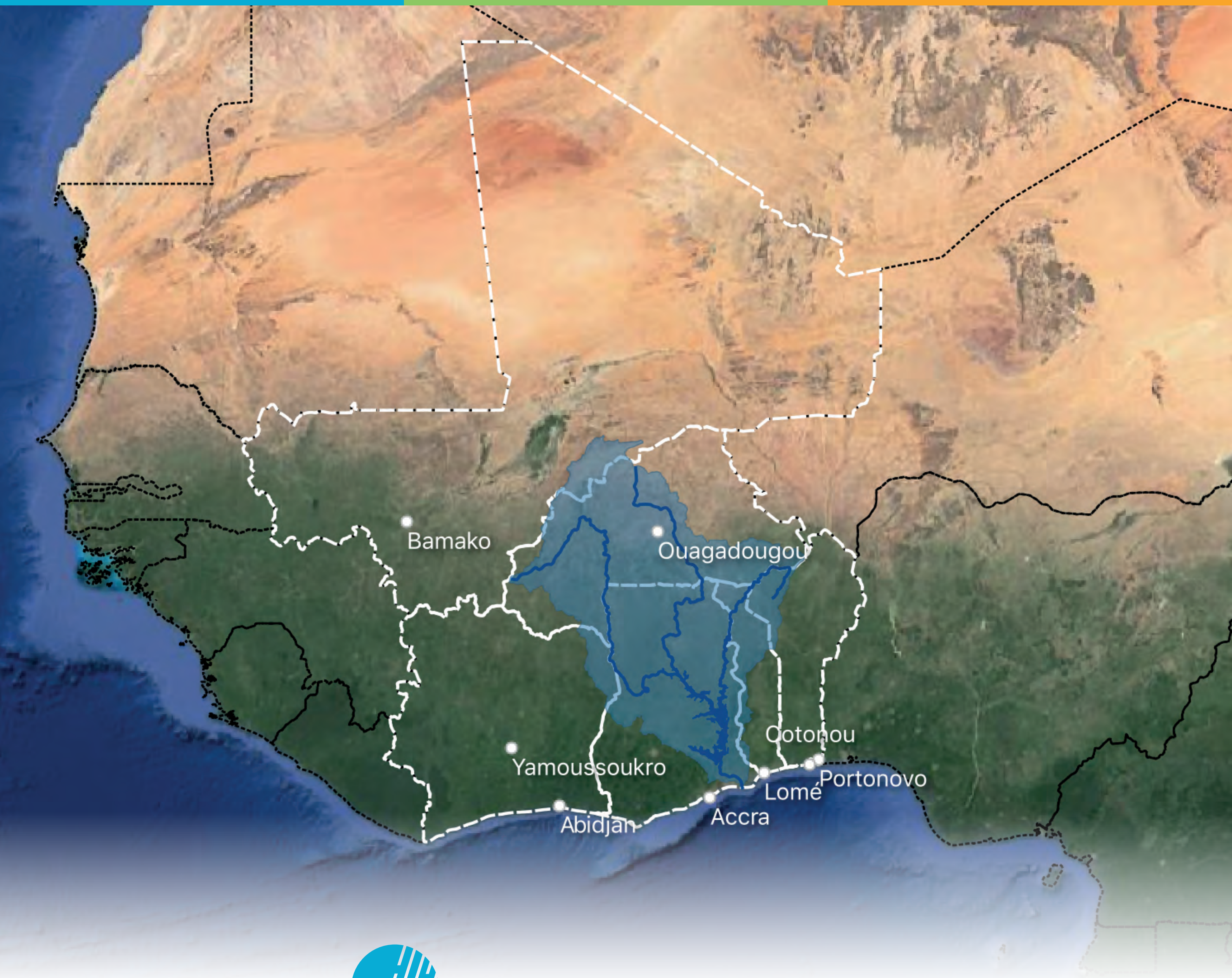
DISASTER RISK PROFILE

Volta River Basin

Flood Drought



Volta Flood and Drought Management

ADAPTATION FUND
WORLD METEOROLOGICAL ORGANIZATION
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This report is the result of extensive research and close collaboration between governmental institutions of the riparian countries of the Volta basin, international organizations and scientific research centres.

The scientific consortium was led by CIMA Research Foundation and included the VU University of Amsterdam and the Potsdam Institute for Climate Impact Research (PIK).

During the last year, as the scientific team collected data, carried out a training process on exposure and impact assessment and conducted the risk assessment process, the vital contributions and continuous feedback provided by the national technicians engaged in the trainings and the local institutions of the 6 riparian Countries once again revealed the importance of collaborative, fruitful relationships for knowledge sharing and horizontal learning.

The scientific consortium would like to express its gratitude and acknowledge the valuable support it received from all the project partners, namely: World Meteorological Organization, Global Water Partnership West Africa, Volta Basin Authority and its National Focal Structures, namely the Water Resources Commission in Ghana, the General Directorate of Water Resources in Burkina Faso, the Water Resources Directorate in Togo, the Water General Directorate in Benin, Directorate for Protection and Management of Water Resources in Ivory Coast and the National Directorate of Hydraulics in Mali.

The present disaster risk profile is not only the synthesis of insights gained during several months collecting data and conducting risk modelling in the Volta basin, but also the result of having mobilized sixty national technicians for data collection and training and risk experts from the 6 riparian countries during national training process, consultative meetings and a strategic regional workshop. This opportunity, made possible through the implementation of the Volta Flood and Drought Management project, funded by the Adaptation Fund, allowed us to listen to the real challenges, perceptions and priorities on risk governance and societal needs. As a result, we believe that we have moved towards a common understanding of risk in the Volta basin and each of the six riparian countries.

Aligned to the Sendai Framework for Disaster Risk Reduction, and as representatives of the scientific community, the consortium will always encourage countries to increase research on disaster risk causes and scenarios, supporting local authorities in understanding the value of a systematic interface between policy and

science for decision-making. Under this lens, three main groups of stakeholders were identified as key beneficiaries of this report:

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

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

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Introduction

Over the last few decades, disasters resulting from natural hazards have often derailed hard-earned development plans and progress. Damages due to disasters usually affect infrastructure, lifelines and critical facilities and often result in severe human, financial, cultural and environmental losses. Disasters and development are quite interconnected, not only because disasters can have direct consequences on development efforts, but also considering that, inversely, "bad development" can itself be a driver of risk. Planning and urbanization that are not risk-informed and resilience-driven can result into unsustainable development, increasing the vulnerability of populations and of existing economic systems, while depleting the natural ecosystems, in a vicious cycle.

Over the last four decades, Sub-Saharan Africa has experienced more than 1000 disasters (World Bank, 2017), affecting approximately 320 million people (Preventionweb). The majority of disasters in Africa are hydro-meteorological in origin, with droughts affecting the largest number of people and floods occurring frequently along major river systems and in many urban areas. The geographic setting of the Volta Basin, covering an area of about 400'000 km^2 and extending from semi-arid to sub-humid areas, is highly vulnerable to meteorological and hydrological events. Over the last 20 years, almost two million people have been affected by floods in the Volta basin. On the other side, studies that holistically look at drought episodes in the entire Basin as a unit are few, but even considering Burkina Faso alone, close to 20 million people suffered from drought periods since the 1980s.

The Volta disaster risk profile relates information on natural hazards, specifically floods and droughts, to the basin population and economic exposures and vulnerabilities. These exposures and vulnerabilities are exacerbated by riparian countries' limited coping capacities and resources for investing in disaster risk reduction and recovery measures. In this context, post-disaster rehabilitation often implies the intervention of international aid, or the diversion of national funds originally planned for development interventions, resulting in a tremendous setback for societal development as a whole.

Disasters, however, can be significantly minimised with rigorous scientific risk modelling, risk information dissemination and through effective institutional and community preparedness.
Considering that natural hazard events will likely change in frequency and magnitude due to climate change in the near future, Risk Assessment should be the basis of many risk-related activities aiming at providing a quantitative basis for disaster risk reduction and climate adaptation measures. As such it needs to be based on scientific risk information that assesses vulnerability, hazard and exposure to estimate disaster impacts, quantifying population, economic losses and other indicators across different regions and sectors.

Risk reduction processes must also be based on the effective communication and application of risk information through the strengthening of institutional and human capacities. Risk assessments and the risk information they provide should support risk-informed decision-making towards resilience building across all levels and within all socio-economic development sectors.

As widely known, disasters' consequences depend not only on the socio-economic conditions of the affected communities but also on the institutional preparedness and capacity to manage such events. Thus, to be able to predict when events will happen, and which impacts are they likely to have on the ground is of extreme importance to build strong institutional responses.

Probabilistic risk assessment: methodology

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. Often there is not a better or worse methodology, but they are intimately linked with the application they are intended to be used for. However, some methodologies have a higher information content and allow for more flexibility in their practical use. One of these is the probabilistic risk assessment approach, which was used to develop this disaster risk profile for floods and droughts. This approach has been used by UNDRR and other DRR stakeholders to develop quantitative risk profiles at the national and sub-national level.

The probabilistic risk assessment is based on a modelling approach to best predict possible present and future scenarios, taking into consideration the spatial and temporal uncertainties involved in the analysed process. Probabilistic disaster risk profiles consider all possible risk scenarios in a certain geographical area. A realistic set of all possible hazardous events (scenarios) that may occur in a given region, including very rare, catastrophic events, is simulated. This means that both low frequency, high loss impact events, as well as high frequency, lower loss impact events are calculated, meaning that their probability of occurrence is included in the assessment. Events which have never been historically recorded but might occur in projected climate conditions are also considered in the risk analysis. This feature is particularly useful in the context of climate change which is dramatically increasing uncertainty about future hazard patterns. Thus, societies need to calculate the possible impacts of those uncertain patterns in order to be prepared. Under this lens, there is no valid alternative to a probabilistic analysis to address this uncertainty in a usable, quantitative way.

For each event, defined through the probability of occurrence of the event magnitude, potential impacts are computed in terms of number of people, assets affected or economic losses, considering publicly available information on Hazard, Exposure, and Vulnerability.

Finally, statistics of losses are computed and summarized through proper quantitative risk metrics, such as: the Annual Average Loss (AAL) and the Probable Maximum Loss (PML).

Annual Average Loss (AAL)
The expected loss per year, averaged over many years.

Probable Maximum Loss (PML)
The likelihood of a certain scenario producing an estimated amount of losses.

While there may actually be little or no loss over a short period of time, the AAL also accounts for much larger losses that occur less frequently. As such, AAL can represent the funds that would be required annually in order to cumulatively cover the average disaster loss over time.

On the other hand, the PML describes the maximum loss that could be expected corresponding to a given likelihood, expressed in terms of annual probability of exceedance or its reciprocal, the return period. Typically, when referred to economic losses, PML is relevant to define the size of reserves which, insurance companies or a government should have available to manage losses.

In computing the final metrics (PML, AAL), the uncertainties that permeate the different steps of the computations are explicitly quantified and taken into account: uncertainties in the hazard forcing, uncertainties in the exposure values and their vulnerabilities.

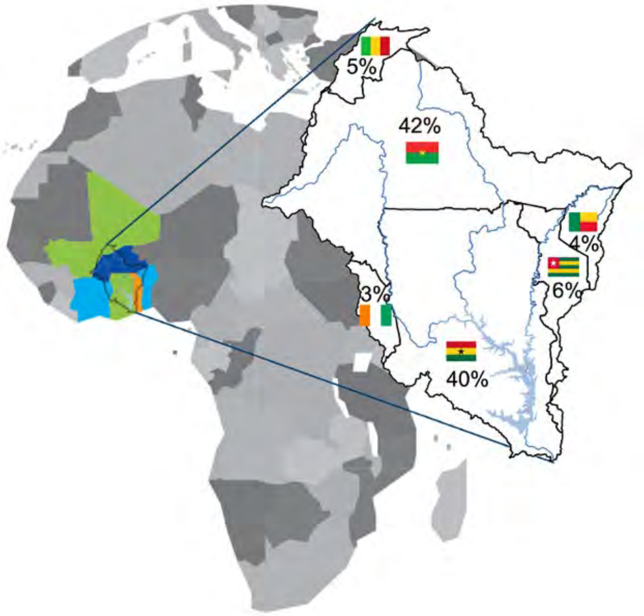
These risk metrics can be calculated both at a regional and national scale, as well as by sector and by administrative unit, which allows for a geographic and quantitative comparison of disaster losses, both within a country and/or between countries. These analyses and comparison exercises are an important step of the risk awareness processes, key in pushing for risk reduction, risk adaptation and risk management mechanisms to be put in place.

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

- under current climate conditions: with disaster risk assessed using the observed climate conditions in the 1979 - 2016 period;
- under projected climate conditions: with disaster risk being assessed under projected climate conditions (projected period 2017 - 2100), considering the IPCC SSP3-RCP7.0 scenario, which foresees CO_2 emissions double in 2100, an increase in the global temperature between 2,8°C and 4,6°C by 2100, and assuming resurgent nationalism, concerns about competitiveness and security and a low international priority for addressing environmental concerns.

The Disaster Risk Profile for the Volta River basin provides a comprehensive view of hazard, risk and uncertainties for floods and droughts in a changing climate, with projections for the period 2017-2100. 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.

Socio-economic outlook in the Volta basin



The Volta River basin is a trans-national catchment shared by six riparian countries covering about 400'000 km^2. The watershed is 40% in Ghana, 42% in Burkina Faso, 6% in Togo, 5% in Mali, 4% in Benin, and 3% in Cote d'Ivoire. The Volta River has an average mouth discharge of 1,210 m^3/s into the Gulf of Guinea and it's the ninth largest basin in Sub-Saharan Africa.

The basin's riparian states have shared a long history of high poverty partly related to water, weak national economic performance, and low human development (UNDP, 2019; World Bank, 2019). These countries face significant water and environmental challenges such as water scarcity, frequent droughts and floods, ecosystem degradation (Lemoalle and de Condappa, 2010).

Country	GDP/capita [$]	HDI	Population growth rate (annual average)
Burkina Faso	858	0.452	2.9
Mali	862	0.434	3.0
Benin	1'291	0.545	2.7
Togo	915	0.515	2.4
Ivory Coast	2'325	0.538	2.6
Ghana	2'205	0.611	2.2

**Sources : World Bank (2020), UNDP (2019) and ECOWAS (2019).*

POPULATION

2016
24
[Million People]
34
2025 Projection
59
2050 UN Projection

The total population living on the Volta Basin is over 24 million, of which more than 70% reside in rural areas and depend on the basin's natural resources for their livelihood. The basin faces a rapid increase of population, especially in its upstream part (Kolavalli and Williams, 2016).

The population is expected to grow at a rate of between 2.5% to 3% – reaching a projected 34 million people by 2025. This will put greater pressure on the Volta River and its resources as a result of human activities.

Water resources play a major role in the promotion of economic growth and reduction of poverty in the basin. The main economic activities within the Volta Basin are agriculture, livestock rearing, fisheries and aquaculture, logging, mining, trade and tourism.

The agricultural sector employs about 83% of the population of the basin. Rain-fed, and to a lesser extent irrigated agriculture, are the main livelihood activities that most people are engaged in, generating about 40% of the basin's economic output GEF-UNEP-DHI-IWA, 2017).

Climate outlook in the Volta basin

West Africa has been known as a region plagued by droughts ever since the declining rains during the 1970s. Nonetheless, it should be considered that many studies refer to the Sahel, as the region hit most severely. In the Volta basin, located more to the south with only the norther part belonging to Sahel, the picture seems to be more mixed. Large scale oceanographic and atmospheric patterns are correlated with rainfall patterns within West Africa. This means that observed changes may be related to changes in global circulation patterns.

The situation is complicated by the fact that, at least for the Volta Basin, a high sensitivity is found of rainfall with respect to land surface properties. So a mixed pattern of decreasing trends and stability in rainfall is probably the product of the complex interactions between large scale and regional scale changes. This stresses the need for (further) regional climate models and predictions as GCMs are not designed to reproduce such variability over space.

Recent climate and trends

The Volta River basin extends across two climatic zones, with the northern parts, essentially Mali and northern Burkina Faso, characterized by a hot, semi-arid climate (BSh) and the central and southern parts by a tropical humid savanna climate (Aw) (Kottek et al., 2016). There is a precipitation gradient from north to south with annual mean precipitation of 760 mm/a and a five-month rainy season in the north and annual precipitation of 1350 mm/a in the south, where rainfall can occur in any month of the year. The annual mean temperature difference between the north (28.7°C) and the south (27.7°C) is only about 1°C.

According to Hulme (2001), "There is no such thing as 'normal' rainfall in the Sahel." The "normal" is rather the natural variability of rainfall in space, from year to year, and from decade to decade. A cyclic behaviour was observed over the 20th century, with the 1950s and 1960s being wetter than average, the 1970s drier than average, the 1980s characterized by severe droughts and a recovery of Sahel rainfall in the 1990s. This cyclic behaviour with consecutive wet and dry periods is also projected by GCMs to continue in future (Liersch et al., 2019).

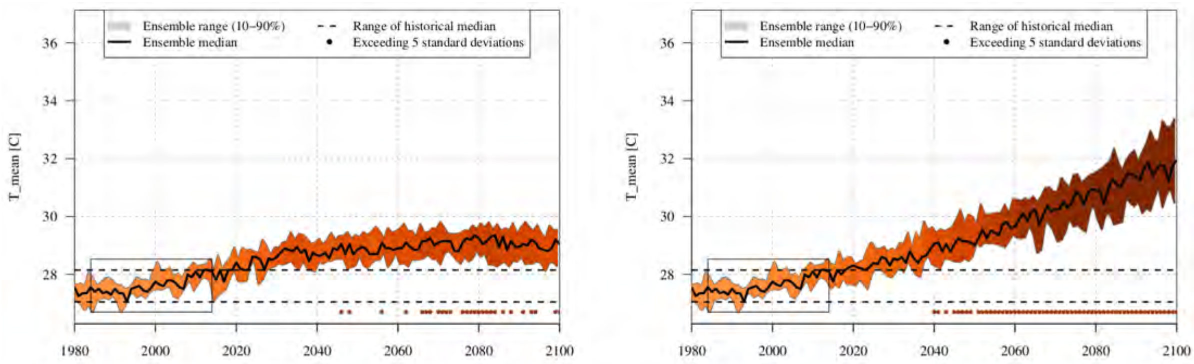
Climate projections

An ensemble of eight bias-adjusted Global Climate Models (GCMs), based on the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP3b) (Huber et al., 2014, Warszawski et al., 2014) under consideration of the two state-of-the-art radiative forcing scenarios ssp126 (based on RCP 2.6) and ssp370 (based on RCP 7.0) are used to assess the impacts of climate change in the Volta River basin. The two scenarios, ssp126 and ssp370, represent different socio-economic developments as well as different pathways of atmospheric greenhouse gas concentrations, leading to different paths of temperature and precipitation development over the 21st century. By about 2040, however, the trends differ little. Substantial differences generally become apparent only from the middle of the 21st century onward.

Time Frame	Climate Projections (RCP 7.0 – Medium emission scenario)
Mid-term Future (2050)	Increase in temperature by 1.7°C Change in precipitation +8%
Far Future (2080)	Increase in temperature by 3°C Change in precipitation +9%

Temperature

Compared to the reference period (1984–2014), mean air temperature is projected to increase by 0.9℃ around 2030 (both scenarios), by 1.2℃ (ssp126) and 1.7℃ (ssp370) around 2050, and by 1.4℃ (ssp126) and 3.1℃ (ssp370) around 2080 (Figure climate1).



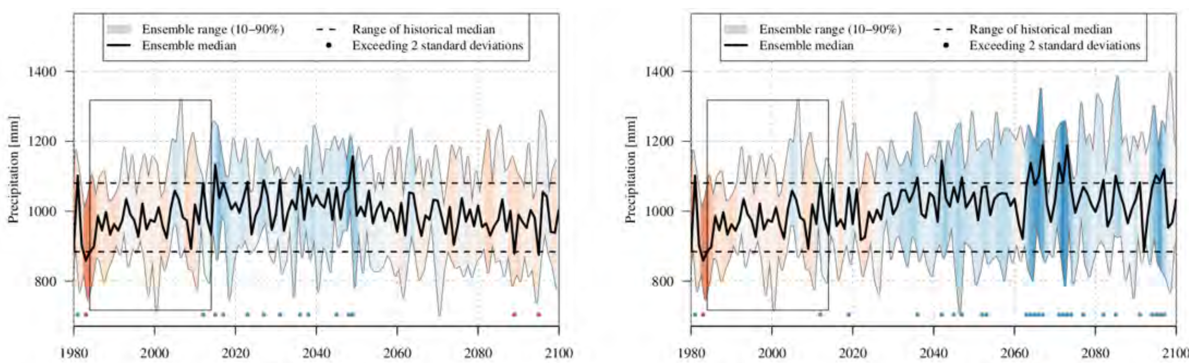
(a) Temperature (ssp126) (b) Temperature (ssp370)

Figure climate1: *Mean air temperature development over the entire Volta River basin. The black line represents the multi-model median and the coloured areas the range of the inner 80% of the ensemble.*

Precipitation

The hydro-climatic conditions until 2050 are projected to be generally wetter than the reference period in both scenarios. The multi-model median projects an increase in mean annual rainfall by 3% (ssp126) and around 8% in the ssp370 scenario. In the second half of the 21st century, the scenarios show different trends. Under ssp126 the annual rainfall amount drops to a level slightly below the reference period (-2.4%), whereas under ssp370 they tend to remain on a higher level than in the reference period (~9%), see Figure climate2.

It should be noted here that although the multi-model median projects positive rainfall changes in several future periods, there are always some models showing decreasing rainfall amounts. Depending on the scenario and future period, 10-60% of the simulations project a drier future.



(a) Precipitation (ssp126) (b) Precipitation (ssp370)

Figure climate2: *Precipitation development over the entire Volta River basin. The black line represents the multi-model median and the coloured areas the range of the inner 80% of the ensemble.*

Choosing the risk Indicators

Several indicators can be used to quantify the impacts of floods and droughts under current and project climate and socio-economic conditions. The choice of indicators can be influenced by several factors: relevance for the country and the context, availability of data and coherency with international policies such as Sendai framework. The indicators selected for the Volta Disaster Risk Profile for Floods and Drought reflect the following needs and constraints:

- Availability of homogeneous and reliable exposure data to be used for the risk indicators definition
- Availability of homogeneous and reliable impact data to calibrate the risk estimation method
- Relevance of the exposure layers and related risk indicators for early warning and early action in the DRM domain
- Feasibility of deriving reliable metrics

THE FOLLOWING SET OF RISK INDICATORS WERE THEREFORE SELECTED FOR FLOODS

PEOPLE LIKELY TO BE AFFECTED

Number of people likely to be affected based on flood extent and magnitude.

ECONOMIC LOSS TO BUILT-UP AREA

Direct economic loss to built-up area, divided into three sector classes, according to the exposure categories reported in the Sendai Framework Indicators: housing sector distribution, service sector distribution and productive sector distribution (limited to the industrial sector).

CROP PRODUCTION LOSS

Number of hectares of crops within the flood zone and likely to be submerged depending on flood extent, leading to loss of production.

LOSS OF GRAZING LAND

Number of hectares of livestock grazing land likely to be inundated and cut off from access, depending on inundation extent and leading to hindered access to grazing lands.

IMPLICATIONS ON CRITICAL INFRASTRUCTURES/ FACILITIES

Kilometres of roads that could be submerged depending on flood extent and magnitude.
Schools that could be affected depending on flood extent and magnitude, hindering access to education.
Health facilities that could be affected depending on flood extent and magnitude, hindering access to health services.

IMPLICATIONS ON WATER RESOURCES AND HYDROPOWER PRODUCTION

Variation (%) of the mean annual discharge from current climate to projected climate conditions.
Evolution in hydropower production in four main dams of the Volta basin considering projected climate conditions.

PROTECTED AREAS LIKELY TO BE FLOODED

Number of hectares of protected areas likely to be flooded based on flood extent and magnitude.

THE FOLLOWING SET OF RISK INDICATORS WERE THEREFORE SELECTED FOR DROUGHT

PEOPLE LIKELY TO BE AFFECTED

Number of people likely to be affected, living in an area hit by a severely impactful drought.

CROP YIELD LOSS

Percentage of maize yield below the expected value; maize yield is considered in ton/ha and the evaluation is relative to the average production of the area.

ECONOMIC LOSS TO CROP PRODUCTION

Crop production loss, determined using thenmean yield of each administrative unit (level 1) and converted into monetary values using mean maize price per country over the period 2010-2016.

LIVESTOCK LIKELY TO BE AFFECTED

Number of livestock units likely to be affected, expressed as amount of cattle, goat, sheep living in an area hit by a severely impactful drought.

PROTECTED AREAS LIKELY TO BE AFFECTED

Number of hectares of protected areas likely to be affected, situated in an area hit by a severely impactful drought.

Floods risk analysis

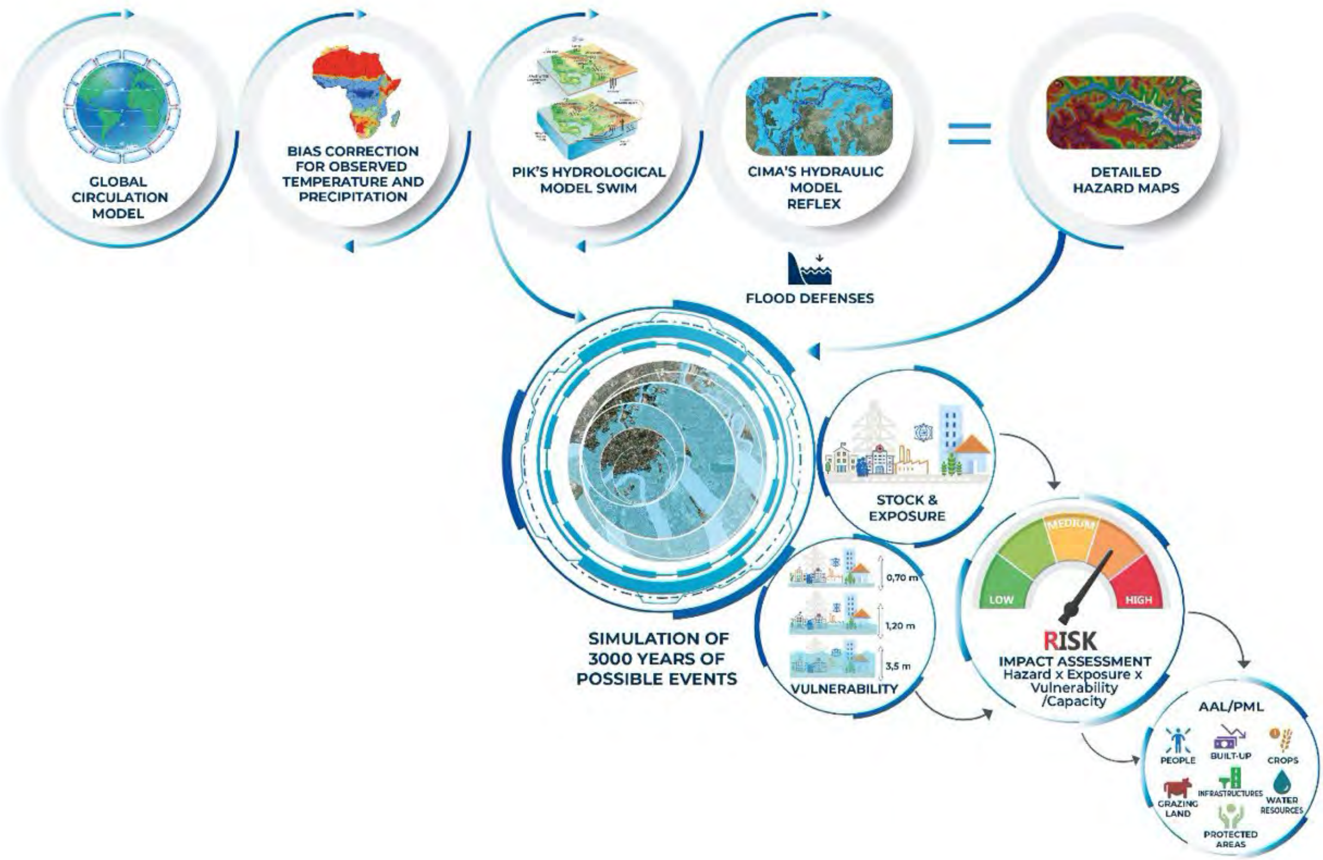
The flood risk assessment aims at understanding the probability that different magnitudes of damaging flood characteristics will occur over an extended period of time. These estimates can be calculated both in current and projected climate conditions, resulting in detailed hazard maps, to be then combined with the reproduction of past events patterns and the modelling of projected future events. Information on the performance capacity of flood protection measures is finally added to the analysis. This workflow allows for the estimation of the "expected" water depth for a certain location and/or individual infrastructures, for a set of reference scenarios.

From this step on, it is possible to explore the full frequency distribution of events and the consequent damage to exposed assets, taking into consideration their different levels of vulnerability.

More details on flood risk profile methodology can be found at: http://riskprofilesundrr.org/ .

Flood risk results are calculated in terms of annual average loss (AAL) and probable maximum loss (PML) curves for several indicators at different spatial levels of aggregation: regional, national, and subnational level (administrative level 1).

Their spatial distribution has been computed in current and projected climate conditions using the SSP3-RCP7.0 scenario and considering three different global circulation models, selected on the basis of the different effects on the values of maximum annual discharge on the Volta basin. The medium one in terms of such hydrological characteristics has been considered representative for the projected conditions in the Volta basin (in this profile referred to as "Reference Model"). The Reference Model is used for displaying the spatial distribution of results in projected climate conditions, and the associated figures are explicitly indicated in all the graphs. In AAL graphs and PML curves, also the results for the other global circulation models are shown to represent the variability of potential effects of climate change.



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

POPULATION

Population estimates were obtained through official censuses at the maximum level of detail available. Global datasets on population were only used in this study to retrieve spatial binary information (population/ no-population at any point in space) or information on the relative distribution of population inside a given area. This study considered population according to its density, meaning the spatial distribution of population across the country.

Projections for future population were produced starting from UN 2100 projections, based on all available sources of data on population size and levels of fertility, mortality, and international migration.

BUILT-UP

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

The built-up data prepared for the present risk profile were obtained from the exposure dataset used in the Global Assessment Report 2015 and in the Atlas of the Human Planet 2017. They have been divided into three sector classes, according to the exposure categories reported in the Sendai Framework Indicators: housing sector distribution, service sector distribution and industrial sector distribution. The spatial resolution of such information has been improved through a proper downscaling procedure, guaranteeing coherence among the distributions of population and residential areas.

AGRICULTURAL PRODUCTION AND GRAZING LAND

Agricultural production is described through a two-fold approach, addressing crop production and grazing land separately. Both these elements are described in terms of land coverage, each pixel of the exposure layer expressing the hectares of area covered by crop production or rangeland.

The layers prepared for this report are based on the land cover data developed by the Joint Research Centre (JRC) as reference data within the ASAP (Anomaly hotSpot of Agricultural Production) initiative; the layers have been downloaded at 90 meters resolution, ensuring that potential overlapping with built-up area is avoided.

CRITICAL INFRASTRUCTURES

Critical infrastructures data refer to the description of the physical exposure in terms of spatial location of school, medical and hospital facilities, as well as the transport network combined with their economic values. The main added values of this information rely on knowing the exact location of the infrastructure, the typology of its construction materials, and, for roads, also its average elevation and the construction costs per km.

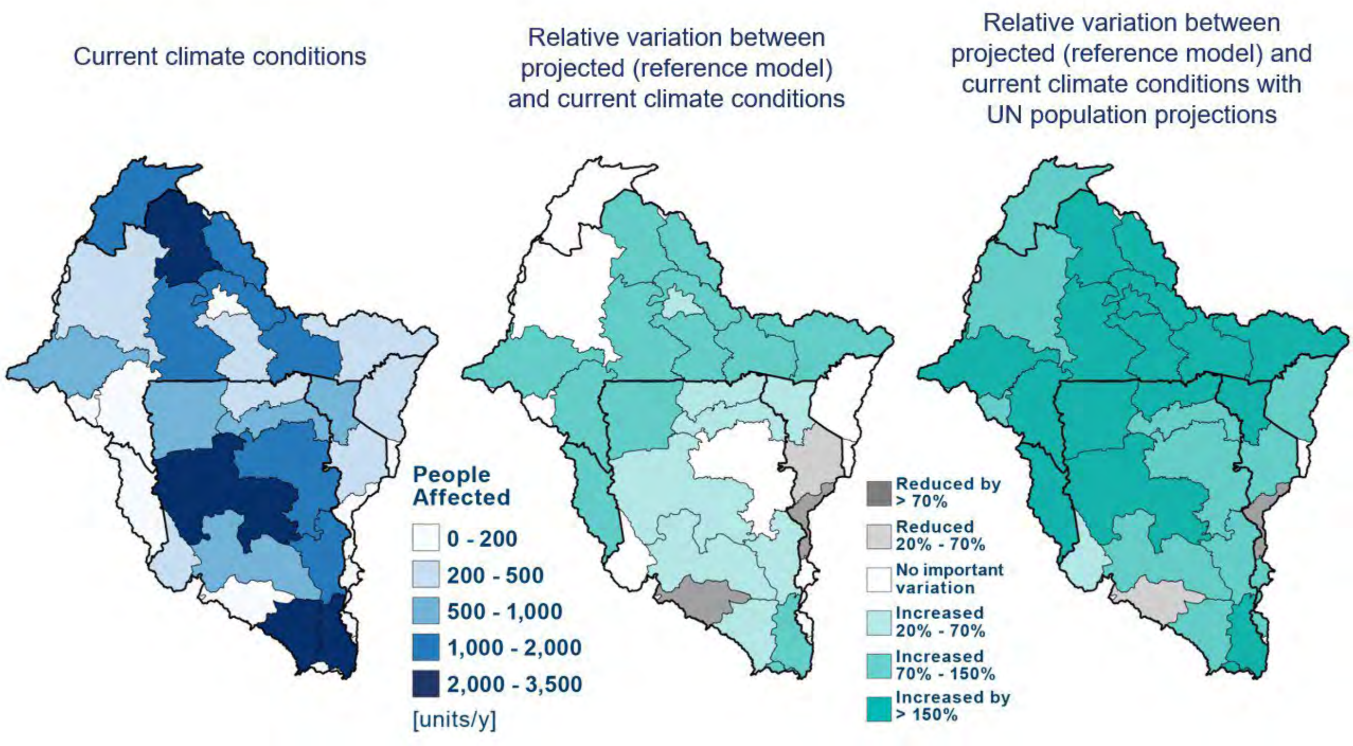
Local datasets made available by national entities were combined with global datasets from OpenStreetMap to have a uniform representation of the spatial location of critical infrastructures in the whole Volta basin.

PROTECTED AREAS

As for cropland and rangeland, also protected areas are expressed in terms of hectares of area covered. The information come from IUCN datasets, reporting different typologies of protected areas (e.g., botanic reserves, forest reserves, hunting areas, faunal reserves, parks,…); the layer has been downloaded at 90 meters resolution, ensuring that potential overlapping with built-up area is avoided.

The effects of floods on protected areas are to be determined; for this reason, in this context we won't refer to impacts, but generally to number of hectares likely to be flooded.

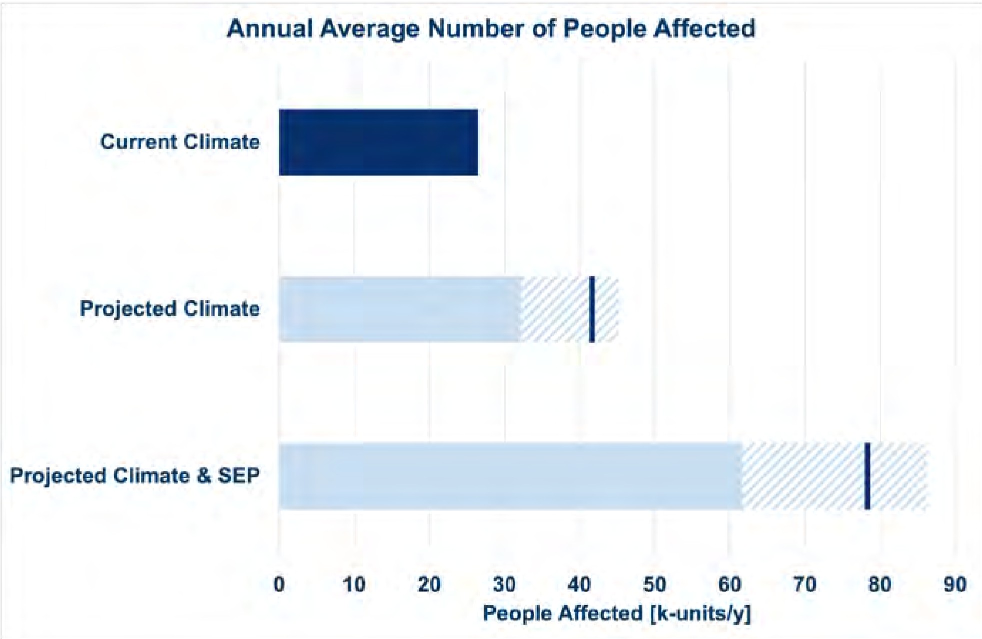
Floods' results
Population

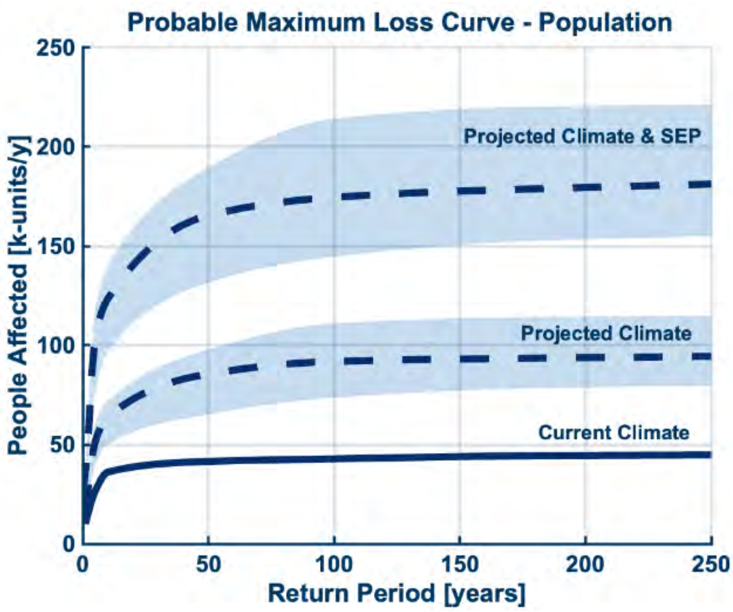


KEY MESSAGES

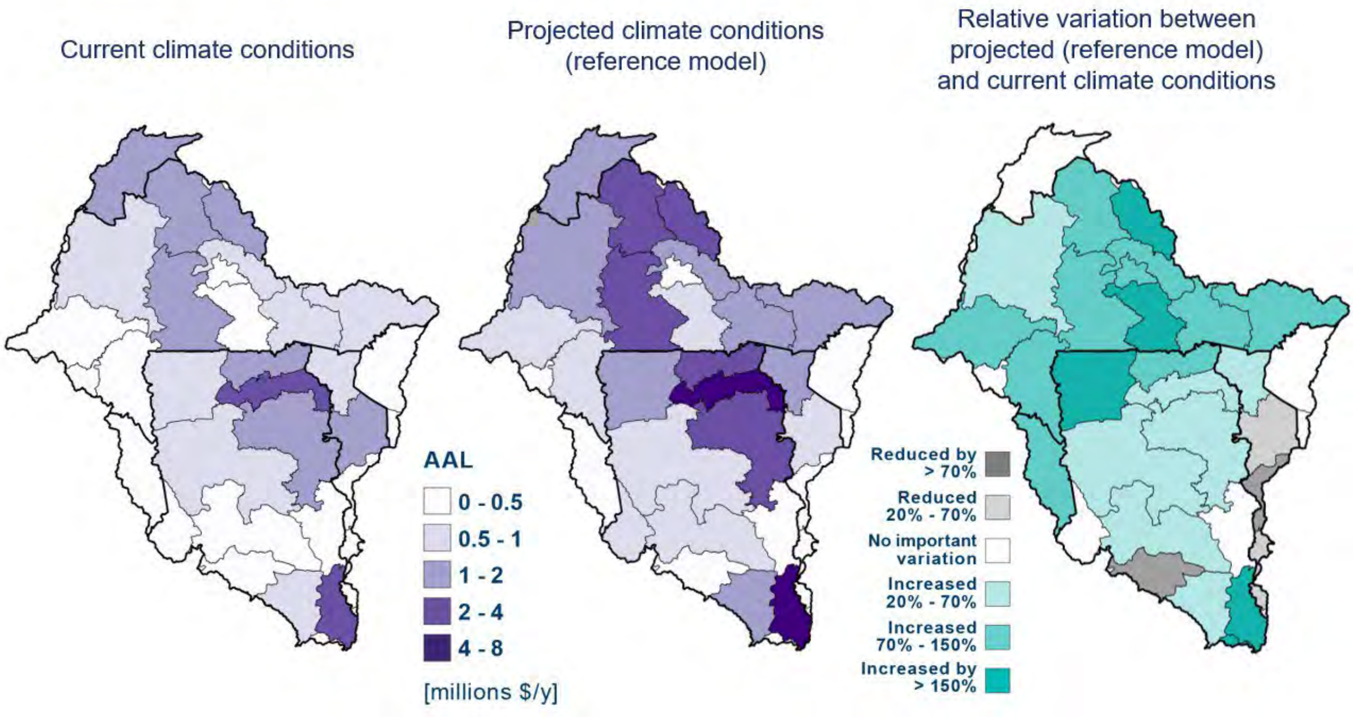
- Impacts of floods on population in current climate conditions are spread in almost all regions in the Volta basin.
- The highest values of annual average number of people affected are concentrated mainly in Ghana – in the regions of Volta, Eastern and Savannah – and in the Nord region of Burkina Faso, where the average number of people affected per year exceeds two thousand.
- Apart from the basin edge area, a general worsening in terms of population affected by floods can be observed in projected climate conditions, with the northern Ghana and most of Burkina Faso more than doubling the average annual number of people affected.
- The same worsening pattern is exacerbated by considering UN socio-economic projections (SEP) for the population.
- At basin level, the annual number of people affected grows from almost 30 thousand in current climate conditions to more than 40 thousand in projected climate conditions, and up to almost 80 thousand considering SEP too.

- When the PML curves are analysed, one can observe that a 50-year return period loss can determine in current climate conditions up to 50 thousand people affected; the figure could increase in projected climate conditions (reference model) up to 80 thousand, or to 165 thousand when considering SEP.
- Considering both the graph of average annual people affected and the PML curves, it is worth observing that the variability of the values for projected climate conditions – obtained by considering not only the reference scenarios but also additional ones – is roughly the 30% of the corresponding value in the reference model.





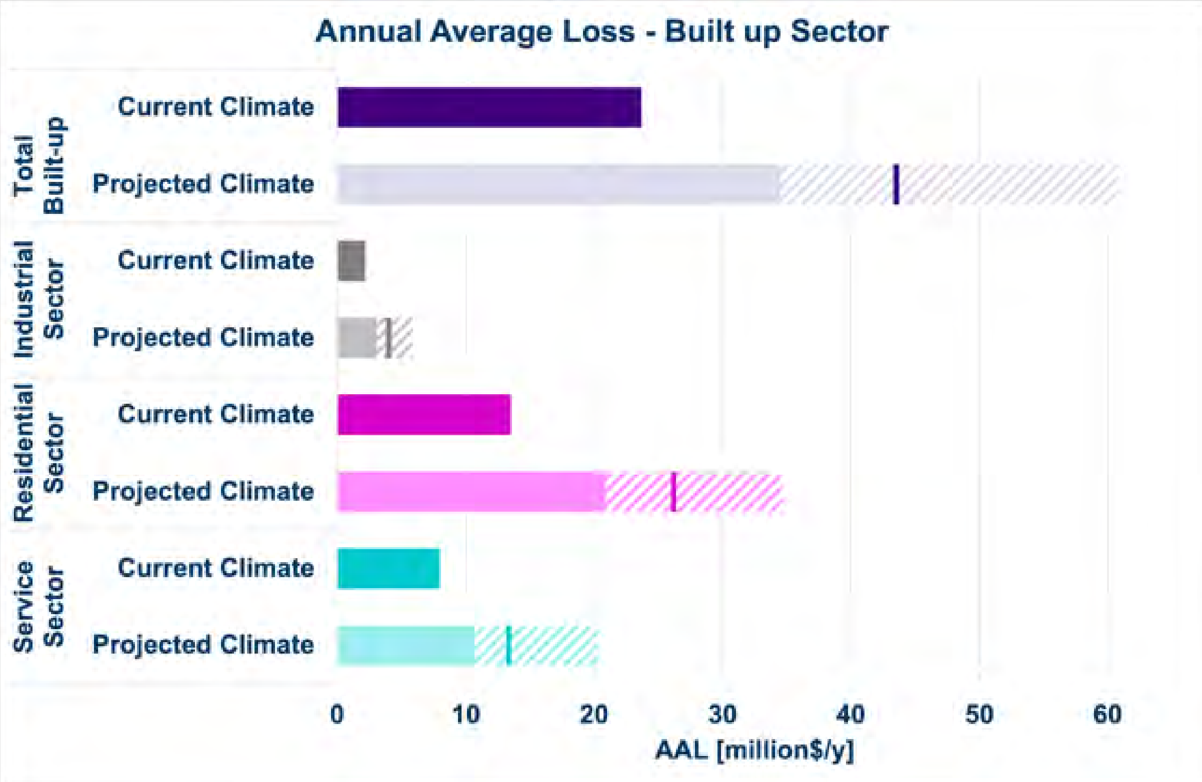
Built-up area economic loss

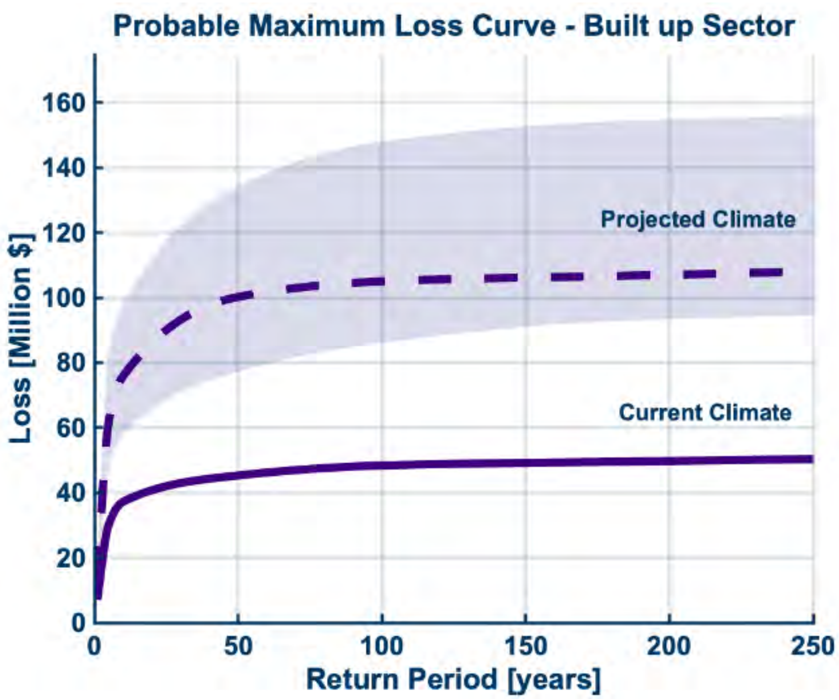


KEY MESSAGES

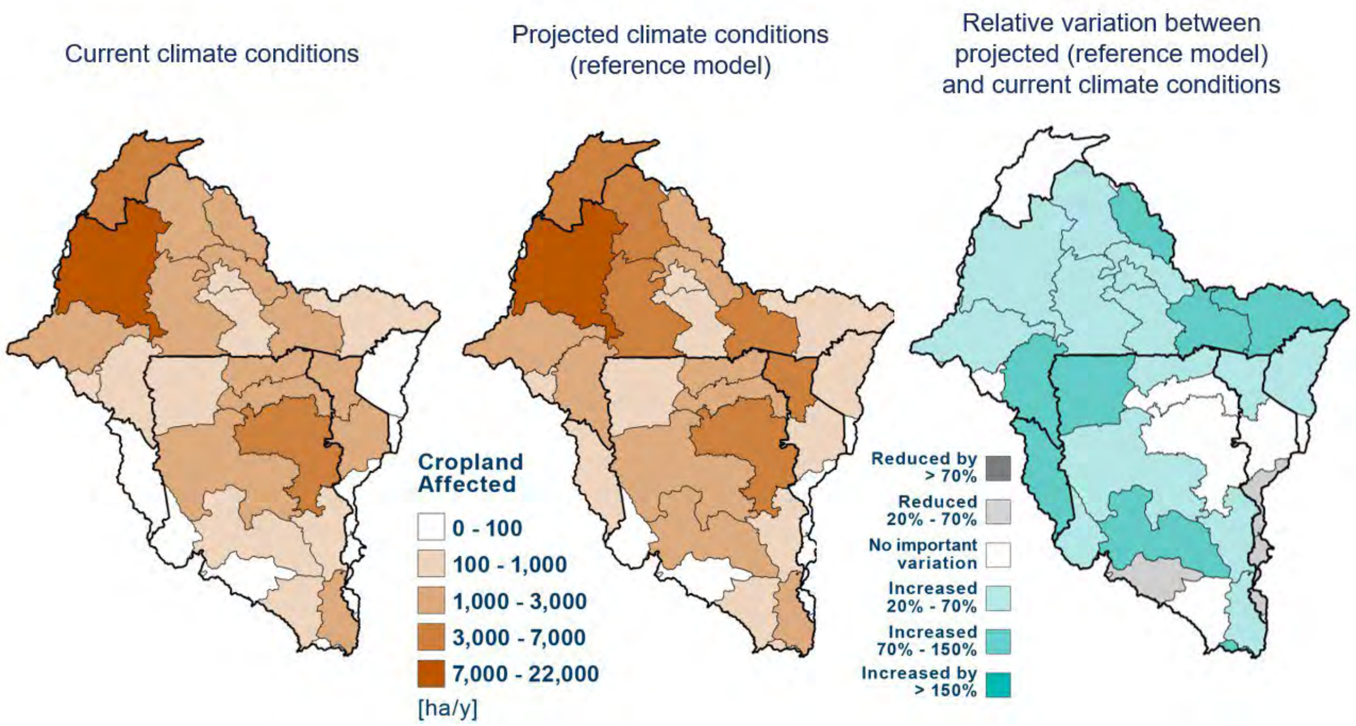
- Average annual losses for the built-up sector reach about USD 25 million per year under current climate conditions.
- The residential sector accounts for 50% of the economic losses for the built-up, followed by construction used by services and industrial.
- Average annual losses are distributed in almost all the basin area, with absolute values depending also on the economic value of the buildings, and on their physical vulnerability.
- The most impacted regions belong to Ghana, with values of AAL that in projected climate conditions (reference model) exceeds USD 4 million.
- Looking at the PML curves, it's worth observing that the value for a 50-year return period loss more than doubles (from USD 45 million to USD 100 million) when going from current climate conditions to the reference model in projected climate conditions.

- When considering the results for projected climate conditions, the variability is quite wide, ranging – for a 50-year loss – from almost USD 80 million to more than USD 130 million.



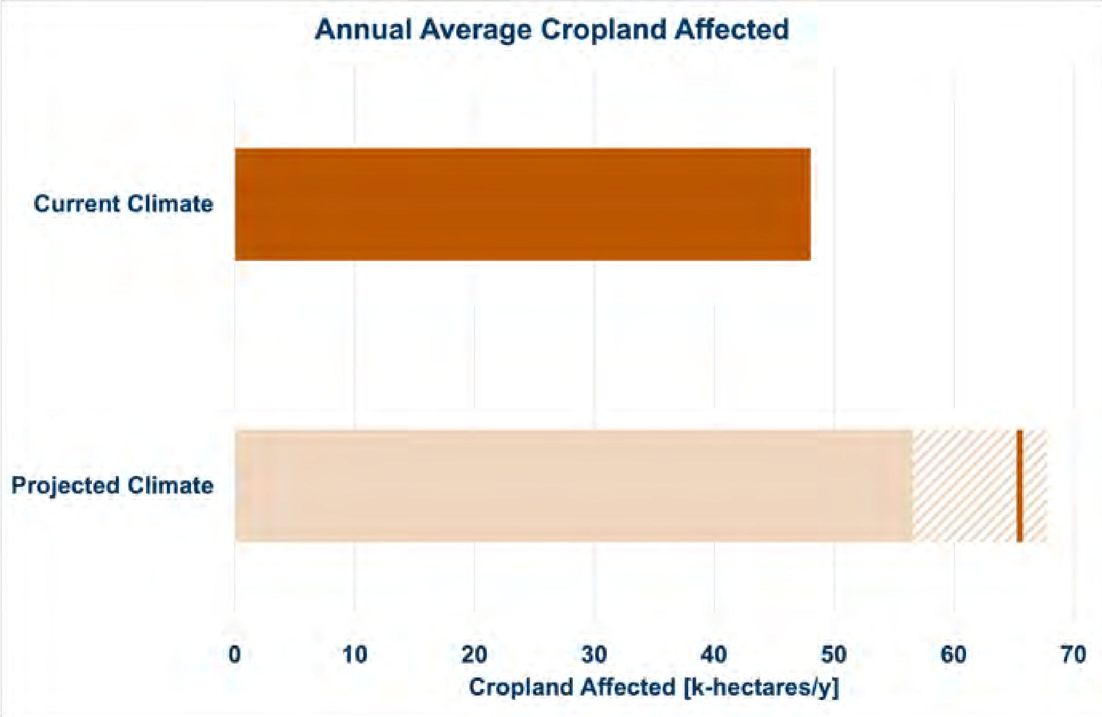


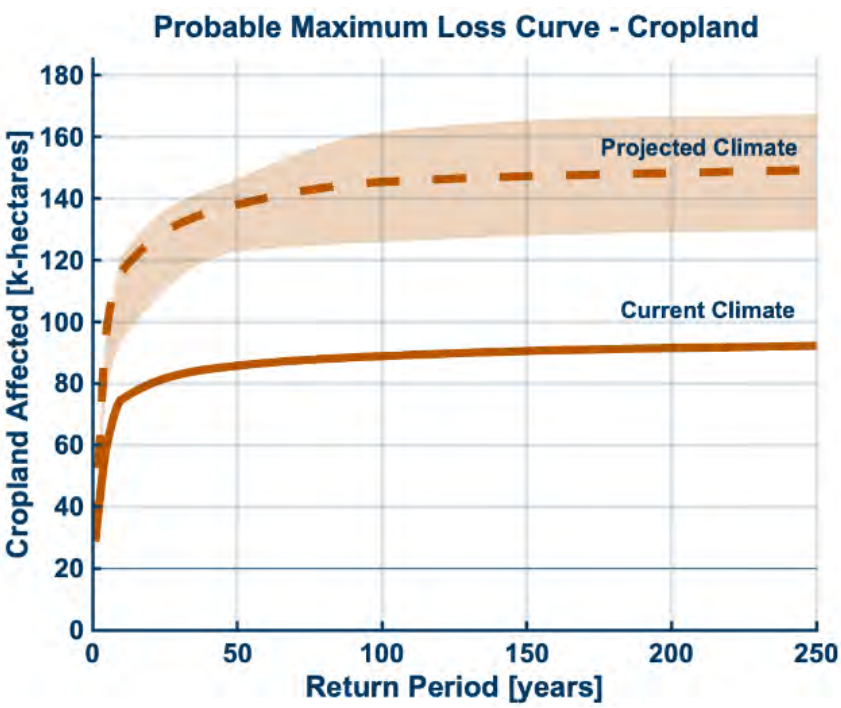
Crop production loss



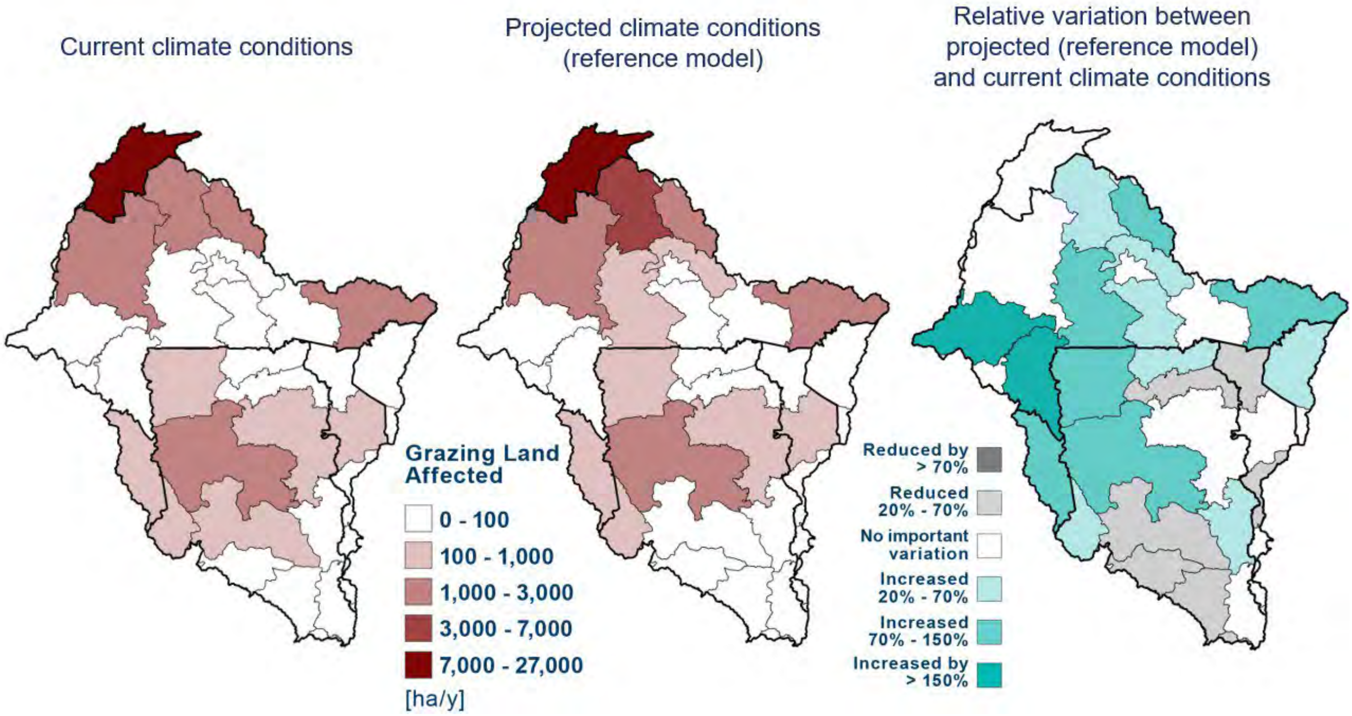
KEY MESSAGES

- Impacts of floods on croplands are distributed in all the Volta basin.
- The most affected region is Boucle du Mouhoun in Burkina Faso, where the number of hectares affected is greater than 16 thousand in current climate condition and almost 18 thousand in projected climate conditions (reference model).
- Conditions worsen in almost all the regions within the Volta basin; such a worsening is almost 40% at basin level, comparing current climate conditions and the reference model in projected climate conditions.
- The worsening effect is more evident when analyzing the effects of a 50-year return period loss, for which one can expect roughly 80 thousand hectares of cropland affected in current climate conditions, and more than 140 in projected climate conditions (reference model), corresponding to a 75% increase.


Annual Average Cropland Affected
Current Climate
Projected Climate
0
10
20
30
40
50
60
70
Cropland Affected [k-hectares/y]

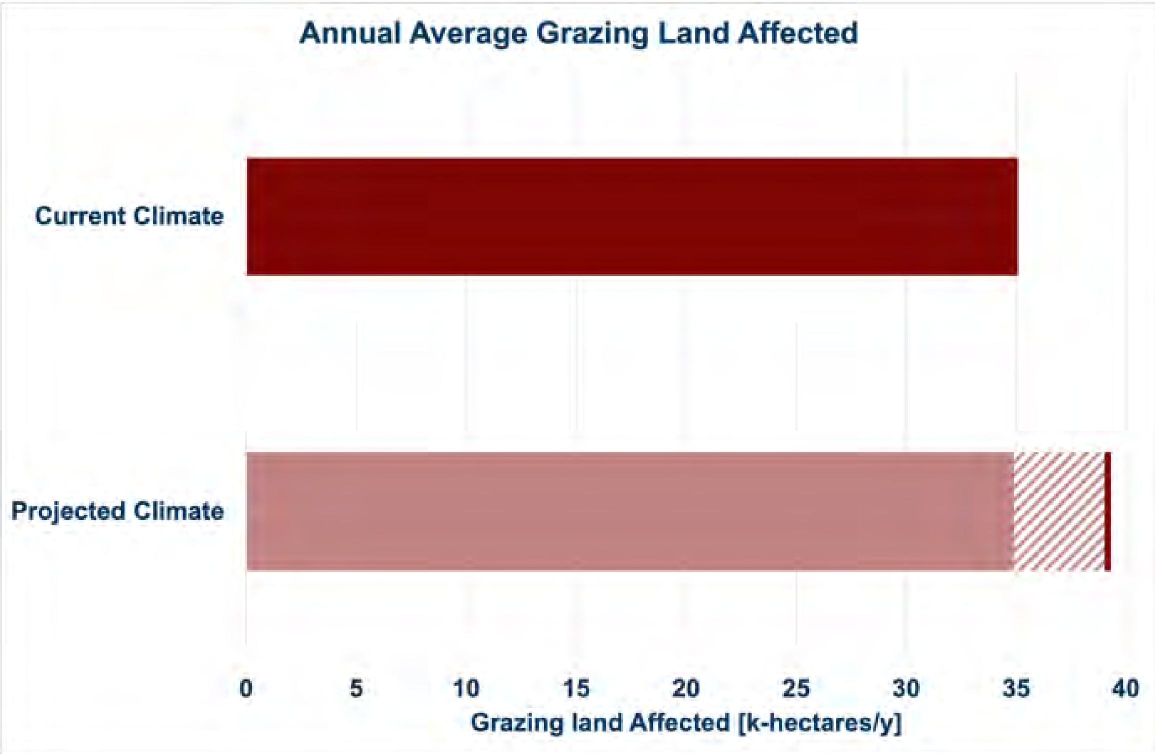

Probable Maximum Loss Curve - Cropland
Cropland Affected [k-hectares]
180
160
140
120
100
80
60
40
20
0
Projected Climate
Current Climate
0
50
100
150
200
250
Return Period [years]

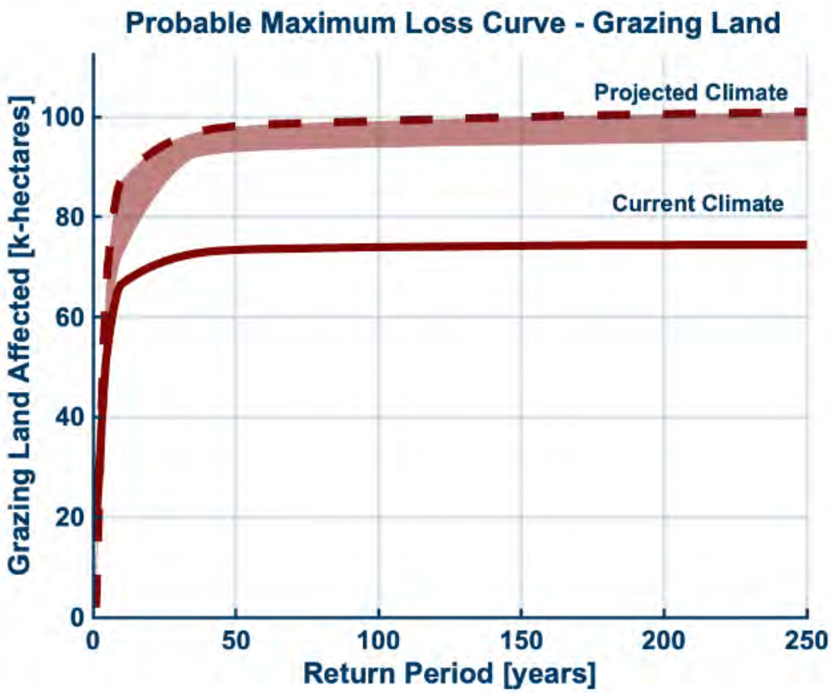
Grazing land affected



KEY MESSAGES

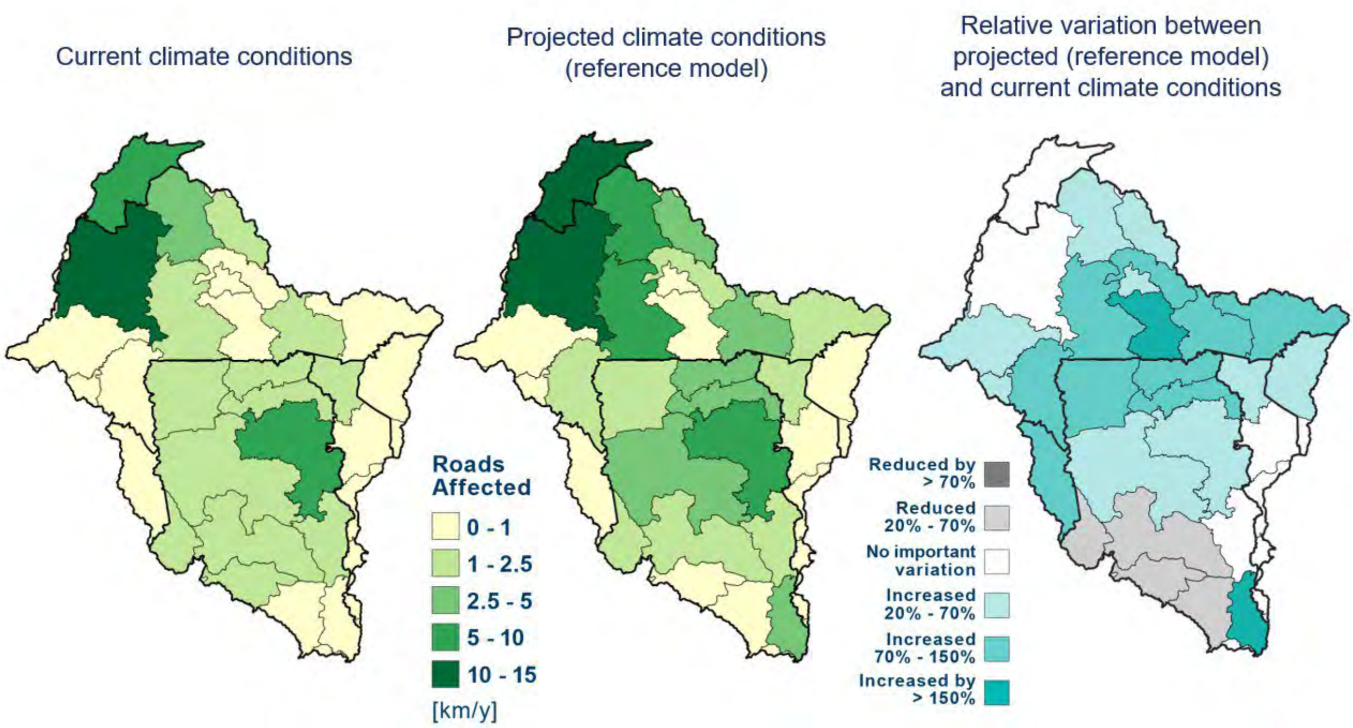
- Flood impacts on grazing land are distributed in all the regions where such assets are present.
- The highest impact is concentrated in the Mopti region in Mali, both in current and projected climate conditions (reference model)
- The main increase of impacts between current and projected climate conditions can be found in the central area of the basin; some of the other areas, instead, show a decrease in terms of impact.
- The mixed tendency in projected climate conditions is evident also comparing the values of AAL in current climate conditions with the different models for projected climate conditions, showing low or null worsening effect.
- Nevertheless, focusing on a 50-year loss, it's impact increases by about 30% when going from current to projected climate conditions.


Annual Average Grazing Land Affected
Current Climate
Projected Climate
0
5
10
15
20
25
30
35
40
Grazing land Affected [k-hectares/y]


Probable Maximum Loss Curve - Grazing Land
Projected Climate
Current Climate
Grazing Land Affected [k-hectares]
0
20
40
60
80
100
0
50
100
150
200
250
Return Period [years]

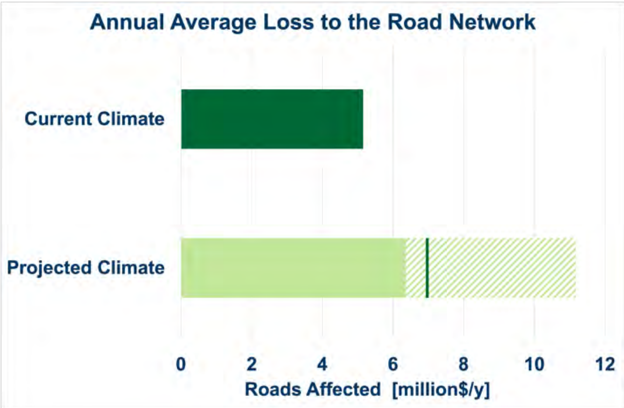
Implications on critical infrastructures/facilities

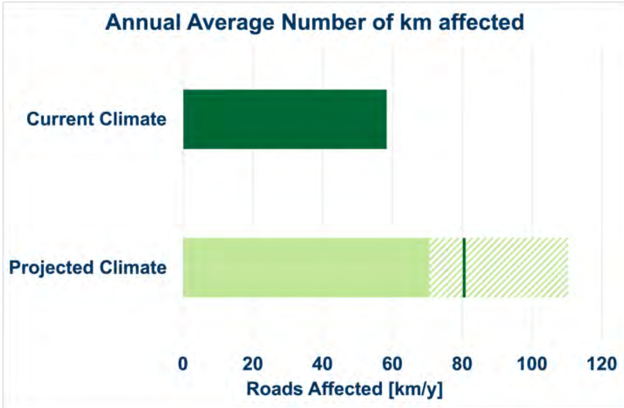
Transportation networks (roads)

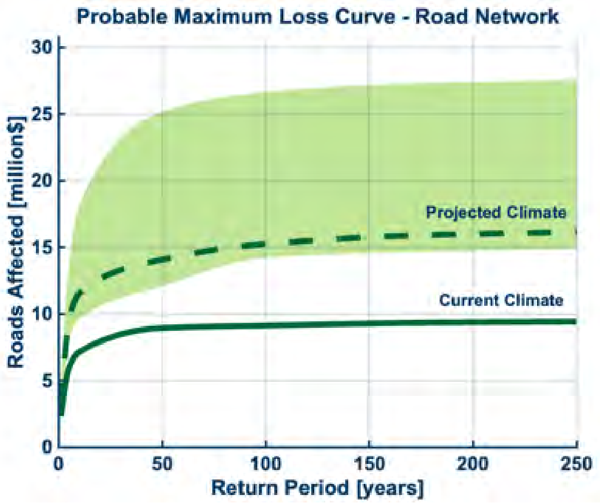


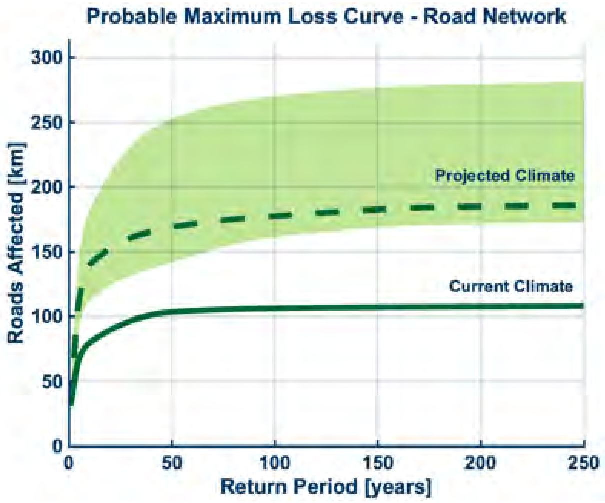
KEY MESSAGES

- Impacts of floods on road infrastructures are moderate in the Volta basin, even if they are quite spread.
- A local criticality in the road network, even if moderate and temporary, should never be underestimated, as it can have serious cascading effects on the country/area functionality, especially when a disastrous event strikes.
- Comparing current and projected climate conditions, the impacts show an increase, in terms of both economic losses and kilometers interrupted (and thus potential indirect effects).

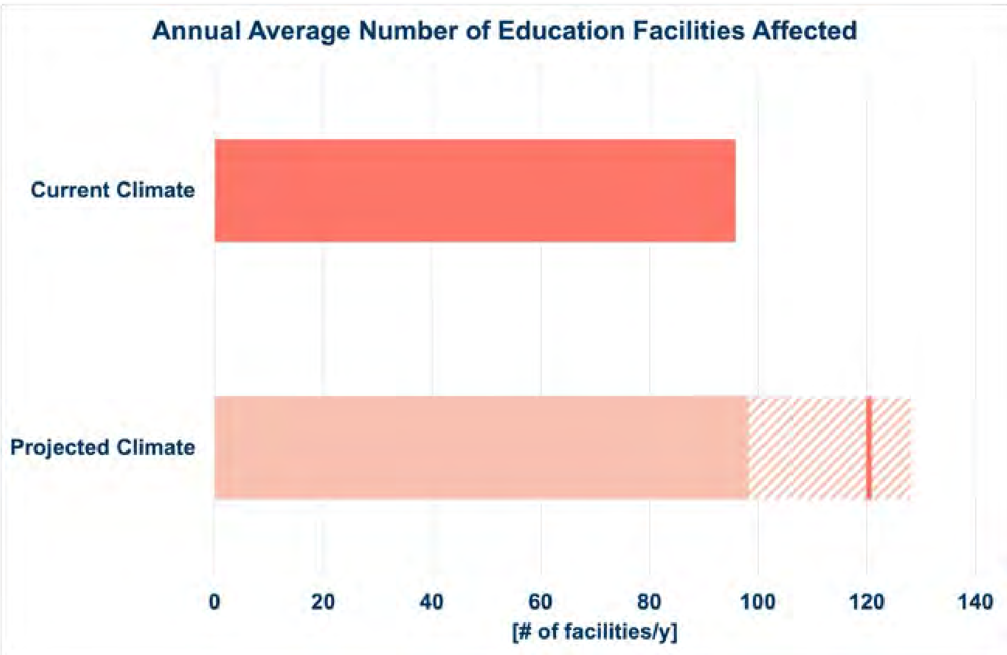


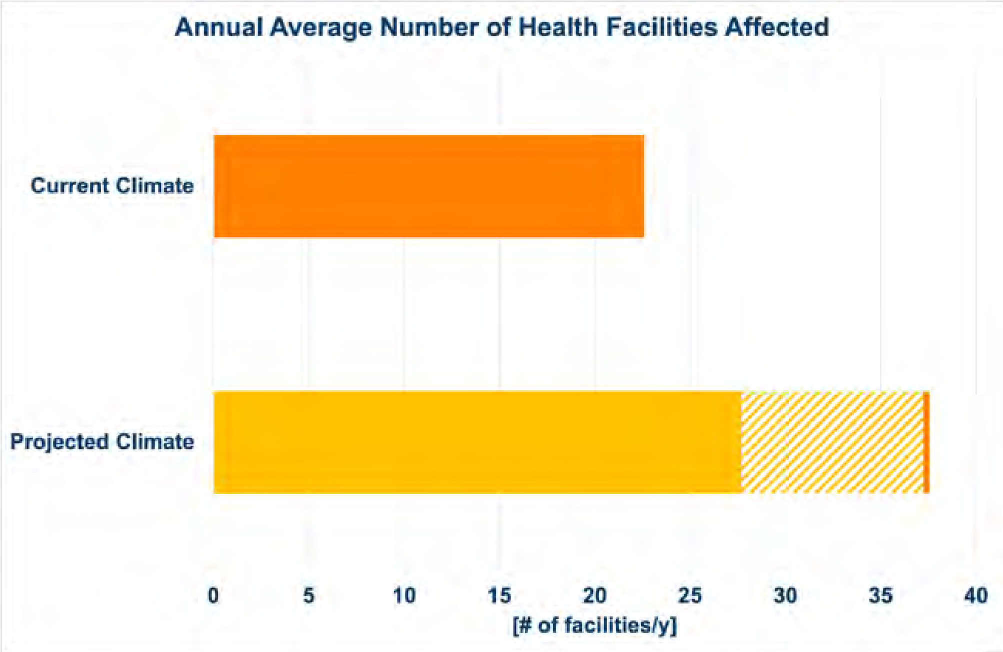






Education and health facilities



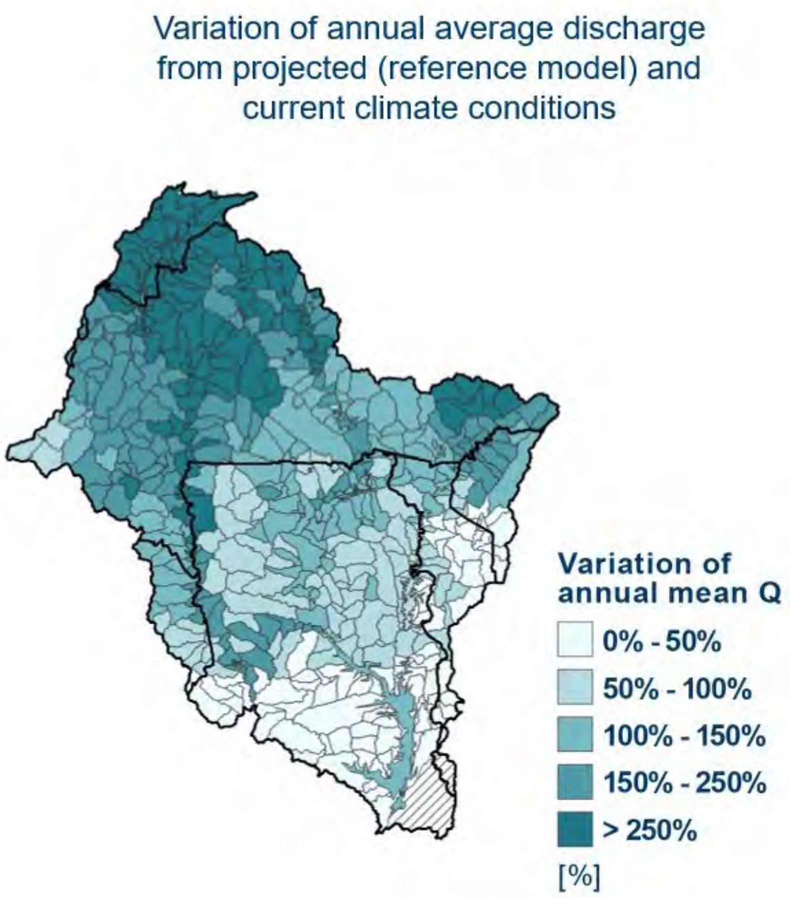


KEY MESSAGES

- Impacts of floods on health and education facilities in the Volta basin are not too high, in fact the AAL for both the two types of facilities is about 0.3% of the overall stock; nevertheless, such elements are pivotal for the right functioning of the social fabric, thus their protection from the effects of floods should be ensured.

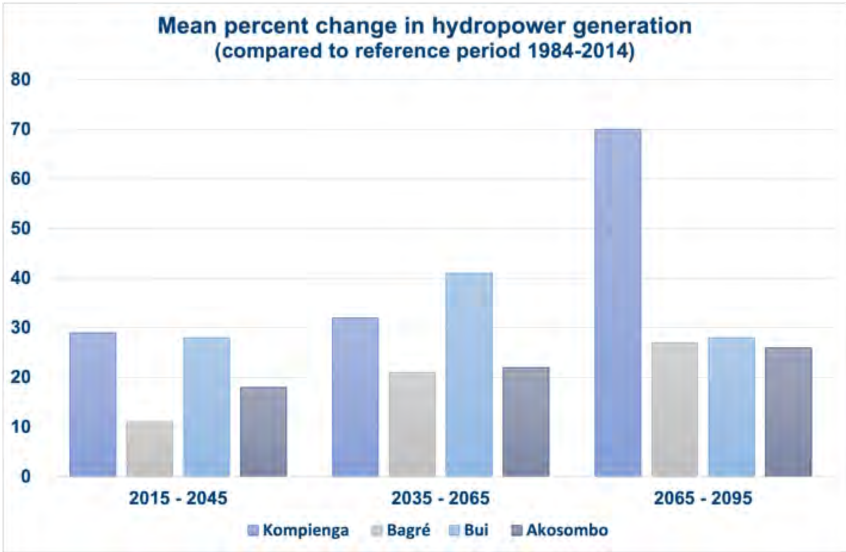
- The impacts are expected to increase in the reference model of project climate conditions by 20% for education facilities, and by 70% for health facilities, with a variability among the different models of 25% and 50%, respectively.

Implication on water resources and hydropower production



KEY MESSAGES

- A significant increase in water availability is expected in projected climate conditions for the period 2017-2100.
- The increase is greater in the northern part of the basin.
- The average increase is not in contrast with the analyses on droughts. The foreseen climatic variability will lead to an increase of the magnitude and the frequency of extreme events and to an increase of the impacts of drought even in a hydrological regime of average increase of river flow rates. Very scarce rainfall years will be more frequent, alternating with years with more abundant rainfall.

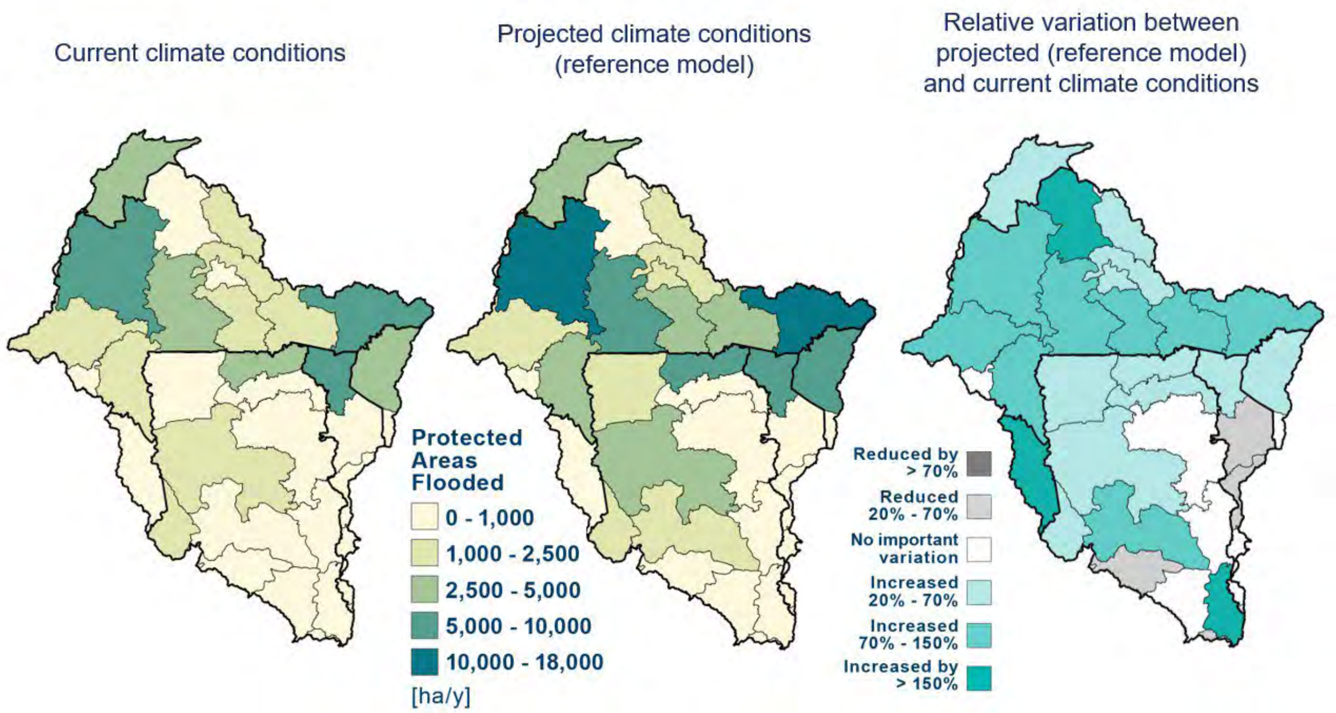


** The analysis is performed comparing the multi-model median in projected climate projection with the reference period 1984-2014, considering three future periods and four main dams*

KEY MESSAGES

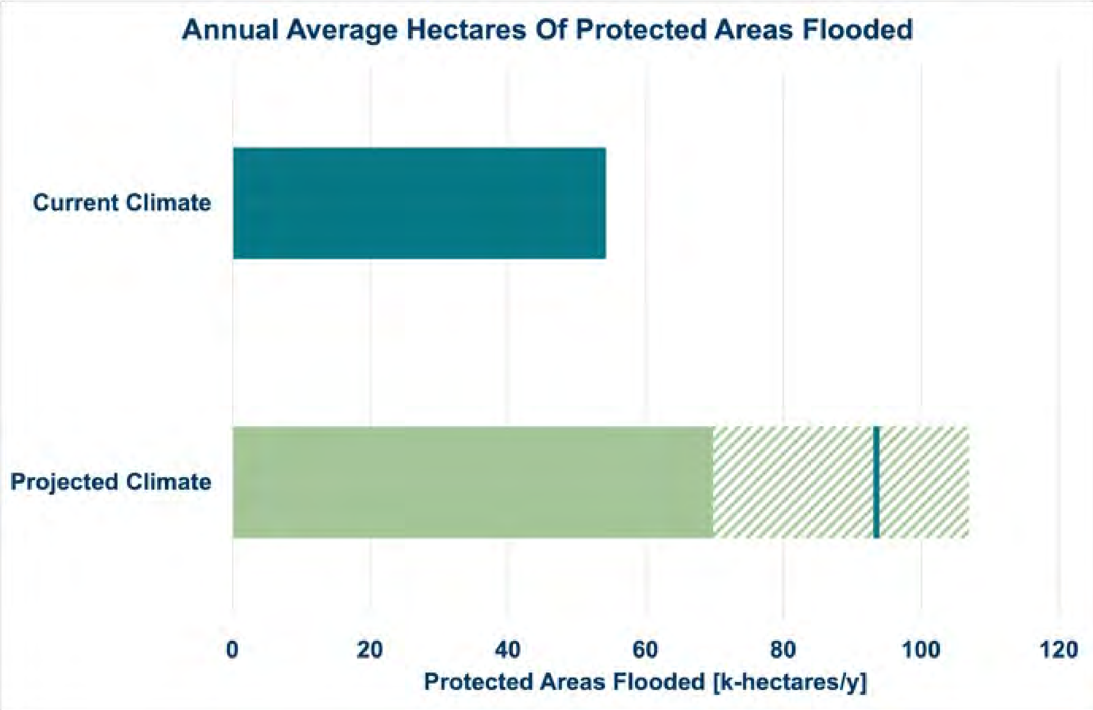
- All reservoirs show an increase in hydropower potential in all future periods in projected climate conditions.
- Around 2030 and 2080, the highest increase is for the Kompienga reservoir (29% and 70%), while around 2050 is for the Bui reservoir (41%).
- However, it is emphasized here again that, while there is a tendency to increasing mean annual flows (mainly caused by more frequent and higher flood flows), all simulations also show recurring dry years and drought periods.
- The above numbers refer to the multi-model median, while some global circulation models tend to project a drier future leading to a reduction in hydropower potential.
- In addition, the hydropower potential trends do not include planned future increased withdrawals for irrigation.

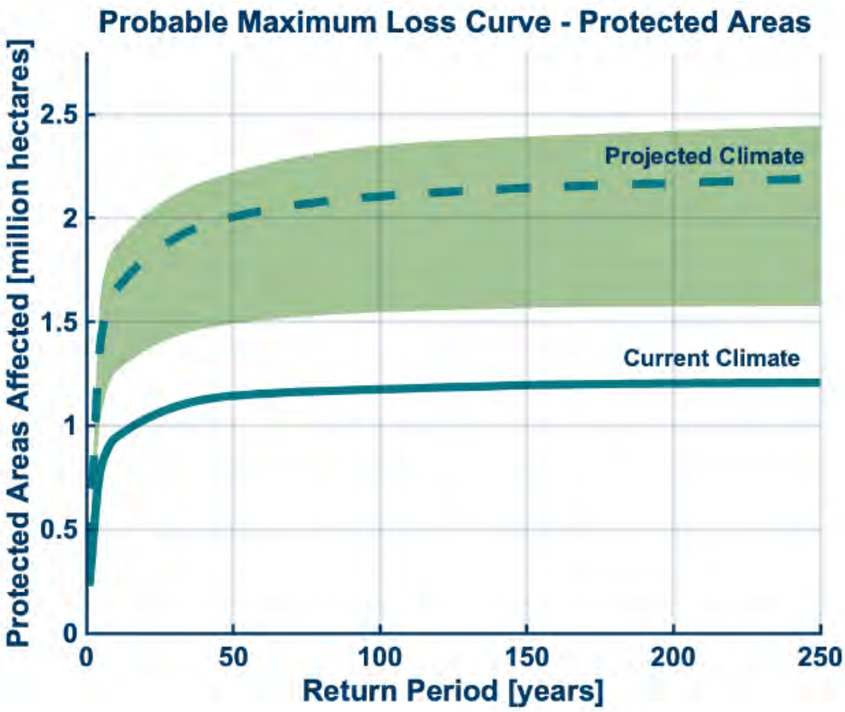
Protected areas to be flooded



KEY MESSAGES

- The effects of floods on protected areas are to be determined; for this reason, in this context we won't refer to impacts, but generally to number of hectares likely to be flooded.
- Several protected areas are present in the basin, and thus also the areas expected to be flooded are well distributed in the area, with a predominance in the upper regions.
- At basin level, an increase in the number of hectares to be flooded is expected when going from current climate conditions to projected climate conditions; nevertheless, a few regions in Ghana and Togo show the opposite behavior.
- Considering a 50-year loss, the number of hectares expected to be flooded in current and projected (reference model) climate conditions almost doubles.
- The variability of effects associated to the different models in projected climate conditions is relevant, and it is about 50% of the corresponding value in current climate conditions.


Annual Average Hectares Of Protected Areas Flooded
Current Climate
Projected Climate
0
20
40
60
80
100
120
Protected Areas Flooded [k-hectares/y]


Probable Maximum Loss Curve - Protected Areas
Protected Areas Affected [million hectares]
2.5
2
1.5
1
0.5
0
Projected Climate
Current Climate
0
50
100
150
200
250
Return Period [years]

Drought Risk Analysis

Drought disaster risk can be seen as the probability of experiencing harmful drought events with different severities of impacts over a certain period of time. These harmful impacts can be caused by a diversity of hydro-meteorological conditions that induce a less-than-average availability of water. The severity of drought impacts is also influenced by what is exposed to these conditions, as well as by the vulnerability of the exposed items to a reduction in water availability.

Most drought assessments evaluate one or more hydro-meteorological conditions using drought indices, which can express the abnormality of the water available in the atmosphere (meteorological drought indices), hydrological system (hydrological drought indices) or the soil (agricultural drought indices), or in all three (combined drought indices). Quite often, a threshold is determined (e.g., 1 standard deviation below average, or, the lowest 10%) to identify drought events. However, the abnormality, or rarity, of a drought situation does not necessarily indicate the severity of potential impacts felt on the ground.

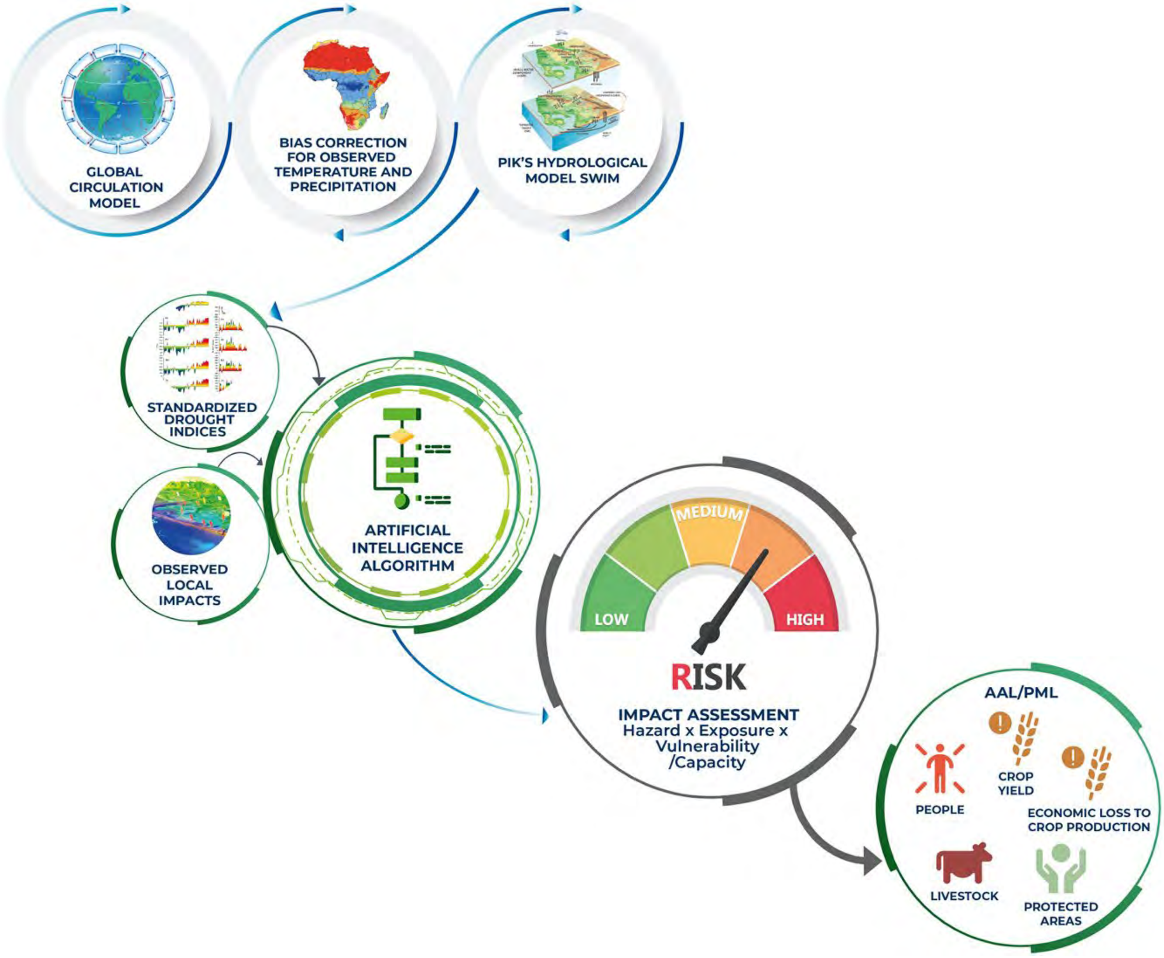
In this study, observed variability in maize yields (a rain-fed staple crop that is quite sensitive to water shortages) is the starting point. Such observations give a good indication of how drought impacts are felt on the ground (not only on cropland but also on grassland). We identified multiple impact severity categories (5% less than average yield, 10% less than average yield, 30% less than average yield, etc.) and used machine learning techniques to identify the hydrometeorological conditions that can lead to such impacts. In doing so, we assume that this can be different per sub-national region, i.e. we take into account the diverse vulnerabilities of different regions. This step results in a selection of drought indicators and their thresholds tailored to each region's characteristics.

After identifying the hydrometeorological conditions that have led to observed drought impacts in the past, we calculated the probability of occurrence of such conditions, both under current climate conditions and under future climate conditions. This allows us to create probable maximum loss curves that show the average return period of certain reductions (-5%, -10%, -30%) in maize yield. Using these curves, we estimated annual average yield losses, i.e. the average yearly reduction of maize yield caused by drought conditions. All of these estimates express drought impact in relative terms: a percentage reduction compared to the average expected maize yield in each region.

To estimate the average annual loss (and probable maximum losses) in economic terms (USD), the percentage reductions of maize yields are translated to absolute values (ton production loss) and multiplying this with country-specific average maize prices.by multiplying them with the average yields and the area under cropland 278USD/ton, 383USD/ton, 348USD/ton, 230USD/ton, 292USD/ton and 383USD/ton for Benin, Burkina Faso, Côte d'Ivoire, Mali, Togo, and Ghana respectively).

To calculate the amount of people and livestock affected by drought, we assume that a reduction of 15% in maize yield indicates such severe drought conditions on the land, that all people and animals living in the region hit by such a drought will be affected by it in one way or another (e.g. a shortage in food or fodder, losing income due to a distorted market, reduced health due to diminished water supply, etc.). Similarly, to calculate the protected areas potentially affected by droughts, we assume that a reduction of 15% in maize yield will also reflect a reduced greenness in these areas. We thus can multiply the people / livestock / protected area with the probability of such severe drought conditions to obtain the annual average people / livestock / protected area likely to be affected by droughts.

Drought risk indicators are assessed at different spatial levels of aggregation: regional, national, and subnational level (administrative level 1). Their spatial distribution has been computed in present and possible future climate conditions (using the ssp370 scenario).


GLOBAL CIRCULATION MODEL
BIAS CORRECTION FOR OBSERVED TEMPERATURE AND PRECIPITATION
PIK'S HYDROLOGICAL MODEL SWIM
STANDARDIZED DROUGHT INDICES
OBSERVED LOCAL IMPACTS
ARTIFICIAL INTELLIGENCE ALGORITHM
LOW
MEDIUM
HIGH
RISK
IMPACT ASSESSMENT
Hazard x Exposure x Vulnerability /Capacity
AAL/PML
PEOPLE
CROP YIELD
ECONOMIC LOSS TO CROP PRODUCTION
LIVESTOCK
PROTECTED AREAS

CROP YIELD

In this study, we started from observed variability in maize yields (a rain-fed staple crop that is quite sensitive to water shortages) as observed in the global dataset of historical yields for major crops 1981-2016 (Iizumi & Sakai, 2020). Such observations give a good indication of how drought impacts are felt on the ground (not only on cropland but also on grassland).

CROP PRODUCTION

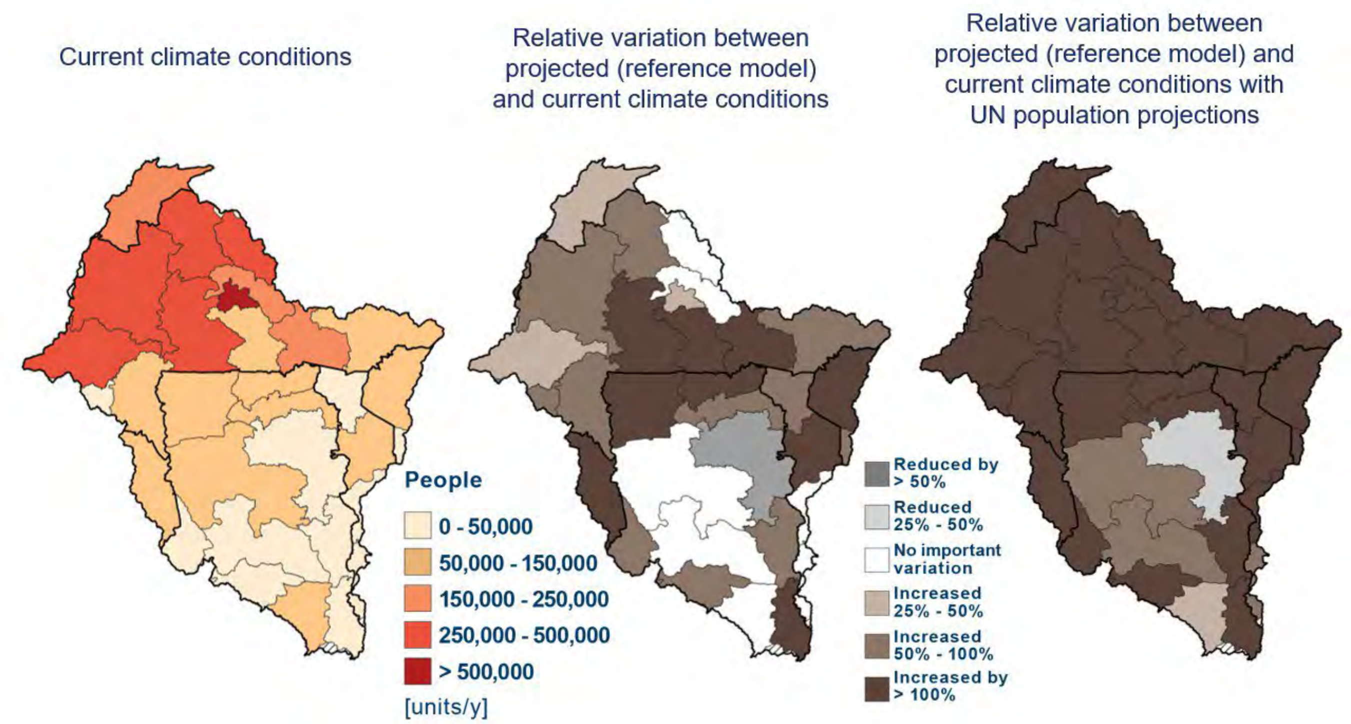
To estimate the average annual loss (and probable maximum losses) in economic terms (USD), the percentage reductions of maize yields are translated to absolute values (ton production loss), by multiplying them with the average yields and the area under cropland, and multiplying this with country-specific average maize prices according to FAO database 2010-2016 (Benin 278USD/ton, Burkina Faso 383USD/ton, Côte d'Ivoire 348USD/ton, Mali 230USD/ton, Togo 292USD/ton and Ghana 383USD/ton).

LIVESTOCK

To calculate the number of livestock affected by drought, we considered the spatial database developed by FAO representing the distribution of the main livestock species with global coverage and sub-national resolution (Gridded livestock of the world). In particular, the focus was placed on cattle and small ruminants, taking into consideration three species of animals (cattle, goats and sheep).

Droughts' results

People living in drought affected areas

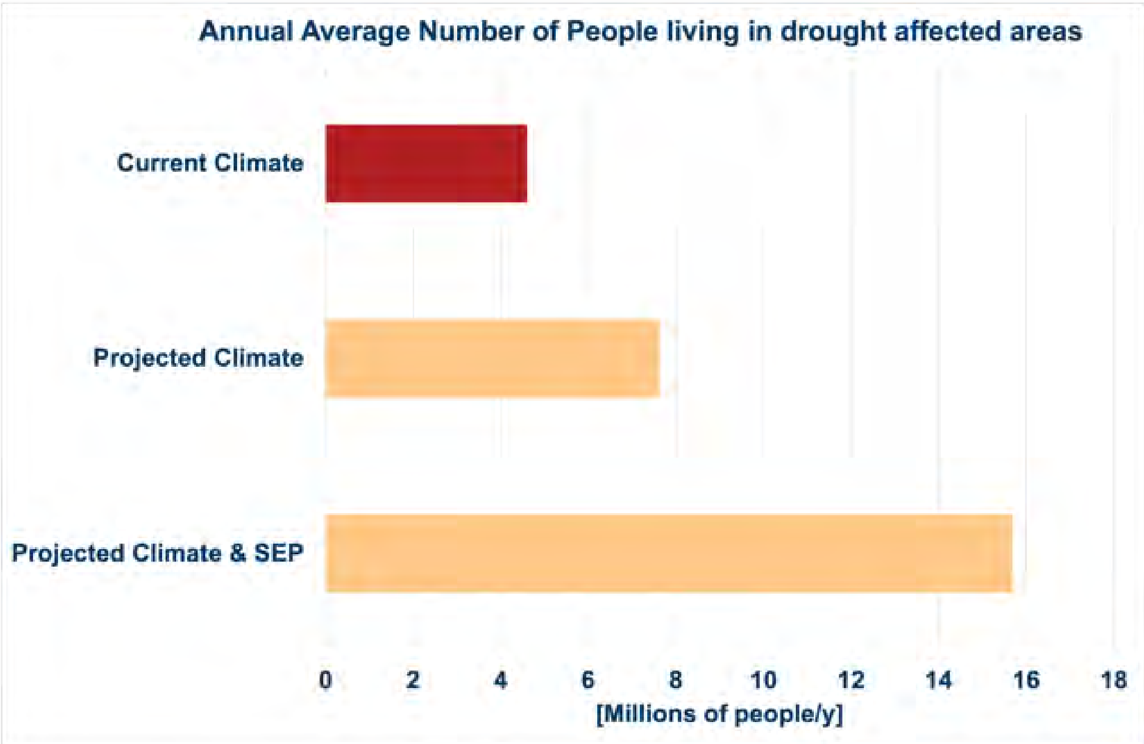


KEY MESSAGES

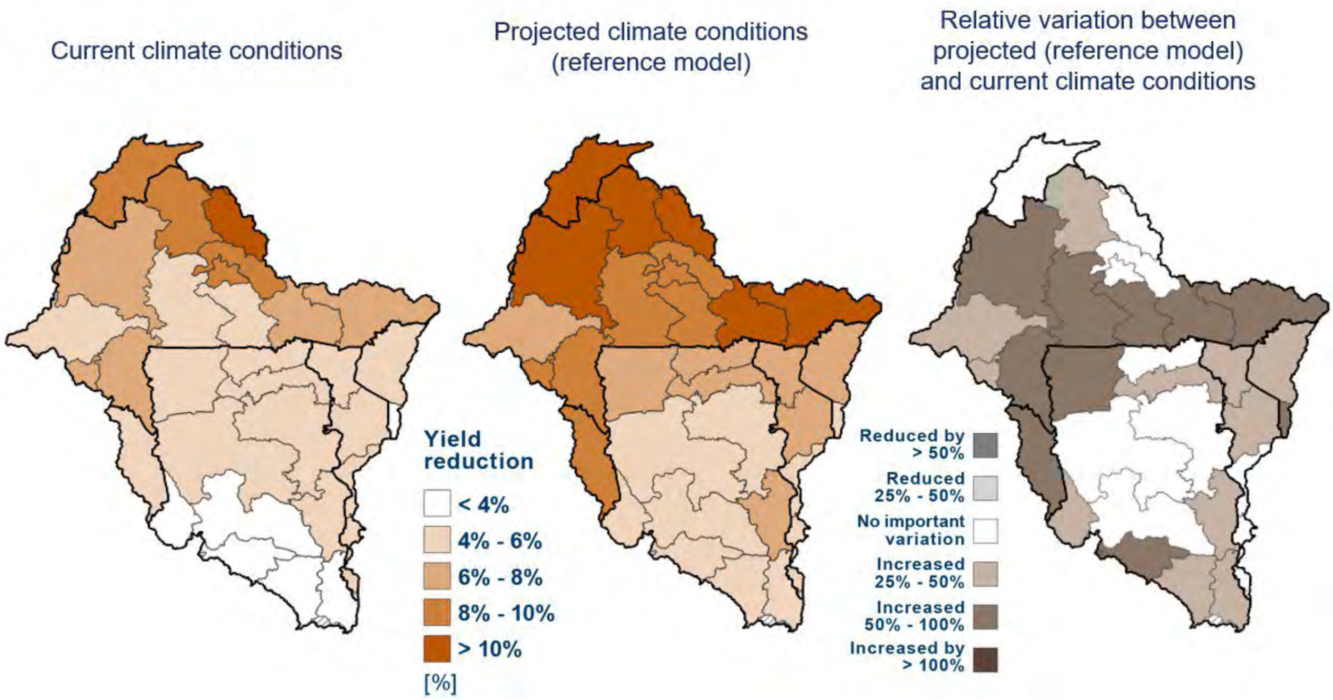
- On average, in the Volta basin, more than 4.5 million people per year are exposed to severe drought conditions in current climate
- Under projected climate conditions, this indicator increases of 66% compared to the current climate conditions, reaching on average almost 8 million people per year living in areas hit by severe drought conditions in the Volta Basin.
- If moderate population growth (UN socio-economic projections - SEP) for the population is included, the annual average amount of people living in areas hit by severe drought conditions per in the Volta basin overcomes 15 million, three times more than in current climate conditions.

- In the northern regions of the Volta Basin, more people are estimated to be exposed to impactful drought events. This is mainly because of the higher frequency of such events, which shows a clear gradient from south to north and is linked to aridity patterns.

- Densely populated regions in Burkina Faso (such the Centre region, which contains the capital city Ouagadougou) are characterised by a high population exposure to impactful droughts.



Annual Average Crop Yield Loss



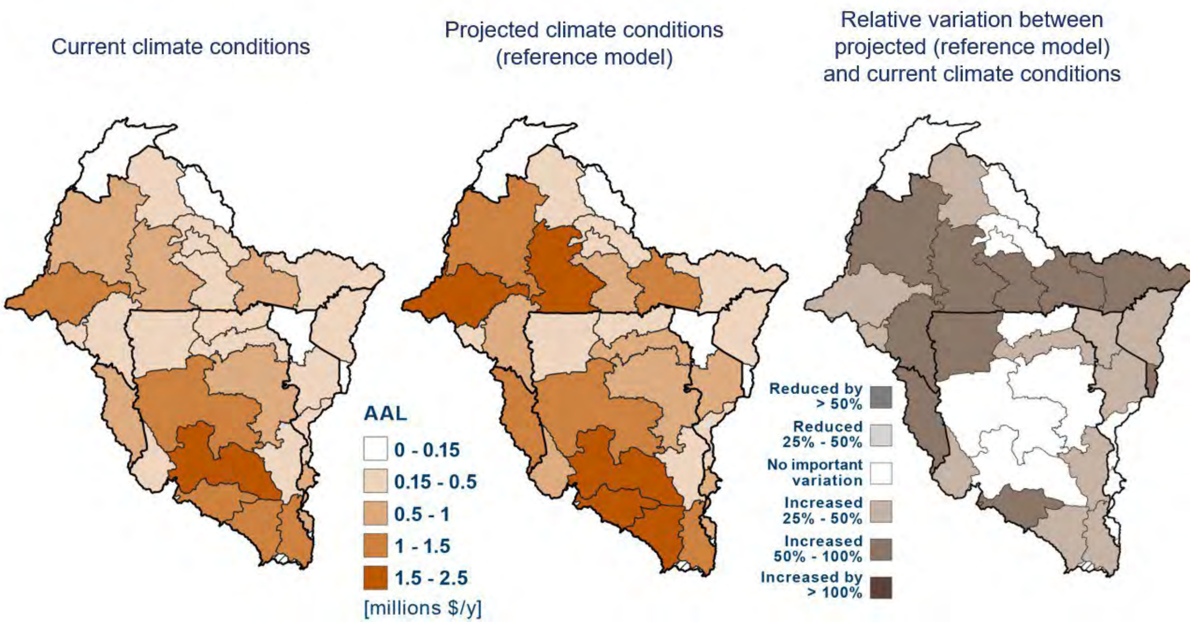
KEY MESSAGES

- It is evident that, under the current climate conditions, the drought-induced agricultural yield losses are estimated to be the highest in the northern regions of the Volta Basin, especially Mali and Burkina Faso. Under current climate conditions, the highest average annual yield loss (about 10% reduction) can be found around the Centre-Nord of Burkina Faso.

- Under projected future climate conditions, the contrast between north and south of the Volta Basin is estimated to augment. Most regions in Burkina Faso are estimated to face annual average reductions of over 8% while the north of Ghana, Togo and Benin elevate to 6%. In Côte d'Ivoire, a strong relative increase (+50%) in drought induced annual average maize yield loss is expected.

Dryland areas are more sensitive to droughts given the fragile balance between water supply (rainfall) and demand to sustain agricultural production: for example, while in Mopti (Mali), a –15% yield loss occurs on average once every 4 years, this same reduction occurs on average once every 16 years in Oti (Ghana).

Crop production loss

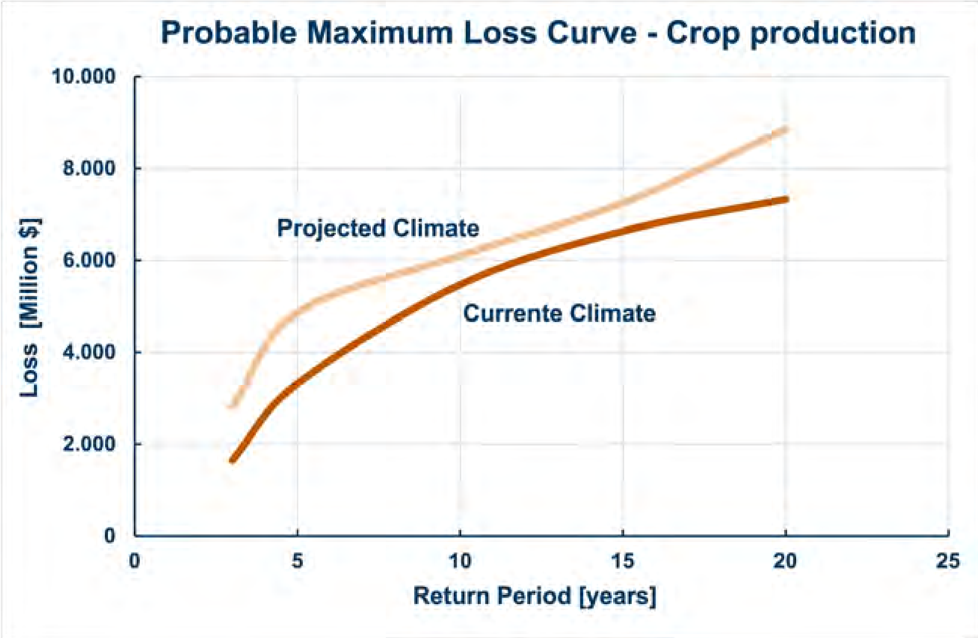


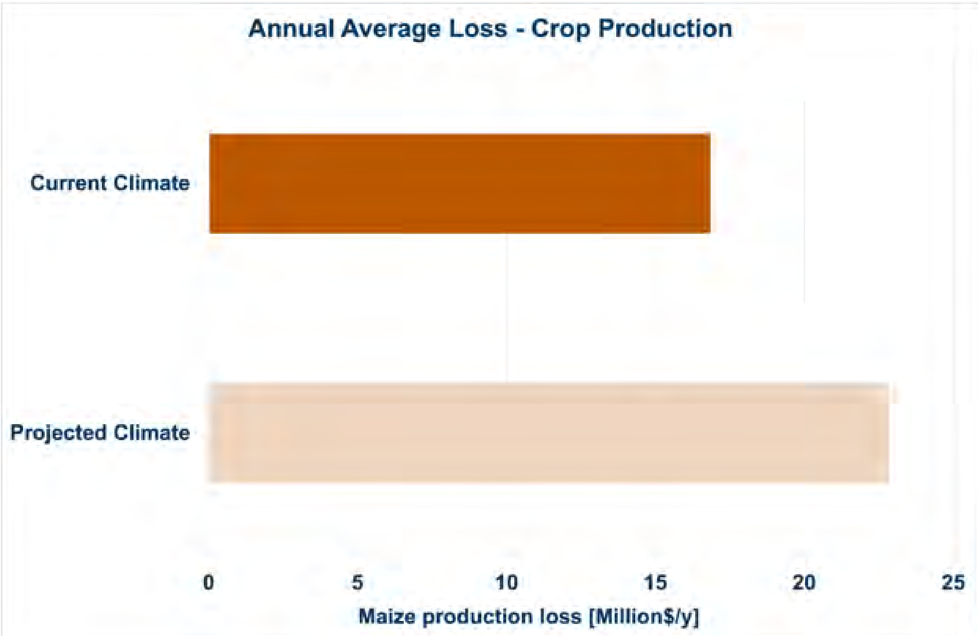
Key messages

- Converting the relative maize yield losses into absolute monetary terms (using fixed maize prices per country, not accounting for any other price effects), we see that the regions with high monetary losses are often regions with a very high agricultural maize output (high average yields, large area used for cropland; e.g., centre of Ghana: Bono East, Eastern, Ashanti), or regions where relatively frequent drought conditions are expected, combined with considerable maize production (e.g., western part of Burkina Faso: Hauts-Bassins, Centre-Ouest, Boucle du Mouhoun).

- The largest increases (+60%) in AAL under projected climate conditions are expected in Zanzan (Côte d'Ivoire), Upper West, Ahafo (Ghana), and Centre-Ouest, Centre-Sud (Burkina Faso).

- From the PML graph we see that on average once every 10 years, losses related to maize production in the Volta basin can amount to USD 5.5 Billion. Towards the future (projected climate conditions), increases in PML are estimated, notably in the frequent 1/3- and 1/5-year events (+70% and +45% respectively).

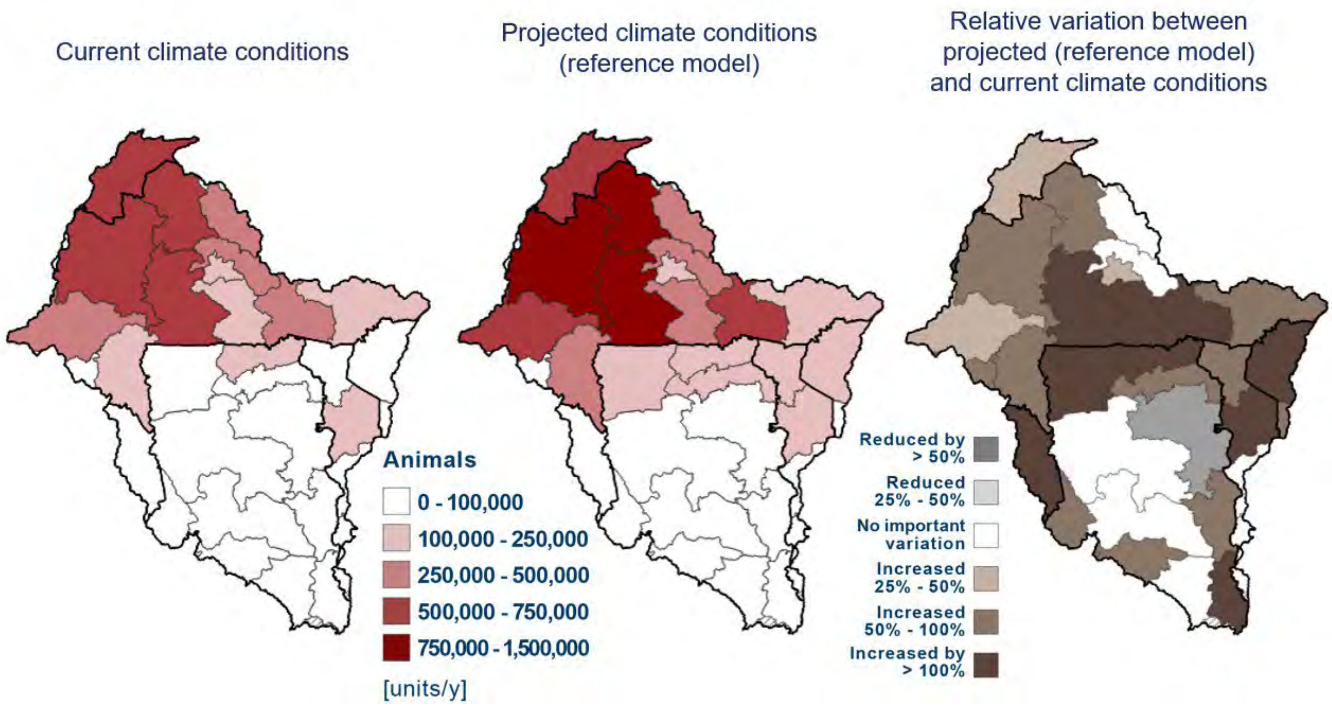




- In the Volta basin, drought-induced maize production losses cause an annual average loss of almost USD 17 million. This is expected to increase (+36%) to almost USD 23 million due to projected climate conditions.

- Burkina Faso is estimated to have the highest losses per hectare (on average 30-55 USD/ha per year); Sikasso (Mali) has an average annual loss 35 USD/ha per year. Plateaux (Togo) has the largest area under cropland, has a large yield reduction (more than 12 k-tonnes maize losses) but this region only falls partly in the Volta Basin.

Livestock likely to be affected



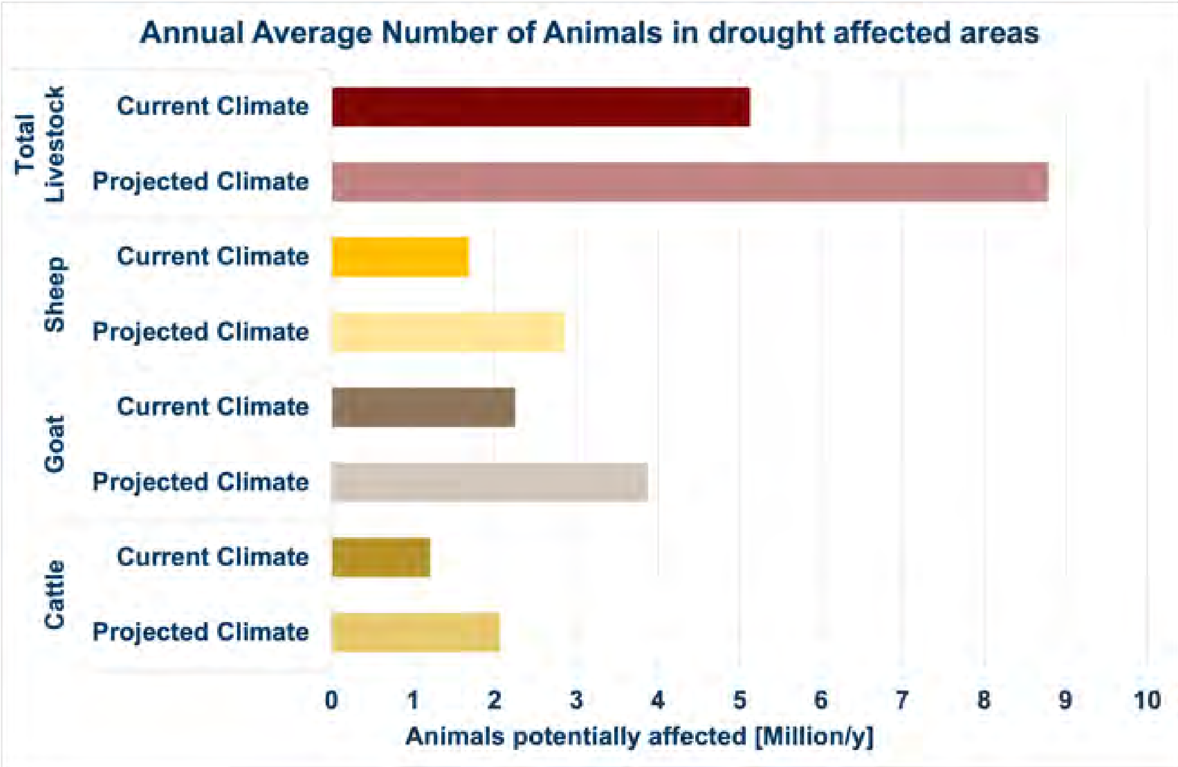
KEY MESSAGES

- On average, more than 5 million animals (cattle and small ruminants only) are exposed per year to severe drought conditions in the Volta Basin.

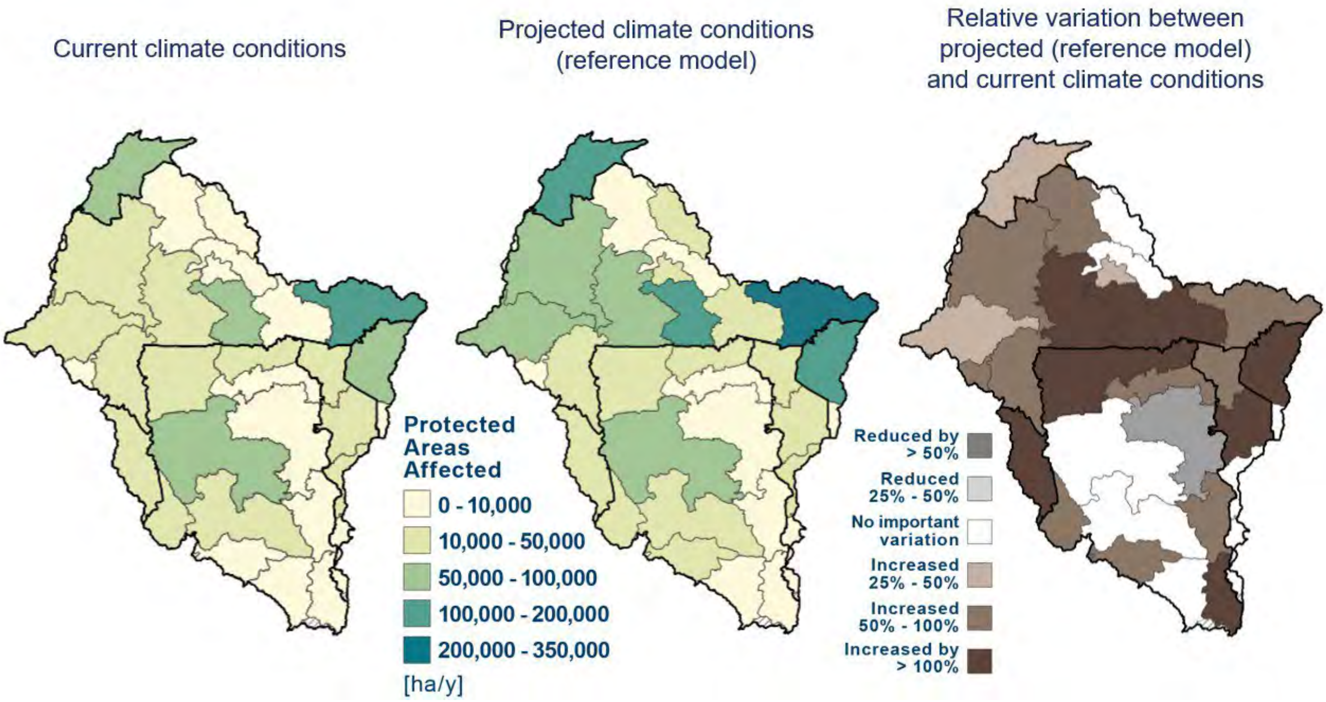
- Under projected climate conditions, on average almost 9 million animals per year are living in areas hit by severe drought conditions in the Volta Basin. This is an increase of 71% compared to the current situation and excludes changes in livestock populations.

- In both current and projected climate conditions it is evident that in the northern regions of the Volta Basin, more cattle, goats, and sheep are estimated to be yearly exposed to impactful drought events. This is mainly because of the higher frequency of such events, which shows a clear gradient from south to north and is linked to aridity patterns.

- Looking into the livestock exposed under projected climate conditions, the contrast between north and south is estimated to be augmented. An increase in the frequency of impactful droughts is projected in all of the Volta basin, but varies between regions and within the countries.

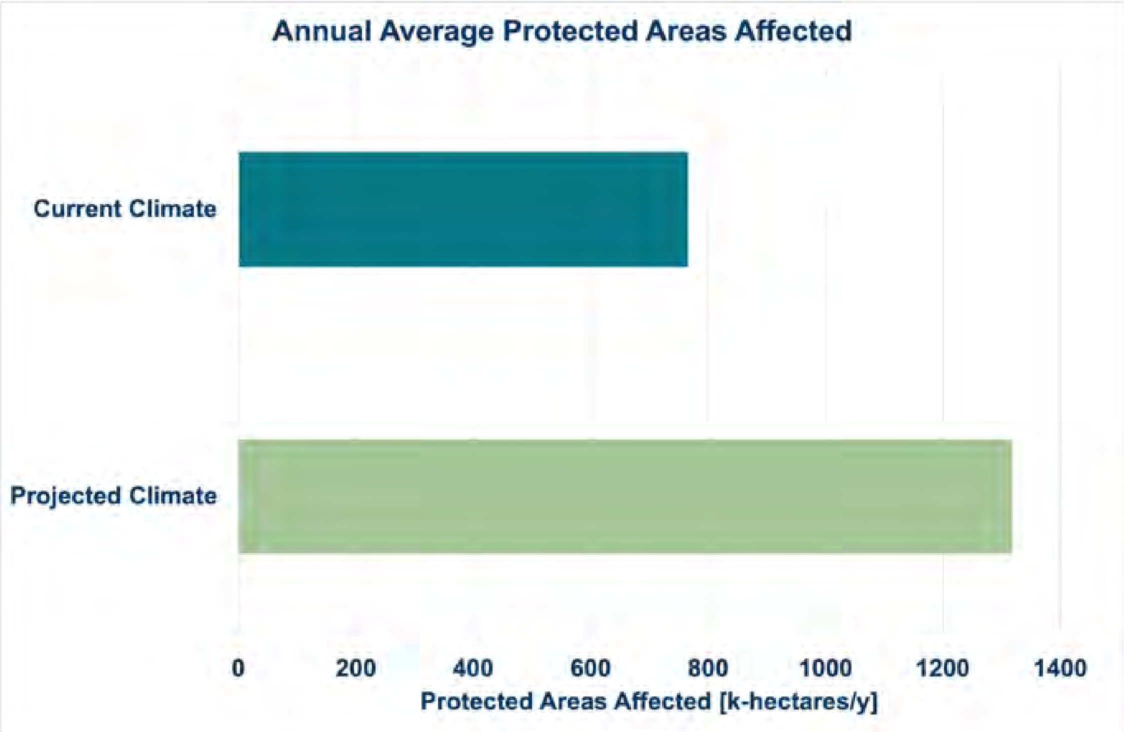


Protected areas likely to be affected



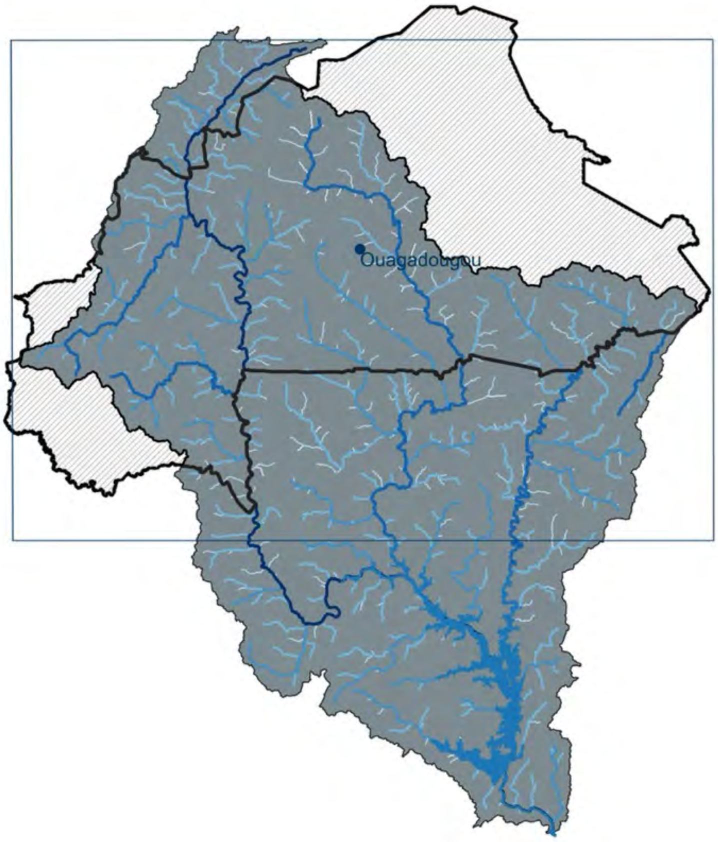
KEY MESSAGES

- On average, more than 750,000 hectares of protected nature area are exposed per year to severe drought conditions in the Volta Basin.
- Under projected future climate conditions, on average more than 1,300,000 hectares of protected area per year are hit by severe drought conditions in the Volta Basin. This is an increase of 72% compared to the current situation and excludes potential changes in areas under protection.
- In the Eastern regions of the Volta Basin, more protected fauna and flora are estimated to be exposed to impactful drought events. The Est province in Burkina Faso and Atacora in Benin have large amounts of protected area and have a high frequency of severe drought events.


Annual Average Protected Areas Affected
Current Climate
Projected Climate
0
200
400
600
800
1000
1200
1400
Protected Areas Affected [k-hectares/y]

Burkina Faso's results

Floods



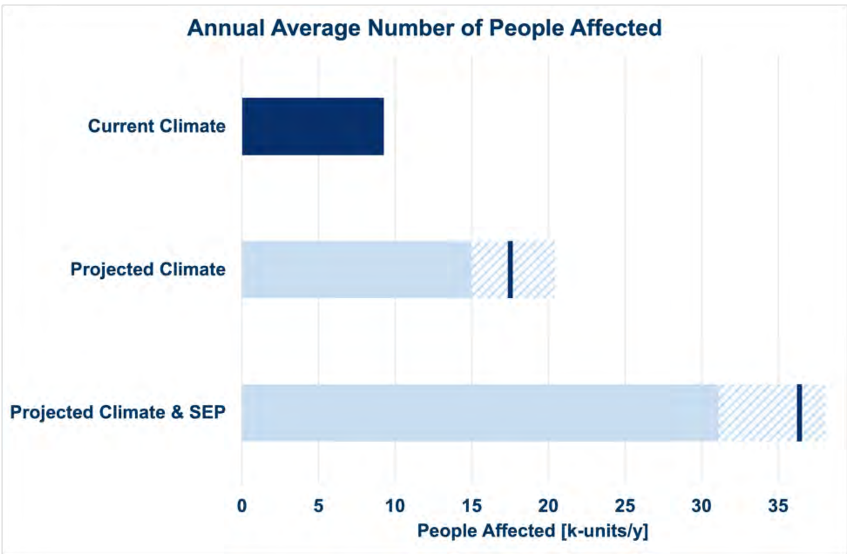
KEY MESSAGES

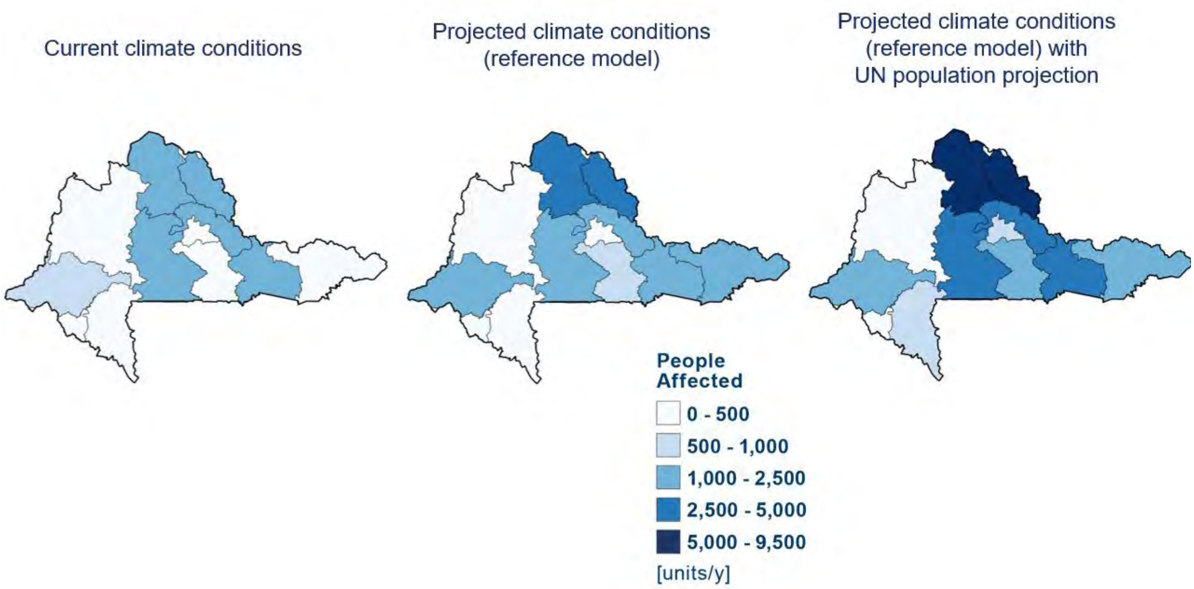
- Only the regions of Burkina Faso within the Volta basin are included in the risk profile.
- The distribution of impacts among the regions is different according to the various indicators; this is mainly due to a different distribution of assets, and their vulnerability to floods.
- In terms of population, almost 10 000 people are affected in current climate conditions, corresponding to more than 30% of overall affected people in the basin.
- Economic losses to the built-up area are almost exclusively concentrated to the residential sector.
- Considering the reference model in projected climate conditions, impacts are expected to increase significantly (between 40% and 100%), with the exception

of point critical infrastructures (education and health facilities), showing only a limited increase.

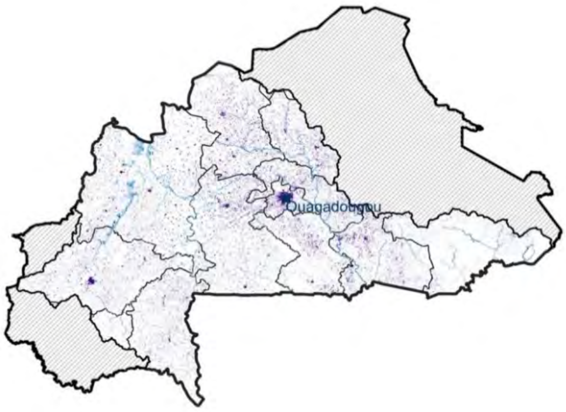
Population

** Context map showing population distribution (WorldPop Unadj 2020 constrained + quantitative information from the National Institute of Statistics and Demography) overlaying on a reference hazard map (1000 years).*

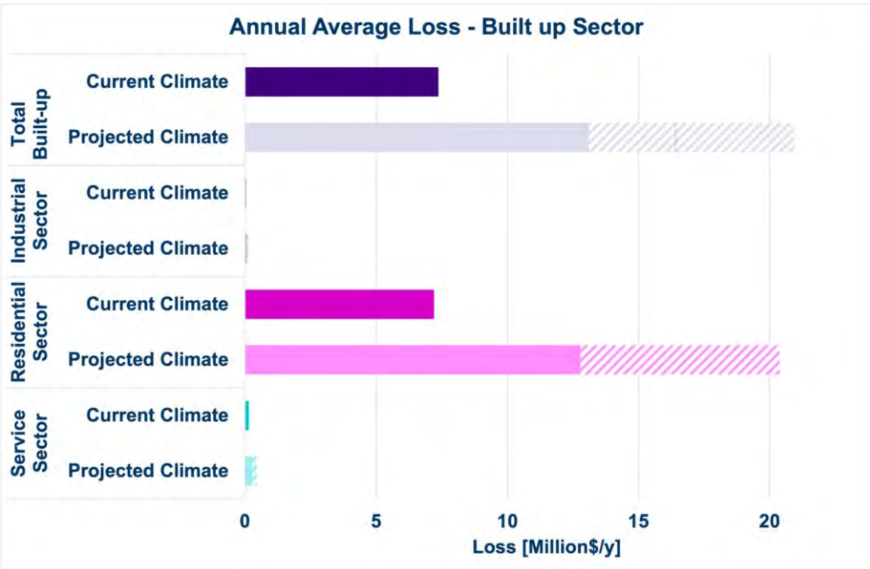


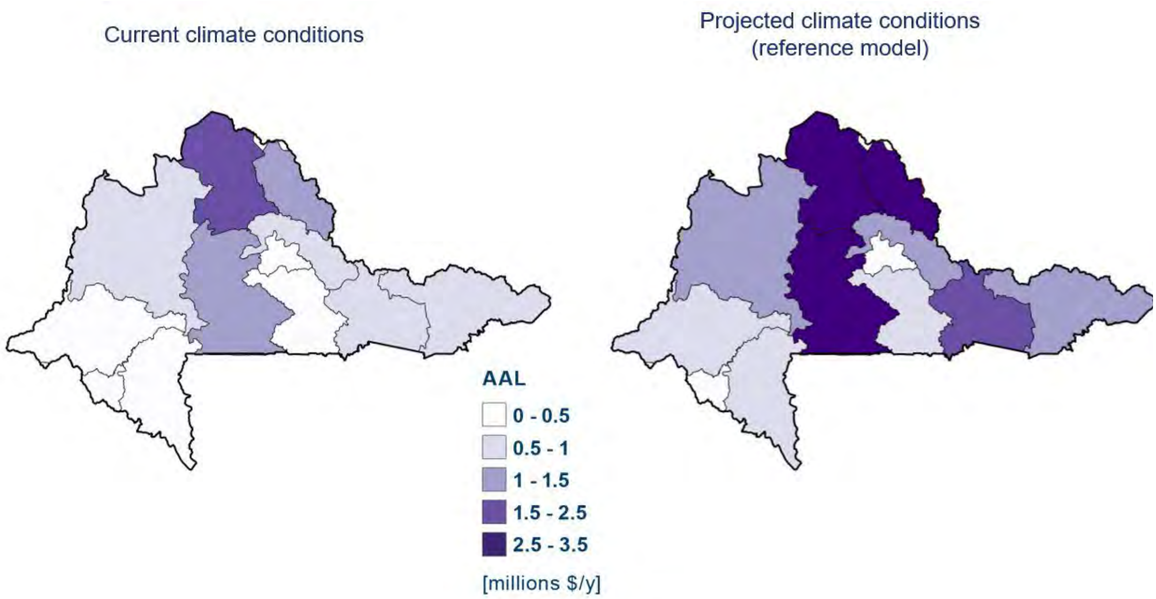


Built-up

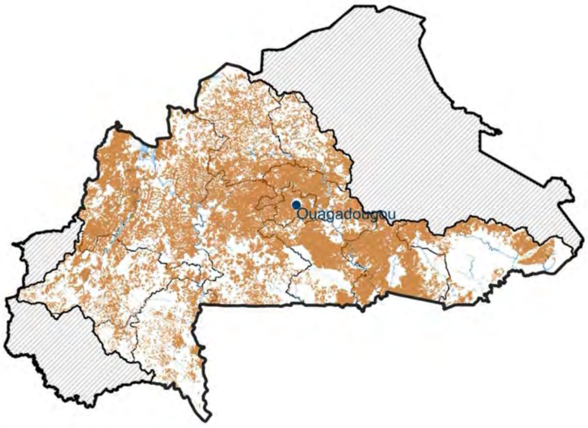


** Context map showing the distribution of the built-up area (from Land Cover data and populated areas according to WorldPop Unadj 2020 constrained) overlaying on a reference hazard map (1000 years).*

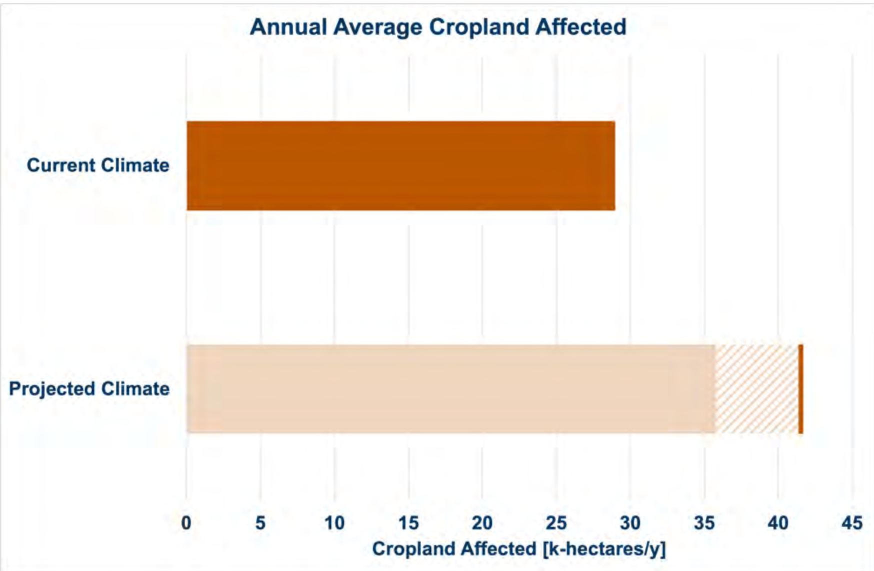


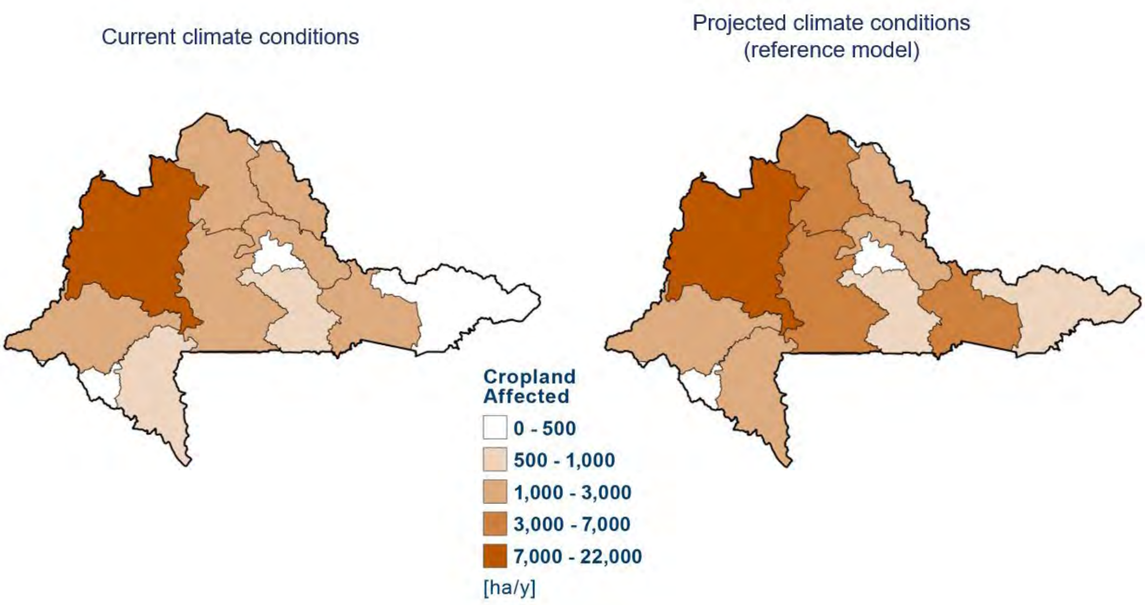


Cropland

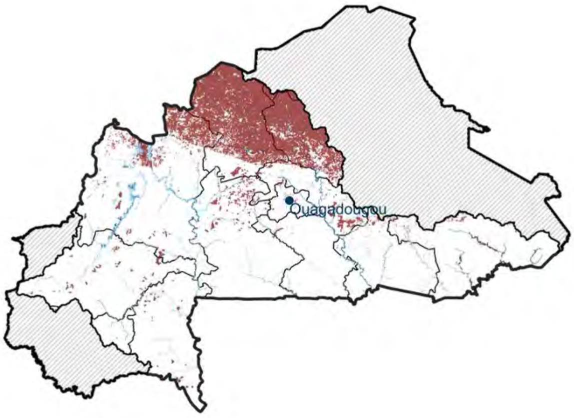


** Context map showing the distribution of cropland areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).*

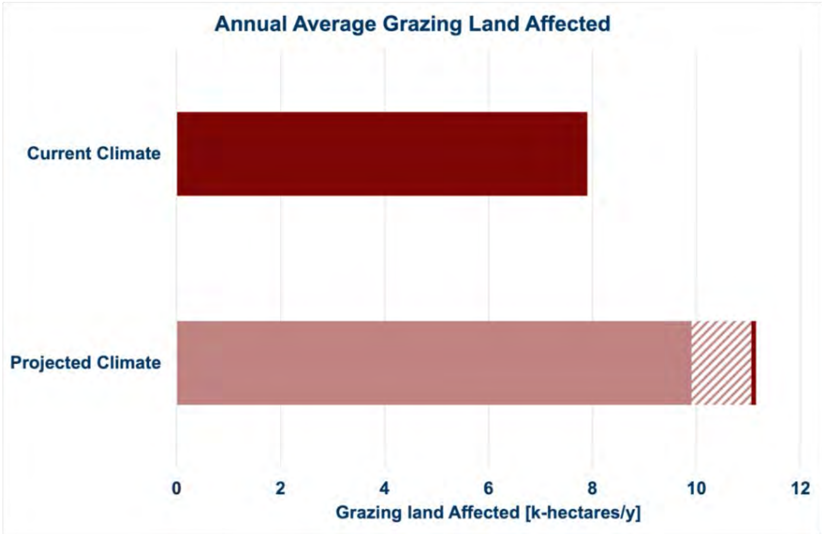


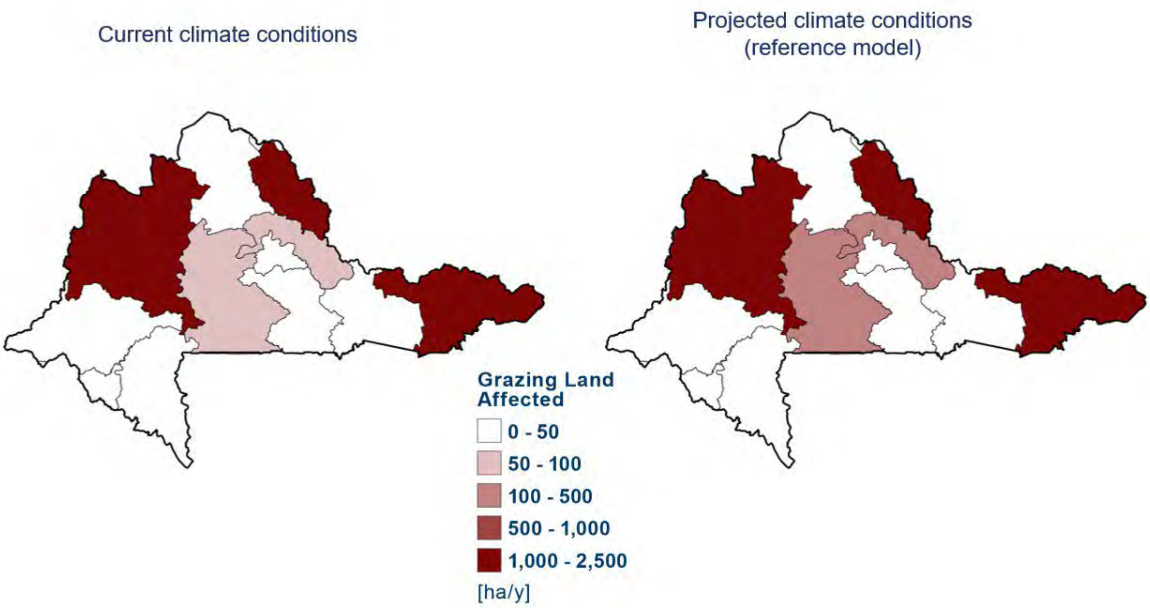


Grazing land



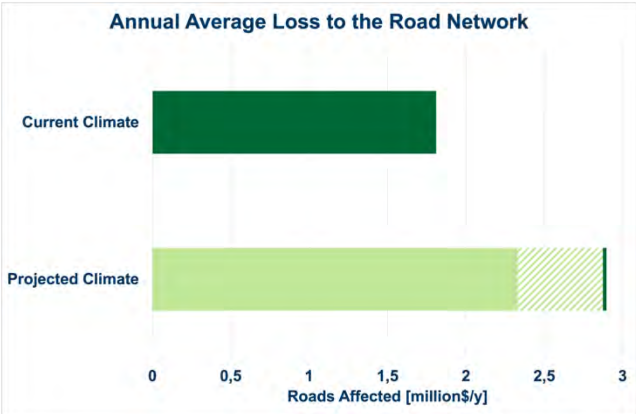
** Context map showing the distribution of grazing land areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).*

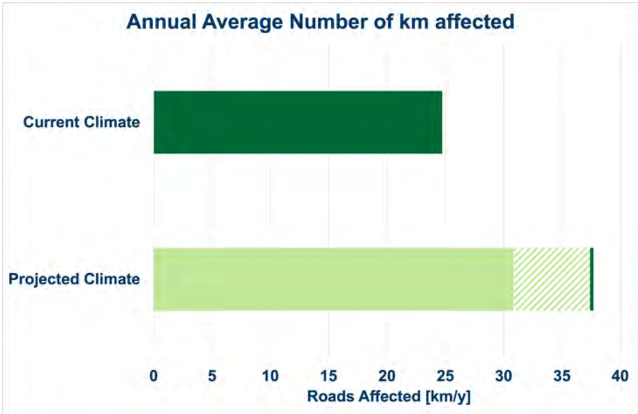


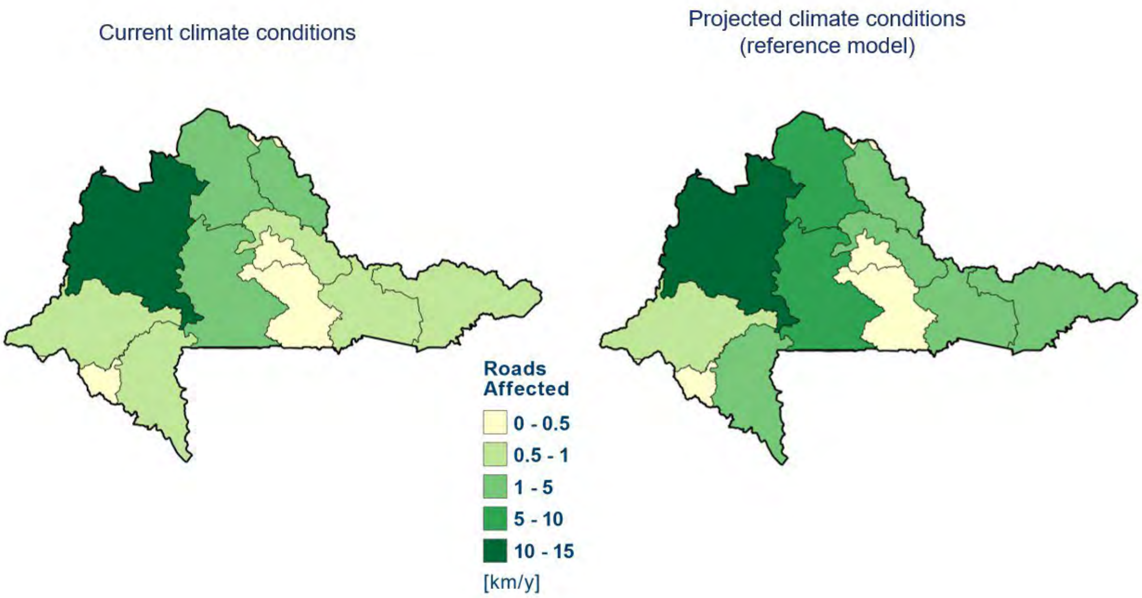


Roads network

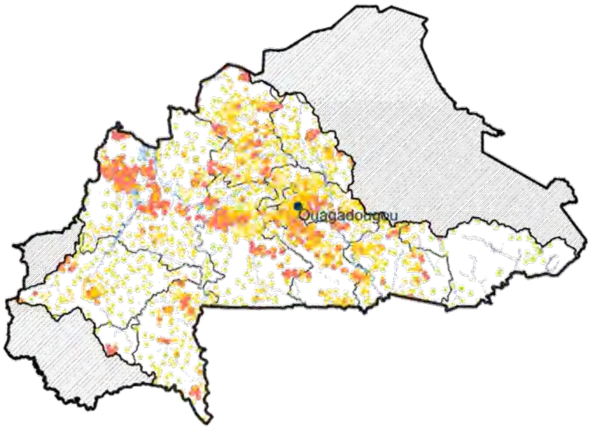
** Context map showing the location of roads network (from data provided by the National Geographic Institute of Burkina Faso) overlaying on a reference hazard map (1000 years).*

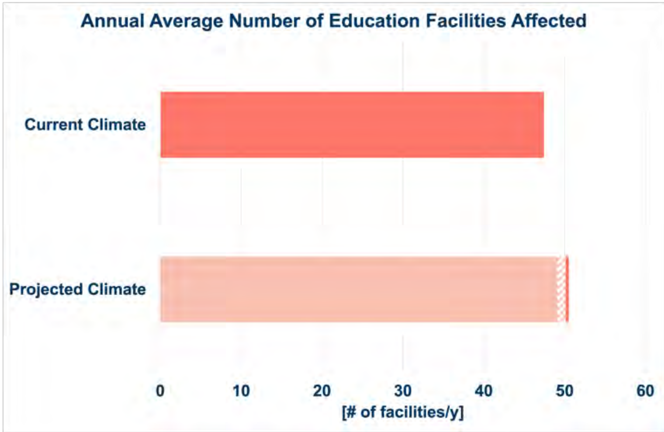


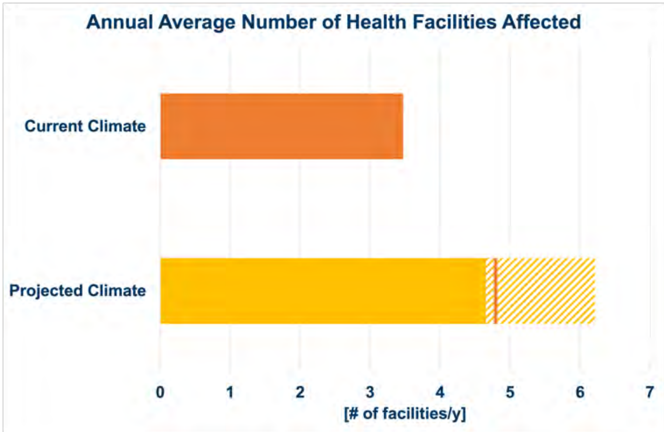




Critical facilities

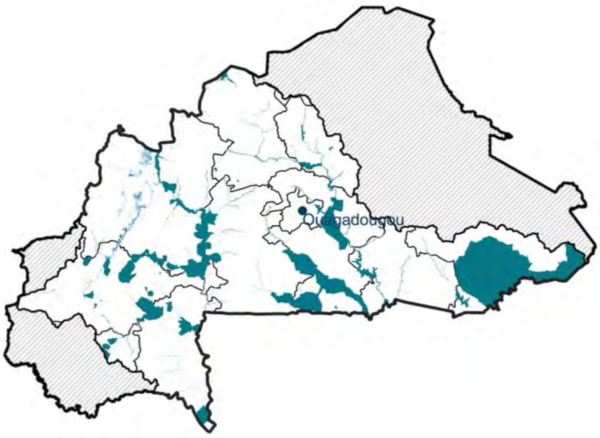


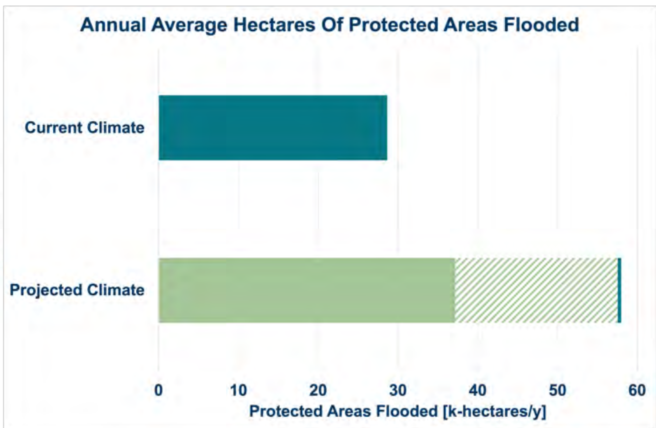




** Context map showing the location of education and health facilities (from OpenStreetMap data) overlaying on a reference hazard map (1000 years).*

Protected areas





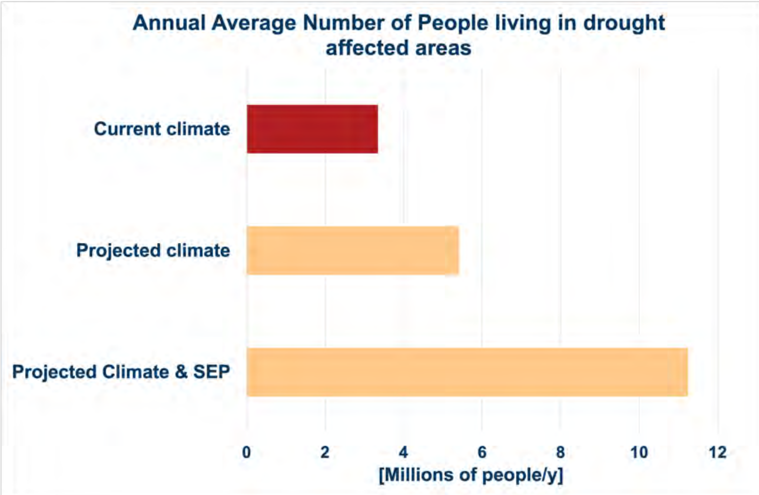
** Context map showing the distribution of protected areas (from the IUCN database) overlaying on a reference hazard map (1000 years).*

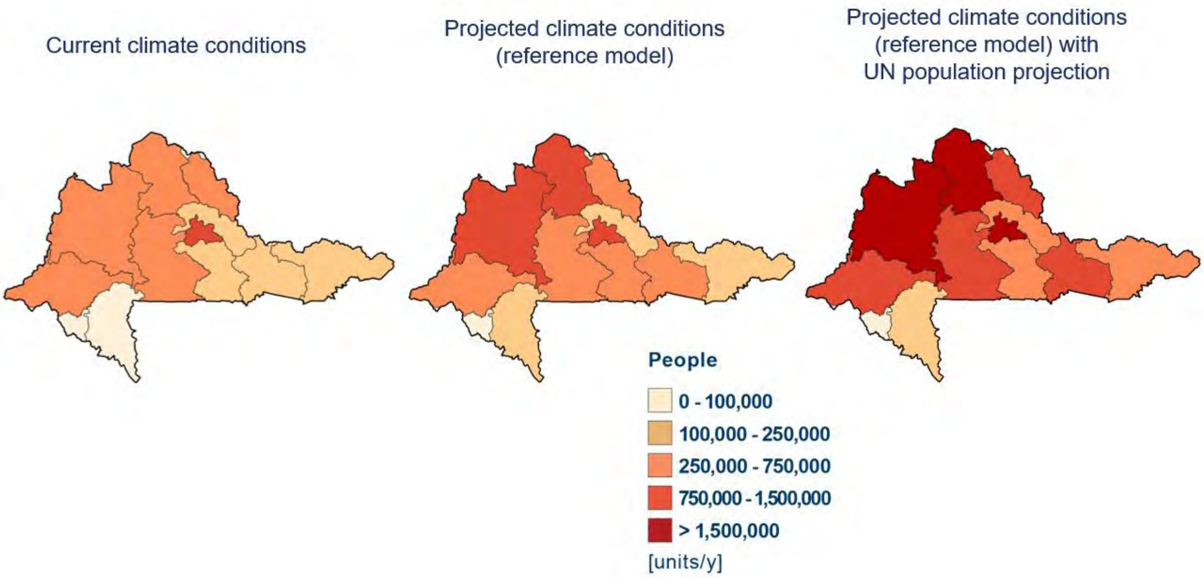
Drought

KEY MESSAGES

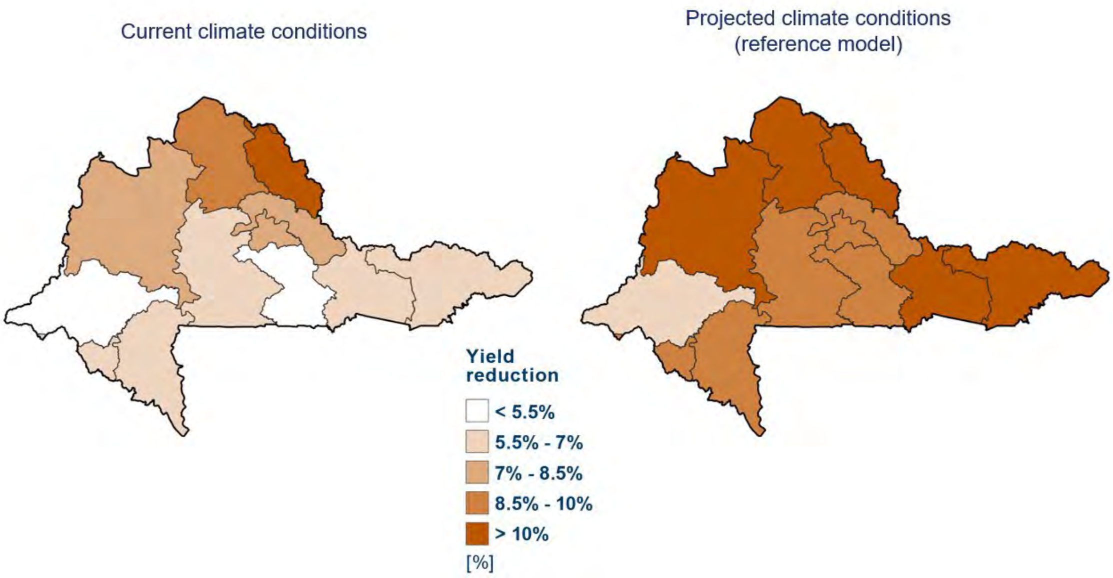
- In the part of Burkina Faso situated in the Volta Basin, on average 3.4 millions of people and 3.8 millions of animals are exposed to droughts per year.
- Climate change projections will increase these numbers with 62% and 72% respectively (excluding changes in population and livestock).
- The Centre region has the highest value of average annual people living in areas affected by severe drought.
- Nord is the region with most animals exposed in the Volta Basin. Goats are the animal type mostly exposed to severe droughts, both under current and projected climate conditions.
- In the part of Burkina Faso situated in the Volta Basin, on average more than 5.4 millions USD per year is lost due to drought-induced maize yield reductions.
- Among the regions of Burkina Faso in the Volta Basin, Hauts-Bassins (a region with a high maize yield under normal conditions) and Centre-Ouest experiences the highest economic losses under current conditions.
- Centre Nord and Sahel experience high annual average yield reductions but have a low average yield in normal years, and, in the case of Sahel, not a lot of hectares under agricultural production.
- The highest increase in drought-induced losses under projected climate conditions is expected in Centre-Ouest (+66%), Centre-Sud (+62%) and Sud-Ouest (+60%).

Population

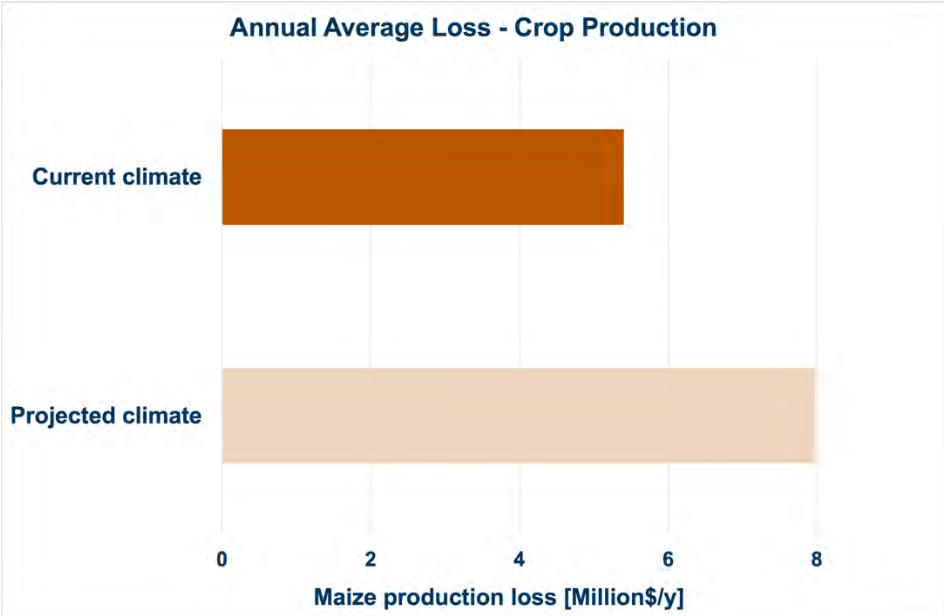


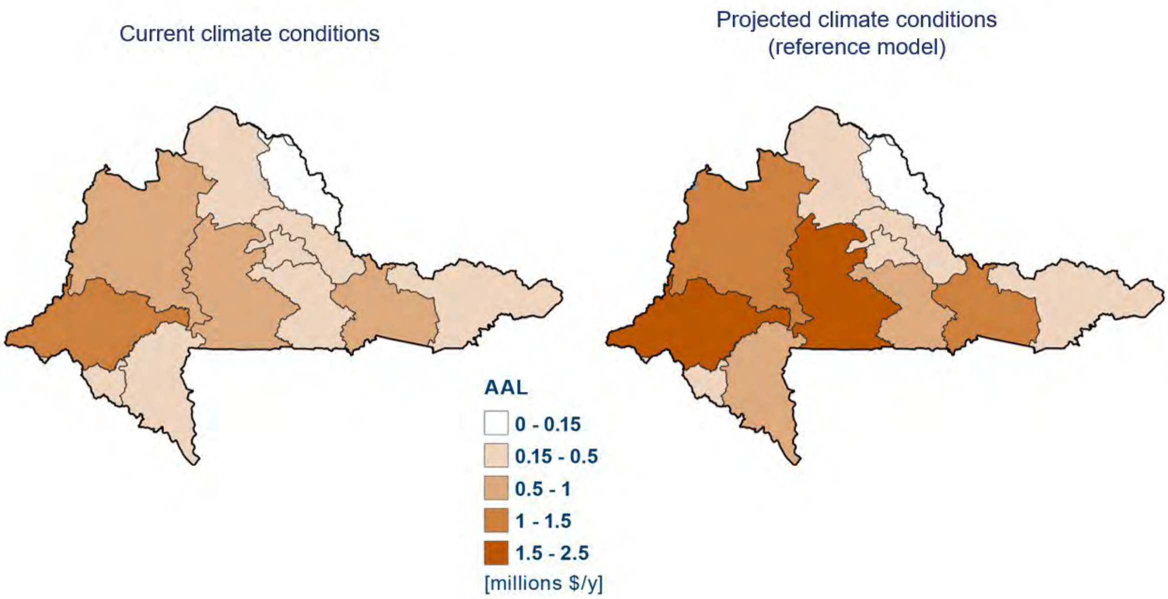


Crop Yield

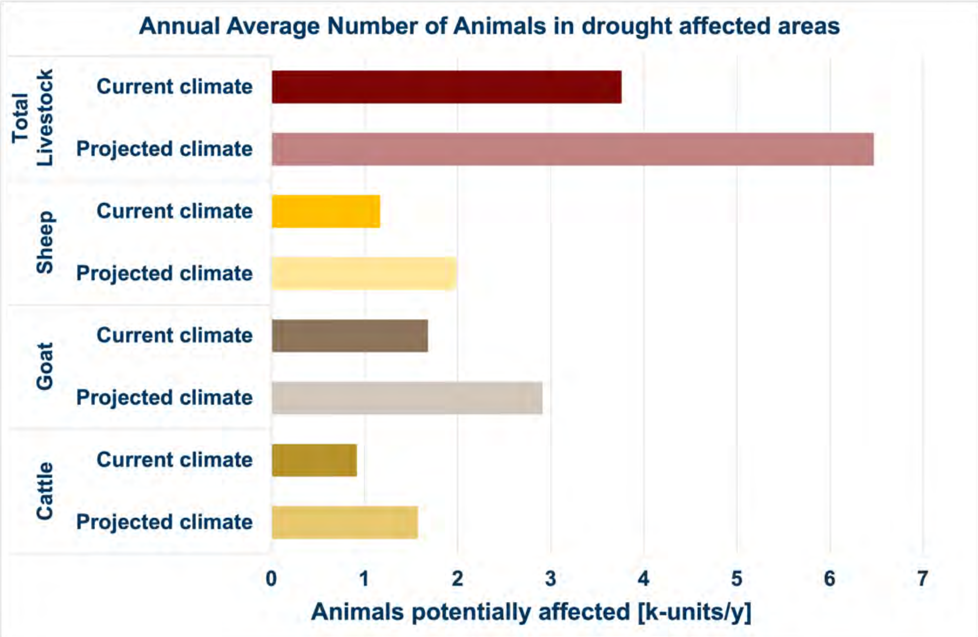


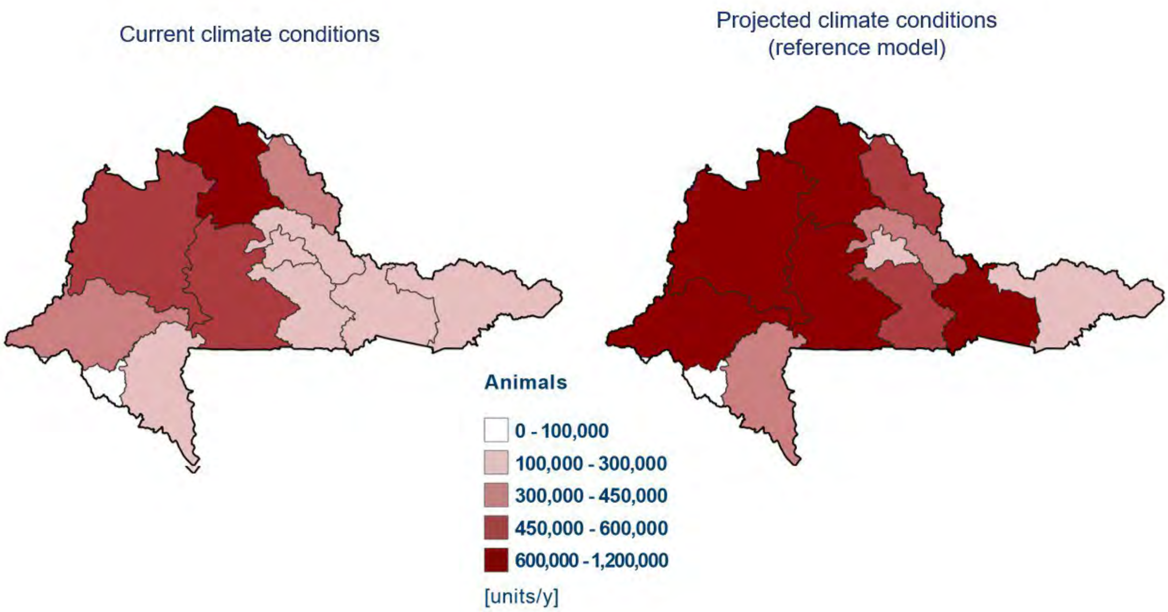
Crop production



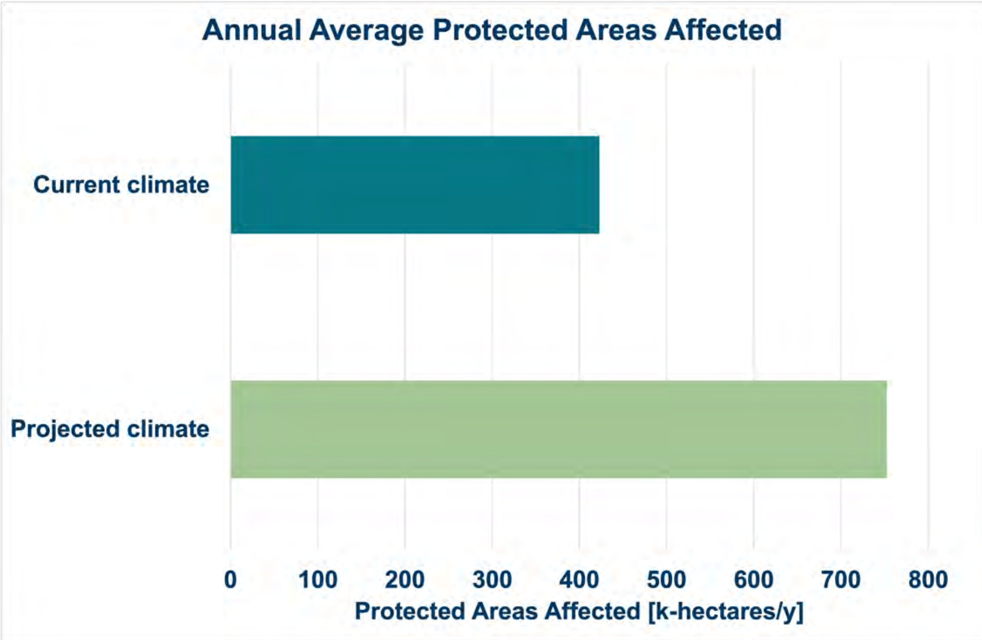


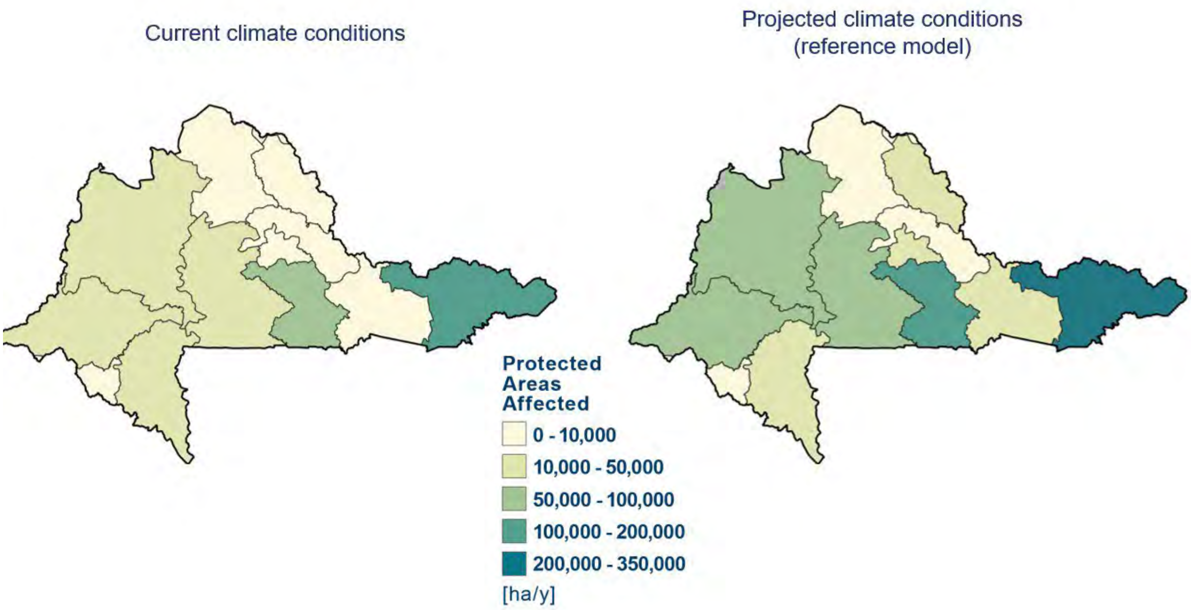
Livestock


Annual Average Number of Animals in drought affected areas
Total Livestock
Current climate
Projected climate
Sheep
Current climate
Projected climate
Goat
Current climate
Projected climate
Cattle
Current climate
Projected climate
0
1
2
3
4
5
6
7
Animals potentially affected [k-units/y]


Current climate conditions
Projected climate conditions
(reference model)
Animals
0 - 100,000
100,000 - 300,000
300,000 - 450,000
450,000 - 600,000
600,000 - 1,200,000
[units/y]

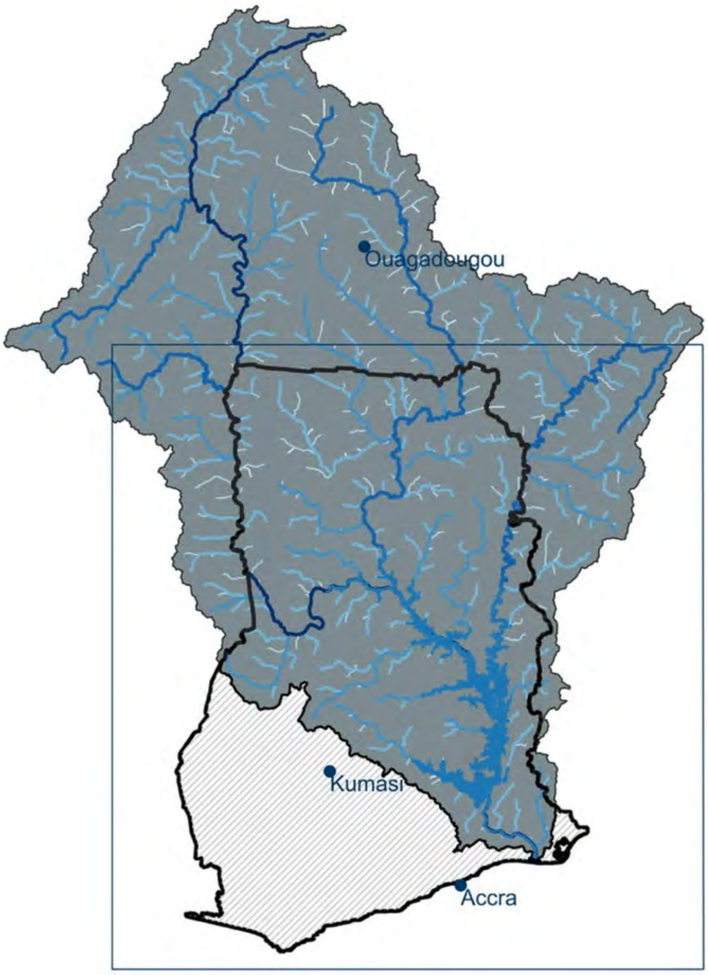
Protected areas





Ghana's results

Floods



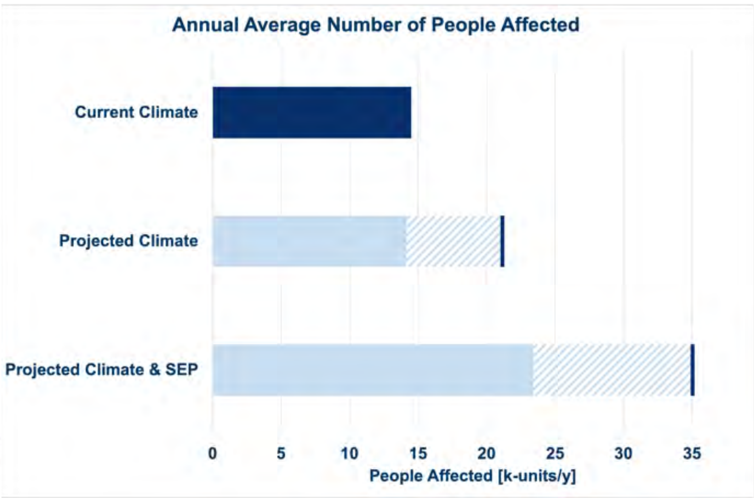
KEY MESSAGES

- Only the regions of Ghana within the Volta basin are included in the risk profiles.
- Considering the overall impacts, the most impacted regions are the one in the north-eastern part of the Country.
- In terms of population, on average about 15 thousand people are affected per year in current climate conditions, and they are more than the 50% of overall affected people in the Volta basin.
- The impacts are important – in comparison to the overall basin – also in terms of economic losses to the built-up area; the average annual loss in current

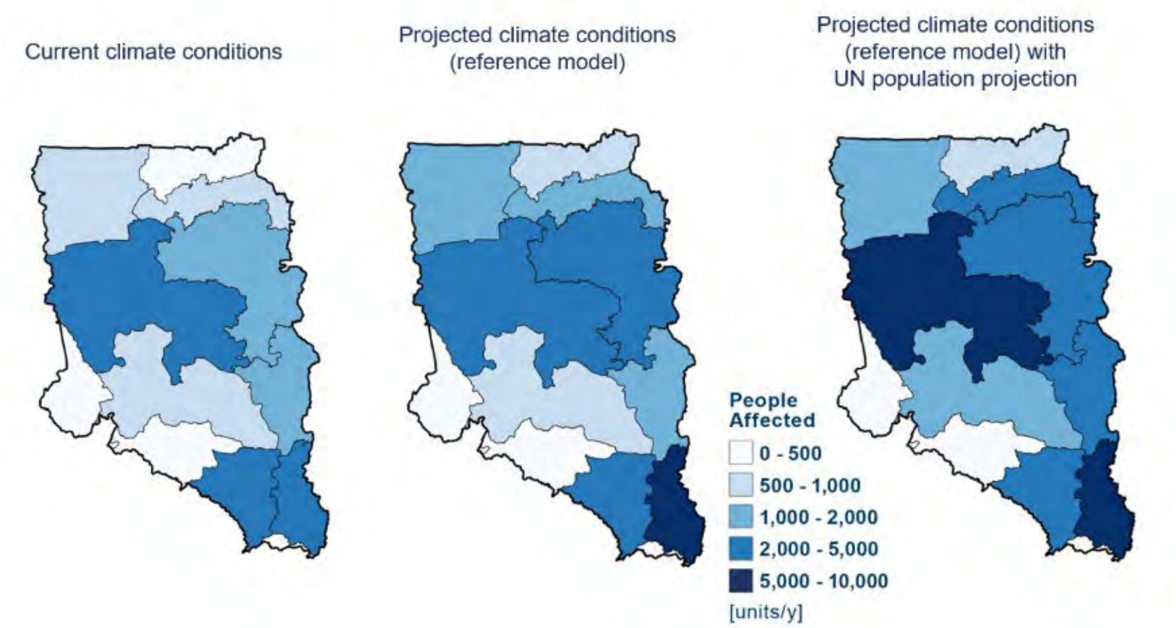
climate conditions is about USD 12.5 million for the Ghanese portion of the basin, compared to a loss of about USD 22 million for the entire Volta basin.

- Considering projected climate conditions, the overall impact increases, but with a high variability among the considered models.

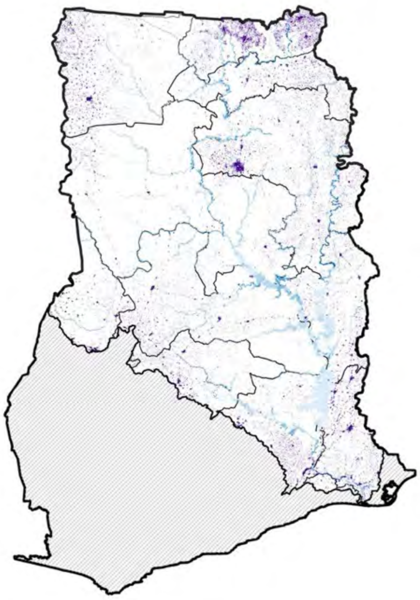
Population

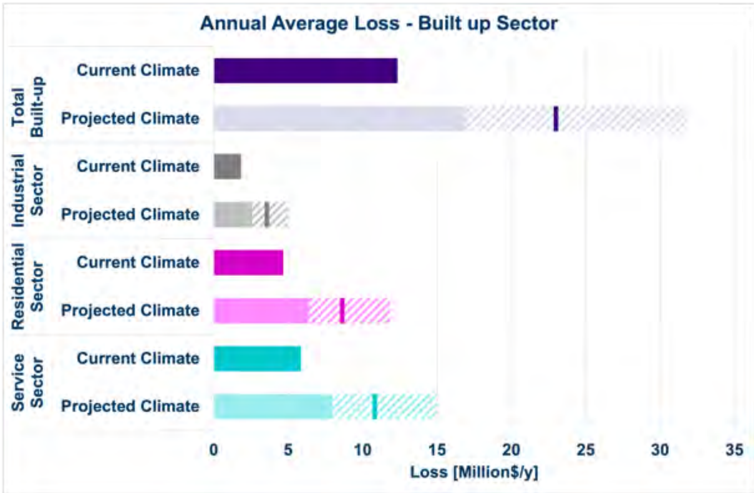


** Context map showing population distribution (WorldPop Unadj 2020 constrained + quantitative information from the Ghana Statistical Service) overlaying on a reference hazard map (1000 years).*

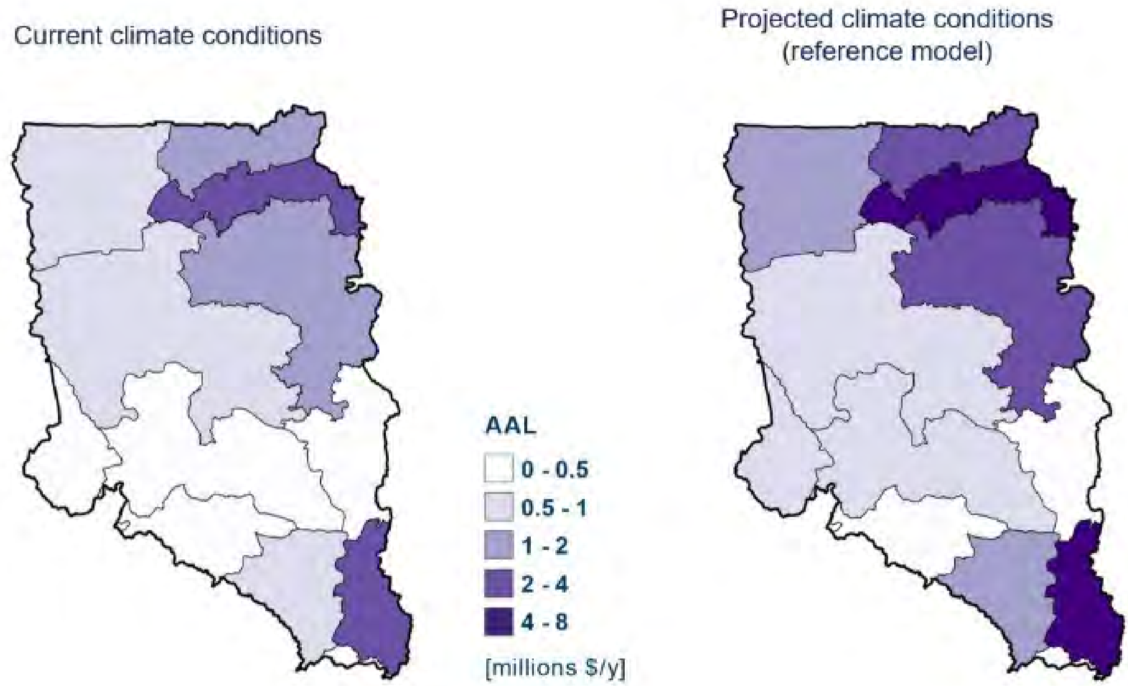


Built-up

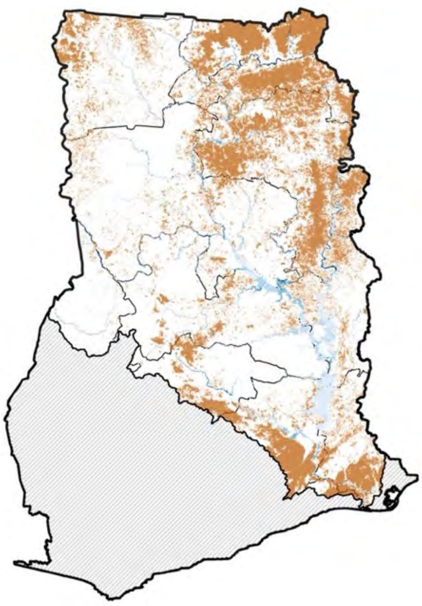


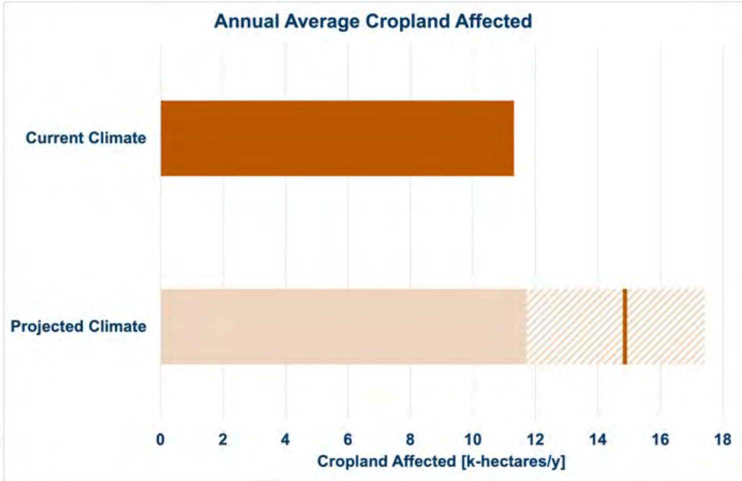


** Context map showing the distribution of the built-up area (from Land Cover data and populated areas according to WorldPop Unadj 2020 constrained) overlaying on a reference hazard map (1000 years).*

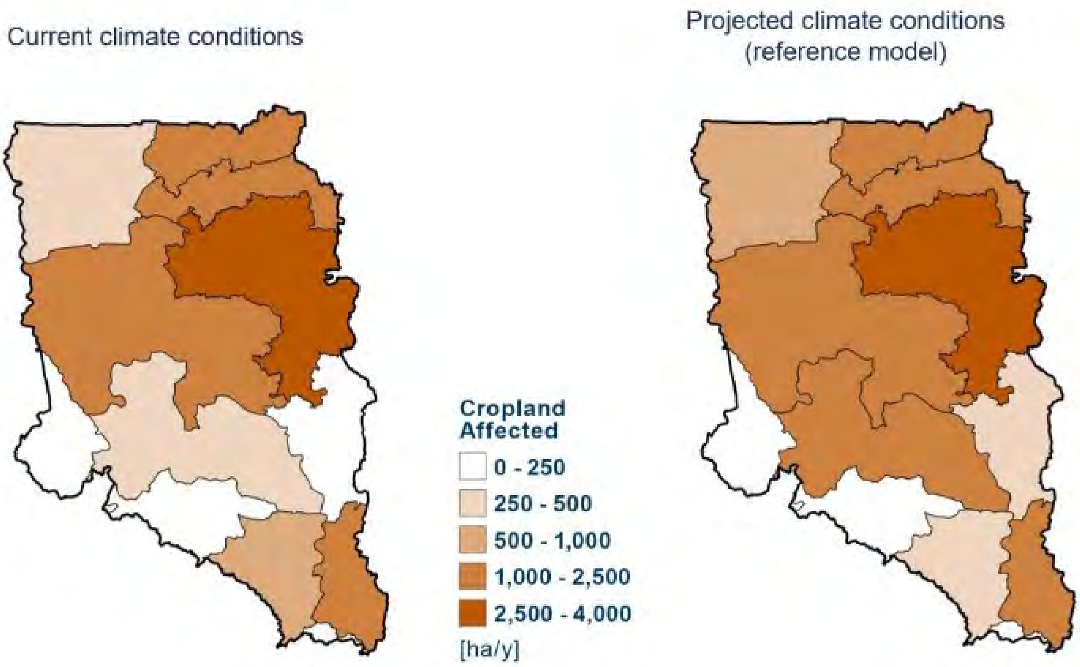


Cropland

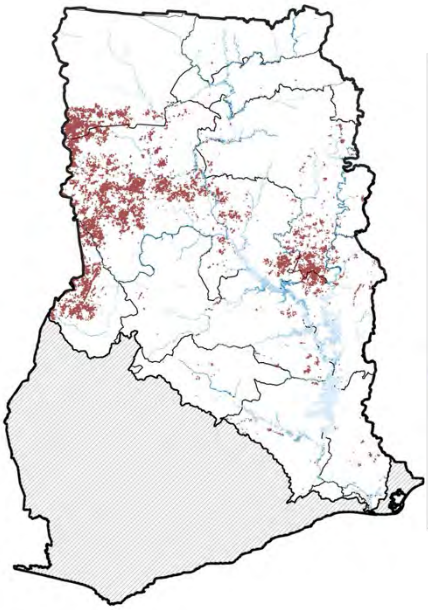


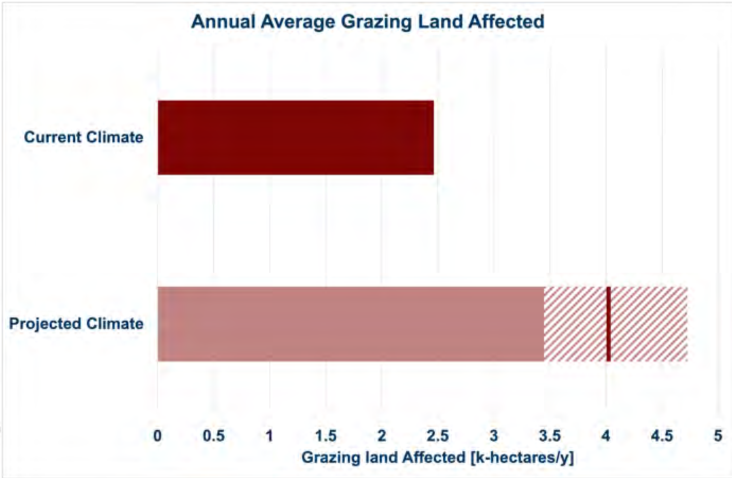


** Context map showing the distribution of cropland areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).*

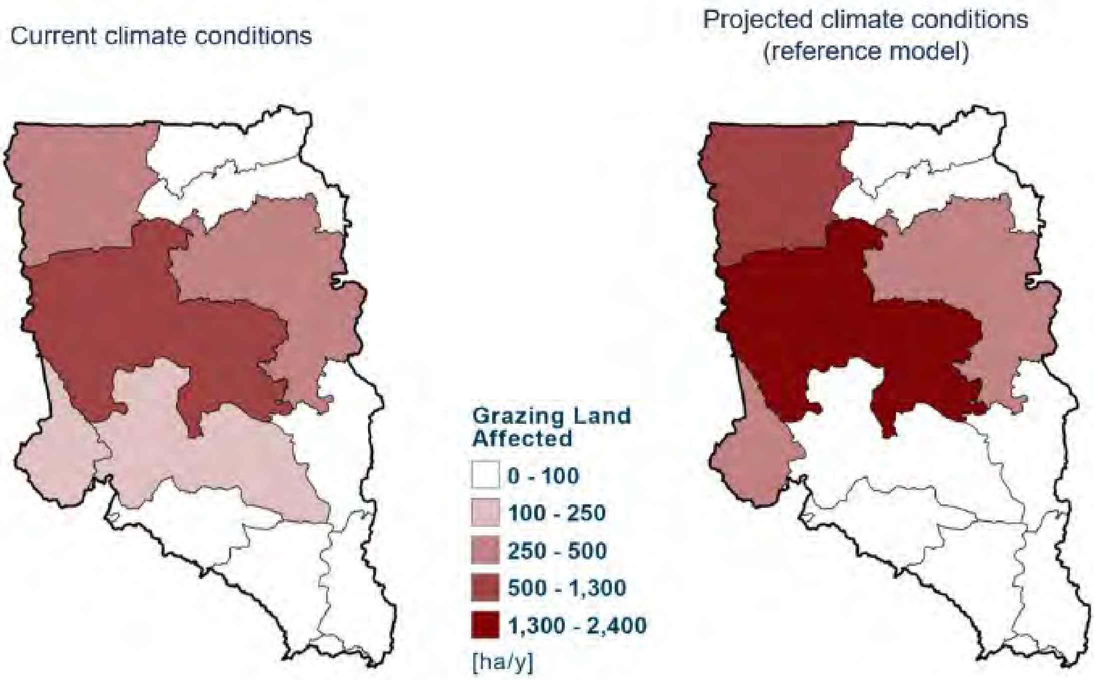


Grazing Land



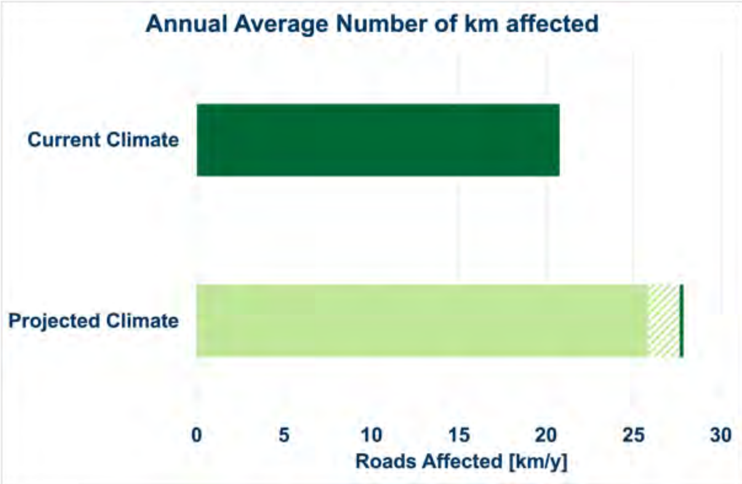


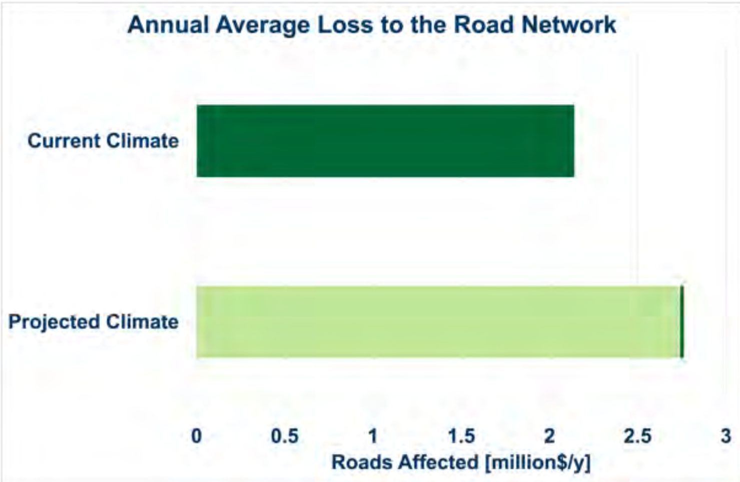
** Context map showing the distribution of grazing land areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).*



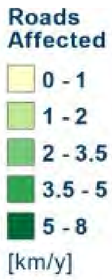
Roads Network

* *Context map showing the location of roads network (from data provided by the Ministry of Transports) overlaying on a reference hazard map (1000 years).*



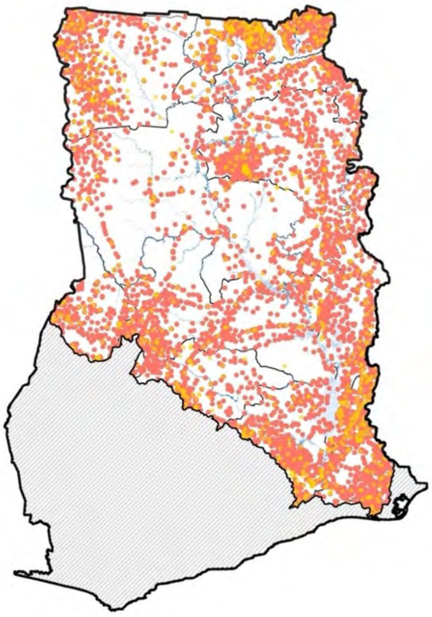


Current climate conditions

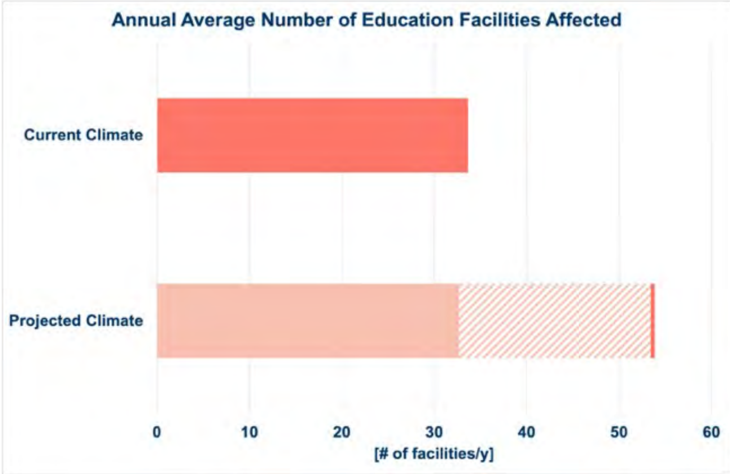


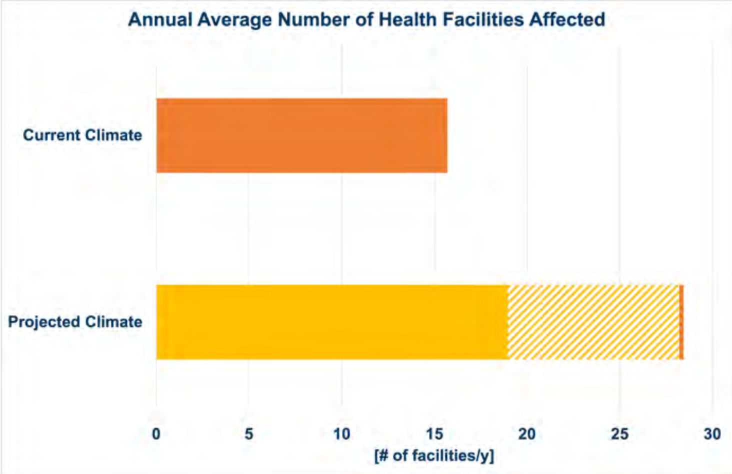
Projected climate conditions (reference model)

Critical Facilities

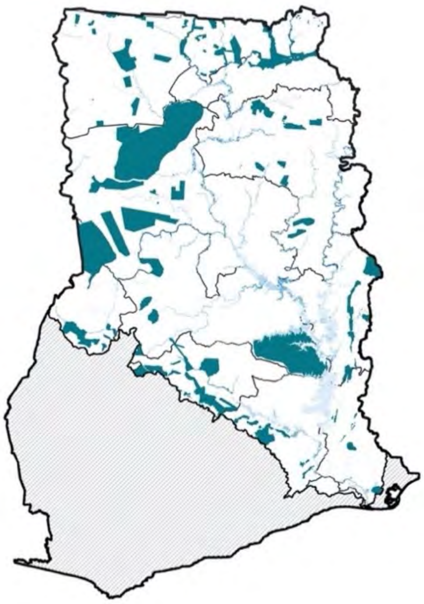


* Context map showing the location of education and health facilities (from data provided by the Ministries of Health and Education) overlaying on a reference hazard map (1000 years).

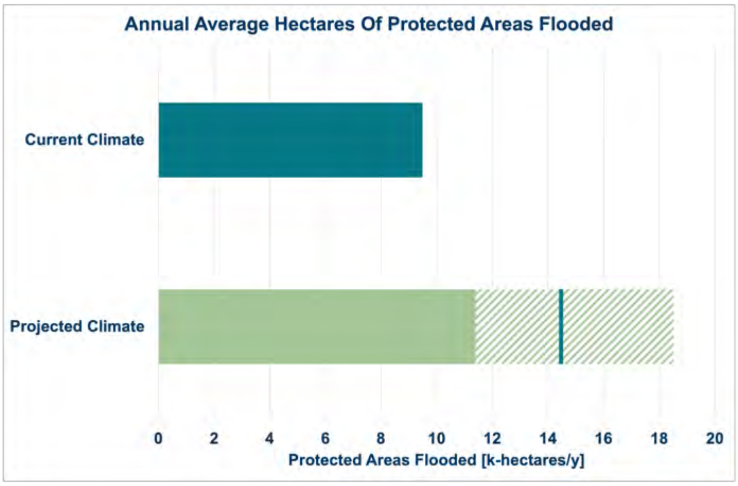




Protected Areas



* Context map showing the distribution of protected areas (from the IUCN database) overlaying on a reference hazard map (1000 years).

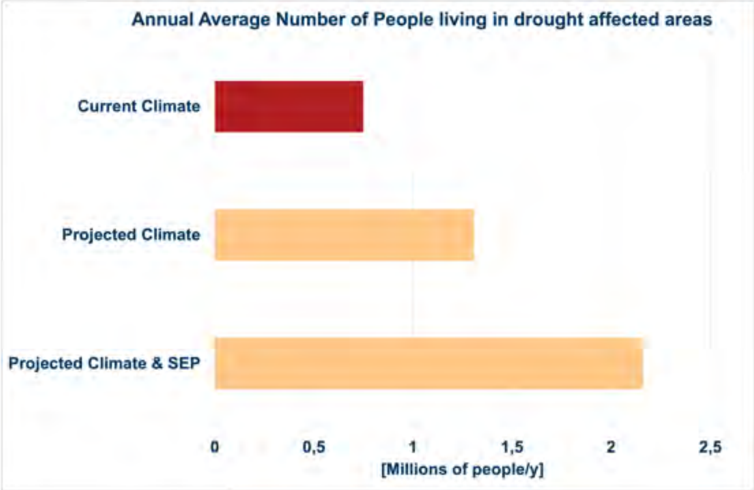


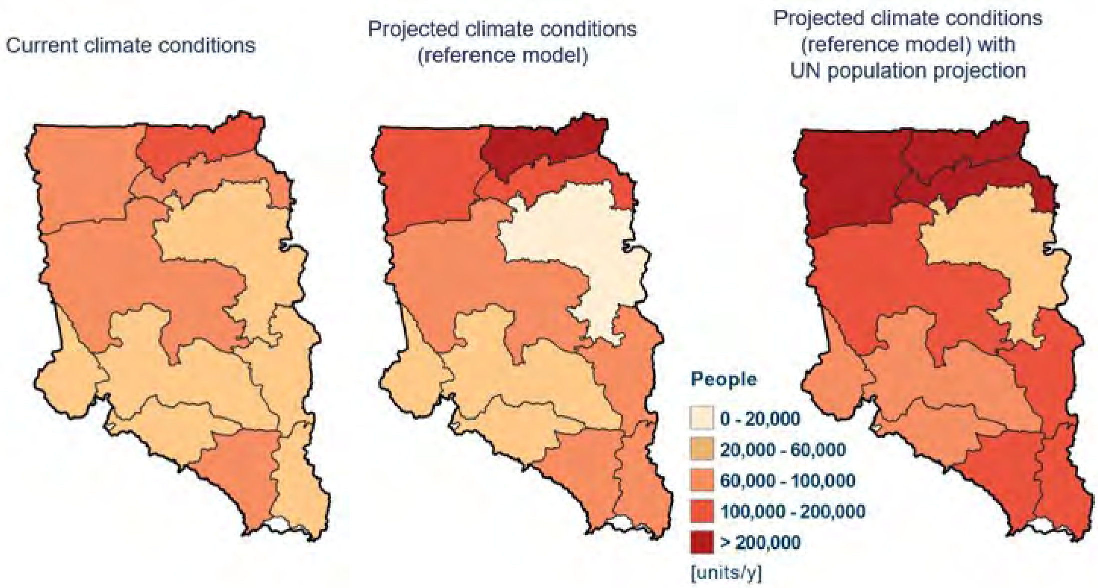
Drought

KEY MESSAGES

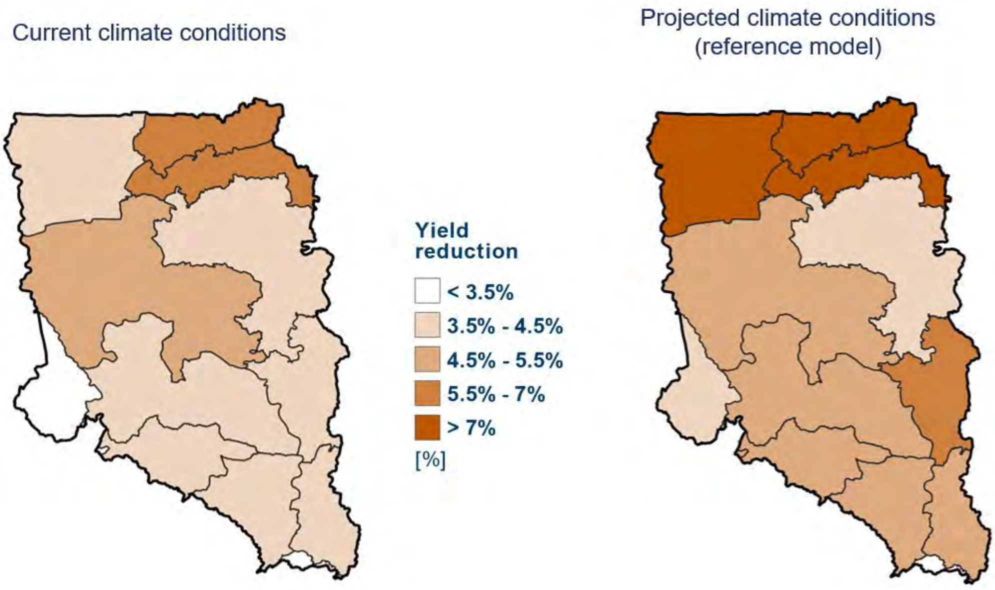
- In the part of Ghana situated in the Volta Basin, on average almost 750,000 people and more than 530,000 animals are exposed to droughts per year.
- Projected climate conditions will increase these numbers with 75% and 82% respectively (excluding changes in population and livestock), while also considering UN socio-economic projections (SEP) for the population, an increase of 188% is computed.
- The Northern East, the Upper East and the Upper West regions have the highest average annual exposed animals. Goats are the animal type mostly exposed to severe droughts, both under current and projected climate conditions.
- In the part of Ghana situated in the Volta Basin, on average more than USD 9 million per year is lost due to drought-induced maize yield reductions in current climate conditions.
- Bono East (the region with the most hectares of crop production) experiences the highest crop production losses under current conditions.
- Northern East and Upper East regions experience the highest annual average reductions per hectare (in percentage lower than average yield) under both current and projected future climate conditions. Upper West and Ahafo are expected to see the largest change (>66%) under climate projected conditions.

Population

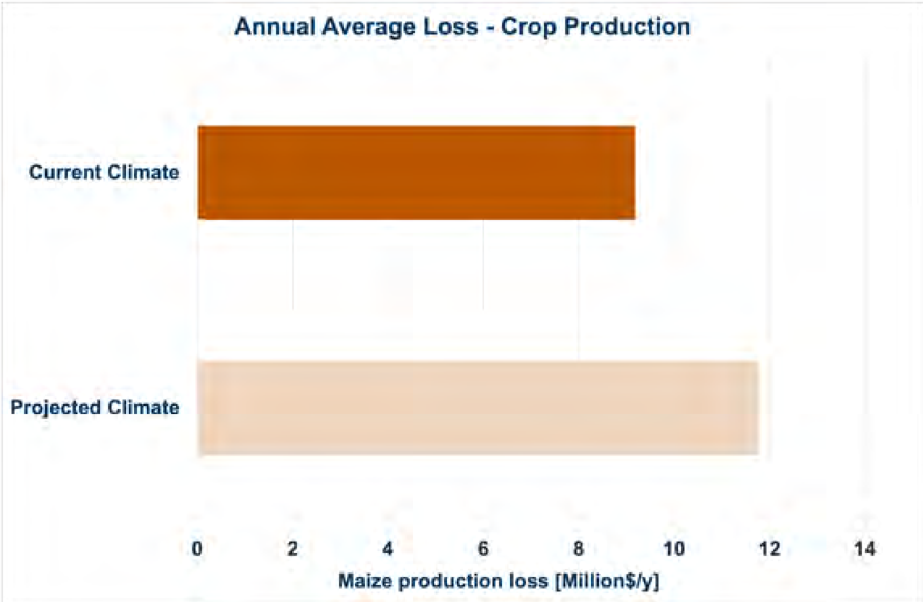


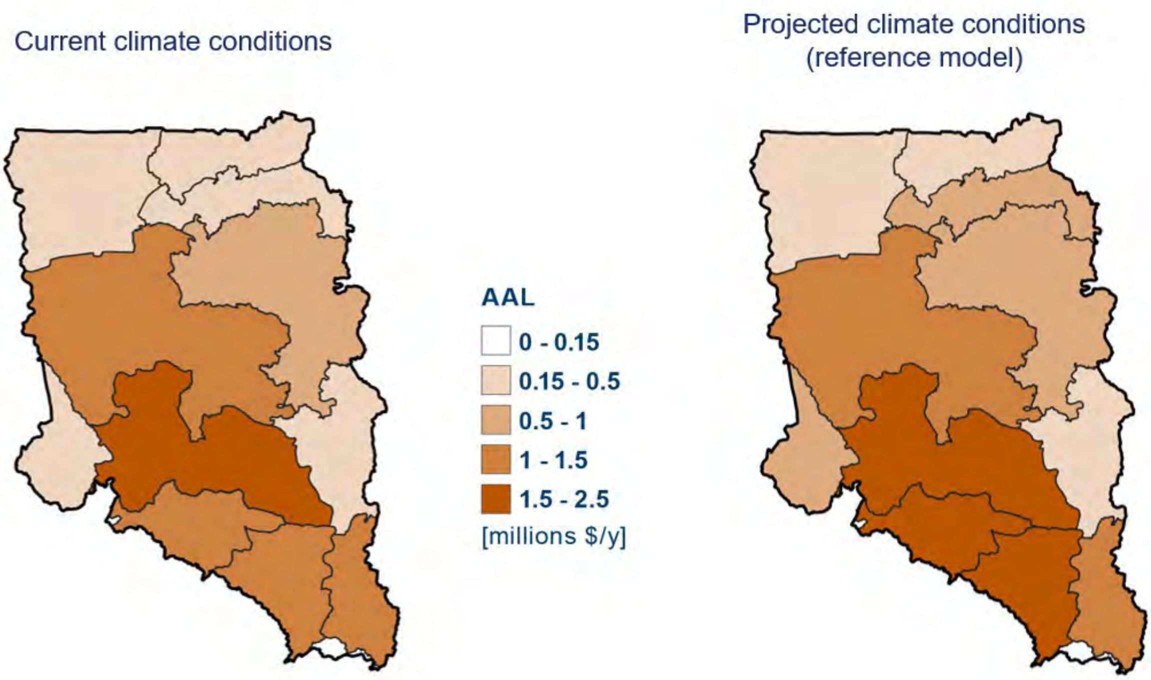


Crop Yield

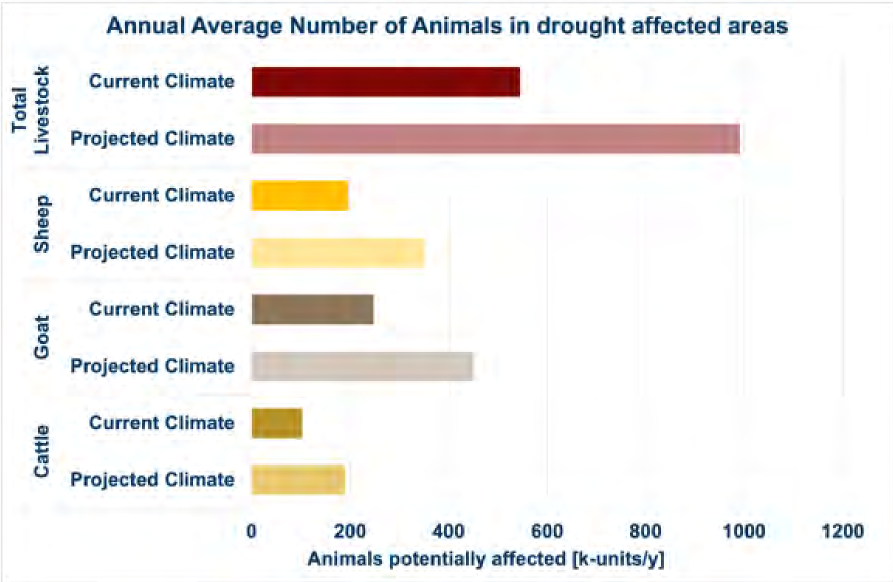


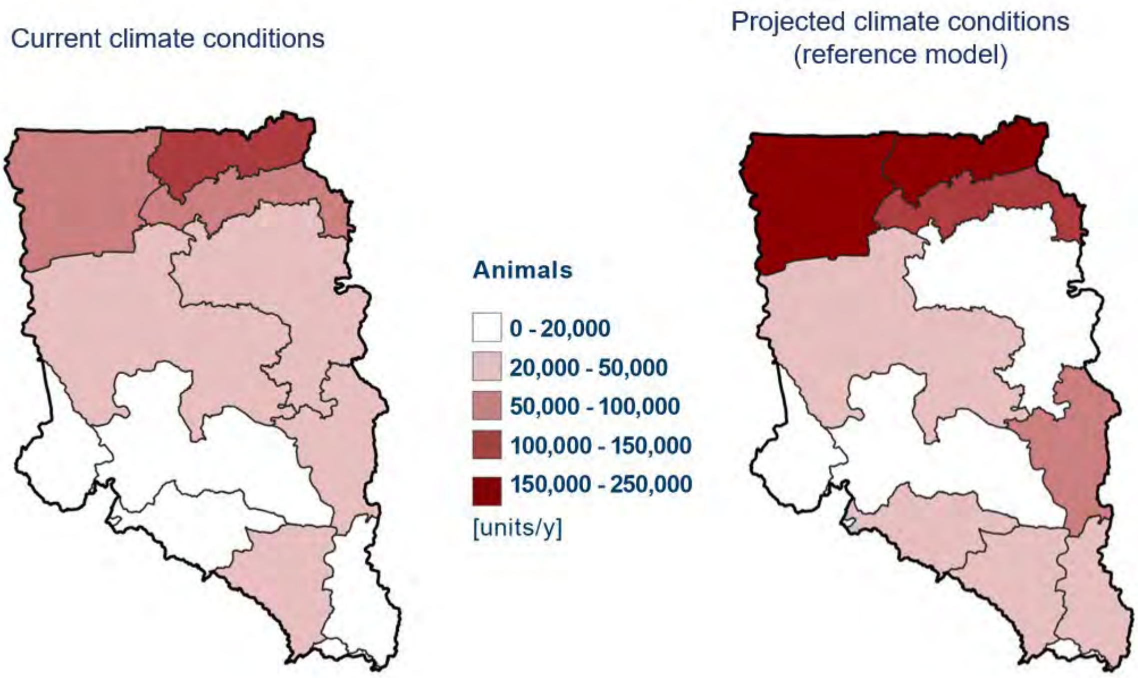
Crop Production



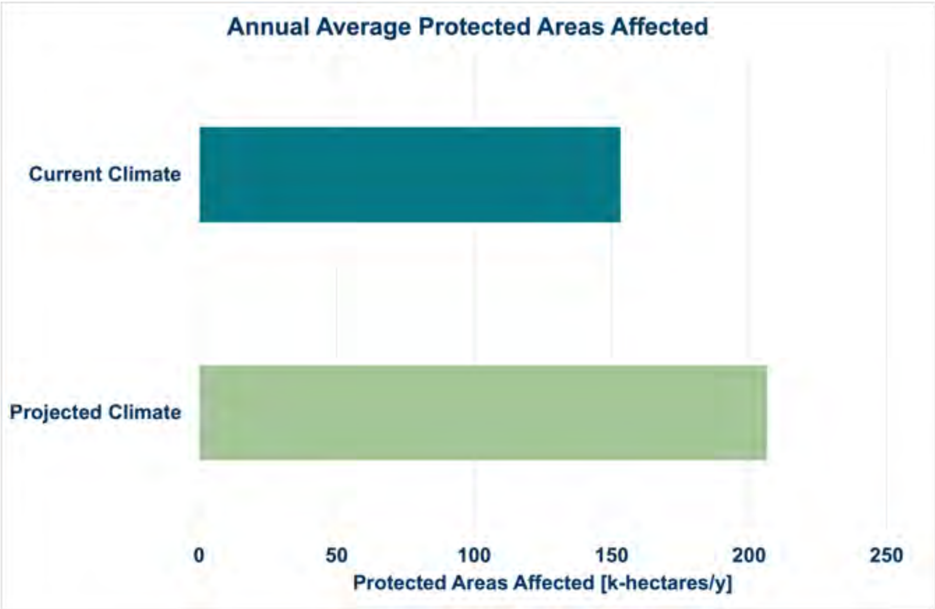


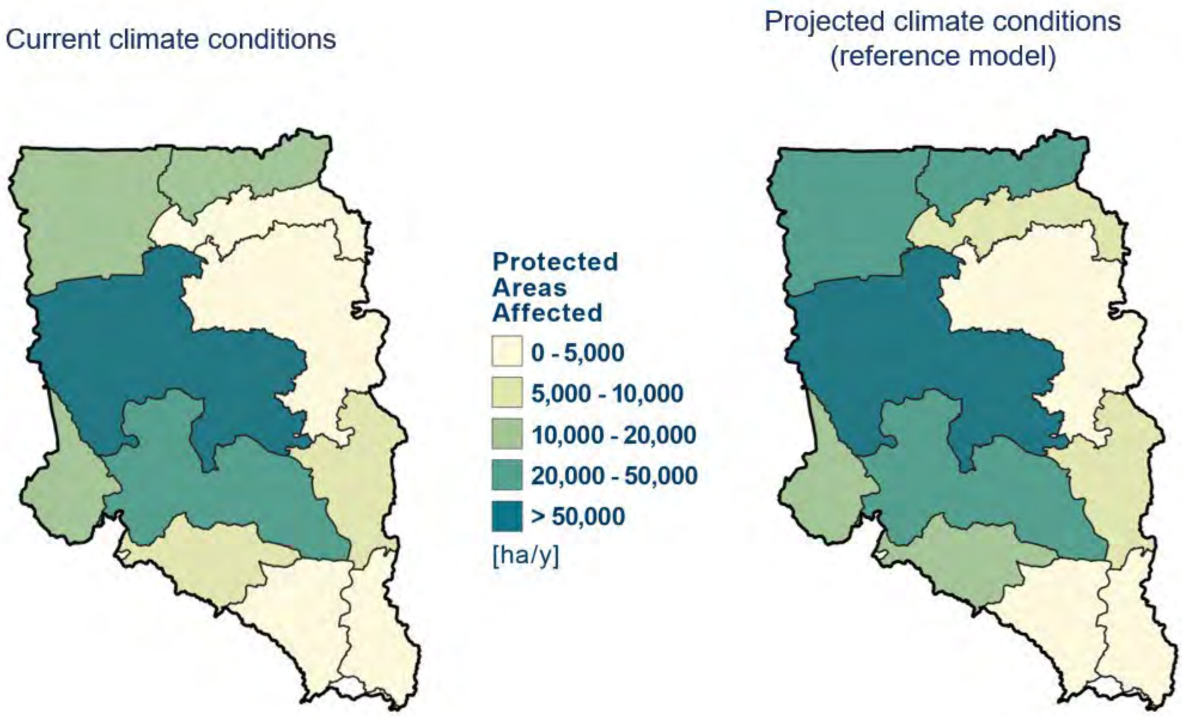
Livestock


Annual Average Number of Animals in drought affected areas
Total Livestock
Current Climate
Projected Climate
Sheep
Current Climate
Projected Climate
Goat
Current Climate
Projected Climate
Cattle
Current Climate
Projected Climate
0
200
400
600
800
1000
1200
Animals potentially affected [k-units/y]


Current climate conditions
Projected climate conditions
(reference model)
Animals
0 - 20,000
20,000 - 50,000
50,000 - 100,000
100,000 - 150,000
150,000 - 250,000
[units/y]

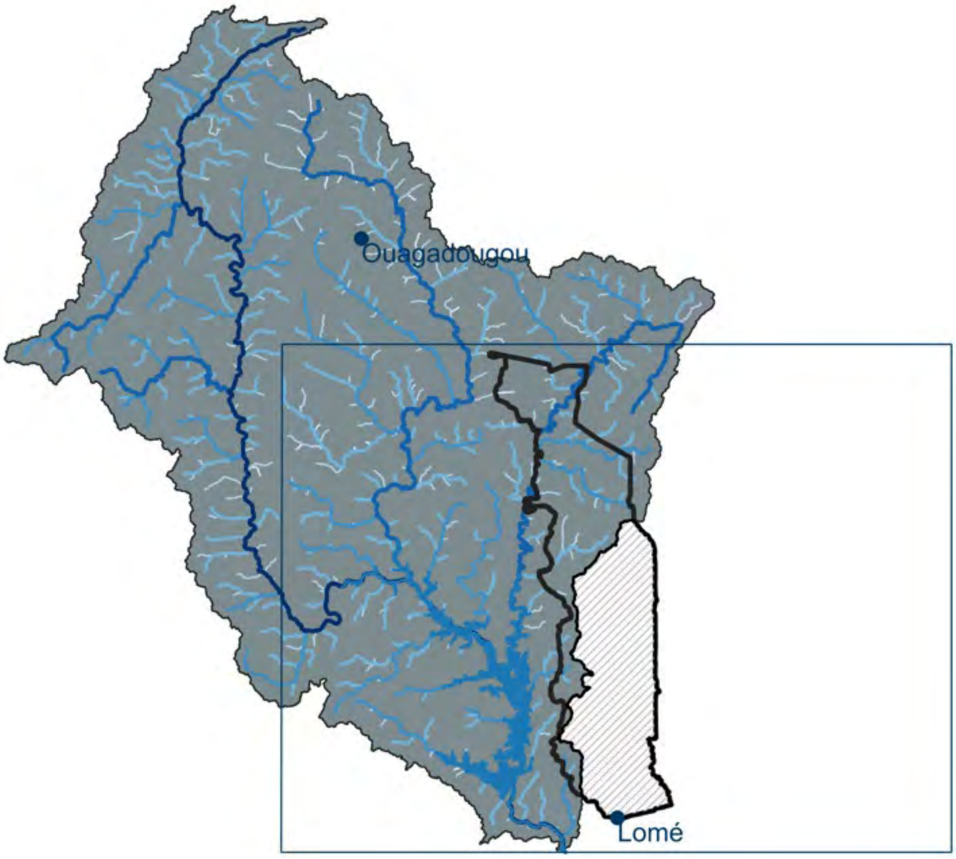
Protected Areas





Togo's results

Floods



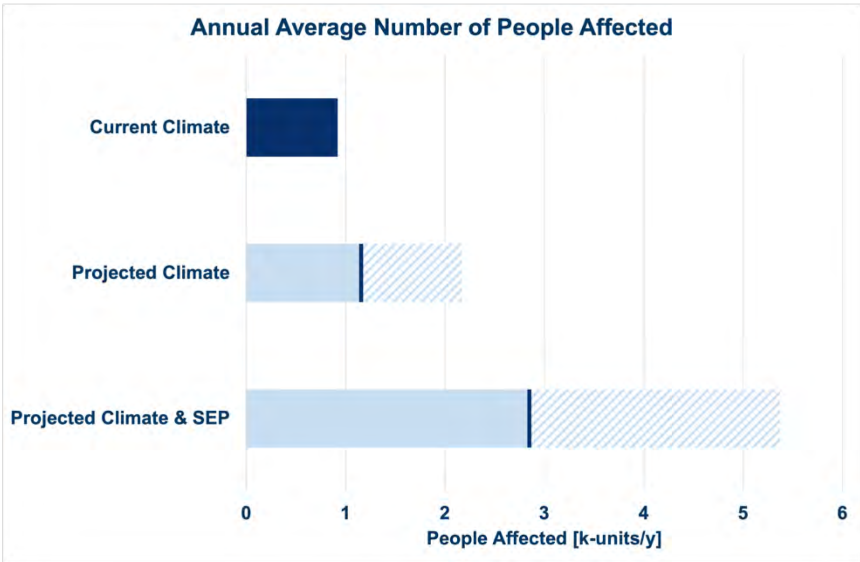
KEY MESSAGES

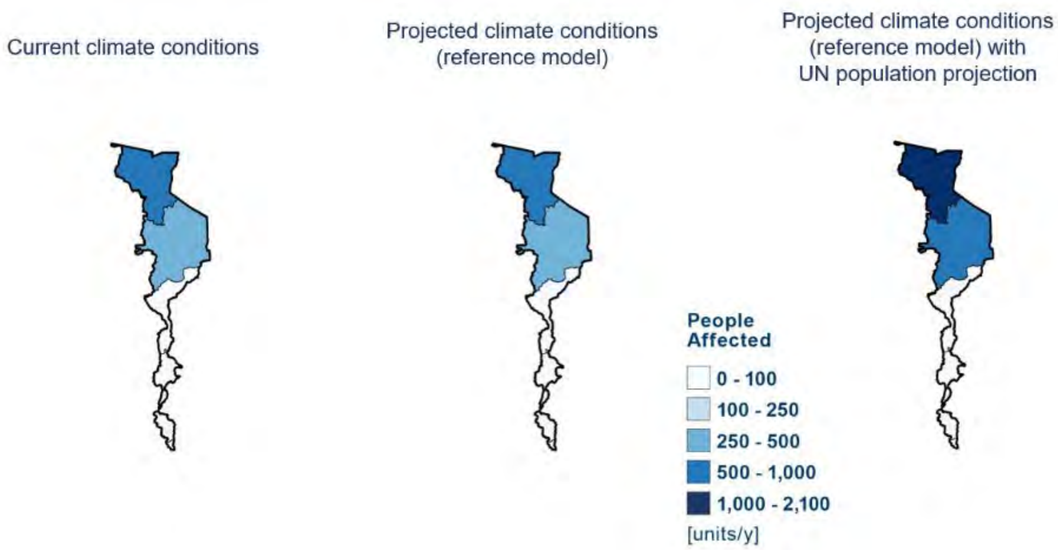
- Only the regions of Togo within the Volta basin are included in the risk profile.
- The distribution of impacts among the regions is different according to the various indicators; this is mainly due to the different distribution of assets, and their vulnerability to floods.
- Impacts in the Central and Plateau regions are negligible for most indicators; this may be related to the fact that the portions of these regions within the Volta basin are limited.
- Considering the different indicators, the impacts for the national portion of the basin in Togo under current climate conditions correspond to a variable percentage between 2% and 15% of the impacts calculated for the whole Volta basin.

- Contrary to the basin-wide analysis (where the most impacted sector is the residential sector), in the national portion of the basin in Togo the economic losses for the built-up area affect in particular the service sector.
- Considering the reference model in projected climate conditions, impacts are expected to increase to a limited extent for most indicators, with the exception of the loss of grazing land, showing a decrease.

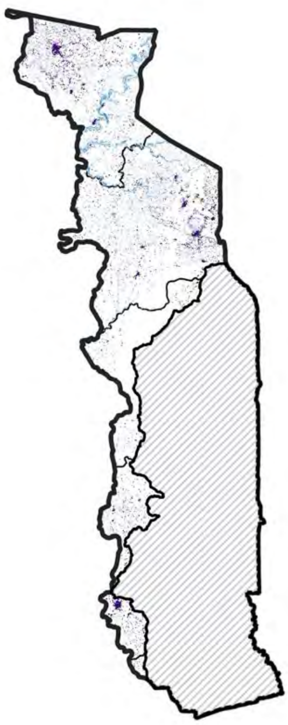
Population

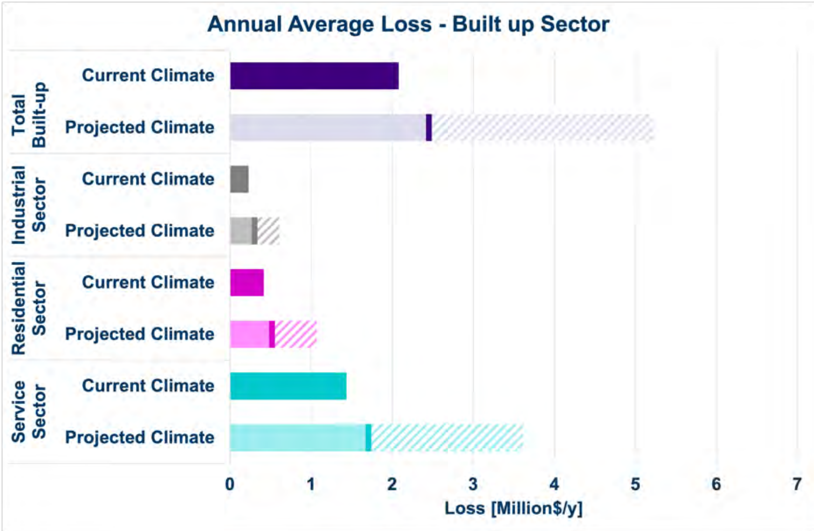
** Context map showing population distribution (WorldPop Unadj 2020 constrained + quantitative information from the National Institute of Statistics and Economic and Demographic Studies) overlaying on a reference hazard map (1000 years).*



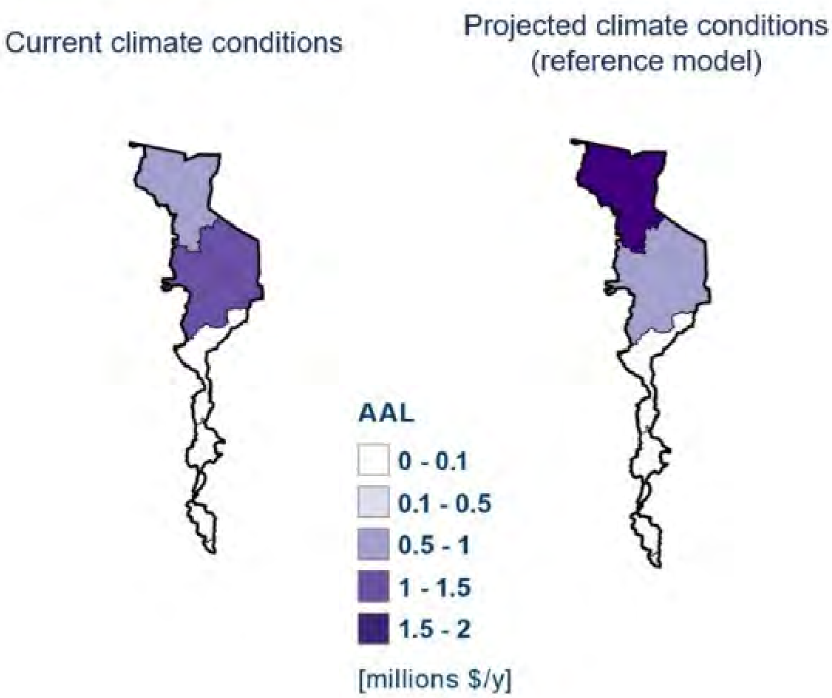


Built-up

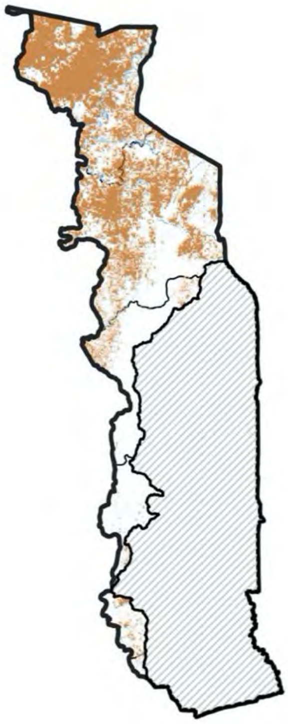


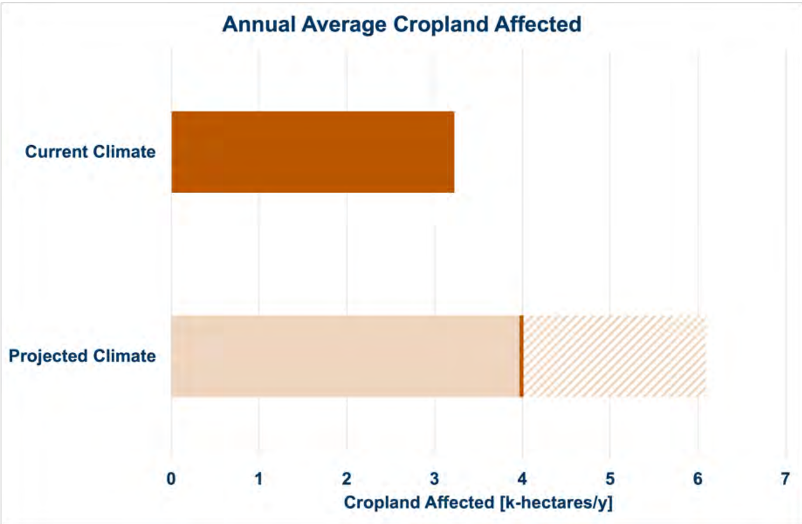


** Context map showing the distribution of the built-up area (from Land Cover data and populated areas according to WorldPop Unadj 2020 constrained) overlaying on a reference hazard map (1000 years).*

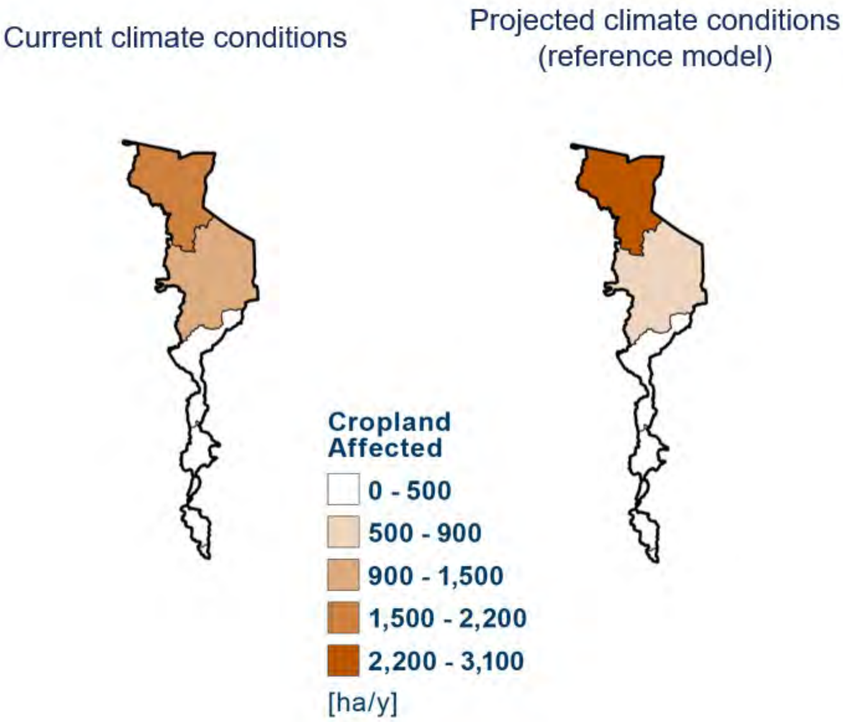


Cropland

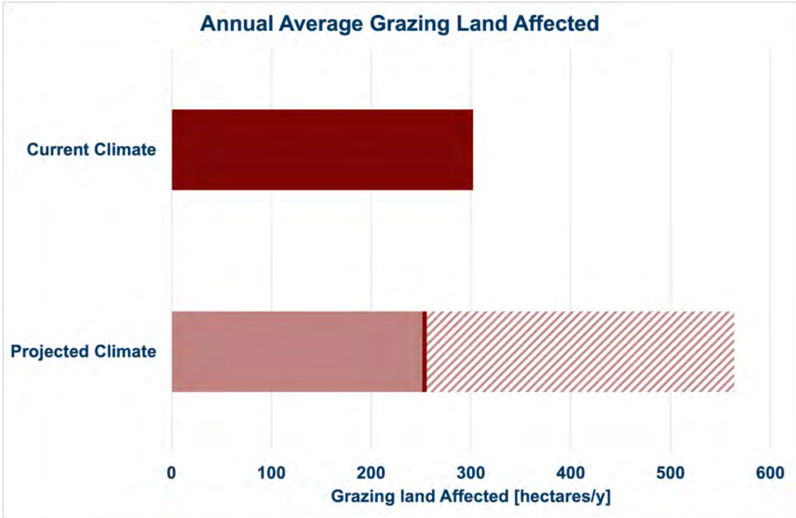




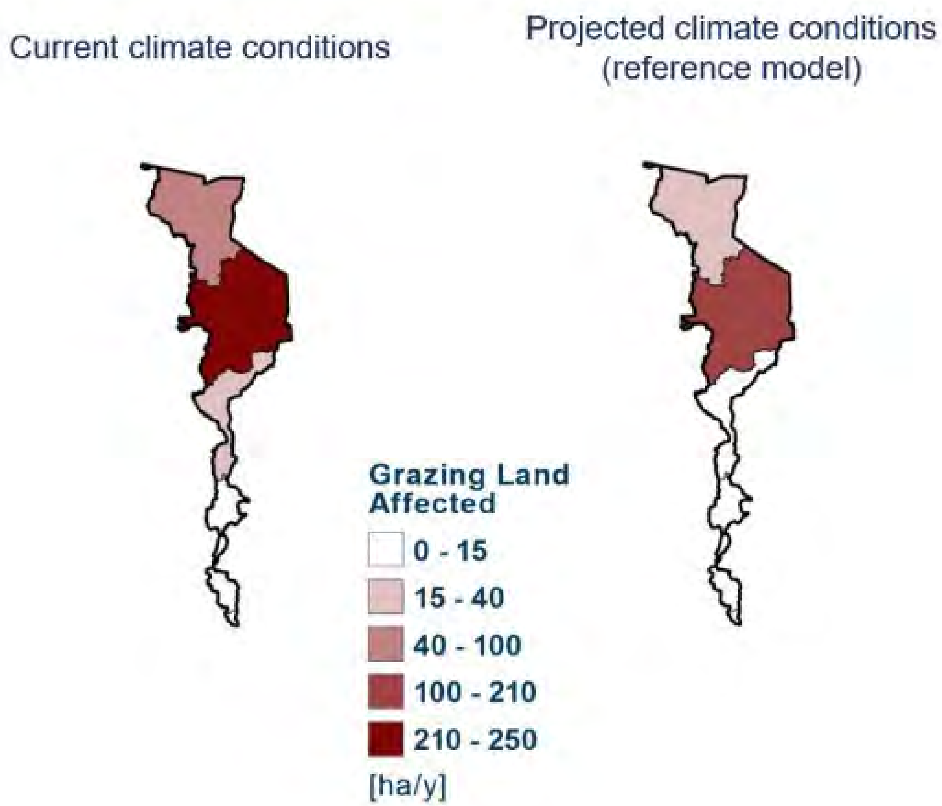
** Context map showing the distribution of cropland areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).*



Grazing land

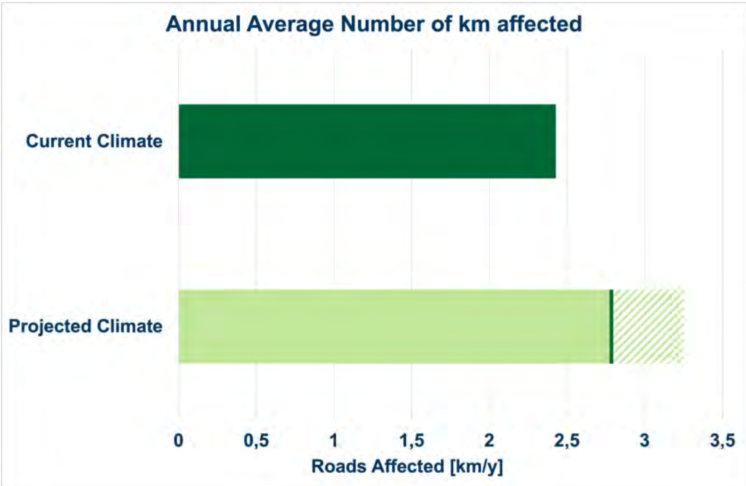


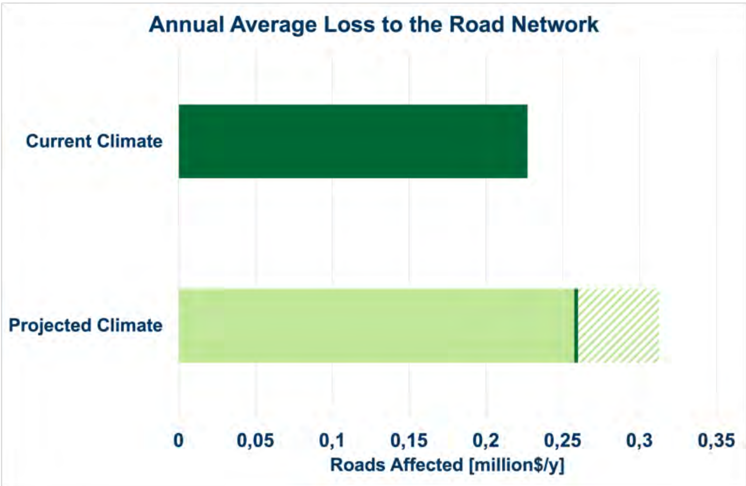
** Context map showing the distribution of grazing land areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).*

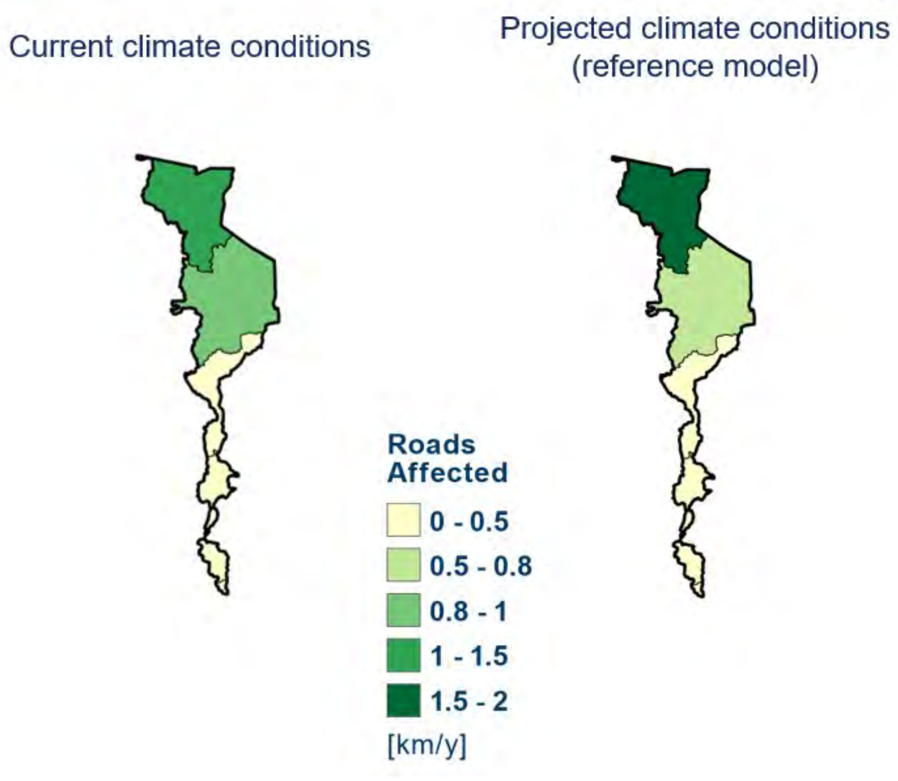


Roads Network

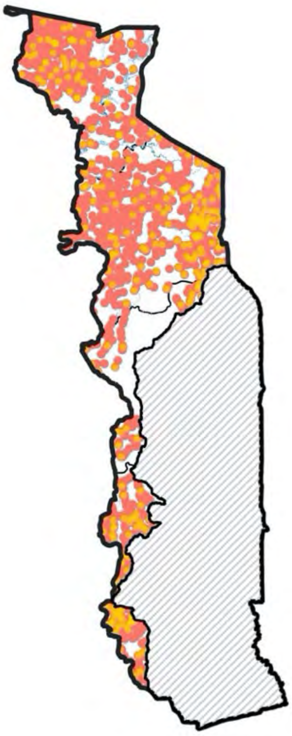
* *Context map showing the location of roads network (from data provided by the National Institute of Statistics and Economic and Demographic Studies) overlaying on a reference hazard map (1000 years).*



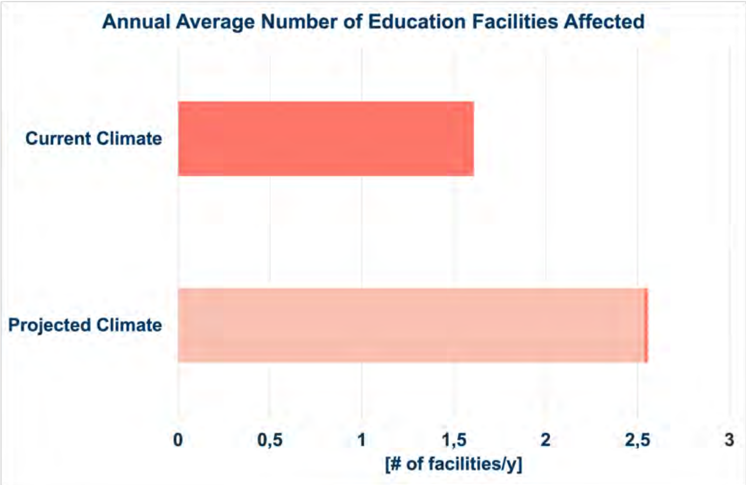


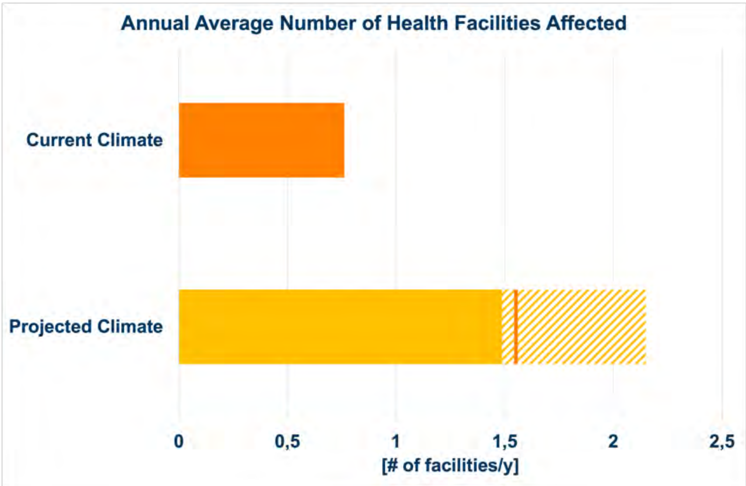


Critical facilities

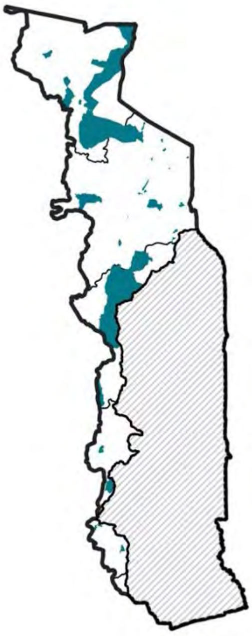


** Context map showing the location of education and health facilities (from data provided by the Ministries of Health and Education) overlaying on a reference hazard map (1000 years).*

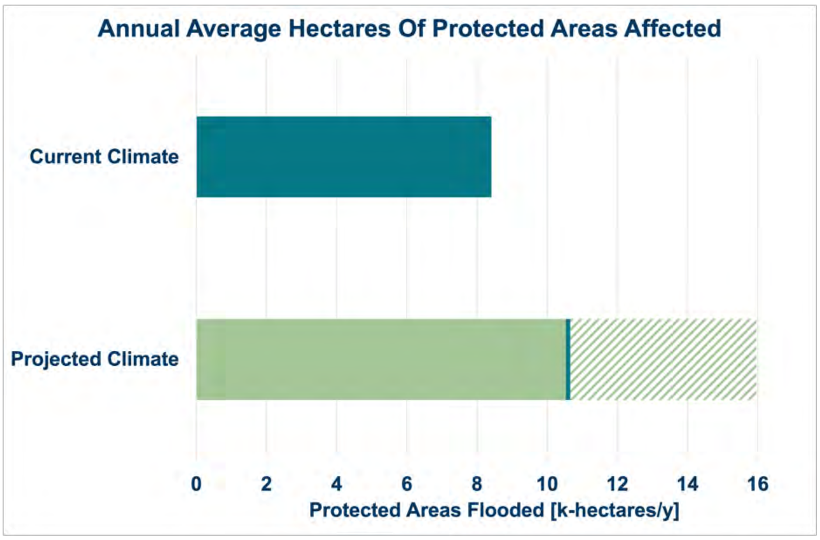




Protected areas



** Context map showing the distribution of protected areas (from the IUCN database) overlaying on a reference hazard map (1000 years).*

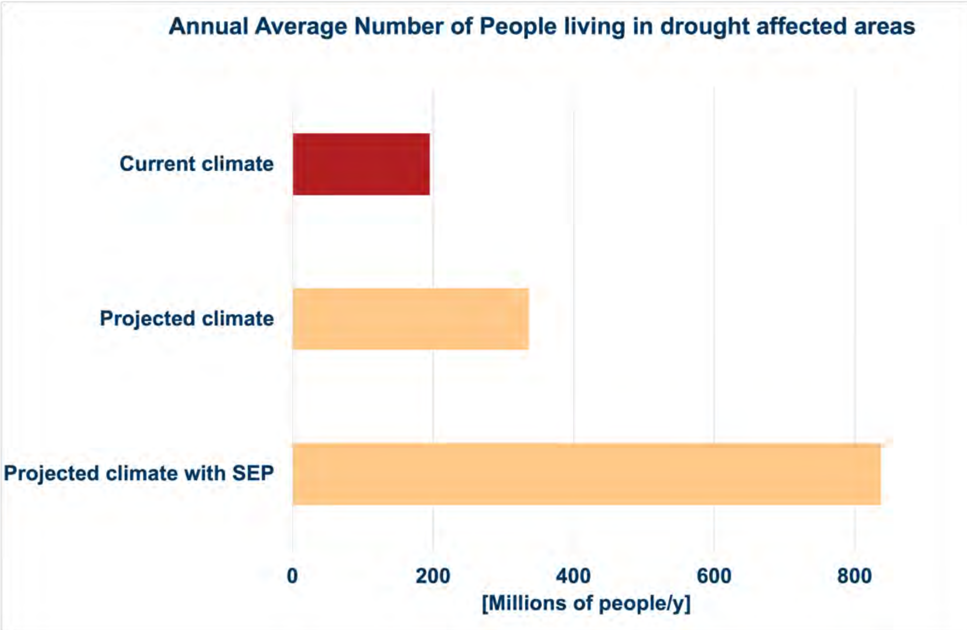


Drought

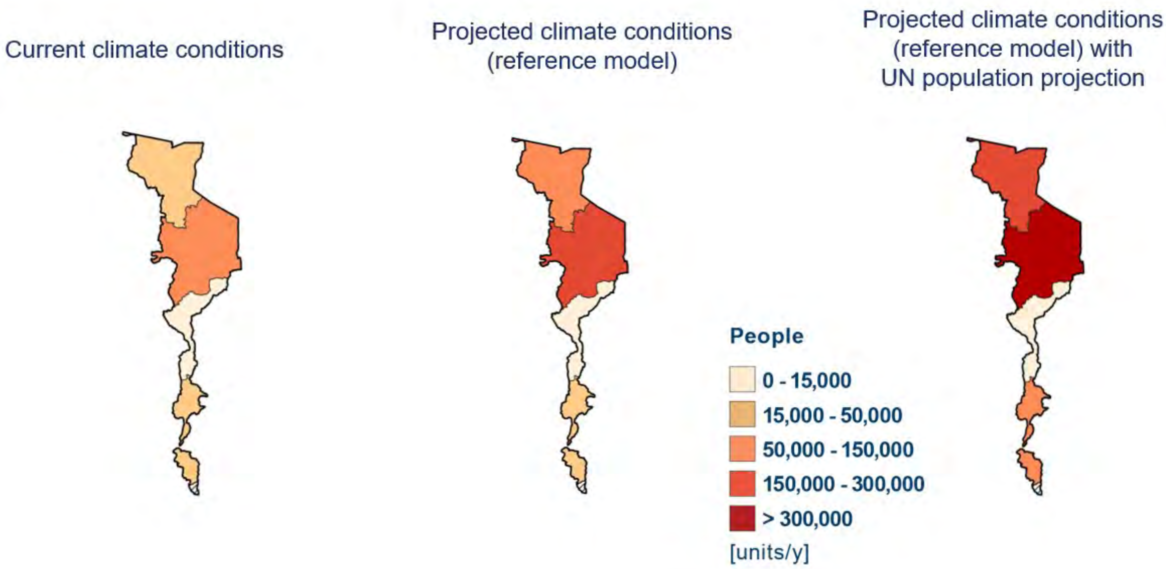
KEY MESSAGES

- In the part of Togo situated in the Volta Basin, on average 195 thousand people and 320 animals are exposed to droughts per year.
- Climate change projections will increase these numbers with 72% and 84% respectively (excluding changes in population and livestock).
- The Kara region has the highest average annual exposure.
- Sheep are the animal type mostly exposed to severe droughts, both under current and projected climate conditions.
- In the part of Togo situated in the Volta Basin, on average more than USD 1.4 million per year is lost due to drought-induced maize yield reductions.
- Among the regions of Togo in the Volta Basin, Plateaux (the area with the most agricultural land in the Volta Basin portion) experiences the highest losses under current conditions.
- Kara will see the largest increase in losses under climate change (+43%). In addition, in Kara also the largest annual average yield reductions (in percentage lower than average) will be experienced under projected climate conditions.

Population

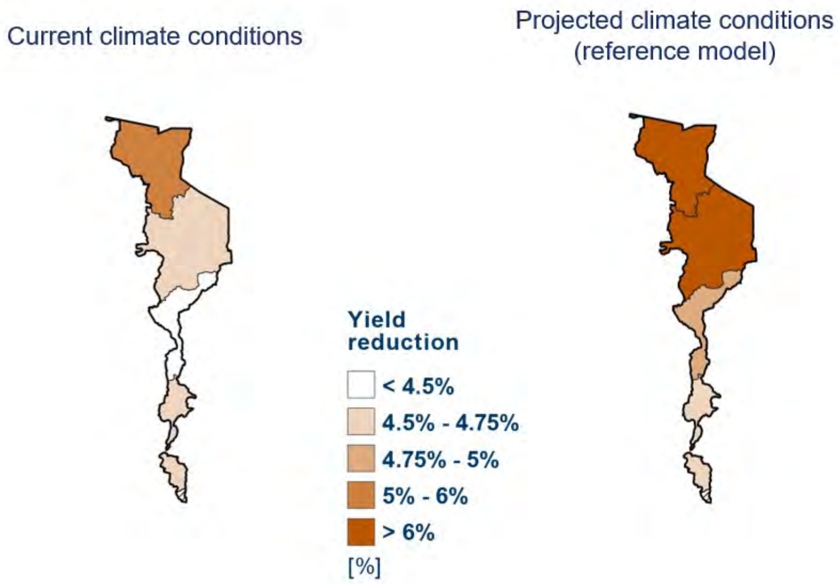


Annual Average Number of People living in drought affected areas
Current climate
Projected climate
Projected climate with SEP
0
200
400
600
800
[Millions of people/y]

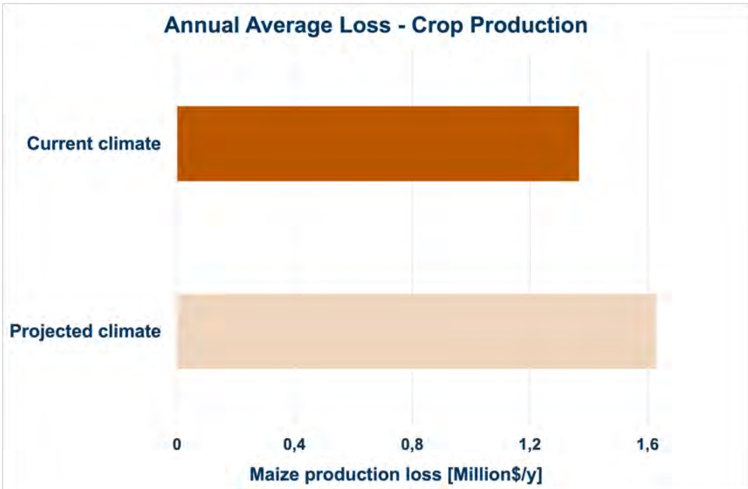


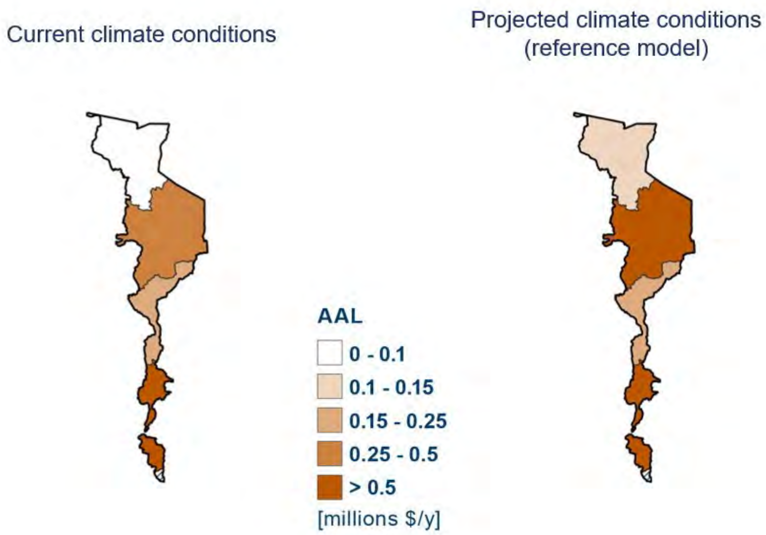
Current climate conditions
Projected climate conditions (reference model)
Projected climate conditions (reference model) with UN population projection
People
0 - 15,000
15,000 - 50,000
50,000 - 150,000
150,000 - 300,000
> 300,000
[units/y]

Crop yield

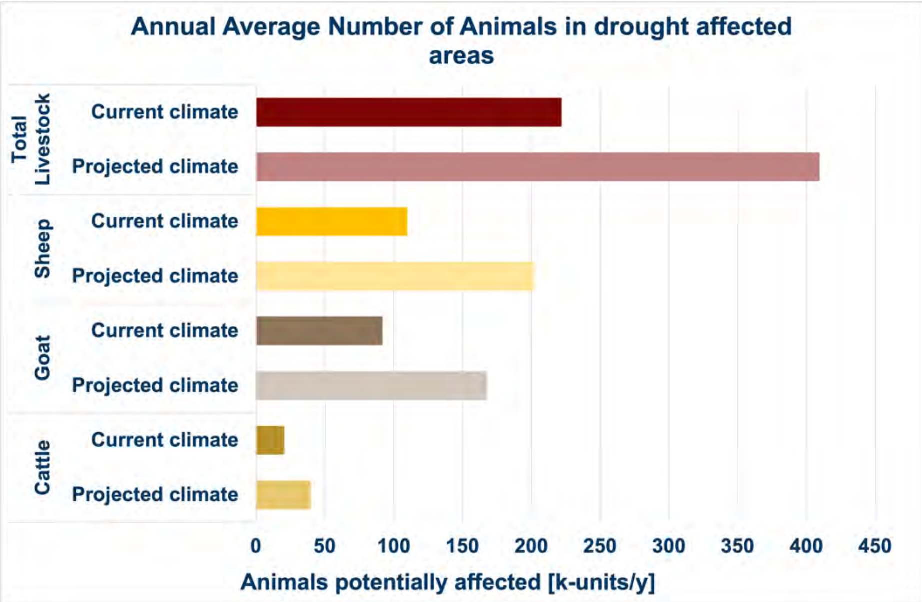


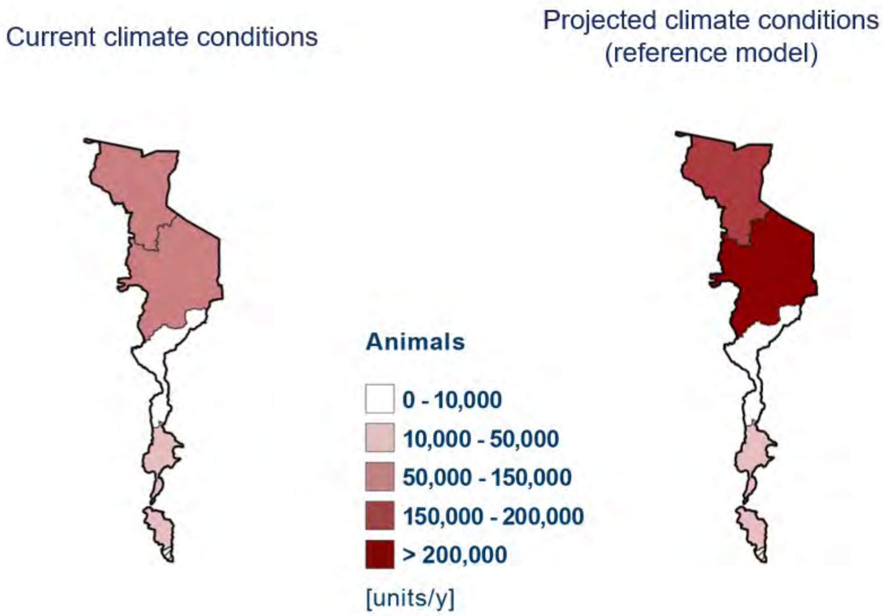
Crop production



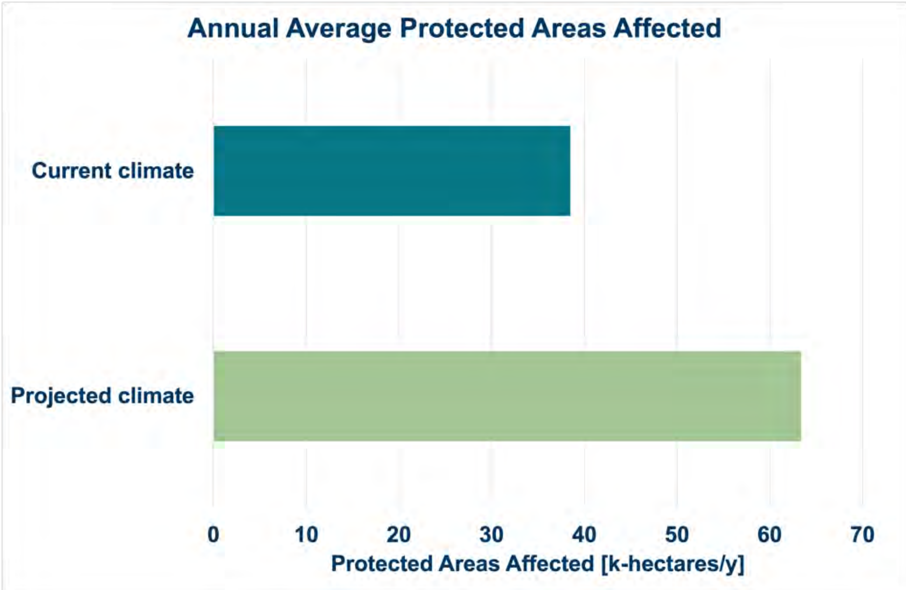


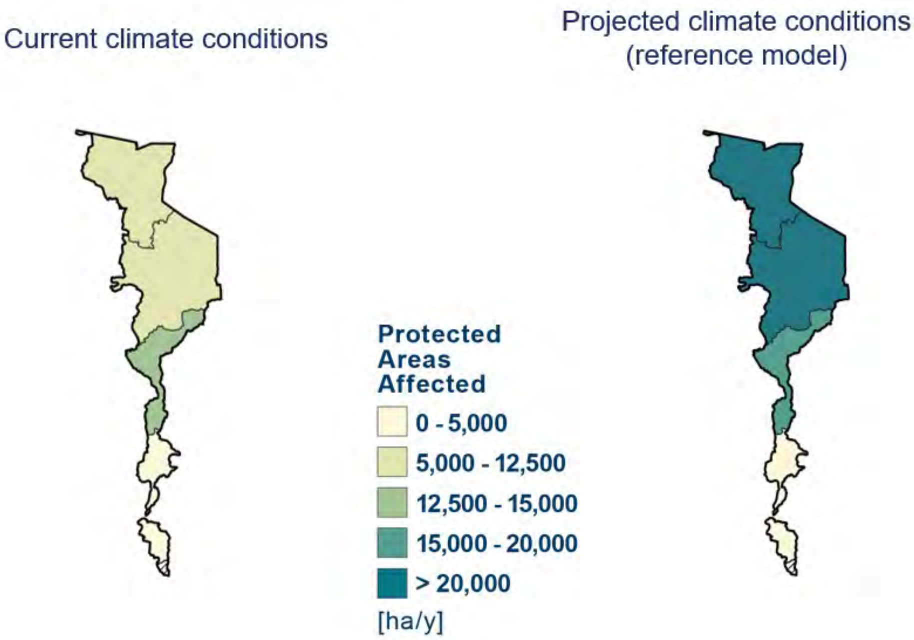
Livestock


Annual Average Number of Animals in drought affected areas
Total Livestock
Sheep
Goat
Cattle
Current climate
Projected climate
0
50
100
150
200
250
300
350
400
450
Animals potentially affected [k-units/y]


Current climate conditions
Projected climate conditions (reference model)
Animals
0 - 10,000
10,000 - 50,000
50,000 - 150,000
150,000 - 200,000
> 200,000
[units/y]

Protected areas





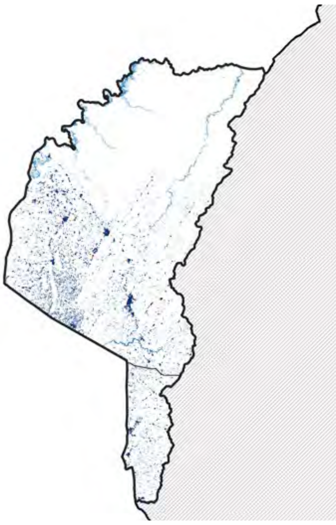
Benin’s results

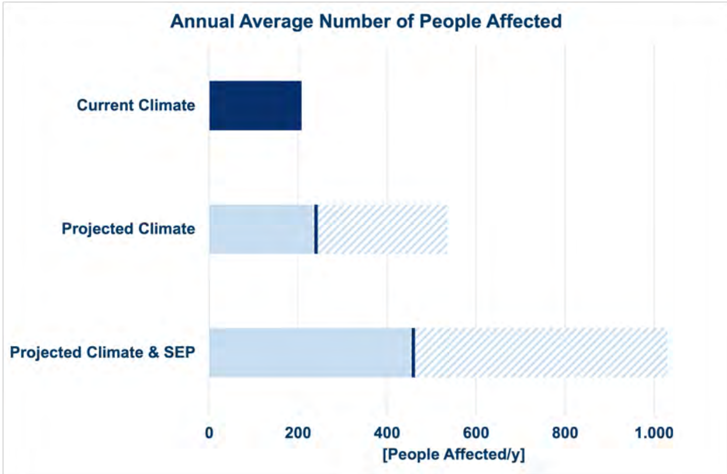
Floods

KEY MESSAGES

- Only the northwestern part of Benin (portions of the departments of Atacora and Donga) is included in the risk profile, being the only one that is part of the Volta Basin.
- In the Beninese portion of the basin, flood-related impacts are very limited and the contribution to the overall basin-wide AAL for most of the different indicators is around 1%.
- However, the contribution to the overall basin-wide indicator regarding protected areas likely to be flooded is more important and reaches around 7%.
- Some increase in impacts can be associated with projected climate conditions, at least compared to the situation under current climate conditions.

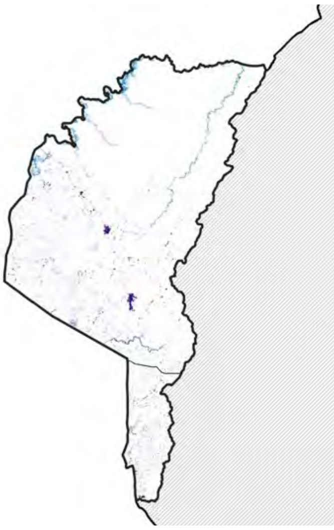
Population

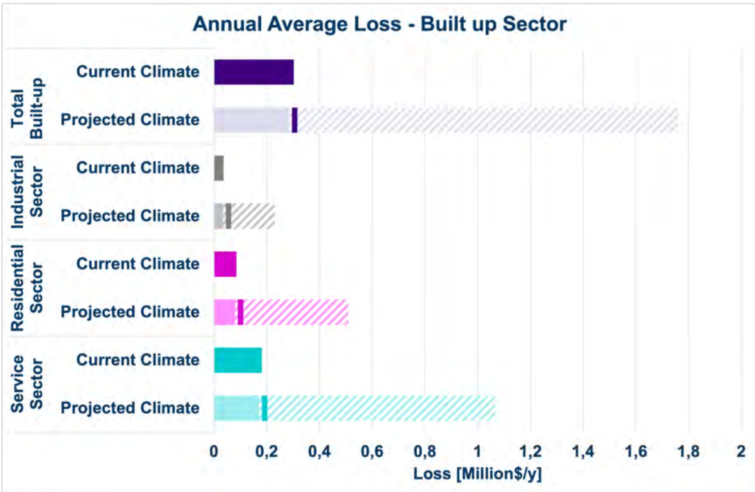




** Context map showing population distribution (WorldPop Unadj 2020 constrained + quantitative information from the National Institute of Statistics and Economic Analysis) overlaying on a reference hazard map (1000 years).*

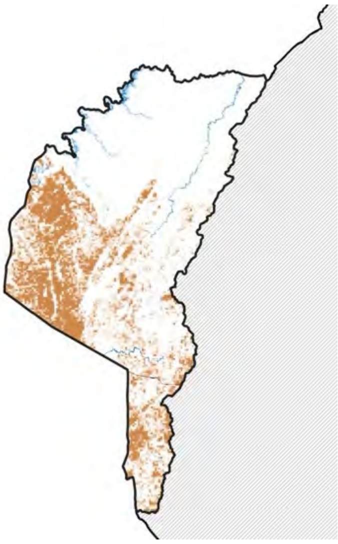
Built-up

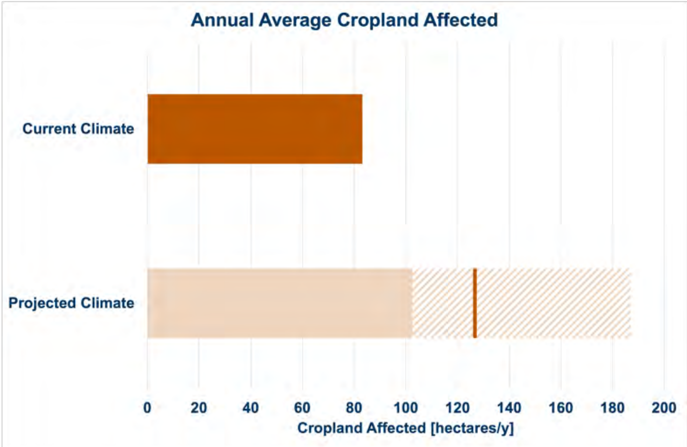




** Context map showing the distribution of the built-up area (from Land Cover data and populated areas according to WorldPop Unadj 2020 constrained) overlaying on a reference hazard map (1000 years).*

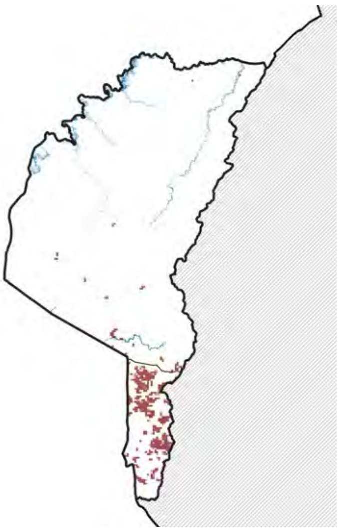
Cropland

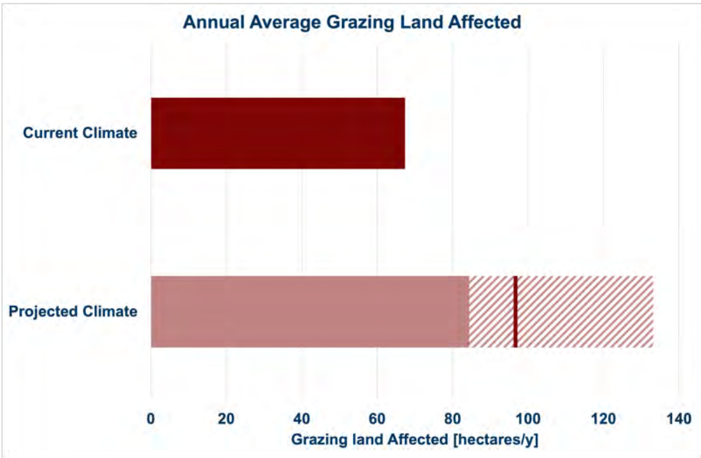




** Context map showing the distribution of cropland areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).*

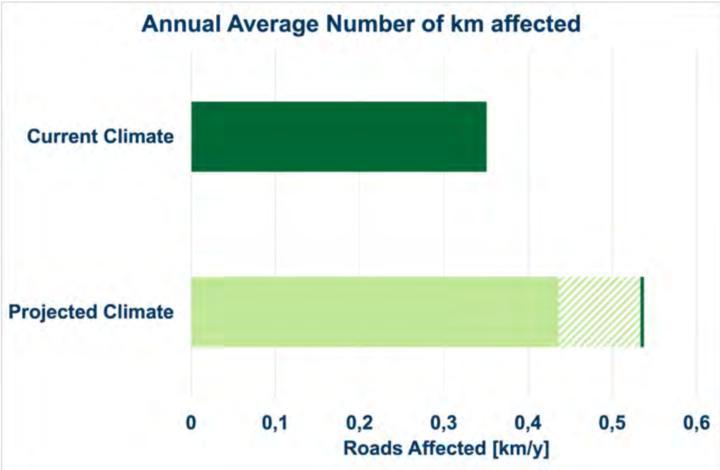
Grazing land

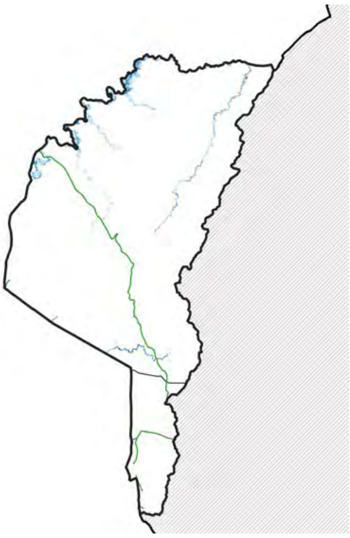




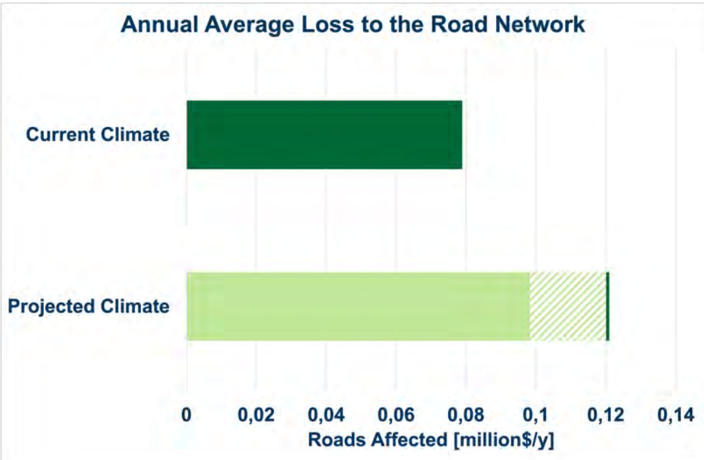
** Context map showing the distribution of grazing land areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).*

Roads Network

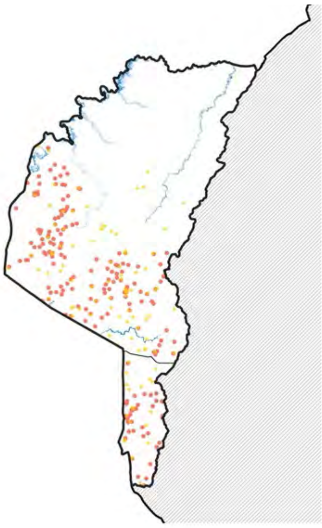




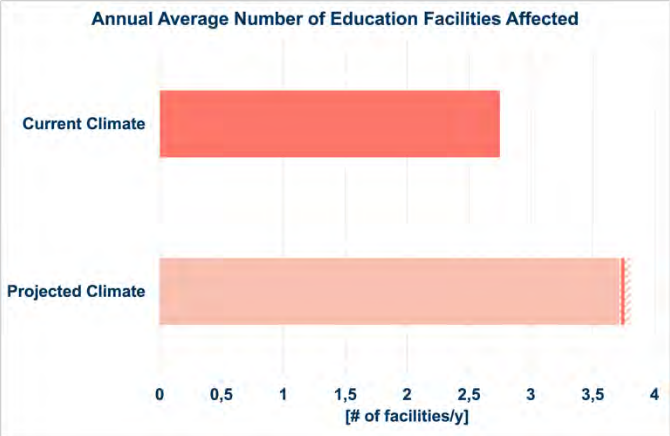
** Context map showing the location of roads network (from data provided by the National Geographical Institute) overlaying on a reference hazard map (1000 years).*

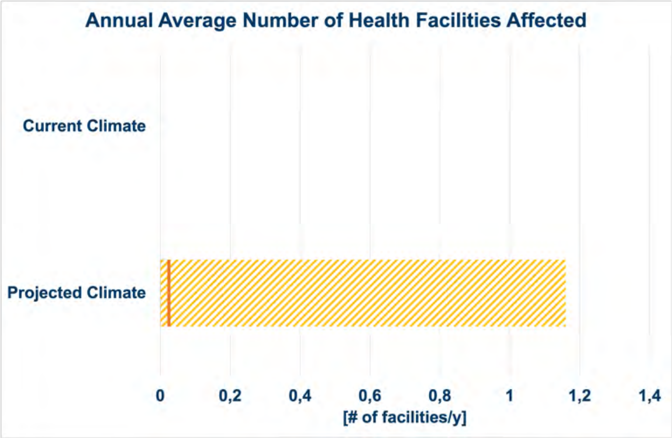


Critical facilities

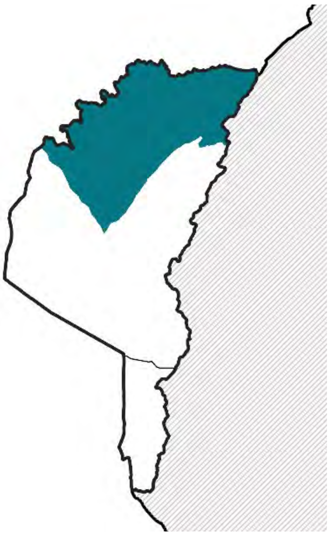


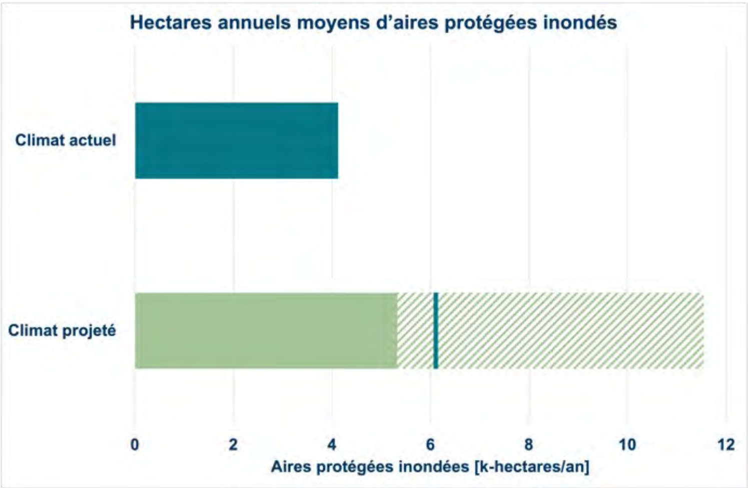
* Context map showing the location of education and health facilities (from national entities data) overlaying on a reference hazard map (1000 years).





Protected areas





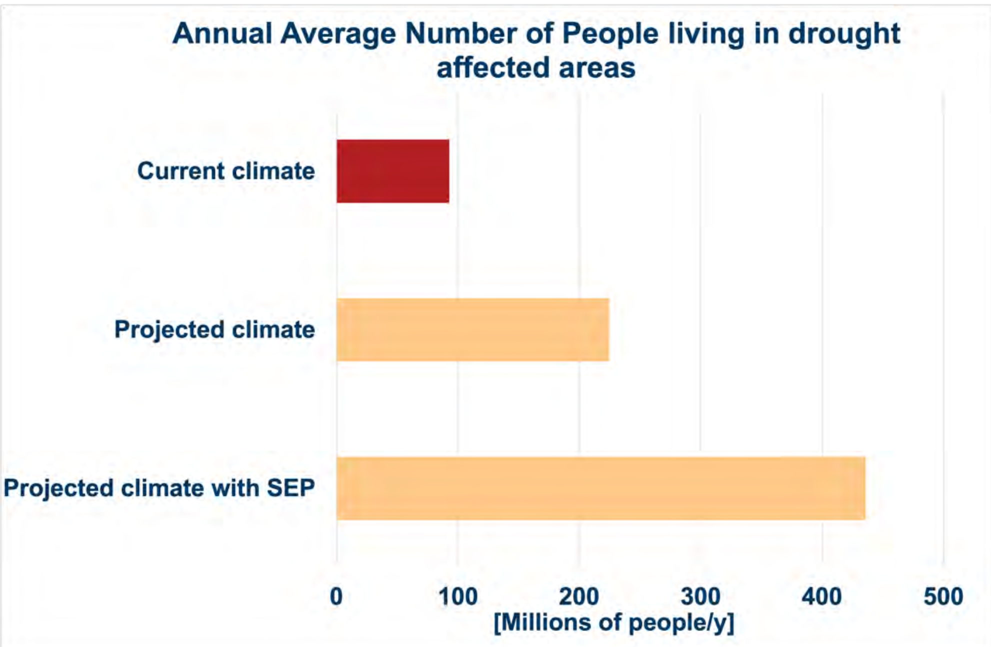
* Context map showing the distribution of protected areas (from the IUCN database) overlaying on a reference hazard map (1000 years).

Drought

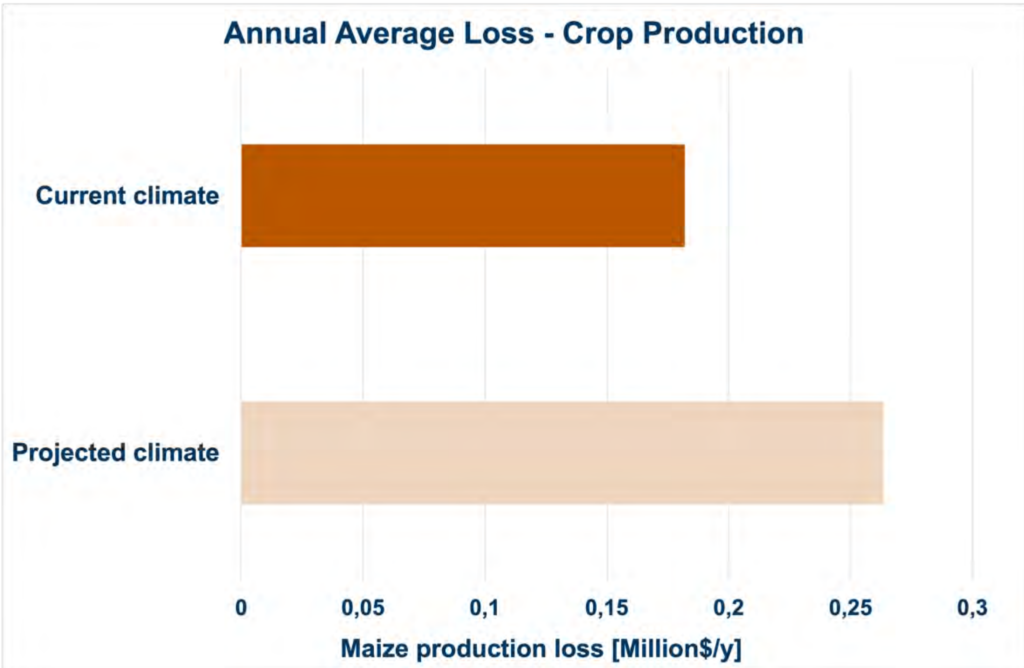
KEY MESSAGES

- In the part of Benin situated in the Volta Basin, on average 93 thousand people and 49 thousand animals are exposed to droughts per year.
- Climate change projections will increase these numbers with 142% and 146% respectively (excluding changes in population and livestock).
- Goats are the animal type mostly exposed to severe droughts, both under current and projected climate conditions.
- In the part of Benin situated in the Volta Basin, on average almost USD 0.2 millions per year is lost due to drought-induced maize yield reductions.
- Among the departments of Benin in the Volta Basin, Atacora (the area with the largest amount of hectare under agricultural production in the Volta Basin) experiences the highest losses under current climate conditions.

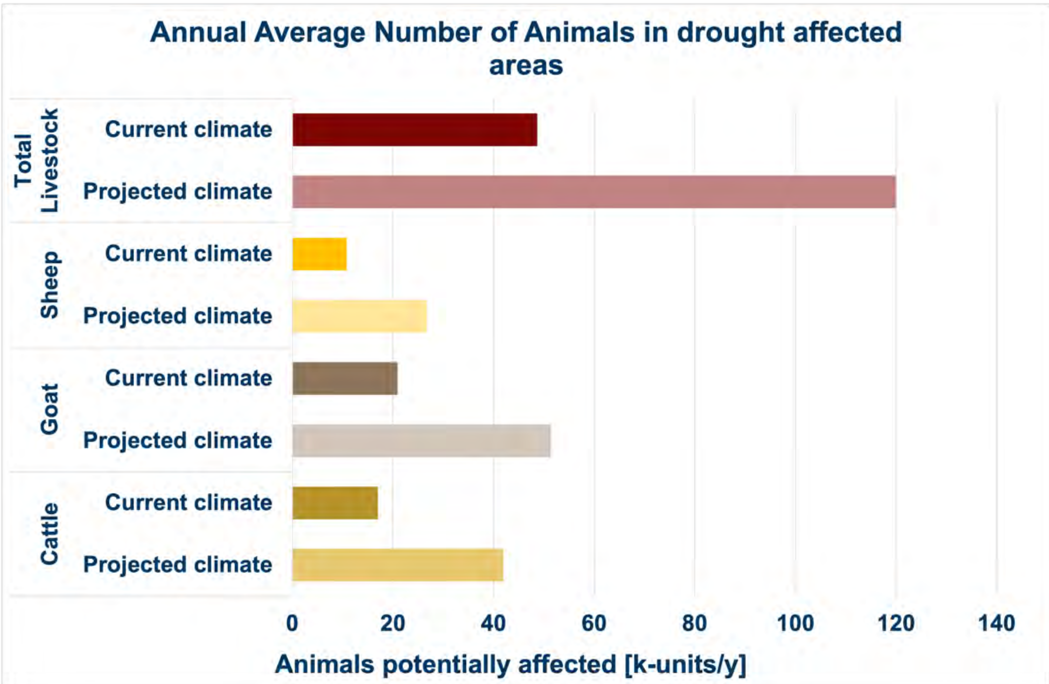
Population



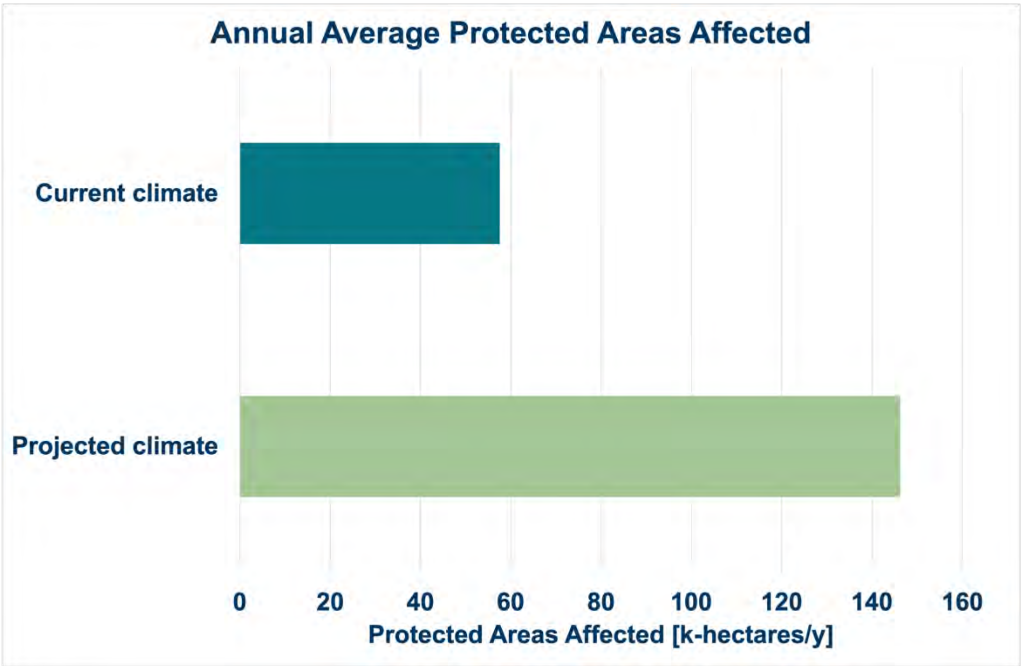
Crop production



Livestock



Protected areas



Mali's results

Floods

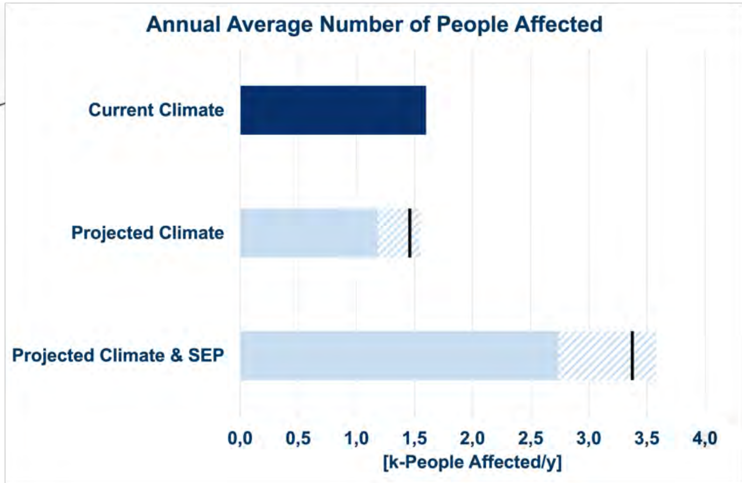
KEY MESSAGES

- Only the portion of the Mopti region in Mali that is part of the Volta basin is included in the risk profile.
- The contribution to the overall impacts at basin level is quite limited, being lower than 20% for almost all the indicators.
- In this region, the reference model shows a slight decrease of impacts related to projected climate conditions with respect to current climate conditions for almost all the indicators.
- The variability among the different models in terms of impacts reaches the 20%.

- A relevant increase of impacts on population is highlighted when considering also socio-economic projections.

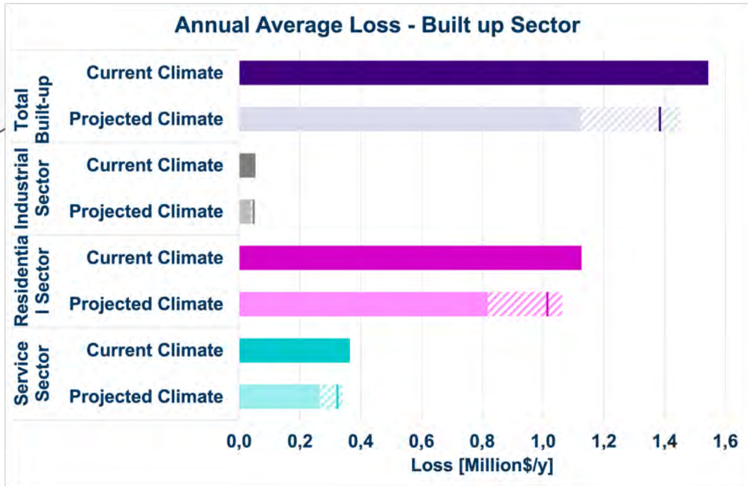
Population

** Context map showing population distribution (WorldPop Unadj 2020 constrained + quantitative information from the National Population Directorate) overlaying on a reference hazard map (1000 years).*

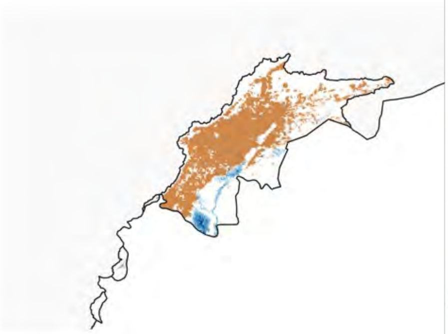


Built-up

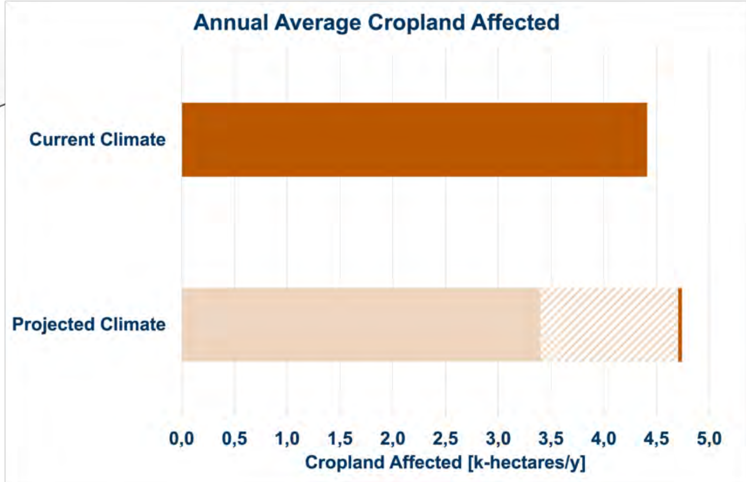
of the built-up area (from Land Cover data and populated areas according to WorldPop Unadj 2020 constrained) overlaying on a reference hazard map (1000 years).



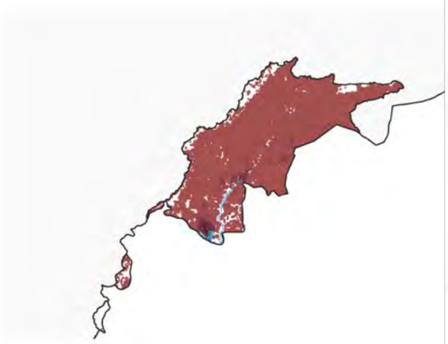
Cropland



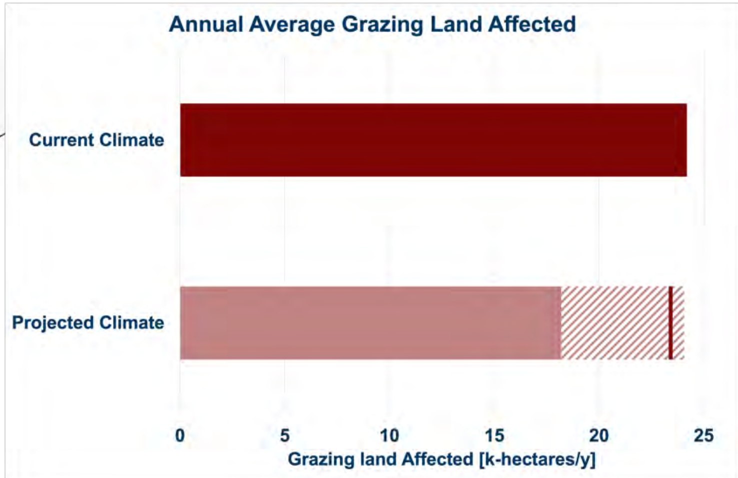
* Context map showing the distribution of cropland areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).



Grazing land

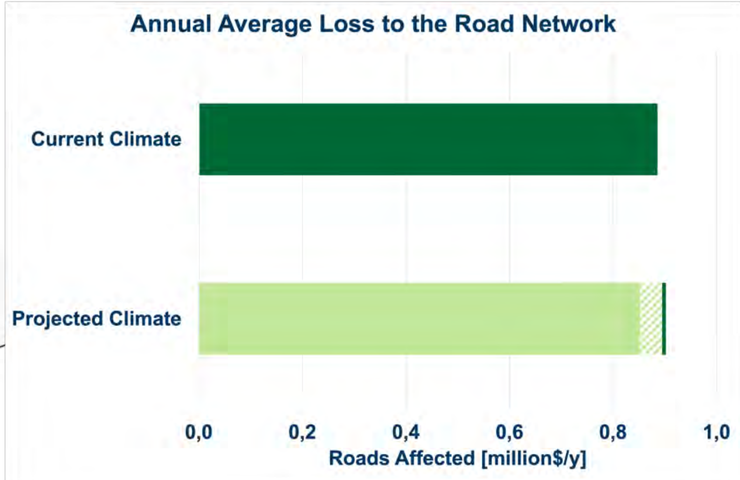


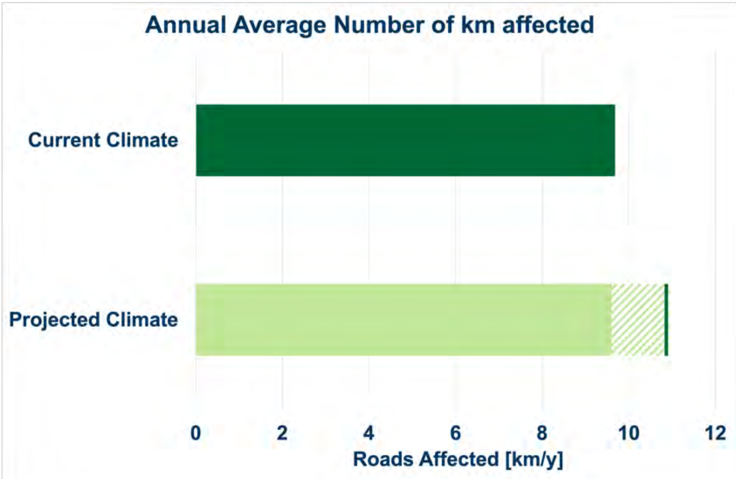
* Context map showing the distribution of grazing land areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).



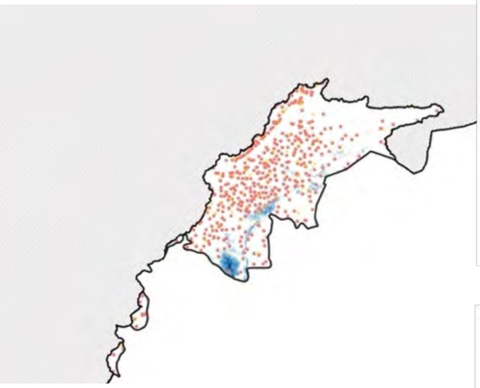
Roads Network

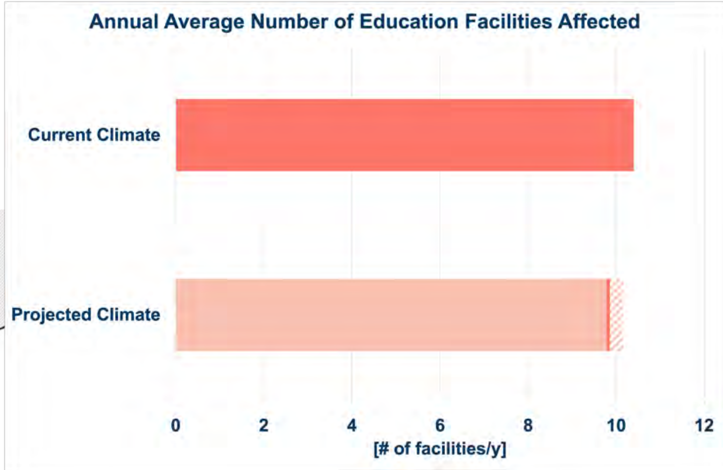
* Context map showing the location of roads network (from national entities data) overlaying on a reference hazard map (1000 years).

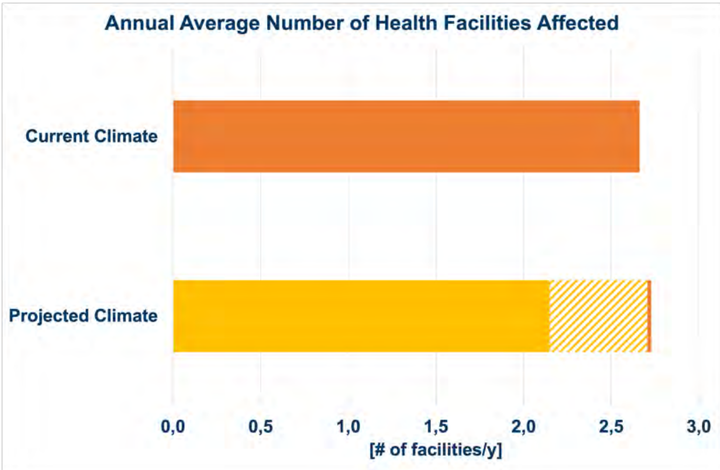




Critical facilities

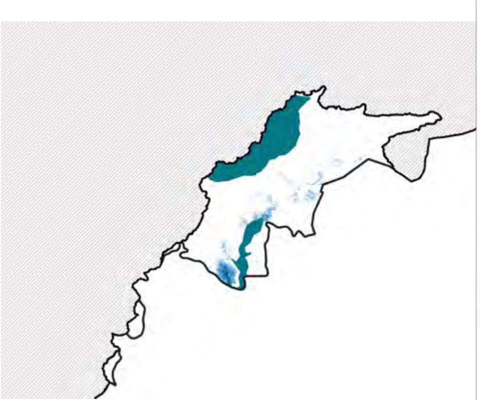


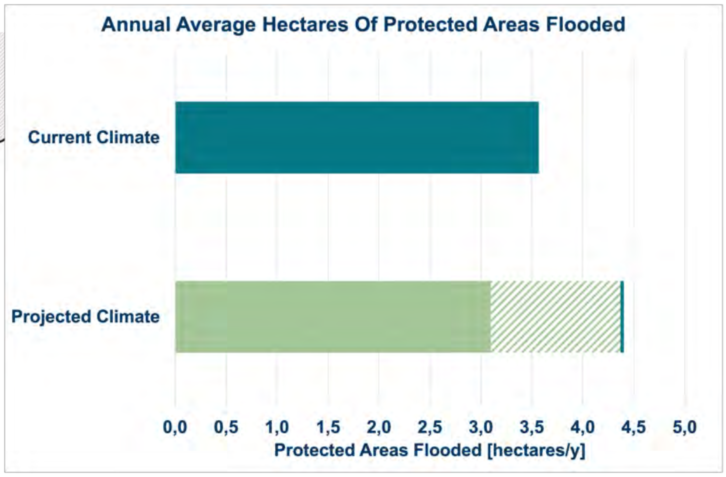




** Context map showing the location of education and health facilities (from OpenStreetMap data) overlaying on a reference hazard map (1000 years).*

Protected areas





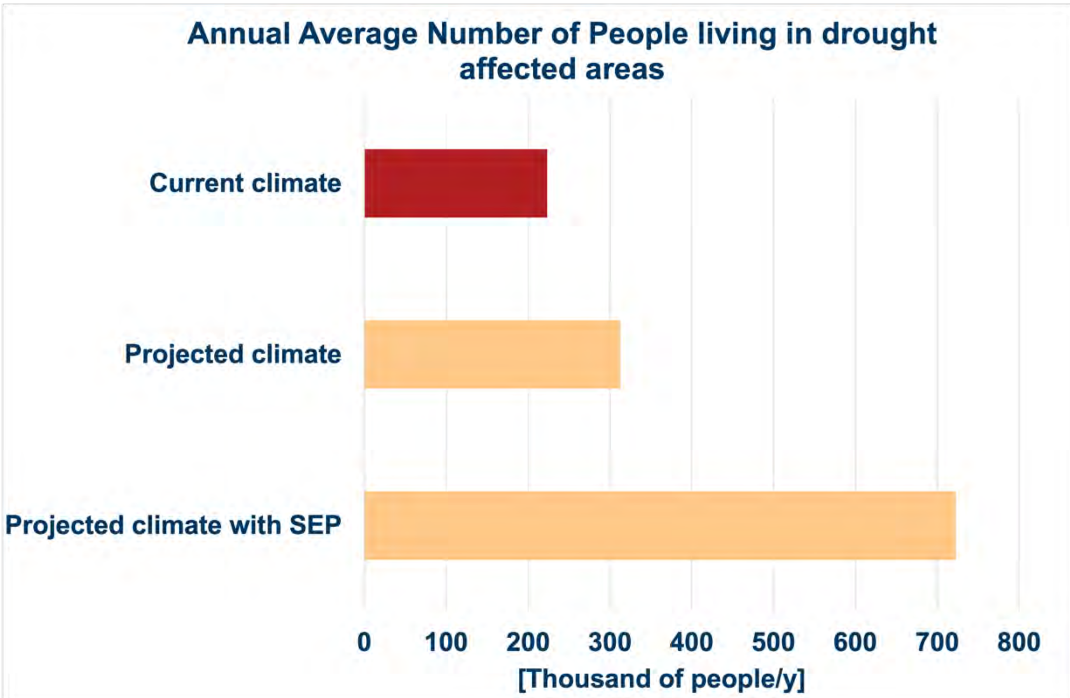
** Context map showing the distribution of protected areas (from the IUCN database) overlaying on a reference hazard map (1000 years).*

Drought

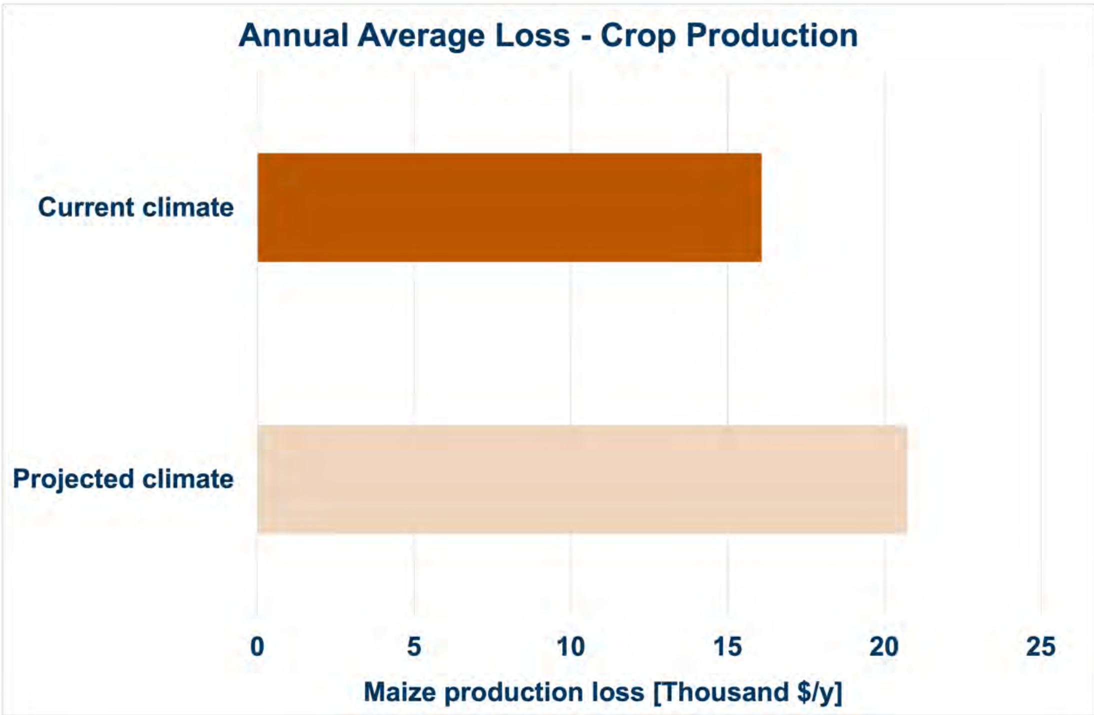
KEY MESSAGES

- In the part of Mali situated in the Volta Basin, on average 223 thousand people and 530 thousand animals are exposed to droughts per year.
- Climate change projections will increase these numbers with 40% (excluding changes in population and livestock).
- The Mopti region has the highest average annual exposure.
- Goats, closely followed by sheep, are the animal type mostly exposed to severe droughts, both under current and projected climate conditions.
- In the part of Mali situated in the Volta Basin, on average more than USD 16 thousand per year is lost due to drought-induced maize yield reductions.
- Among the regions of Mali in the Volta Basin, Mopti has the largest annual average reductions per hectare (in percentage lower than average yield) both under current and under projected climate conditions.

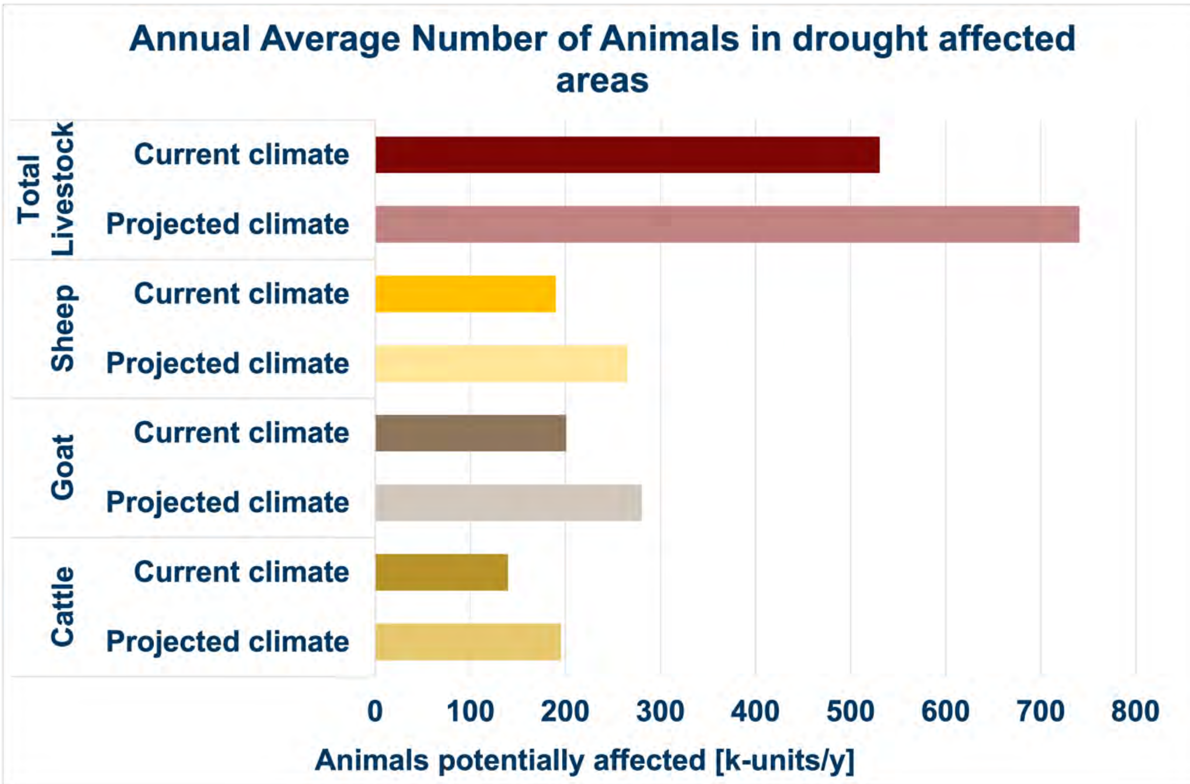
Population



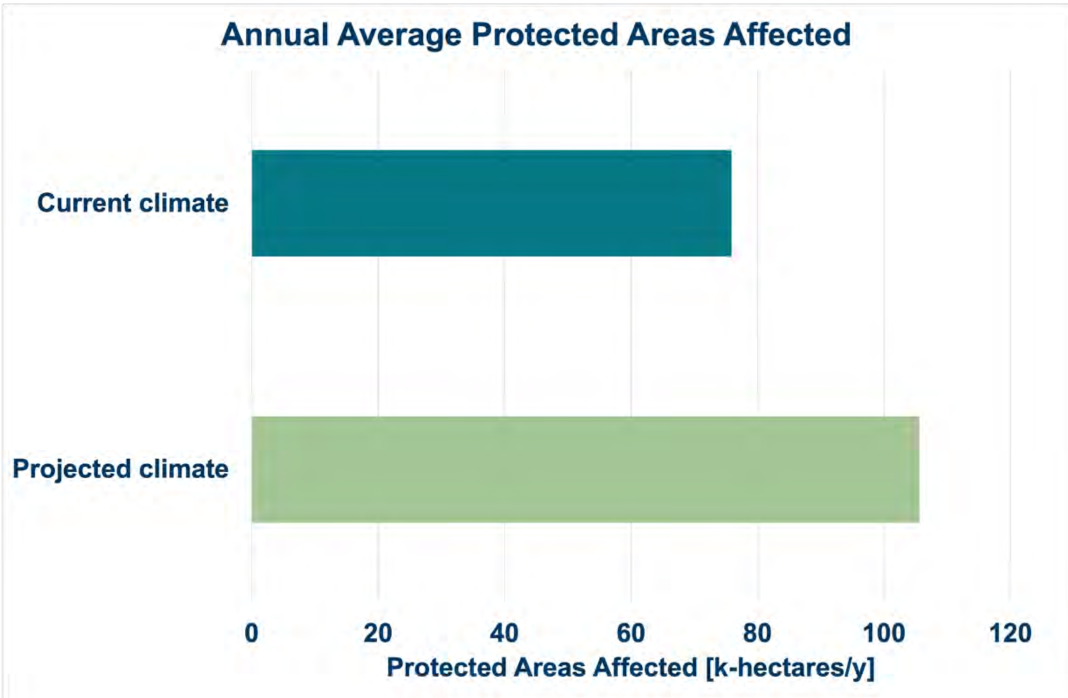
Crop production



Livestock



Protected areas



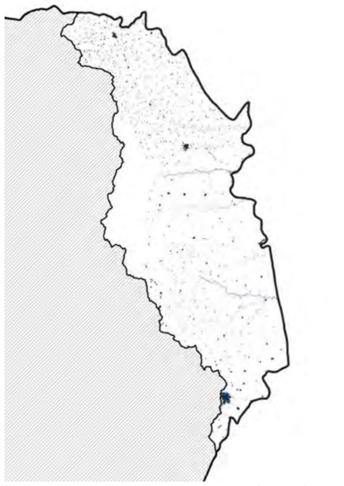
Cote d'Ivoire's results

Floods

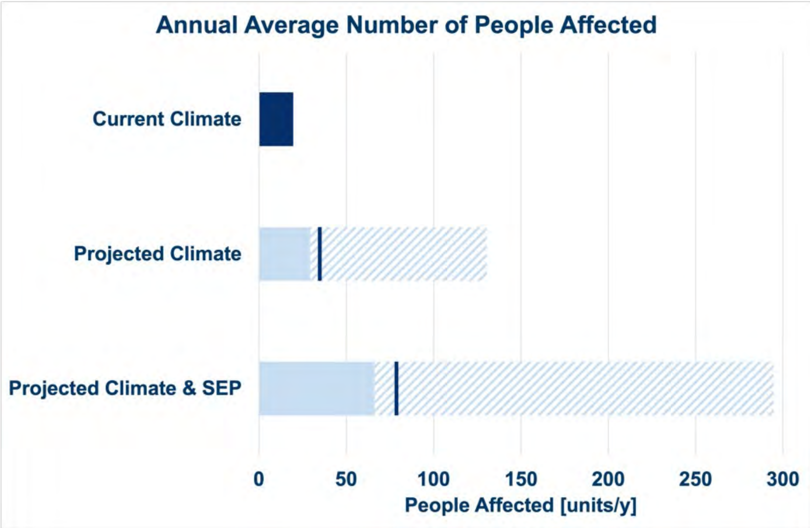
KEY MESSAGES

- Only the portion of the Zanzan region in Coté d'Ivoire, that is part of the Volta basin, is included in the risk profile.
- In this region, impacts related to floods are very limited, and the contribution to the overall AAL for the various indicators is always almost negligible.
- Nevertheless, some increase in the impacts can be associated to projected climate conditions, at least in comparison with the situation in current climate conditions.

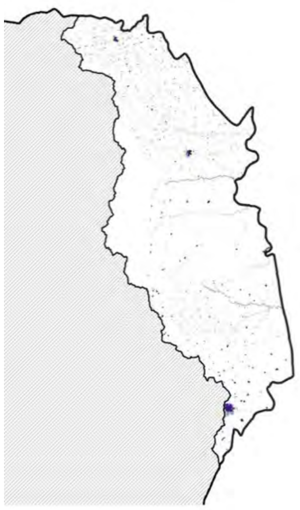
Population



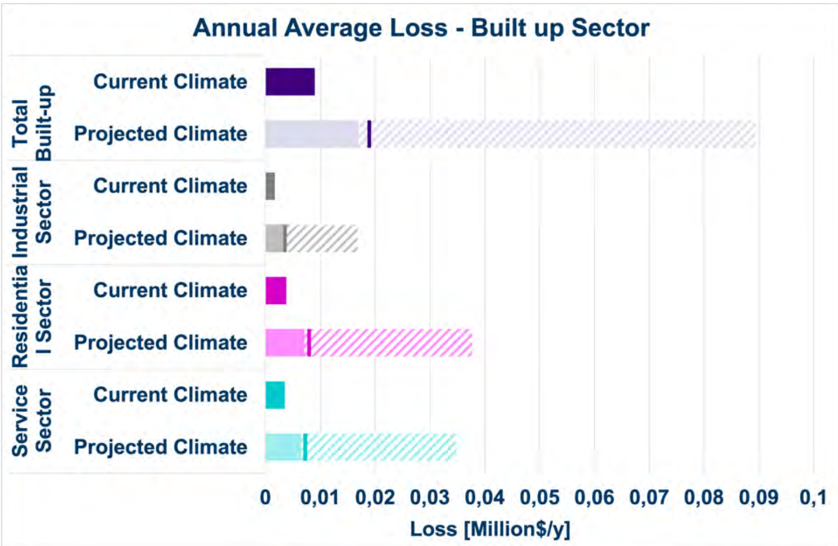
* Context map showing population distribution (WorldPop Unadj 2020 constrained + quantitative information from the National Institute for Statistics) overlaying on a reference hazard map (1000 years).



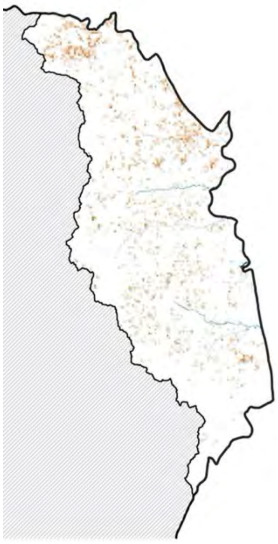
Built-up

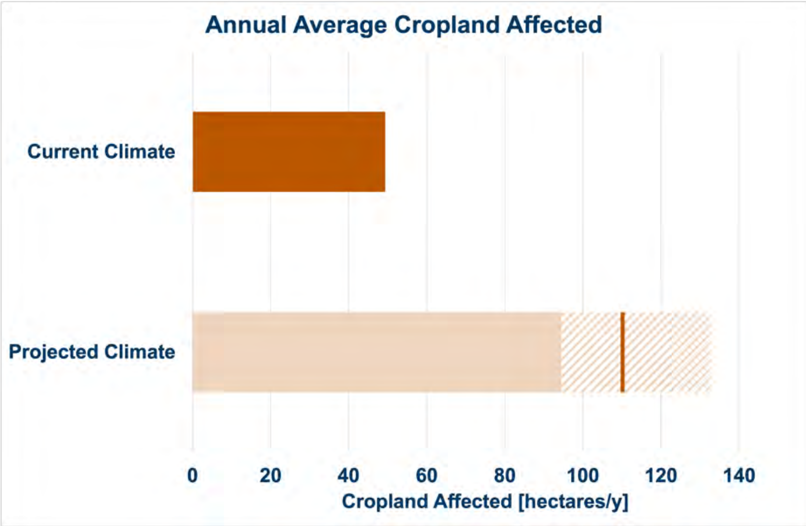


* Context map showing the distribution of the built-up area (from Land Cover data and populated areas according to WorldPop Unadj 2020 constrained) overlaying on a reference hazard map (1000 years).



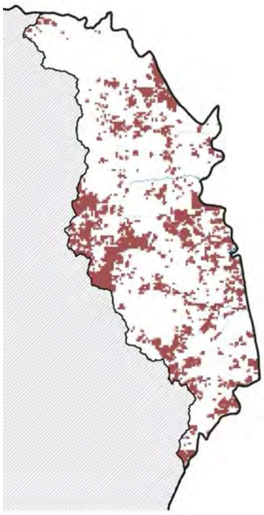
Cropland

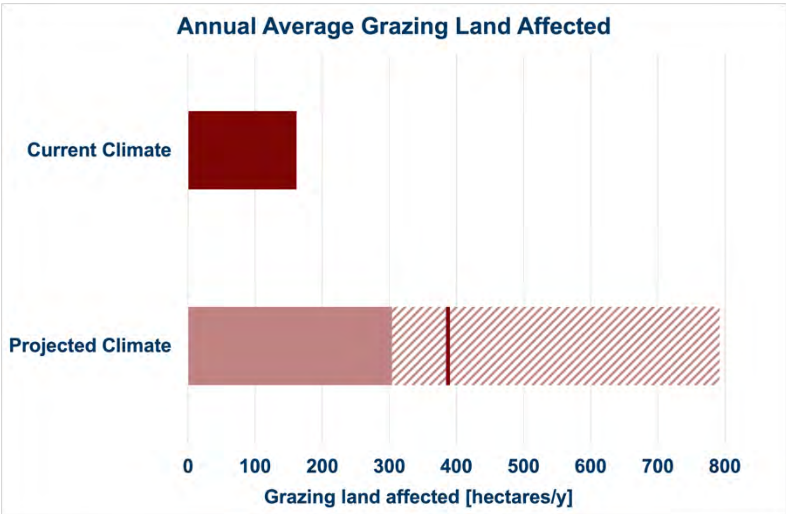




** Context map showing the distribution of cropland areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).*

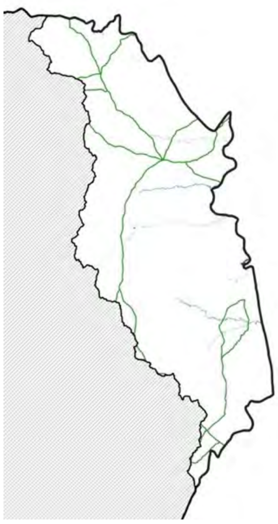
Grazing land



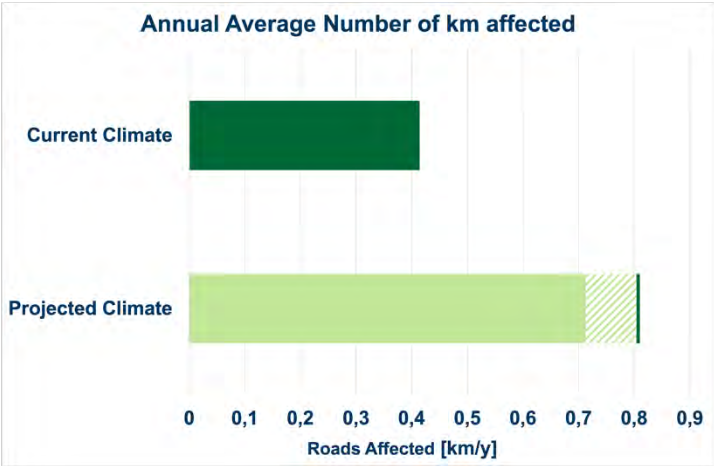


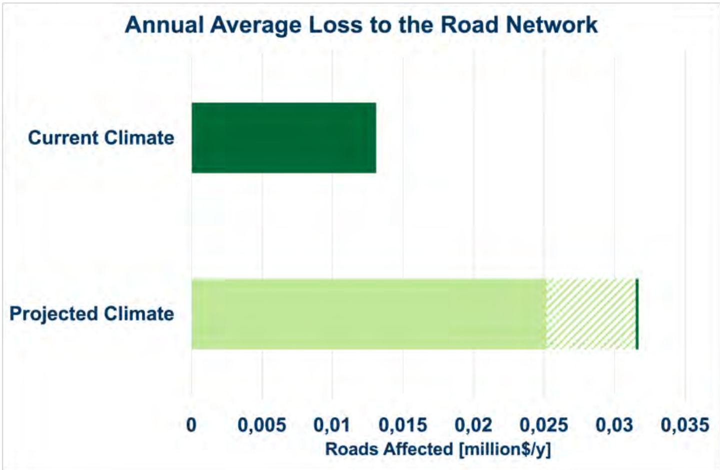
** Context map showing the distribution of grazing land areas (from Land Cover data and ASAP initiative data as mask) overlaying on a reference hazard map (1000 years).*

Roads Network



* Context map showing the location of roads network facilities (from OpenStreetMap data) overlaying on a reference hazard map (1000 years).



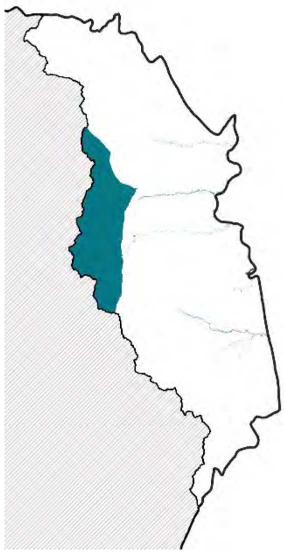


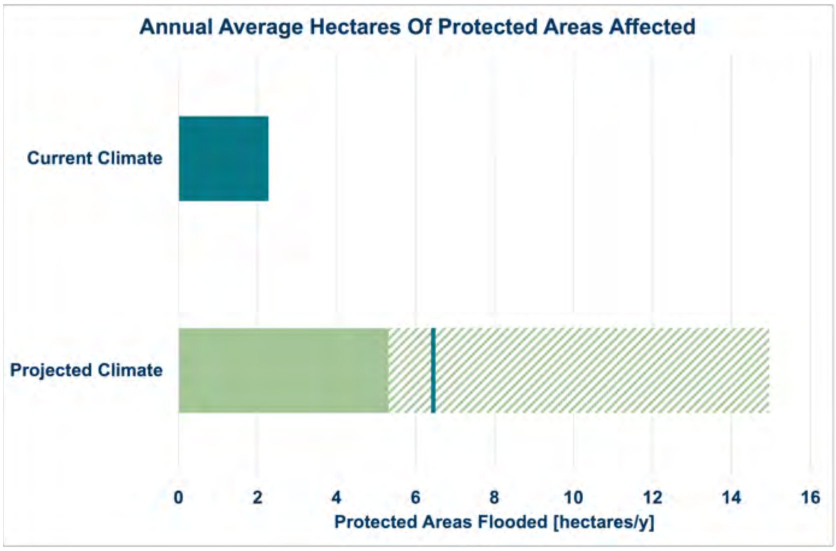
Critical facilities

* Context map showing the location of education and health facilities (from OpenStreetMap data) overlaying on a reference hazard map (1000 years).

AAL = 0 in current and projected climate conditions

Protected areas





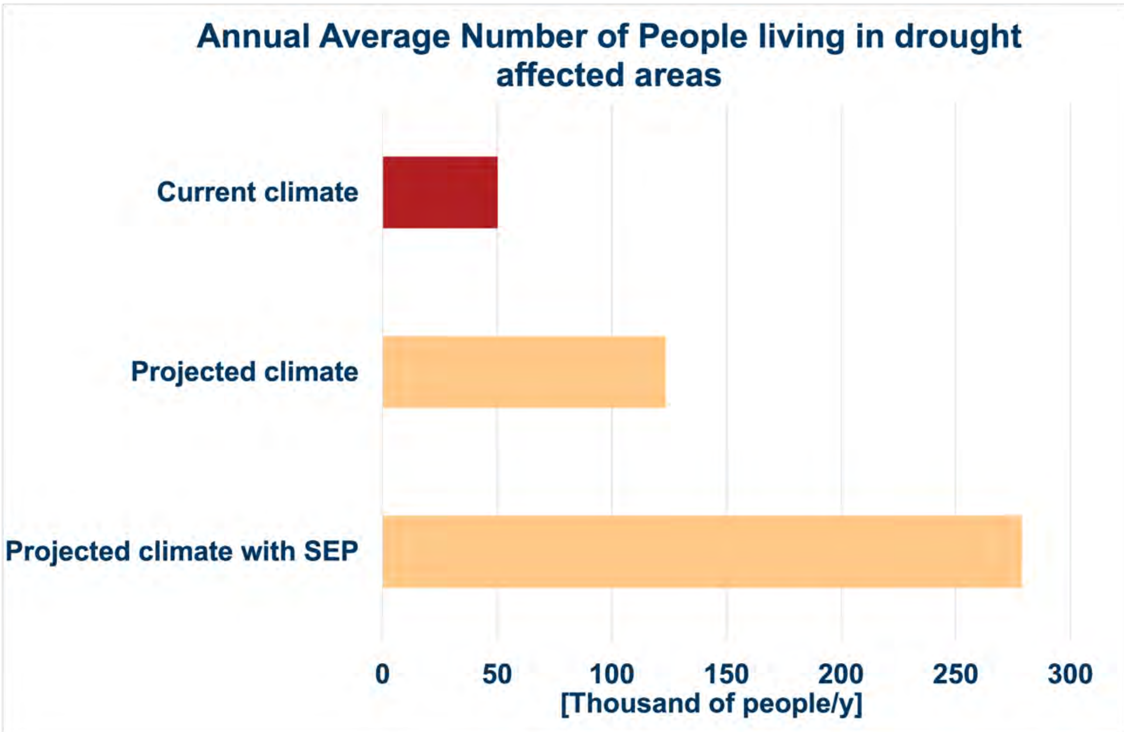
** Context map showing the distribution of protected areas (from the IUCN database) overlaying on a reference hazard map (1000 years).*

Drought

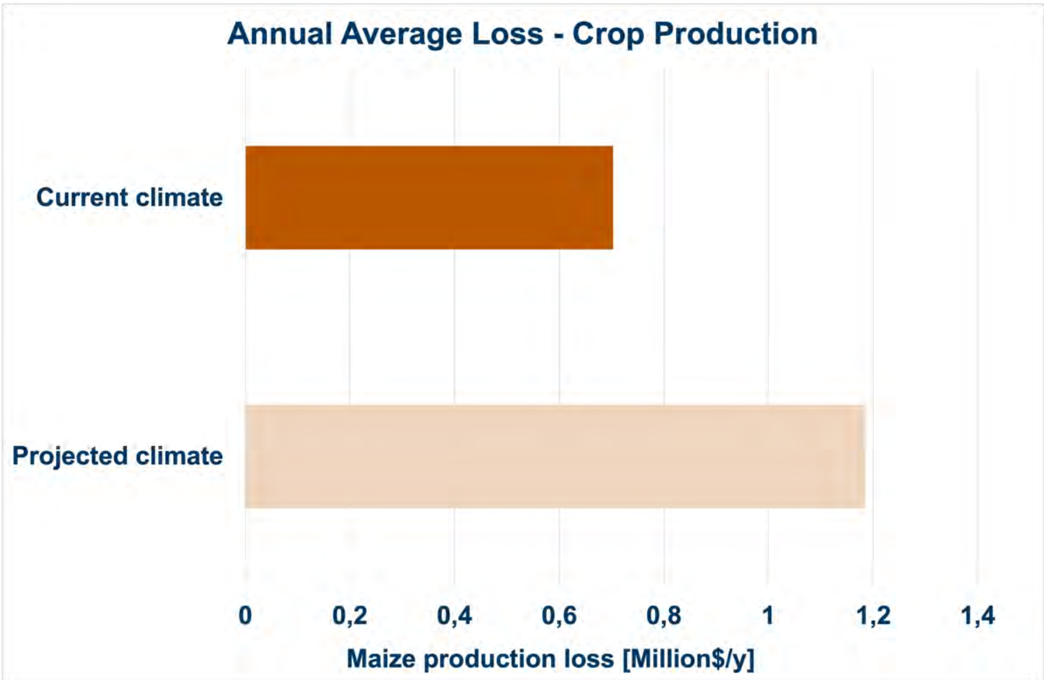
KEY MESSAGES

- In the part of Côte d'Ivoire situated in the Volta Basin (part of Zanzan), on average 50 thousand people and 23 thousand animals are exposed to droughts per year.
- Climate change projections will increase these numbers with 146% respectively (excluding changes in population and livestock).
- Cattle is the animal type mostly exposed to severe droughts, both under current and projected climate conditions.
- In the part of Cote d'Ivoire situated in the Volta Basin, on average almost USD 0.7 million per year is lost due to drought-induced maize yield reductions.
- Zanzan will see a large increase (+69%) in losses under climate change, as large annual average yield reductions are estimated under projected climate conditions.

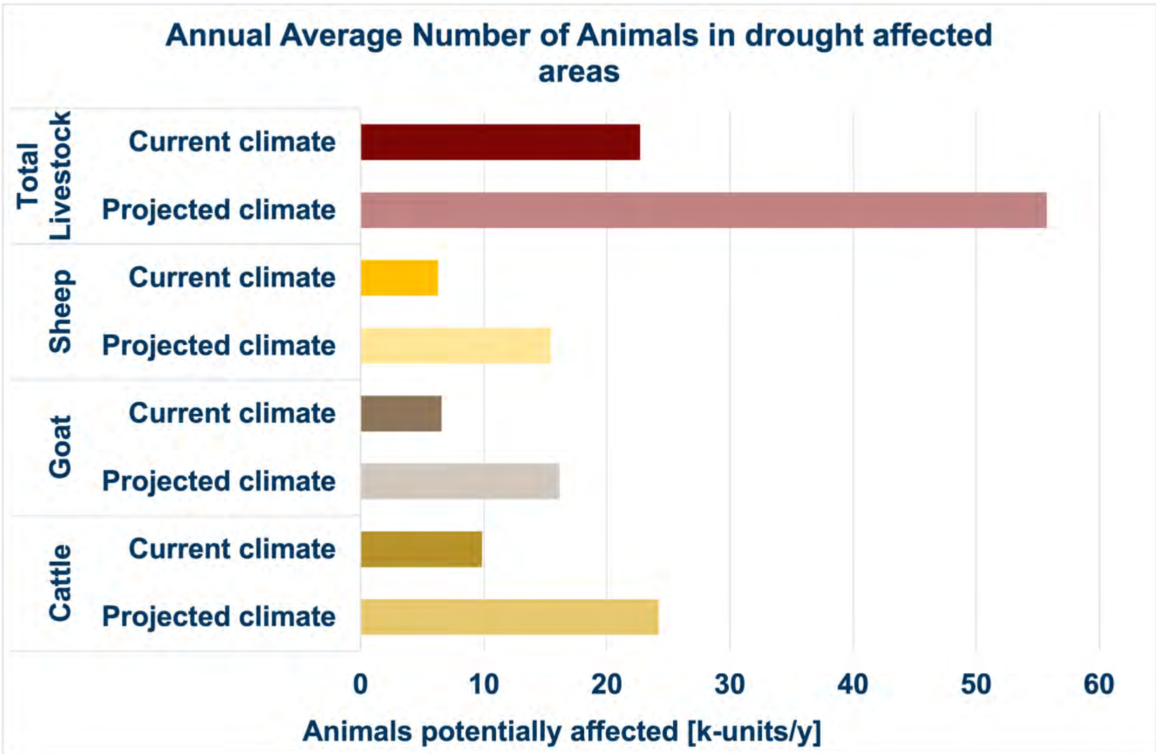
Population



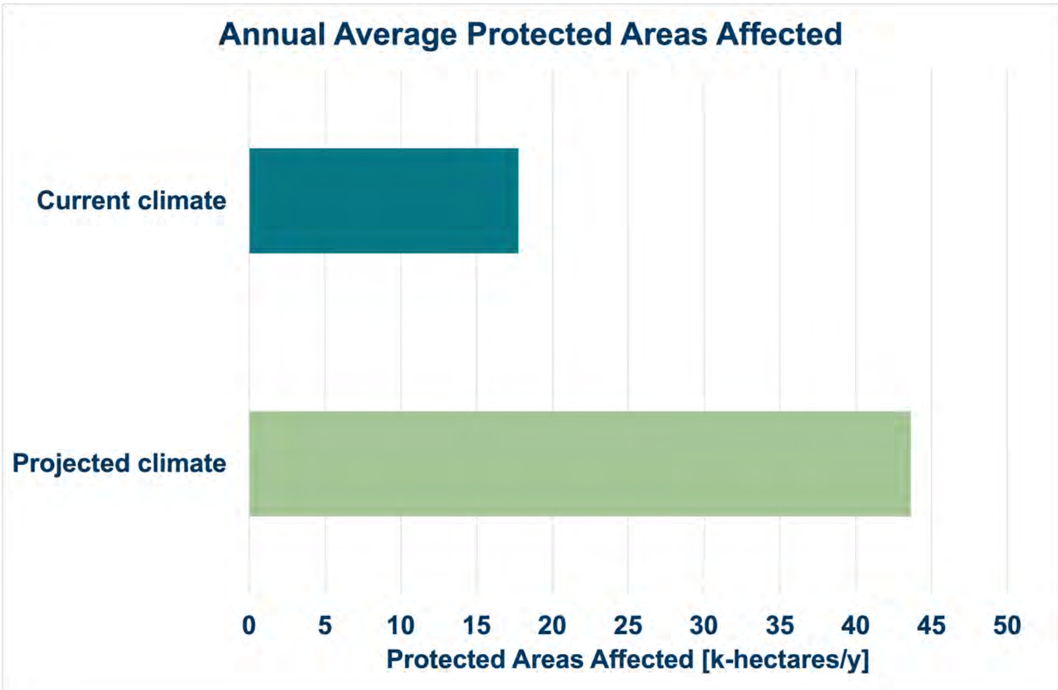
Crop production



Livestock



Protected areas



Recommendations

From 4 April to 25 May 2022, six National Workshops took place to present the flood and drought Disaster risk profile for the Volta basin, one in each of the riparian countries (Ghana, Cote d'Ivoire, Benin, Burkina Faso, Mali, Togo). These workshops were organized by GWP-WA, VBA, WMO, the VBA National Focal Structure of each country and CIMA Research Foundation (Italy).

Each workshop was opened by a speech of the local VBA line ministry or its representative. The coordinator of the local National Focal Structure chaired the opening, with the remarks from a representative of the Volta Basin Authority and a representative of CIMA Research Foundation.

Following working discussions over three days of activities in each country, the workshop's participants over the six riparian countries proposed several recommendations, resumed and harmonized in the following 12 Disaster Risk Reduction Policies Recommendations. The final table provides an overview of the countries that suggested main elements of each recommendation.

The recommendations are specific for the basin and addressed to national actors, the Volta Basin Authority and international partners. Each recommendation requires the involvement of several national authorities, institutions and stakeholders that are different in the riparian countries, considering their institutional and legal framework. The Volta Basin Authority could provide a common reference framework, promoting coordination among policies and interventions in the riparian countries, and, together with international partners, will have a key role in facilitating and advocating for the implementation of the recommendations.

Floods and droughts

1. **Mainstreaming Risk Profile**. The Floods and Droughts Disaster Risk Profile of the Volta basin highlights annual average losses over several sectors. DRR investments are key to reducing these drought- and flood- induced losses. As such, DRR measures must be integrated across different sectors to increase the future resilience of the Volta basin. The government should therefore promote development actions that consider disaster and climate risks in order to reduce flood and drought impacts across all sectors by mainstreaming the findings of the present risk assessment in all related plans and policies. The mainstreaming can includes: presentation to

parliamentarians, relevant national and local institutional responsible for adaptation and development plans, scientific institution and civil societies organization.

2. **Risk Informed Sustainable Development and Water Resources Management.** The general increase of impacts in projected climate conditions for all indicators of the risk profile, for both floods and drought, highlights the importance of strengthening the legal and institutional framework for DRR and DRM in all the six riparian countries with a regional transboundary coordination at basin scale. It is recommended to review and implement the Water Charter for the Volta River Basin to become a plan for sustainable development, that explicitly includes risk knowledge and focuses on water management related issues, integrating the component of disaster risk management. This could provide a common framework for the national governments for the development of preparedness, contingency, emergency and recovery plans for floods and droughts, from the national to the local level, taking into consideration the areas that are most disaster-prone as identified in the risk profile.

3. **Early Warnings and Anticipatory Actions.** The exacerbated level of risk in projected climate conditions highlighted by the risk profile points to the importance of anticipation, preparedness and prevention for reducing losses and damage. Within this framework, it is crucial to establish and make operational an Early Warning System at basin scale and develop capacity building programs, in terms of both skills and equipment, for the concerned services (national agencies for Meteorology, Hydrology, Water Resources, Civil Protection, Agriculture). This would allow to:
    i. strengthen the production, analysis and dissemination of hydro-meteorological information (short-term to seasonal forecasts, local monitoring network data, etc...);
    ii. enhance the elaboration and implementation of protocols for data sharing, interinstitutional and transboundary cooperation;
    iii. empower National agencies involved in DRR in the dissemination of timely warnings and in the definition and implementation of operational procedures for prevention, early action and response, reducing impact and losses due to hydrometeorological hazards.

Additionally, the Volta basin authority could use the risk profile to prioritize areas to be considered for pilot implementation of community early warning systems, based also on empirical local knowledge and indicators, raising awareness on flood and drought risks in local populations.

4. **Advocacy, investments and contingency budget allocation**. Using data from the risk profiles as a starting point, some Flood and Drought Risk financing interventions should be implemented from the governments of the riparian countries. Firstly, it is recommended to elaborate a financing strategy based on drafting funding requests for bankable projects to advocate funds from international financial entities for flood and drought risk management. In addition, the governments should strengthen investments plans for economic, social, cultural and environmental resilience, integrating credit lines for disaster risk management into national, sectoral, communal and departmental budget lines in each country of the Volta Basin. Furthermore, it would be important to define consensual and efficient procedures for making resources available for the establishment of an emergency response and solidarity fund for the Volta basin, supporting VBA in identifying also external sources to feed the fund and setting-up mechanisms to mobilize the identified resources. The results of the risk profile can provide a first basis to dimension the contingency fund. Additionally, the governments could use the risk profile to prioritize areas to be considered for promoting the implementation of community contingency plans and funds as crucial tools for reducing impact of potential floods and droughts at the community level.

5. **Policies for DRR Women empowerment.** The results of the risk profile highlight that the population growth, as foreseen by UN 2050 demographic projections, could triple impacts on population for both floods and droughts in the Volta basin. The increasing trending of climate-related disasters can exacerbates inequalities, included gender one, within and between countries. The Sendai Framework recognizes the importance of integrating a gender perspective into all DRR policies and practices, and the need to empower women to publicly lead and promote gender equitable and universally accessible response, recovery, rehabilitation and reconstruction. Considering this, the governments could promote programs and policies

aiming at encouraging the schooling and long-term permanence in schools of young girls and advocating with customary leaders and heads of families towards empowerment of women and girls for more resilient societies.

6. **Awareness, Communication and Education**. The risk profile is a powerful way to visualize risk and therefore can be used to communicate the likelihood and magnitude of certain drought and flood impacts, hence increasing the awareness of risk at all levels. The Volta Basin authority could develop a general strategy for information, communication and education on flood and drought risks, being the common shared framework for the national governments to develop and conduct awareness programs and communication plans at the national and local level as an integral part of preparedness and emergency response mechanisms to disasters.
   It is recommended to use the results in the risk profiles for flood and drought as reference material for initiatives leading to behavioral change: i) to reinforce the disaster risk awareness programs in vulnerable communities, ii) to promote specific education programs in school curricula and develop sensitization activities for teachers and parents. These initiatives should focus on effects of natural hazards and actions to be taken to reduce potential impact, including good practices in terms of land management and nature conservation.

Floods

1. **Risk-informed land use planning policies**. The results of the risk profile highlight that on average more than 25,000 people per year are potentially affected by flood risk in the Volta basin in current climate conditions, while considering projected climate conditions this number rises to more than 40,000 people. If population growth is considered almost 80,000 people could be potentially affected. This calls for the development of risk-informed land use planning policies, based on updated maps of flood-prone areas, with the objective of identifying safe zones for urban development, crop production and establishment of service and critical infrastructures for the continuously growing population. Using the results provided in the risk profiles, the hotspot areas are easily identified, buffer zones can be defined and preserved and the unplanned occupation of lands along the Volta river

could be resisted and reduced. Local risk assessments should be carried out in the identified high-risk areas to inform the new land use planning policies.

2. **Flood defense and risk mitigation**. The Probable Maximum Loss Curves show a rapid increase in expected damages for very likely flood events (small return period) and become stable for less frequent events. This could be most probably related to poor defense infrastructures. For this reason, it is recommended to the governments of the riparian countries to design and realize flood defense or other mitigation infrastructures, that can decrease the intensity of the hazard, especially for very likely flood events. This should be done considering the catchment system as a whole, to avoid creating increased hazardous conditions downstream the area where the interventions are implemented. The following measures should be considered, with the possibility of realizing the intervention through Nature-based Solutions (NbS):
   i. flood retention ponds, that can reduce the discharge peak;
   ii. regularization of riverbanks to avoid riverine floods to overflow in high risk areas;
   iii. improvement of the carrying capacity of river through adequate cleaning of hydraulic infrastructures and regulation of river sediment;
   iv. afforestation and plantation of new plants that can also contribute to increasing evapotranspiration, reducing the sediment transport and the water discharge during extreme events.
   v. It is very important to envisage and plan the correct maintenance of the new afforestation, as in the long term that can eventually increase the amount of solid material carried during floods.

3. **Improvement of buildings resilience**. According to the results of the risk profile, 50% of the impact on built-up area (25 million USD) focuses on the housing sector. The governments of the riparian countries should adapt their building codes improving the resilience of constructions taking in consideration the indications of the risk profile when climate change is considered. This should also consider the conditions at national level in terms of materials available for exploitation. This would reduce vulnerabilities of buildings and hence reduce the damages of floods to built-up sector. Additionally, the governments should priorities the

implementation of new resilient building code to areas with high risk of flooding.

Droughts

1. **Investments and awareness for climate-smart agriculture**. The agricultural sector is affected with important annual losses by droughts. Under projected climate conditions, most of the regions in the north part of the Volta basin are estimated to face annual average yield reductions of over 8% due to severe drought conditions. This sector is critical, not only because of the direct economic losses that it suffers, but also in consideration of the effects that reduced agricultural production can have on food security for the population.
   It is therefore recommended to implement disaster risk sensitive investments and funding in agriculture aiming at fostering climate-smart agricultural practices: i) investing in climate-resilient seed development; ii) identifying and studying the use of crop and plant varieties suited to the climatic context ; iii) promoting the adaptation of cultivation methods, including best practices coming from agroecology and agroforestry in agriculture (as, for example, plantations of fast-growing species creating a wood-energy nexus) and initiation programs on water and soil conservation techniques.
   To ensure a transition to drought tolerant varieties and encourage farmers to make the switch, governments should provide dedicated subsidies, access to micro-credits and trainings. This would improve food security and reduce economic losses due to climate shocks. Based on data on the effect of drought in the agricultural sector, the whole Volta basin faces losses of up to 17 millions dollars of maize production per year when standard varieties are used. If drought-tolerant maize varieties were to be adopted basin wide, a large part of these losses would be avoided. This and similar policies should be better evaluated and quantified in a cost benefit analysis framework.

2. **Risk-informed land use planning policies**. The risk profile shows that droughts have a significant impact on livestock and the livelihood of pastoral communities in the Volta basin, as well as on protected areas: on average 5 millions of animals and 800,000 hectares of protected areas per

year are exposed to severe drought conditions. It is recommended that the national governments promote, through land use planning and policies:

i. interventions for zero net land degradation, as sustainable land management, erosion control, rangeland regulation and management;
ii. initiatives to reduce community conflicts related to land and livestock, creating conditions for maintaining animals on site (watering troughs, fishponds and fodder production) and for managing transhumance in a safe and sustainable way (creation of dedicated corridors and demarcation and securing of pastoral tracks);
iii. implementation of conservation areas, reforestation and recovery of degraded lands in areas at high risk of drought.

3. **Efficient water management**. The Risk assessment predicts a strong increase in climate variability: while the overall availability of water resources may increase and the hydropower production is expected to rise in the four main dams of the Volta basin, dry periods seem to occur more often and with increasing intensity. This implies that, even in a hydrological regime of increasing average annual river flows, the impacts of drought will increase, passing from 4.5 million people per year exposed to severe drought conditions to more than 15 millions at the end of the century, considering climate change and population growth. Therefore, it is recommended to promote efficient water management through the 3R approach (retention, reuse, recharge) and implement, possibly through Nature-based Solutions:

i. water harvesting and water retention ponds at community level in rural areas;
ii. reservoirs and dams at regional level to store water for use during drought and to be used also as livestock rotary points;
iii. valorization of groundwater through rehabilitation of existing boreholes;
iv. water resources monitoring systems;
v. regulations for enhancing rational use of water resources through seasonal rationing and restrictions;

vi. regulations for improving water demand management to reduce conflicts related to land and livestock through regulated access to water resources.

Overview of the countries suggesting main elements of the 12 Disaster Risk Reduction Policies Recommendations

Recommendations		Benin	Burkina Faso	Cote d'Ivoire	Ghana	Mali	Togo
Floods and Droughts	Mainstreaming Risk Profile						
	Risk Informed Sustainable Development and Water Resources Management	■		■	■		■
	Early Warnings and Anticipatory Actions	■	■	■	■	■	■
	Advocacy, investments and contingency budget allocation	■		■	■		■
	Policies for DRR Women empowerment		■				
	Awareness, Communication and Education	■	■	■	■	■	■
Floods	Risk-informed land use planning policies	■	■	■	■	■	■
	Flood defense and risk mitigation	■			■		■
	Improvement of buildings resilience	■			■		
Droughts	Investments and awareness for climate-smart agriculture		■	■		■	■
	Risk-informed land use planning policies		■			■	■
	Efficient water management		■	■	■		■

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