.9 years *(UNDP - 2017)*

MEAN YEARS OF SCHOOLING : 6.8 years *(UNDP - 2017)*

EMPLOYMENT TO POP. RATIO (AGES > 15) : 38.6% *(WB - 2017)*

EMPLOYMENT IN AGRICULTURE : 68.4% *(WB - 2017)*

EMPLOYMENT IN SERVICES : 18.5% *(WB - 2017)*

data from:
http://hdr.undp.org/en/countries/profiles/
https://data.worldbank.org/indicator/
http://data.un.org/en/iso/sz.html

COUNTRY CLIMATE OUTLOOK

OVERVIEW

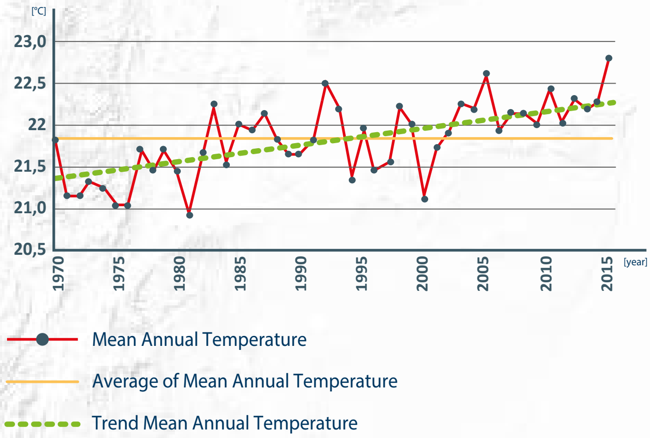
The Kingdom of Eswatini has a summer rainfall season, with about 75% of the precipitation falling from October to March, usually in the form of thunderstorms and frontal rains. The country is divided into four ecological zones based on elevation, landforms, geology, soils and vegetation. The Highveld, Middleveld and Lowveld occupy about one-third of the country each, while the Lubombo Plateau occupies less than one-tenth of the country. The climatic conditions range from subhumid and temperate in the Highveld to semi-arid in the Lowveld. Moreover, the climate is strongly influenced by the country's position on the eastern side of southern Africa, which exposes it to moist maritime tropical air coming off the Indian Ocean for much of the year. These interactions between the atmosphere and the ocean can produce considerable variations in climate [7].

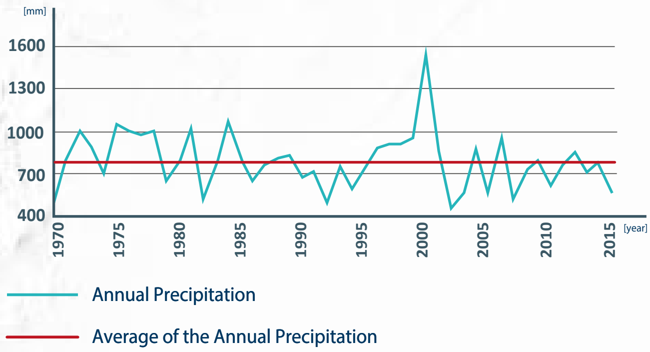
CLIMATE TRENDS

Similarly to other southern African countries, temperature observations indicate that the Kingdom of Eswatini has experienced a considerable increase in temperature over recent years.

An analysis of climate data from 1970 to 2015 [8] shows an average rise of around 1°C. Trends for precipitation are not as clear as those for air temperatures, and are variable in time and space. The trend indicates a slight decrease in annual values from the 1990s. Average annual precipitation for the Kingdom of Eswatini is approximately 780 mm, while the mean number of wet days is around 85.

TEMPERATURE AND PRECIPITATION TRENDS IN CURRENT CLIMATE





RIVERS OF ESWATINI

The Kingdom of Eswatini is abundantly watered, with four large rivers flowing eastward across it into the Indian Ocean. There are four main river systems in the country:

• The Komati and Lomati systems, in the north of the country, both originate in South Africa and flow out of the Kingdom of Eswatini back into South Africa, before entering Mozambique.

•The Mbuluzi River rises in the Kingdom of Eswatini and flows into Mozambique; there are two sources of the river, one in the Highveld north of Mbabane forming the Black Mbuluzi and one in the Middleveld near Manzini forming the White Mbuluzi or imbuluzane.

•The Great Usutu River is the largest river in the Kingdom of Eswatini, with a basin area of 2,682 km^2

Together with a number of major tributaries, it originates in South Africa and flows out into Mozambique, forming the border between Mozambique and South Africa.

•The Ngwavuma, in the south of the country, rises in the Kingdom of Eswatini and flows into South Africa before entering Mozambique. [9]

Photo Credits: World Vision/Geoffrey K. Denye - The Great Usutu River

CLIMATE PROJECTIONS FOR ESWATINI

Climate projection studies are abundant for multiple different time spans and with various scales. Climate models are tools used by the scientific community to assess weather condition trends over long periods. In a recent study [10] , 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).

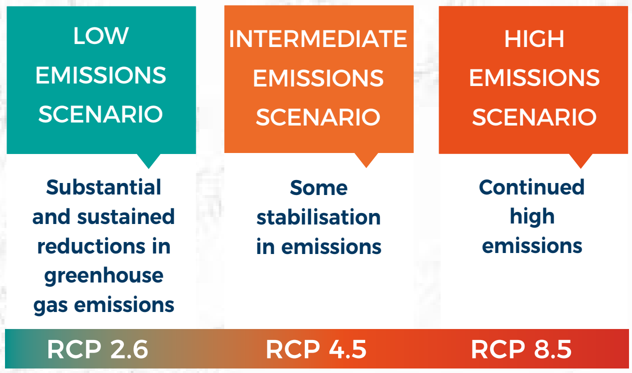
In all periods and all emission scenarios, models showed sharp rises in temperature. This is more evident in long-term period projections. In high emission scenarios (RCP8.5), model projections showed an increase of between 2˚C and 3.5˚C for the mid-term period (2050-2074), and of between 3˚C and 5.5˚C for the long-term period (2071-2095). Future changes in precipitation are less predictable, for all three periods, where variability is high 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 2˚C to 3.5˚C divergent change in precipitation (from -30% to +20%)
Far Future (2071-2095)	Increase in temperature from 3˚C to 5.5˚C highly uncertain change in precipitation (from -40% to +25%)

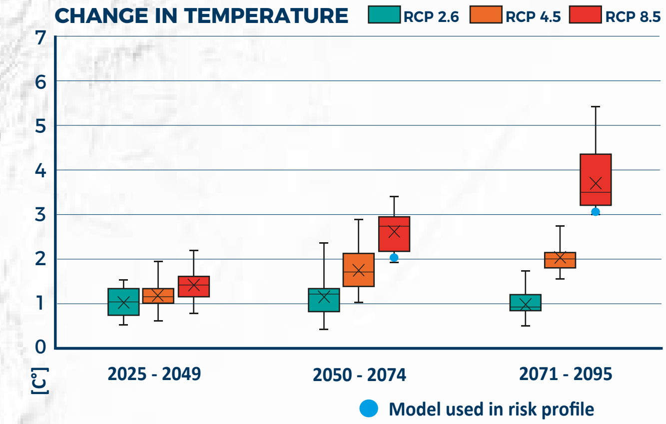
CLIMATE PROJECTIONS USED IN THIS RISK PROFILE

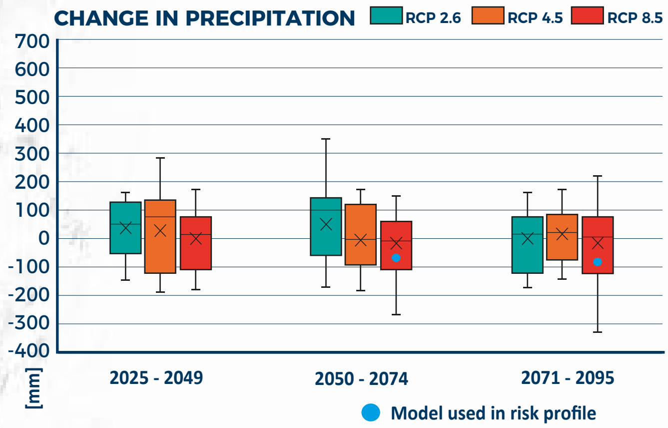
The results in the Risk Profile that refer to climate change were obtained using a climate projection model based on a high emission scenario (SMHI-RCA4 model, grid spacing 0.44˚ -about 50 km- driven by the ICHEC-EC-EARTH model, RCP 8.5, 2006-2100).[11,12,13]

This study uses a high-resolution model, accurately calibrated on the African domain, to better capture climate variability, important for assessing extremes. Regional model projections were checked for consistency against the full ensemble of available global models in the area. The model forecasted changes in temperature and annual precipitation by the end of the century, in line with the range of variability of the global models analyzed in the study by Alder and Hostetler [10].



IPCC's Emissions scenarios for Climate Projections

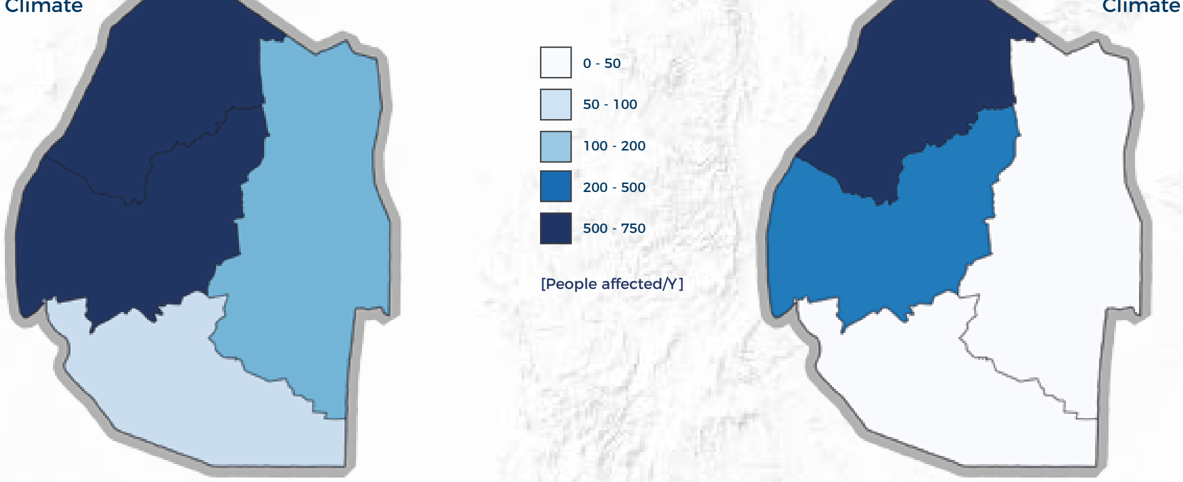




The high emission scenario was maintained as representative of the worst climate change scenario, enabling the analysis of a full range of possible changes. However, in this case, the regional model (blue dot in the above plots) predicts a more moderate increase in temperature (3.1˚C in the long term future), with respect to the global ensemble. For precipitation, a decrease in annual value (less than 10%) is simulated, while the ensemble average is close to zero. This behaviour is frequently observed in high-resolution models with respect to global ones.[14]

RESULTS | FLOODS

[B1] ANNUAL AVERAGE NUMBER OF AFFECTED PEOPLE



KEY MESSAGES

- Floods affect on average more than 1500 people every year, almost 0.12% of the country's total population.

- Affected populations are geographically concentrated in the Hhohho and Manzini regions.

- Future climatic conditions paired with projections of the future population show a decrease in the affected population with respect to present conditions. However, as shown in the climate session, the prediction is highly uncertain.

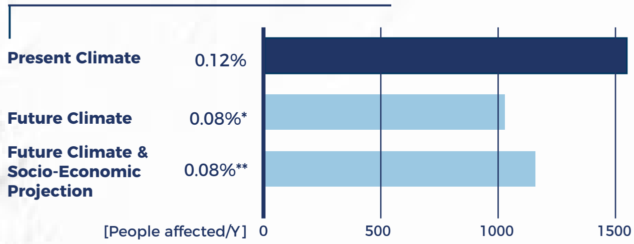
- The average yearly GDP in flooded areas amounts to almost 0.4% of the total national GDP.

- The affected GDP is expected to double by 2100 if future climatic conditions are paired with projections of future GDP growth.

- Future climatic conditions alone, due to a greater probability of a decrease rather than an increase in precipitation, would bring an overall risk decrease, if present population and GDP are accounted for. However, as shown in the climate section, some global climate models predict an opposite trend in the future, with an increase in precipitation and, possibly, flood risk.

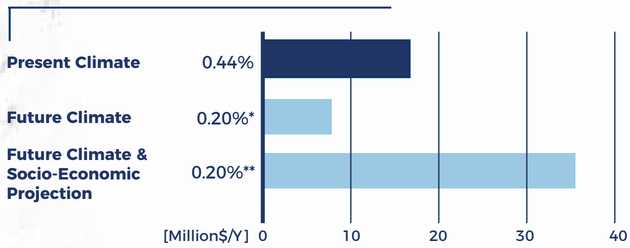
- Taking into consideration the above-mentioned circumstances, risk-informed decision-making for sustainable development is crucial.

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE [B1]



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

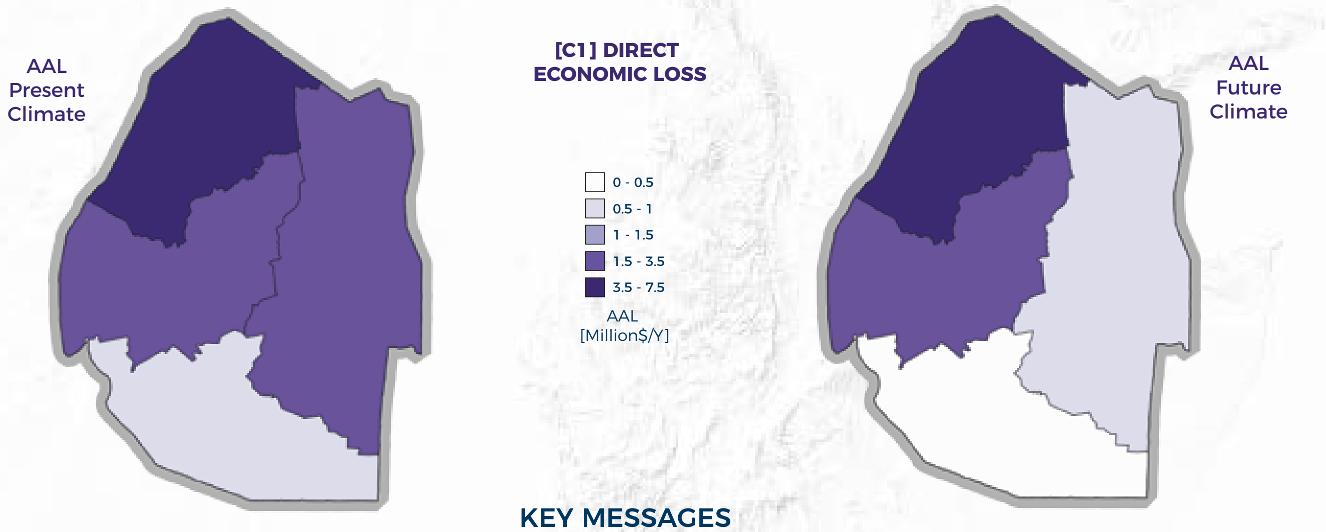
ANNUAL AVERAGE POTENTIALLY AFFECTED GDP



* % 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



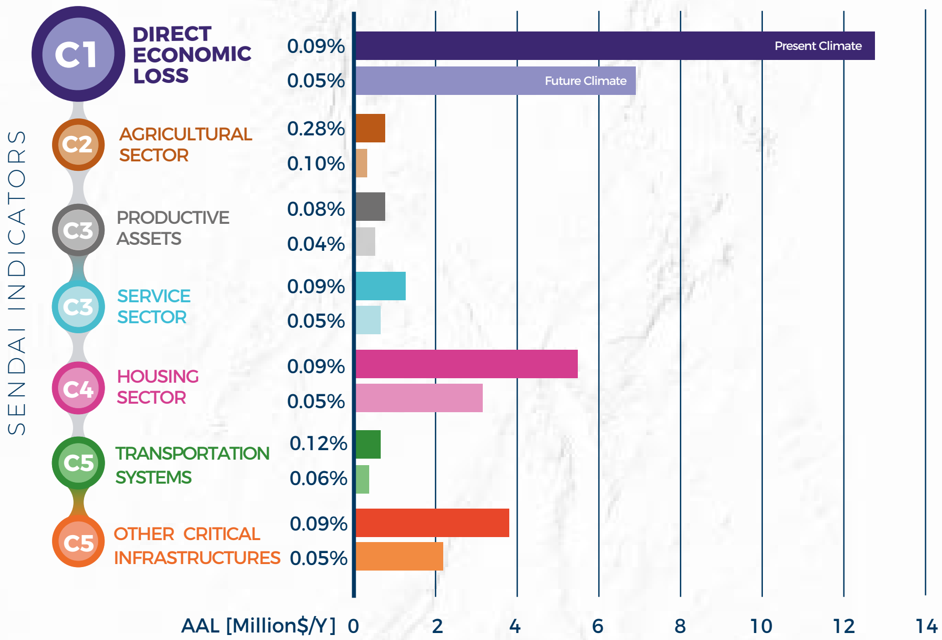
KEY MESSAGES

● The direct economic loss in the Kingdom of Eswatini is geographically distributed in line with exposure concentration, with the highest values in the Hhohho, Manzini and Lubombo regions. The pattern is maintained in the future climate, albeit with a certain decrease in absolute values.

● The average yearly value of direct economic losses amounts to 12 million USD, almost 0.09% of the total stock value in the current climate. The largest portion of losses is due to housing and critical infrastructures (i.e. health and education), accounting for almost 70% of the total loss.

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

● Considering the present exposed assets, average annual losses tend to decrease under future climate conditions, for all sectors. However, as already discussed for GDP and population, risk figures may change when considering future exposure evolution.

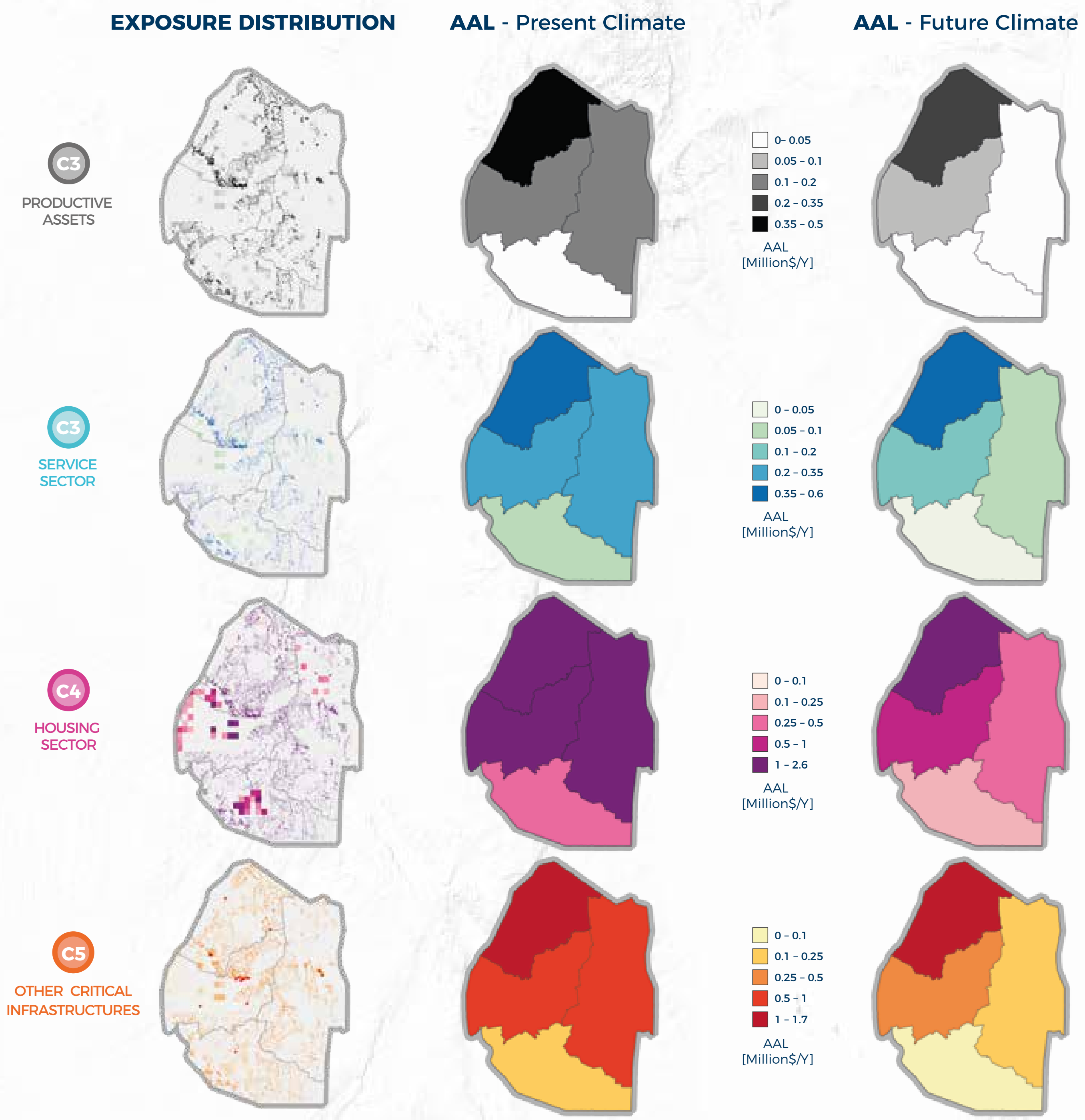


AFFECTED INFRASTRUCTURES [D4]

RESULTS | FLOODS

KEY MESSAGES

- Comparison between present and future climate AALs show a consistent pattern across all regions and sectors with Hhohho and Manzini being the two most affected regions.
- Hhohho is the only region that shows an increase of the loss figures in the future climate in the service and critical infrastructure sectors.



RESULTS | FLOODS

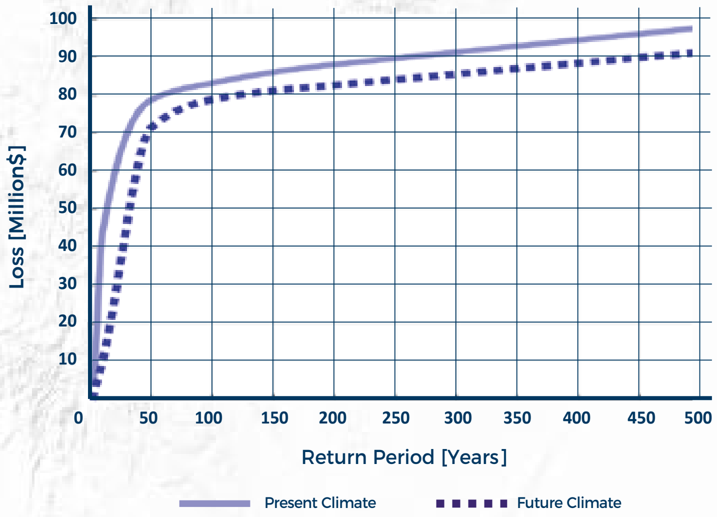
KEY MESSAGES

● In both present and future climates, the PML curves rise steeply for very frequent and frequent losses. A change of slope is observed at the 50-year losses, and after that losses increase slowly with the return period.

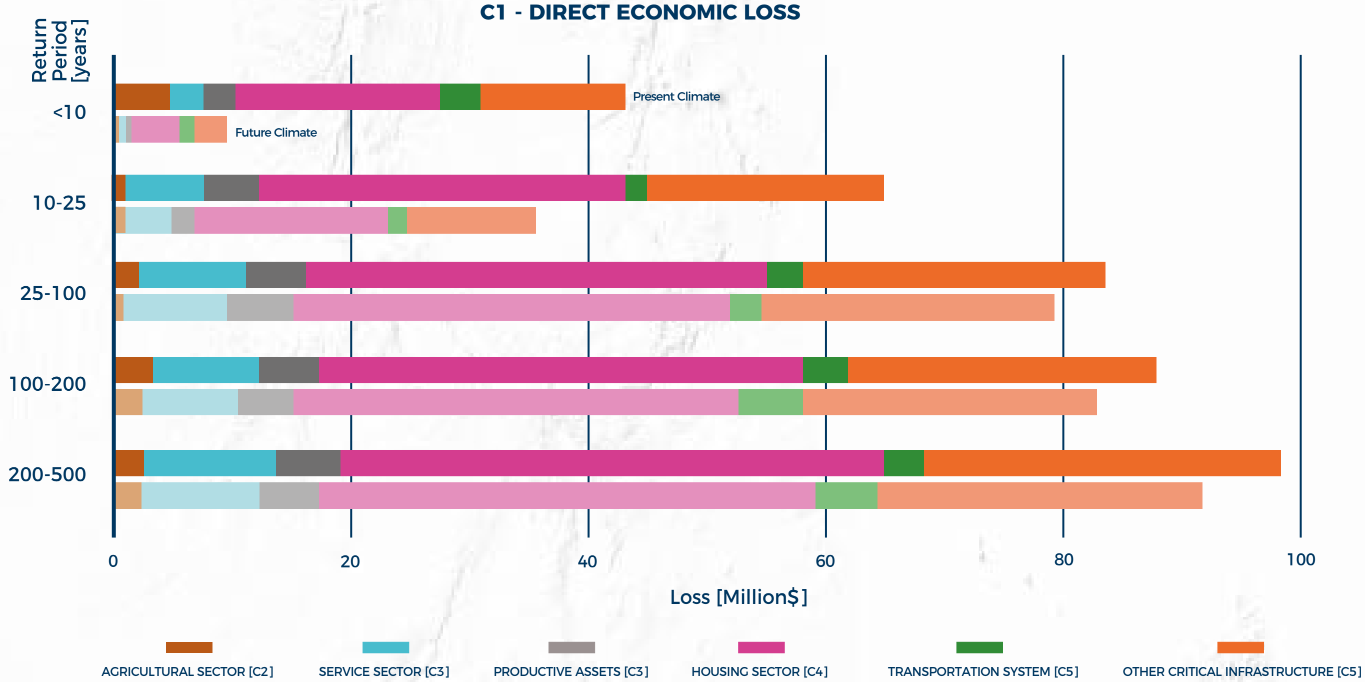
● Both rare and frequent losses may decrease under future climate conditions. However, given the high level of uncertainty in climate prediction, worse scenarios may still be possible (compare climate section at p.8).

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

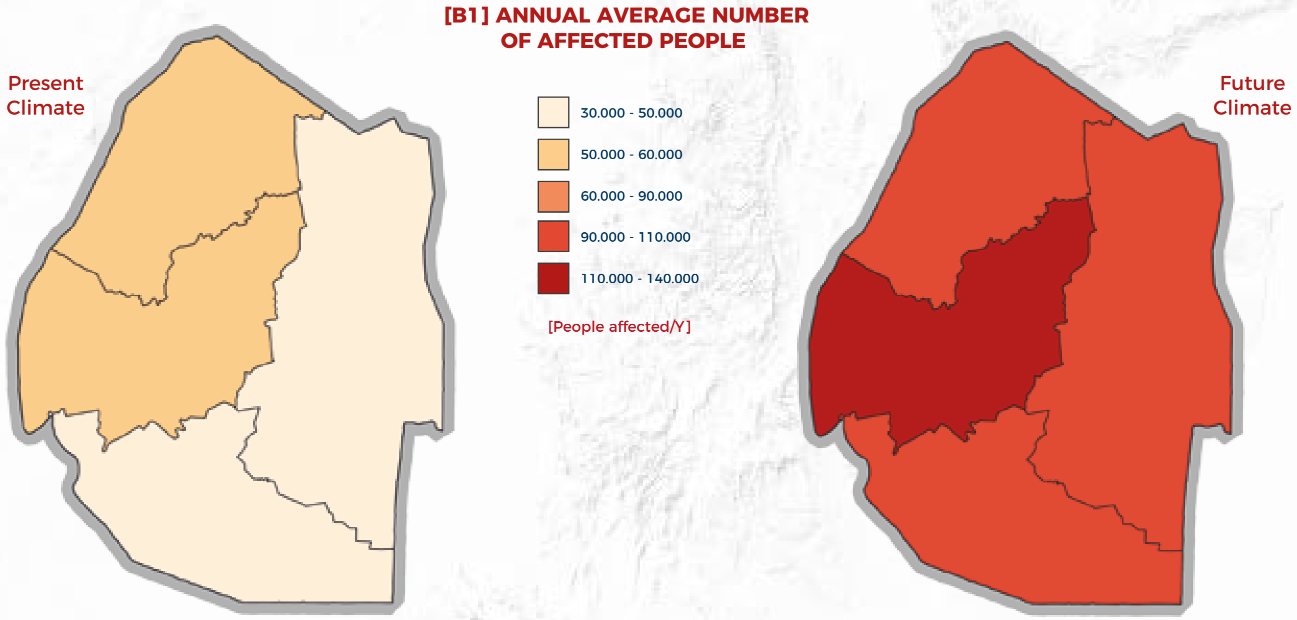
PROBABLE MAXIMUM LOSS CURVE (PML)
C1 - DIRECT ECONOMIC LOSS



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

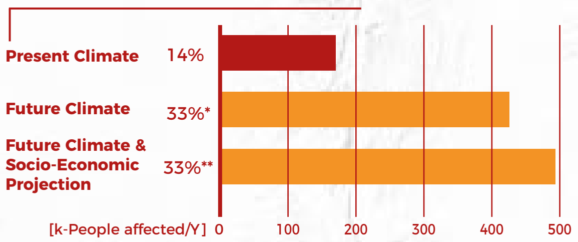


RESULTS | DROUGHTS



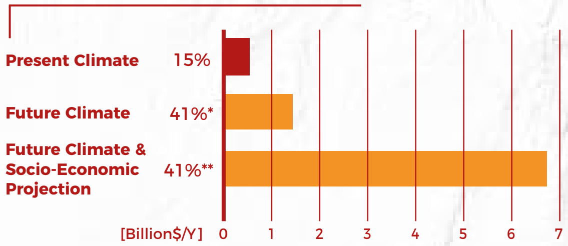
Annual average of population potentially affected by at least three months of drought conditions, as calculated using the standardized precipitation-evapotranspiration index (SPEI) and using a 3-month accumulation period.

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), annual precipitation is expected to decrease while a strong increase in temperature is foreseen under future climate conditions (2050-2100 climate), causing an increase in the frequency of droughts.

- Currently, an average of almost 14% of the population (180,000 people) per year is potentially affected by droughts. Under future climate conditions, the number of people annually living in drought-hit areas is expected to increase to 33% of the population (almost 500,000 people if population growth is accounted for).

- GDP exposed to droughts is expected to increase by a factor of two. Currently, an average of 15% of GDP (0.5 billion USD) is potentially affected by droughts but this is expected to rise to 41%.

RESULTS | DROUGHTS

KEY MESSAGES

- Under future climate conditions, double the amount of livestock is expected to be hit by droughts on an annual basis. Currently, an average of 15% of livestock is annually exposed to drought events. This is expected to increase to 38%.

- Agricultural losses in absolute terms are mainly due to sugarcane. In relative terms, root crops could be heavily affected under future climate conditions, when approximately 10% of the production may be affected by droughts.

- The distribution of agricultural (crop) losses shows a concentration of losses in the eastern and southern parts of the country, in line with exposure distribution. Under future climate conditions, the same spatial pattern will be maintained, although an increase in losses is estimated throughout the entire country.

- An approximate fourfold increase in lost working days is expected under future climate conditions. The loss of working days is estimated at less than 1% for both present and future conditions. However, the number of working days lost, expressed as a percentage of the average amount of days required for harvesting, will be approximately three times higher in the future.

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

53.4 | 0.2% Present climate

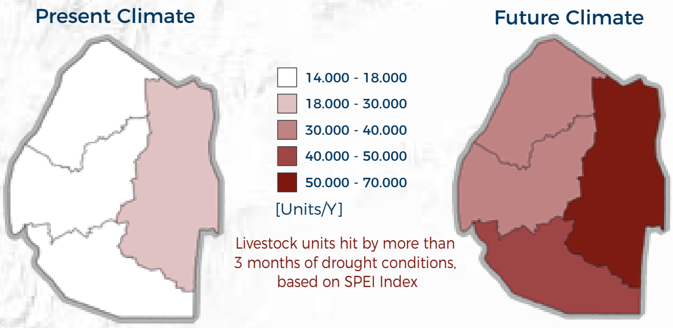
22.5 | 0.8% Future climate

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

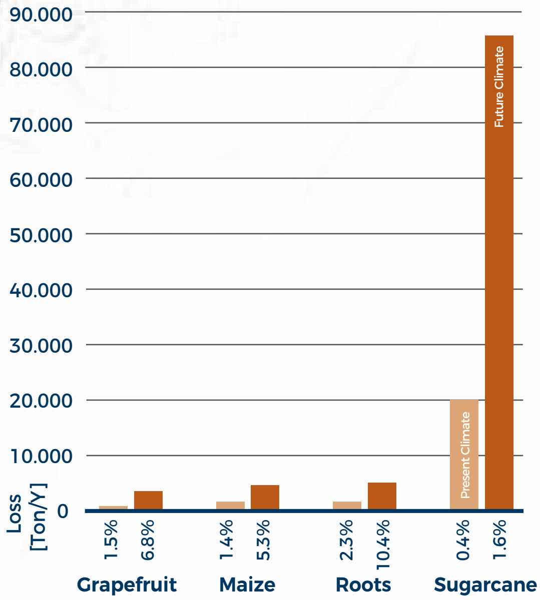
68 | 15% Present climate

174 | 38% Future climate

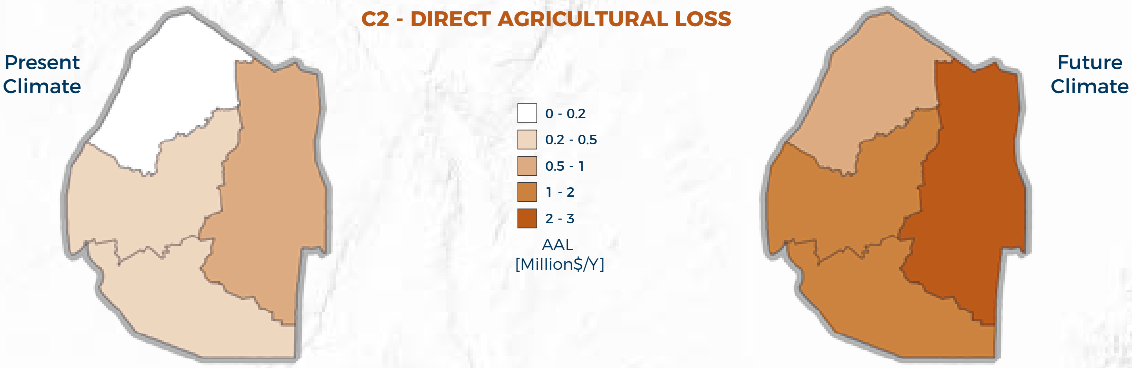
*Livestock is a summation of all livestock animals (referred to as livestock units) using FAO conversion factors



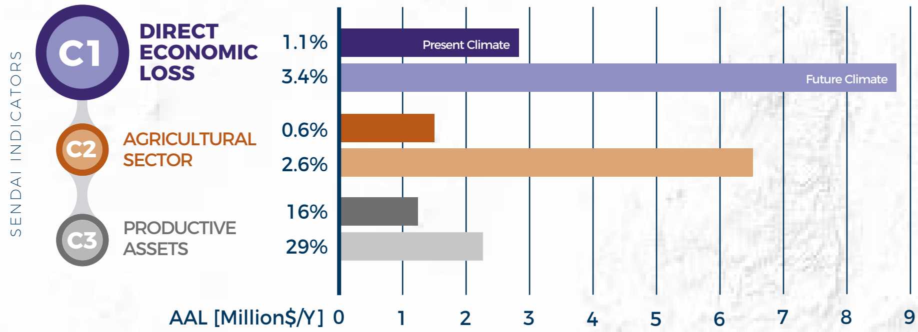
AGRICULTURAL PRODUCTION LOSS



C2 - DIRECT AGRICULTURAL LOSS



RESULTS | DROUGHTS



C2 is computed considering only direct loss associated with reference agricultural (crop) production. Reference crops considered in the analysis are the ones which contribute to at least 85% of the total country-level gross crop production value. It might therefore happen that crops which have an important role in local commercial or 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

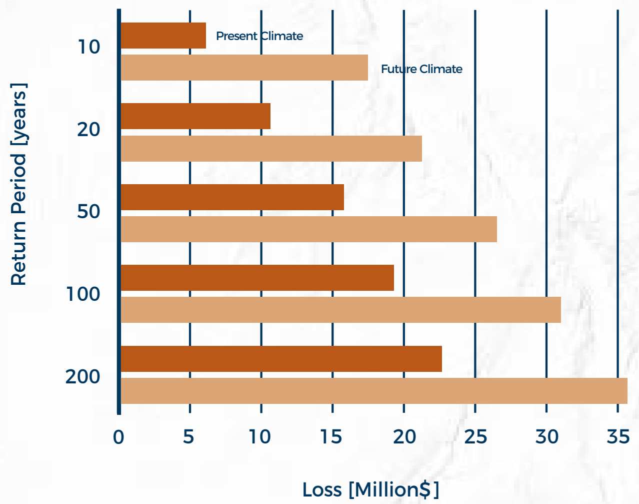
- Total direct economic losses (C1) due to drought is for the most part attributable to the agricultural sector (C2), and to a lesser extent to hydropower losses (C3).

- Losses in agricultural production (C2) are projected to increase substantially (by about four times), but are still low compared to the total income from crops (<3%). Losses in hydropower generation (C3) due to drought are set to double under future climate conditions, compared to present conditions (for Lubholho and Maguga dams).

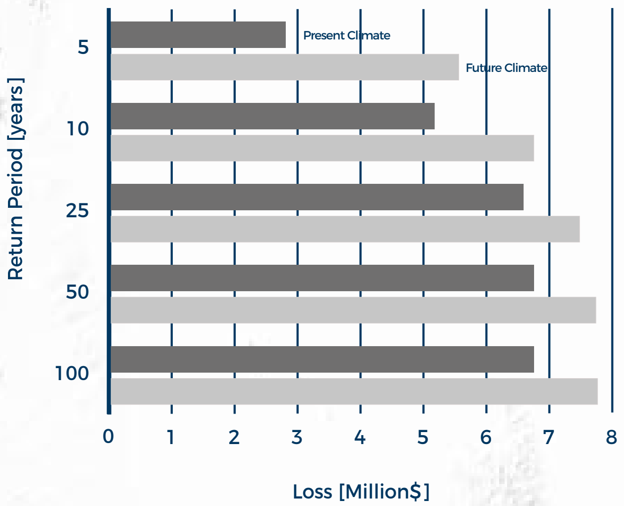
- In the case of agricultural income losses (see Glossary), current climate conditions present a gradual increase in expected losses when return periods go up from 10 to 200 years. It is worth noting that these results might be affected by a high level of uncertainty as we move into the very rare losses domain. Under future climate conditions, agricultural income losses increase significantly in absolute units, compared to present climate conditions, where relative increases are highest for the lowest return periods of 10 and 20 years.

- For hydropower losses (defined as the production below production with average reservoir conditions under the present climate), losses do not increase much with higher return periods under present climate conditions. Significant increases in losses under future climate conditions are expected for frequent events: in relative terms the largest increase for low return periods (+100% and +30% for the 5 and 10 year return periods respectively). For high return periods, the relative increase will be much smaller (around 14%).

PROBABLE MAXIMUM LOSS (PML)
C2 - AGRICULTURAL LOSS

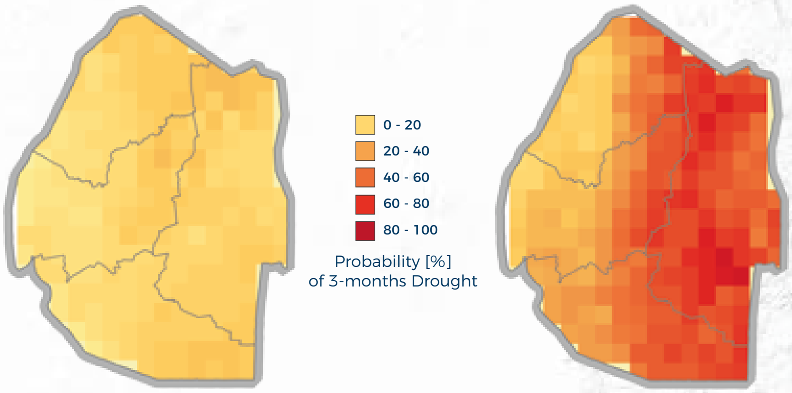


PROBABLE MAXIMUM LOSS (PML)
C3 - PRODUCTIVE ASSETS (HYDROPOWER LOSS)



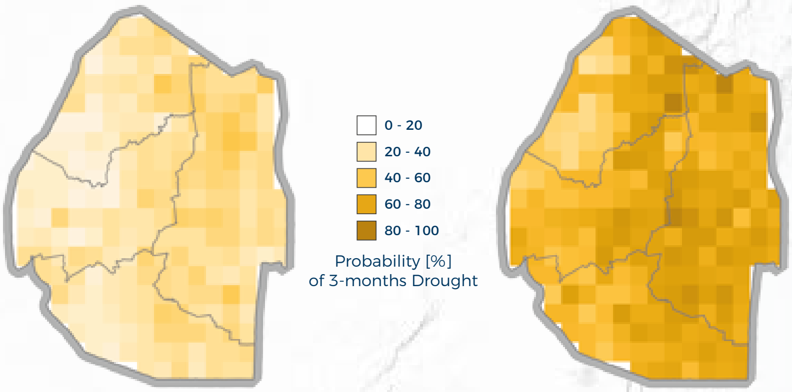
RESULTS | DROUGHTS

Present Climate | Future Climate



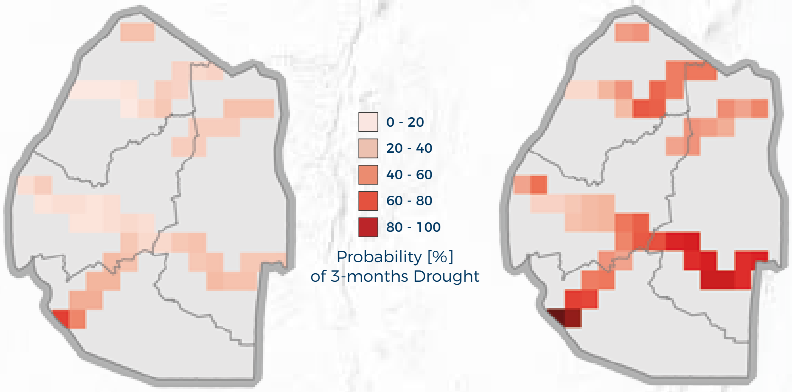
SPEI
Standardised Precipitation-Evapotranspiration Index

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



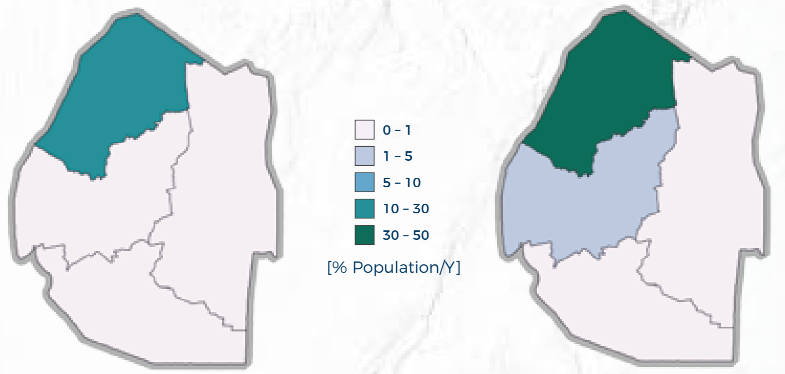
SSMI - Standardised Soil Moisture Index

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).
Under future climate conditions, Eswatini will experience more 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 Eswatini, an increase in drought frequency is expected under future climate conditions; mainly felt in the bigger rivers. 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 and areas with arid and semi-arid climates are dependent on outside water resources, such as rivers and water importation.

PROBABILISTIC RISK ASSESSMENT FOR RISK MANAGEMENT

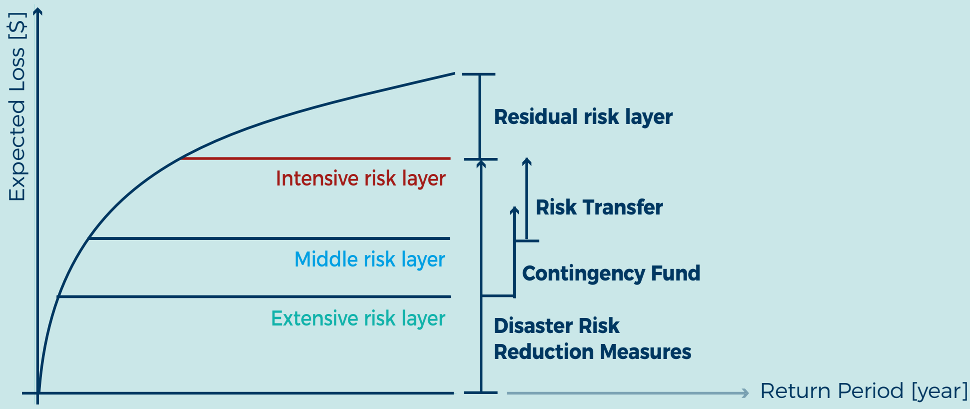
METRICS FOR RISK MANAGEMENT

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*

[1]CIA- https://www.cia.gov/library/publications/the-world-factbook/geos/wz.html)

[2] https://www.indexmundi.com/swaziland/economy_profile.html

[3] Kingdom of Eswatini overview, WorldBank, https://www.worldbank.org/en/country/eswatini/overview

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

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

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

[7] http://www.fao.org/nr/water/aquastat/countries_regions/SWZ/SWZ-CP_eng.pdf

[8] Harris, I. P. D. J., Jones, P. D., Osborn, T. J., & Lister, D. H. (2014). Updated high-resolution grids of monthly climatic observations-the CRU TS3. 10 Dataset. International Journal of Climatology, 34(3), 623-642.

[9] Africa's climate helping decision-makers make sense of climate information, Future Climate for Africa, November 2016.

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

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

[12] Nikulin, G., Jones, C., Giorgi, F., Asrar, G., Büchner, M., Cerezo-Mota, R., ... & Sushama, L. (2012). Precipitation climatology in an ensemble of CORDEX-Africa regional climate simulations. Journal of Climate, 25(18), 6057-6078.

[13] Nikulin G, Lennard C, Dosio A, Kjellström E, Chen Y, Hänsler A, Kupiainen M, Laprise R, Mariotti L, Fox Maule C, van Meijgaard E, Panitz H-J, Scinocca J F and Somot S (2018) The effects of 1.5 and 2 degrees of global warming on Africa in the CORDEX ensemble, Environ. Res. Lett., doi:10.1088/1748-9326/aab2b4.

[14] Dosio, A. and Panitz, H.J. (2016). Climate change projections for CORDEX-Africa with COSMO-CLM regional climate model and differences with the driving global climate models. Journal of Climate Dynamics, 10.1007/s00382-015-2664-4, 1599-1625.

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

www.preventionweb.net/resilient-africa

www.undrr.org

RISK PROFILES ARE AVAILABLE AT:

riskprofilesundrr.org

This publication has been produced with the assistance of the European Union.
The contents of this publication are the sole responsibility of CIMA Research Foundation and can in no way be taken to reflect the views of the European Union.