



# Livelihood Security

Climate Change, Migration and Conflict  
in the Sahel



United Nations Environment Programme

This report was produced through a technical partnership between UNEP, the International Organization for Migration (IOM), the Office for the Coordination of Humanitarian Affairs (OCHA) and the UN University, and written in collaboration with the Permanent Interstate Committee for Drought Control in the Sahel (CILSS). The University of Salzburg's Center for Geoinformatics (Z\_GIS) played a key technical role in the development of the maps.

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United Nations Environment Programme  
11-13, Chemin des Anémones  
CH-1219 Châtelaine, Geneva  
Tel. : +41 (0)22 917 8530  
Fax: +41 (0)22 917 8064

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## Climate Change, Migration and Conflict in the Sahel



United Nations Environment Programme

in cooperation with

International Organization for Migration (IOM)  
Office for the Coordination of Humanitarian Affairs (OCHA)  
United Nations University (UNU)  
and

The Permanent Interstate Committee for Drought Control in the Sahel (CILSS)

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# Foreword

Jointly contributed by UNEP, IOM, OCHA and UNU

As this report goes to print, the Horn of Africa faces the worst drought it has seen in 60 years and a humanitarian crisis of untold proportions. Caused by a combination of insecurity and hunger at famine levels in southern Somalia, the crisis has caused massive displacement within the country and across borders into Kenya, Yemen, Ethiopia and Djibouti. To date, over 12 million people have been affected.<sup>1</sup> To add to this tragic situation, it has been reported that food insecurity in the region could persist for several months due to below-average rains forecasted for the end of 2011.<sup>2</sup>

Commenting on the disaster, United Nations Secretary-General Ban Ki-Moon has warned that “today’s drought may be the worst in decades, but with the effects of climate change being increasingly felt throughout the world, it surely will not be the last.”<sup>3</sup> Indeed, the Intergovernmental Panel on Climate Change has shown that the countries of the Sahel are likely to be particularly at risk from changing climatic conditions, which compound existing challenges linked to population growth, environmental degradation, pervasive poverty and chronic instability.<sup>4</sup>

The scale of the crisis in the Horn of Africa underscores the urgent need to better understand climate trends in the wider region and to identify areas where populations are most at risk from climate-related factors. This is essential in order to design more effective responses, including adaptation measures that take into account the potential knock-on effects of changing climatic conditions on issues already affecting the region, such as food insecurity, displacement and conflict.

Based on a unique mapping process analyzing trends in temperature, rainfall, drought and flooding

in the region over the last 40 years, this report provides a timely and important contribution to policy-makers and practitioners seeking to ground adaptation policies and investments in a sound understanding of the nature and scale of historical climate trends in the Sahel, as well as their impacts on livelihoods. The report further examines how these changes in climate exacerbate existing vulnerabilities and may become new drivers for conflict or forced migration.

This study was developed by the UN Environment Programme (UNEP), in close cooperation with the International Organization for Migration (IOM), the UN office for the Coordination of Humanitarian Affairs (OCHA) and the United Nations University (UNU). Equally central to this project was the collaboration with regional partners, in particular the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), which provided invaluable inputs, perspectives and support, and determined the geographical scope of the study.

Although further field research on the potential impacts of climate change on migration and conflict dynamics in the Sahel is still urgently needed, this report is a first important step in calling attention to the risks and catalyzing action to address the vulnerabilities. We invite all national and regional counterparts – as well as the international community – to engage with us in addressing these major challenges. As Jan Egeland, former Special Advisor to the UN Secretary-General for Conflict Prevention and Resolution already noted in May 2008 when visiting the region, “the effects already speak for themselves,”<sup>5</sup> therefore the time to act is now.



# Preface

by the Permanent Interstate Committee for Drought Control in the Sahel (CILSS)

Climate hazards are a real concern for Sahelian people due to their adverse socio-economic and environmental impacts. In the Sahel, 80 per cent of the population depends on natural resources for their livelihoods. Therefore, these resources play a major role in the preservation of peace and social security. Indeed, most West African economies rely heavily on agriculture and natural resources for a significant share of their gross domestic product (GDP), national food needs, employment and export revenue. Therefore, competition for access to and control of these resources remains a real issue, which is at the root of the recurrent conflicts that threaten social peace and hold back development.

In addition to the proliferation of local conflicts, the Sahelian region is increasingly affected by political and social crises that degenerate into armed conflicts, highlighting the disruption of the ecological, social and economic balance.

According to the Intergovernmental Panel on Climate Change (IPCC), the Sahel and West Africa are among the most vulnerable regions to future climate fluctuation. The Sahel also faces substantial population growth (at an average of 3 per cent per year), leading to a severe and continuing degradation of natural resources, thus increasing poverty and food insecurity. Demographic projections agree on a population of 100 million people by 2025, half of whom will live in cities.

Migration as an adaptation strategy to climate change is not a new phenomenon in the Sahel. We remember the significant movements of population from the northern regions of the Sahel toward the south and coastal countries, following the ecological crises of the 1970s, 80s and 90s. According to current estimates, the world will see between 25 million and 1 billion climate-related migrants by 2050. The Sahel will not be spared these population movements imposed by climate change.

The creation of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS) in 1973 is one of the sub-regional responses to this phenomenon, which, by nature, knows no borders. The mission of CILSS is *inter alia* to produce and disseminate information, and provide training in the following areas: food and nutritional security, combatting desertification, and demographic and development issues. The relationship between population, environment and food security is an important element of this mission. Thus, in 2000, the Sahel Institute (INSAH), one of the specialized institutes of CILSS, published an atlas on migration and environment, which demonstrates the relationship between migration and certain environmental indicators, such as land degradation and the length of the rainy season.

Guided by the UN Framework Convention on Climate Change, the Sahelian sub-region and West Africa are now organizing themselves to better manage the impacts of climate change, with the support of the sub-regional institutions. It is within this framework that a Sub-regional Action Programme to reduce vulnerability to climate change in West Africa was developed by ECOWAS, in close collaboration with CILSS, ACMAD, WAEMU and ECA WA.

The present joint report is also a model of cooperation between international organizations and Southern organizations. This cooperation between the international community and CILSS represents a milestone in taking large-scale action jointly – in particular the production of scientific knowledge that will lead to a better understanding of climate change impacts on migration and conflict in this very fragile Sahelian region – for the benefit of populations.

The relationship between climate change, migration and conflict remains complex. Indeed, it is not easy to establish direct links between climate change impacts, natural resource degradation and the political, economic and social factors that

influence the decision to migrate. However, with climate change threatening the integrity of ecosystems that are already made vulnerable by a rapidly growing population, it is evident that this situation will exacerbate competition over natural resources and trigger movements of people and conflicts. In order to mitigate competition, a regional charter on rural land is being developed at CILSS to take into account the mobility of people and the cross-border nature of certain natural resources such as land, water and forests.

Moreover, considering future climate change scenarios and their potential implications on human security, it was necessary to attempt to analyze the impacts of climate change on migration and conflict in order to take efficient counter-action. This

is the merit of this publication, which is intended not only as a guide for awareness-raising and a tool to support decision-making at all levels, but also to inform and improve adaptation strategies in the Sahel.

A handwritten signature in blue ink, appearing to read 'A. Bretaudeau'.

*Prof. Alhousseïni BRETAUDEAU*  
CILSS Executive Secretary



# Executive Summary

"Competition between communities and countries for scarce resources, especially water, is increasing, exacerbating old security dilemmas and creating new ones, while environmental refugees are reshaping the human geography of the planet, a trend that will only increase as deserts advance, forests are felled and sea levels rise." By formulating such a strong statement during the July 2011 debate on climate change and security in the UN Security Council, UN Secretary-General Ban Ki-moon underscored the urgent need to assess the implications of climate change for conflicts and environmentally induced migration.

Dubbed "ground zero" for climate change due to its extreme climatic conditions and highly vulnerable population, the Sahel has faced massive population growth, pervasive poverty, food insecurity, and chronic instability for decades. With a majority of the population directly dependent on natural resources for its livelihood, the predicted impacts of climate change for resource availability and food security in the region could be dramatic.

A mission undertaken to the Sahel in June 2008 by Jan Egeland, then Special Advisor to the UN Secretary-General for Conflict Prevention and Resolution, highlighted three main risks: (i) the threat posed by the potential impacts of climate change for livelihoods, in particular for livelihoods that are dependent on natural resources, such as farming, fishing and herding; (ii) increasing migration pressures due to disasters, conflicts and the associated loss of livelihoods; and (iii) escalating tension and potential conflicts over increasingly scarce natural resources, coupled with the availability of small arms and light weapons.

These findings called for further research and analysis on historical climate trends in the Sahel, in order to understand more about how livelihoods were being affected, what coping mechanisms were emerging, and how these changes related to behavioural responses such as conflict and migration. This report, which was authored by the UN Environment Programme (UNEP) in cooperation with the International Organization for Migration (IOM), the

Office for the Coordination of Humanitarian Affairs (OCHA) and the United Nations University (UNU), as well as the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), provides an initial response to this call.

Aimed at supporting policy and decision-makers in the Member States of the region, adaptation and peacebuilding practitioners worldwide, as well as ongoing international climate change negotiations, this study has two complementary objectives: (i) to analyze the historical climate trends in the region, identify hotspots, and determine the potential implications for natural resource-dependent livelihoods; and (ii) to provide recommendations for improving conflict and migration sensitivity in adaptation planning, investments and policies across the region.

The report presents the findings of a unique mapping process analyzing climate trends over a 24 to 36-year period in 17 countries, from the Atlantic coast to Chad. The nine countries represented by CILSS – Burkina Faso, Cape Verde, Chad, the Gambia, Guinea-Bissau, Mali, Mauritania, Niger and Senegal – determined the core geographical scope of the study. However, given the transboundary nature of climate change, as well as migratory patterns and economic trade in these countries, eight neighbouring members of the Economic Commission of West African States (ECOWAS) – Benin, Côte d'Ivoire, Ghana, Guinea, Liberia, Nigeria, Sierra Leone and Togo – are also included in the analysis.

The maps, which were produced through a technical cooperation with the University of Salzburg's Centre for Geoinformatics, focus on four climate indicators based on the best available data: precipitation (1970-2006), temperature (1970-2006), occurrence of drought (1982-2009), and occurrence of flooding (1985-2009). The potential impact of projected sea-level rise in the region is also mapped. The data is then combined to identify potential "hotspots," including areas where the most extreme changes in the four individual climate indicators have taken place, as well as areas where the most cumulative change in these four climate indicators has occurred. Each map includes two

additional layers showing population trends and conflict occurrence during the same time periods.

On the basis of the research described above, this study examines the relationship between climate change, migration, and conflict, highlighting areas of particular interest or where further research is needed. In no way does it argue that climate change acts as a single and isolated factor in migration or conflict, nor does it attempt to show a direct causal link between these three issues. Climate change, migration and conflict, rather, are interlinked through complex influencing factors that include economic, social and political issues.

On the strength of the findings of the mapping process and information gathered from existing literature, case studies and field observation, as well as an overview of existing adaptation plans in the countries of concern, this report reaches five main conclusions. As a result, seven principal recommendations are presented to national, regional and international policy and decision-makers, as well as adaptation practitioners in the region. The UN system can also address many of the issues highlighted in the recommendations through its specialized agencies and programmes. The conclusions and recommendations are summarized below.

## Conclusions

### *Significant changes in regional climate trends detected, impacting livelihoods and food security*

1) The regional climate trends observed over the last 40 years in the Sahel show that overall temperatures have risen, droughts have been recurrent and severe, rainfall has generally increased, and floods have occurred more frequently and with more intensity: There has been a general increase in mean temperature in the region since 1970, with half the population in the CILSS countries experiencing an increase of between 0.5-1°C, and 15 per cent an increase of more than 1°C. Precipitation has also increased in some parts of the region since the early 1970s, although the mean seasonal rainfall is still below the long-term average from 1900 to 2009. Flooding has increased in frequency and severity, affecting large numbers

of people in the region: 54 per cent of the CILSS population has faced five or more floods since 1985. The area has experienced recurrent and severe drought since the 1970s, which has had a very significant impact on livelihoods. Finally, it is estimated that sea-level rise of up to one metre would directly affect over three million people in the region.

2) **Changes in the regional climate are impacting issues linked to the availability of natural resources essential to livelihoods in the region, as well as food insecurity. Along with important social, economic and political factors, this can lead to migration, conflict or a combination of the two:** Changes in climate most impact livelihoods that are directly dependent on natural resources, for example through a decrease in agricultural yields, the gradual unsuitability of traditional grazing grounds, or the drying of important water bodies. Livelihood vulnerability, however, is also linked to many non-climate factors, such as unequal land distribution, insecure land tenure, poorly developed markets, existing trade barriers and inadequate infrastructure. Underlying all of these factors is the role of governance in planning and regulating development, ensuring access to land, providing infrastructure support to mitigate risks from sudden-onset disasters, and promoting livelihood diversification.

3) The migration and movement of people and livestock are an integral part of ancestral livelihood strategies in the region. However, migration also occurs as a result of traditional and non-traditional livelihoods no longer being viable, due to changes in the environment: Seasonal and circular migration can be considered as traditional adaptation strategies to climate variability in the region, offering opportunities for trade and the exchange of ideas. However, these traditional migration patterns are increasingly being replaced by a more permanent southward shift. In addition, the increased frequency and severity of climate-related disasters – such as floods and drought – could lead to more permanent migration over time. Urbanization, partly due to rural-urban migratory flows, is also a defining trend in the region.





*Livelihoods that depend on natural resources, such as this herder in the grasslands of Mali, are particularly vulnerable to changes in the climate*

- 4) **The impacts of changing climatic conditions on the availability of natural resources, coupled with factors such as population growth, weak governance and land tenure challenges, have led to increased competition over scarce natural resources – most notably fertile land and water – and resulted in tensions and conflicts between communities and livelihood groups:** Northern pastoralists, for example, have pushed further southwards into regions used by sedentary farmers, while increasing demand for food has meant that farmers have expanded cultivation into lands used primarily by pastoralists. Livelihood diversification, a key response to environmental changes that have affected the viability of traditional livelihoods, has also placed different groups in direct competition with each other over land and water, leading to local-level tension and conflict. Finally, changes in climatic conditions affect food security by impacting local food production and the availability of staples. In combination with rising commodity prices, food insecurity in turn increases the risk of social unrest and conflict.
- 5) **A number of adaptation policies in the region recognize the linkages between changing climatic conditions and behavioural responses such as migration and conflict, but few so far have included provisions addressing these**

risks. Systematically considering these issues in adaptation planning can reduce conflict and migration risk, help prioritize adaptation investments and strengthen climate change adaptation capacity: Neglecting the factors that can trigger conflict and migration can result in adaptation policies that compound the risks posed by the climatic conditions they aim to mitigate and threaten development gains. Conversely, adaptation policies that reduce livelihood vulnerability, promote alternatives, improve the quality and quantity of natural resources, and decrease resource competition can reduce migratory pressures and minimize the threat of conflict. Incorporating conflict and migration sensitivities into adaptation policies can also help prioritize the most vulnerable areas for targeted adaptation programming and investment of adaptation funding. Finally, building on existing capacity for conflict and migration management, such as regional structures with conflict prevention, migration management or disaster risk reduction mandates, can strengthen adaptation capacity and improve efficiency, which is important in light of the capacity constraints of many countries in the region.

## Recommendations

### *Major investments in climate change adaptation should be used to reduce the risk of conflict and forced migration*

1) **Conduct follow-up field assessments in the hotspots identified in this study, using a livelihoods approach:** Livelihoods provide a clear stepping stone between climate change and conflict risk, as well as between climate change and migration. A livelihoods approach is therefore well suited for follow-up field assessments that should determine how resource availability is changing; how livelihoods and food security are being affected; what coping strategies or adaptation measures are being adopted; whether competition between livelihood groups over scarce resources is increasing, and whether this is a contributing factor in local-level conflicts or migration decisions; and what specific technical and financial support are needed to increase livelihood resilience to changing climatic condi-

tions in the region, thereby reducing conflict risk and forced migration.

- 2) **Adopt climate change adaptation policies that are migration and conflict-sensitive:** Adaptation policies and programmes that aim to reduce livelihood vulnerability, promote alternatives, and improve the availability and access to natural resources can mitigate the drivers of migration and conflict and help secure development gains. A comprehensive conflict analysis engaging local communities should be conducted before designing and implementing climate change adaptation strategies, in order to fully understand and integrate local and regional conflict dynamics. In addition, the positive role of migration should also be considered, particularly for communities facing less advanced stages of environmental degradation. Finally, the benefits of climate change adaptation policies should be carefully considered across social groups so that they do not reinforce inequalities, for example with regard to ethnicity or gender.
- 3) **Root national adaptation strategies in the “green economy” and promote the creation of “green jobs”:** A green economy aims to improve human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. Employment opportunities and enhanced food security resulting from improved agricultural productivity based on sustainable practices, for example, could increase resilience to climate stressors and reduce local tensions and forced displacement. Adaptation policies should therefore consider “green farming” practices, including “climate proofing” agriculture and integrating traditional farming methods with resource-efficient techniques. It is furthermore important to prioritize investments that benefit the local environment and improve ecosystem services, as it is these services on which the poorest people rely on for their livelihoods. New employment opportunities should also focus on increasing the use of local labour, thus diversifying options for income and reducing vulnerability to changes in natural resource availability.
- 4) **Promote regional environmental cooperation in addressing climate change, migration and conflict:** Issues of climate change and migra-

tion are regional in nature, and as such should not only be managed at the national level, as is most commonly the case today. Likewise many cases of conflict in the region are transboundary, as competition for scarce natural resources pushes various groups beyond national borders in search of improved livelihood conditions. These issues should therefore increasingly be addressed through regional cooperation, including through regional institutions like CILSS and ECOWAS, as well as the African Union. UN organizations should also strengthen their cooperation with these regional structures. In addition, it is important that national laws and policies on natural resources and environmental issues be harmonized across the region, in order to avoid inconsistencies or discrepancies between neighbouring countries that could lead to increased pressure on natural resources in areas with weaker legislation.

- 5) **Strengthen preventive action, resource rights and dispute resolution:** Early action on the environmental drivers of crises can help prevent and defuse both imminent threats and broader instability. Dispute resolution should be promoted by building local, national and international capacity to conduct mediation between conflicting parties where tensions are linked to natural resources. Traditional conflict mediation practices should also be adapted to the new realities on the ground as a result of changes taking place in the climate and local environment. Furthermore, clarifying resource rights and land tenure is a prerequisite for effective national and local-level governance. When doing so, national or regional authorities need to consider potential conflicts between national and local/traditional governance structures and, where possible, build on existing and accepted dispute resolution mechanisms. Follow-up to this study should focus specifically on identifying the most vulnerable and conflict-prone communities and livelihoods. As a first step, the hotspots identified in the mapping process presented in this report can be used to inform and prioritize adaptation planning in the region.
- 6) **Prioritize systematic data collection and early warning systems:** Systematic collection of climate data should be established and improved throughout the region, notably through weather

stations set up within the various microclimates. Indicators should further be identified and mechanisms established to systematically collect data on small-scale and localized conflicts in the region, capturing the various causes and triggers. Surveys should also be conducted directly with migrants in order to better understand reasons behind the decision to migrate. The collection of the different datasets should preferably be mandated under one specific regional organization, building on existing structures within CILSS or ECOWAS, for example, and supported by national institutions and the international community. Finally, early warning systems can help defuse livelihood insecurities by providing the information required to mitigate disaster risk, food insecurity and related conflict and migration outcomes. Environmental and natural resource issues should thus be included in international and regional conflict early warning systems in order to support preventive action and encourage environmental cooperation.

- 7) **Use conflict and/or migration risk to prioritize investments and build donor commitment to long-term engagement in the Sahel:** Addressing climate change impacts on livelihoods in the Sahel requires long-term financial commitment and improved coordination of investments. Identified conflict and migration risks from climate change impacts on livelihoods and food security can help prioritize programming and funding in the region. Existing climate change adaptation funding sources – such as the UNFCCC's Green Climate Fund, the Adaptation Fund and the Clean Development Mechanism (CDM) – should be used to address the emerging issues highlighted in this report. The total estimated cost of the immediate next steps recommended in this study is approximately USD 12 million. This includes capacity-building for national and regional authorities in integrating migration and conflict sensitivities into adaptation planning; establishing and maintaining stand-by mediation capacity; establishing a grid of weather stations; conducting ten follow-up assessments in the hotspots identified by this study to quantify conflict and migration pressures from changing natural resources; and initial resources to collect migration and conflict data systematically and down to the local level.



# 1. Introduction

Building on his 2009 report on *Climate Change and its Possible Security Implications*, UN Secretary-General Ban Ki-moon declared in the Security Council in July 2011 that “climate change not only exacerbates threats to international peace and security;<sup>6</sup> it is a threat to international peace and security.” His statement echoed those of many in the international community who view with growing concern the potential impacts on national security of such phenomena as sea-level rise, extreme weather events and increasing resource scarcity. The Security Council debate, in which 65 speakers took the floor, marked an important shift for the topic in international fora – from the margins of the environmental community to the heart of the security agenda.

In 2008, as the UN system undertook to better understand the potential threat of climate change for international stability, the Secretary-General deployed his then Special Advisor on Conflict Prevention and Resolution, Jan Egeland, to the Sahel, a region dubbed “ground zero” for climate change<sup>7</sup> due to its extreme climatic conditions and highly vulnerable population. Stretching 3,860 km across the African continent, the Sahel faces numerous wars and civil conflicts, increasing population pressures, and pervasive poverty and aid dependency.

Conducted together with experts from the United Nations Environment Programme (UNEP) and other agencies in June 2008, Egeland’s mission highlighted three key areas: (i) the risks posed by the potential impacts of climate change for livelihoods in the Sahel, in particular for livelihoods that are dependent on natural resources, such as farming, fishing and herding; (ii) increasing migration pressures due to disasters, conflicts, and the associated loss of livelihoods; and (iii) escalating tension and potential conflicts over increasingly scarce natural resources, coupled with the availability of small arms and light weapons.<sup>8</sup>

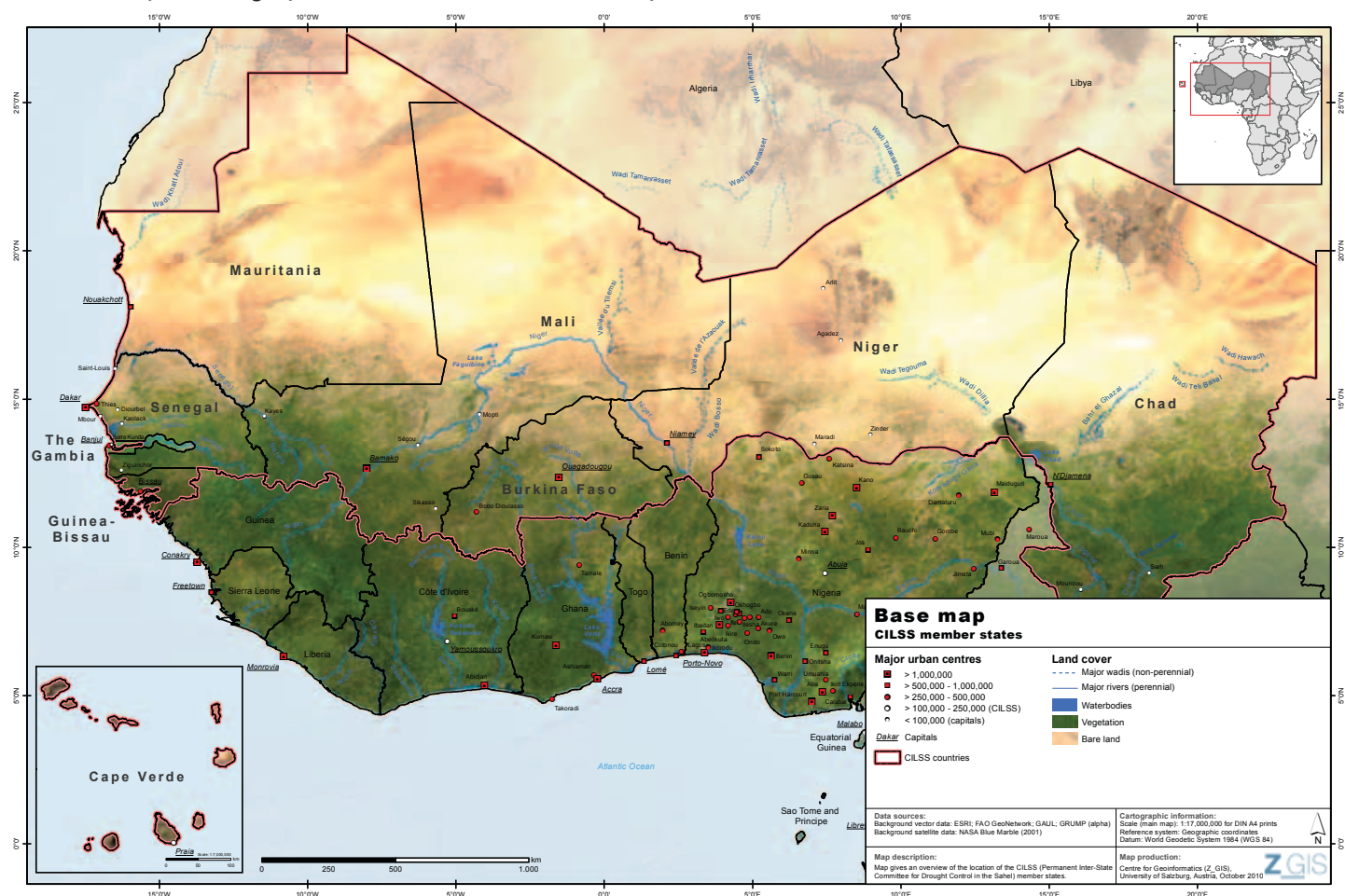
While underscoring the need for greater investment in climate change adaptation, these findings called for further research and analysis on historical climate trends in the region, in order to understand

how livelihoods have been affected, what coping mechanisms have emerged and the potential impacts for conflict and migration. This report answers this call.

Aimed at supporting Member States in the region, as well as adaptation practitioners worldwide, this study provides a timely contribution to policy-making as adaptation financing is increasing. Mechanisms like the newly created United Nations Framework Convention on Climate Change (UNFCCC) Green Fund, for example, are expected to mobilize up to US\$ 100 billion a year by 2020 to help developing countries adapt to the effects of climate change, while multi-million dollar projects such as the much publicized Great Green Wall seek to reduce poverty by addressing severe environmental degradation and climate change impacts across a 7,000 km stretch of the African continent. Given the growing number of complex humanitarian situations in the countries at hand, the report will also be of interest to practitioners working in the field of conflict prevention, conflict resolution and peacebuilding.

This study was authored by UNEP in cooperation with the International Organization for Migration (IOM), the Office for the Coordination of Humanitarian Affairs (OCHA) and the United Nations University (UNU). The Permanent Interstate Committee for Drought Control in the Sahel (CILSS), which represents the nine Sahelian countries of Burkina Faso, Cape Verde, Chad, the Gambia, Guinea-Bissau, Mali, Mauritania, Niger and Senegal, provided critical technical support.<sup>9</sup> The collaboration with CILSS determined the core geographical scope of the study. However, given the nature of migratory patterns and economic trade in these countries, as well as the transboundary nature of climate change, eight neighbouring members of the Economic Commission of West African States (ECOWAS), were also considered: Benin, Côte d’Ivoire, Ghana, Guinea, Liberia, Nigeria, Sierra Leone and Togo. As this study does not cover all the countries of the Sahel, “the region” refers to the 17 countries identified above, as illustrated in Map 1.

Map 1. Geographical area covered in this study



## 1.1 Objectives and methodology

This report has two complementary objectives:

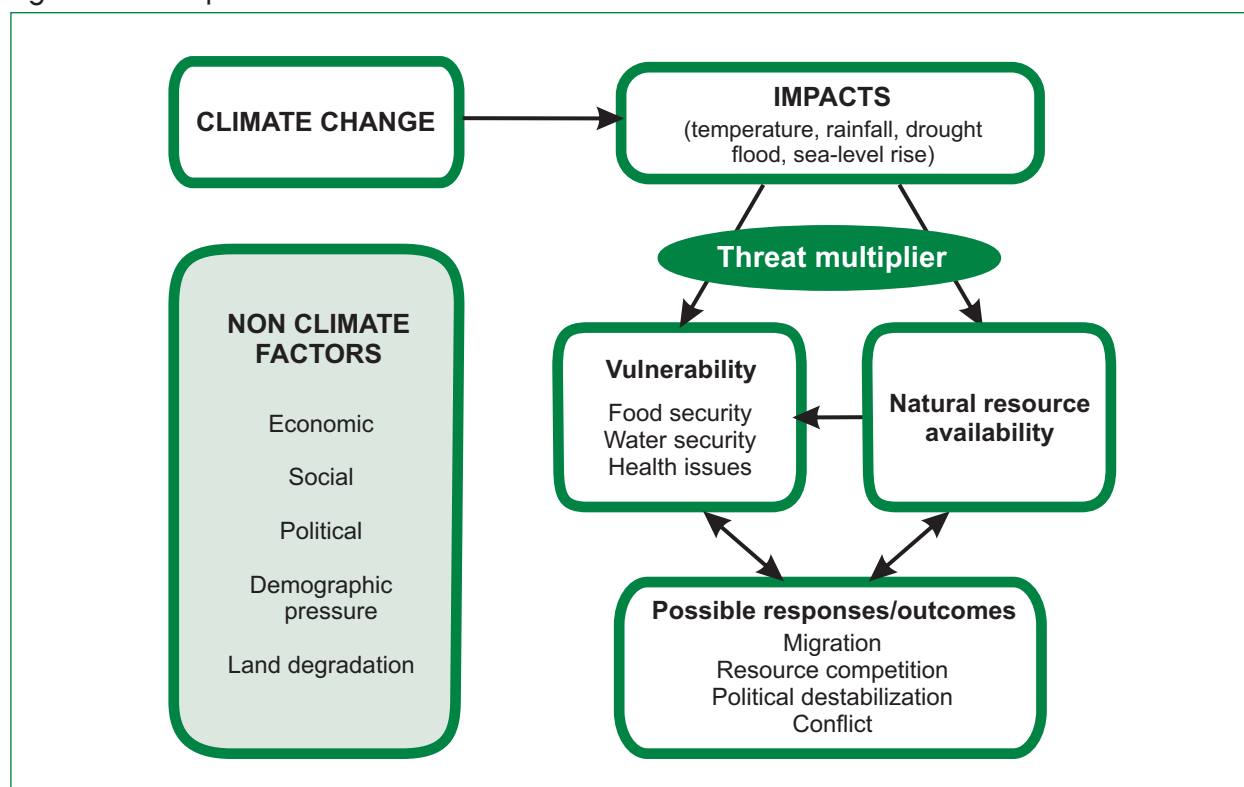
- 1) To analyze the historical climate trends in the region, identify hotspots, and determine the potential implications for natural resource-dependent livelihoods;
- 2) To provide recommendations for improving conflict and migration sensitivity in adaptation planning, investments and policies across the region.

The report's findings and recommendations are based on a unique mapping process analyzing climate trends over a 24 to 36-year period in the 17 countries included in the geographical scope of the study. The maps, which were produced through a technical cooperation with the University of Salzburg's Centre for Geoinformatics, focus on four climate indicators based on the best available data:

precipitation (1970-2006), temperature (1970-2006), occurrence of drought (1982-2009), and occurrence of flooding (1985-2009). The potential impact of projected sea-level rise in the region is also mapped. The data is then combined to identify potential "hotspots," including areas where the most extreme changes in the four individual climate indicators have taken place, as well as areas where the most cumulative change in these four climate indicators has occurred. Each map includes two additional layers showing population trends and conflict occurrence during the same time periods. Secondary sources and case studies are used to explore the challenges that livelihoods in the region face in relation to the climate trends observed in the mapping process, and how these changes may link to migration and conflict dynamics.

On the basis of the research described above, this report examines the relationship between climate change, migration, and conflict, highlighting areas of particular interest or where further research is

Figure 1. Conceptual framework



needed. In no way does it argue that climate change acts as a single and isolated factor in migration or conflict, nor does it attempt to show a direct causal link between these three issues. Climate change, migration and conflict, rather, are interlinked through complex influencing factors that include economic, social, and political issues.

## 1.2 Conceptual framework

The conceptual framework underlying this study, illustrated in Figure 1 above, builds on that of the 2009 report of the UN Secretary-General on *Climate Change and its Possible Security Implications*, which identifies five channels through which climate change could affect security:<sup>10</sup>

- **Vulnerability:** Climate change threatens food security and human health, and increases human exposure to extreme events.
- **Development:** If climate change slows down or reverses the development process, the resulting increased vulnerability may undermine the capacity of States to maintain stability.

- **Coping and security:** Migration, competition over natural resources, and other coping responses of households and communities faced with climate-related threats could increase the risk of domestic conflict and have international repercussions.
- **Statelessness:** There are implications for rights, security, and sovereignty of the loss of statehood because of the disappearance of territory.
- **International conflict:** The impact of climate change on shared or un-demarcated international resources may affect international cooperation.

The first three pathways provide the most relevant approach to conceiving of the linkages between climate change and security in the context of the Sahel: climate change impacts such as temperature rise, increasing variability in rainfall, more frequent droughts and floods and sea-level rise risk compounding existing vulnerabilities, leading to: (i) greater food and water insecurity, as well as health issues and (ii) changes in natural resource availability. Both impacts could in turn result in competition for resources, local-level



conflict, migration and ultimately in broader political destabilization. Non-climate factors, however, such as political, economic and social factors, as well as increasing demographic pressure and environmental degradation, also play a significant role in influencing any result. As a consequence, adaptation policies that are sensitive to migration issues and conflict risk, and promote sound governance of natural resources and sustainable development, have the potential to minimize the threats posed by climate change.

While noting that socio-economic variables play a stronger role than the environment in triggering conflict in the Sahel,<sup>11</sup> the Organisation for Economic Co-operation and Development (OECD) has found some statistical indication of the role climate variability may have.<sup>12</sup> Indeed, a recent report by the organization identifies two main “transmission mechanisms” between climate variables and security in the Sahel: food security and livelihoods.<sup>13</sup> The report notes that these transmission mechanisms are derived from two main characteristics, namely the direct impact of climate variability on livelihoods and food security, as well as their sensitivity to sudden-onset disasters.<sup>14</sup> The report further notes that “the great vulnerability of the Sahelian population to climate change is linked to its high dependence on agricultural activities and absence of alternative income earning activities.”<sup>15</sup>

## Report structure

Following this introduction, Chapter 2 provides background on the region, including a socio-economic profile, a brief history of conflict, population trends, and an overview of natural resource-based livelihoods and the use of migration as a traditional adaptation strategy.

The historical analysis of climate trends in the region is presented in Chapter 3 through five regional maps. Four of the maps show changes in temperature, rainfall, flooding, and drought over time; the fifth illustrates areas that are projected to be affected by sea-level rise. Following each of the first four, the potential implications for livelihoods are discussed. Two concluding synthesis maps combine the data to identify “hotspots.” The first shows areas where the most extreme changes in the four individual climate indicators have taken place, while the second depicts those affected by



*Girls seek water during the long dry season, sometimes travelling 45 kilometers roundtrip in the pastoral zone of Niger*

the most cumulative change in these four climate indicators.

Chapter 4 brings together the findings of the mapping process with an analysis of secondary sources to explore how the observed climate trends could compound existing vulnerabilities and lead to forced migration and conflict in the region.

Chapter 5 presents a cursory examination of existing adaptation plans in the region and discusses the value of considering issues related to conflict and migration in the design of new adaptation policies for risk reduction, prioritization of adaptation investments and action, and the strengthening of climate change adaptation capacity.

The final chapter presents the conclusions of this report and recommendations for improving the integration of conflict and migration considerations into adaptation planning, investments and policies across the region.

## 2. Regional context

This section aims to provide the relevant background information on the region covered by this report, including the prevailing socio-economic conditions, environmental and climatic conditions, natural resource-dependent livelihoods and natural resource governance structures, as well as a historical overview of migration patterns and conflict in the region. This is presented in order to frame the prevailing conditions and existing vulnerabilities that risk being compounded by changes in the regional climate.

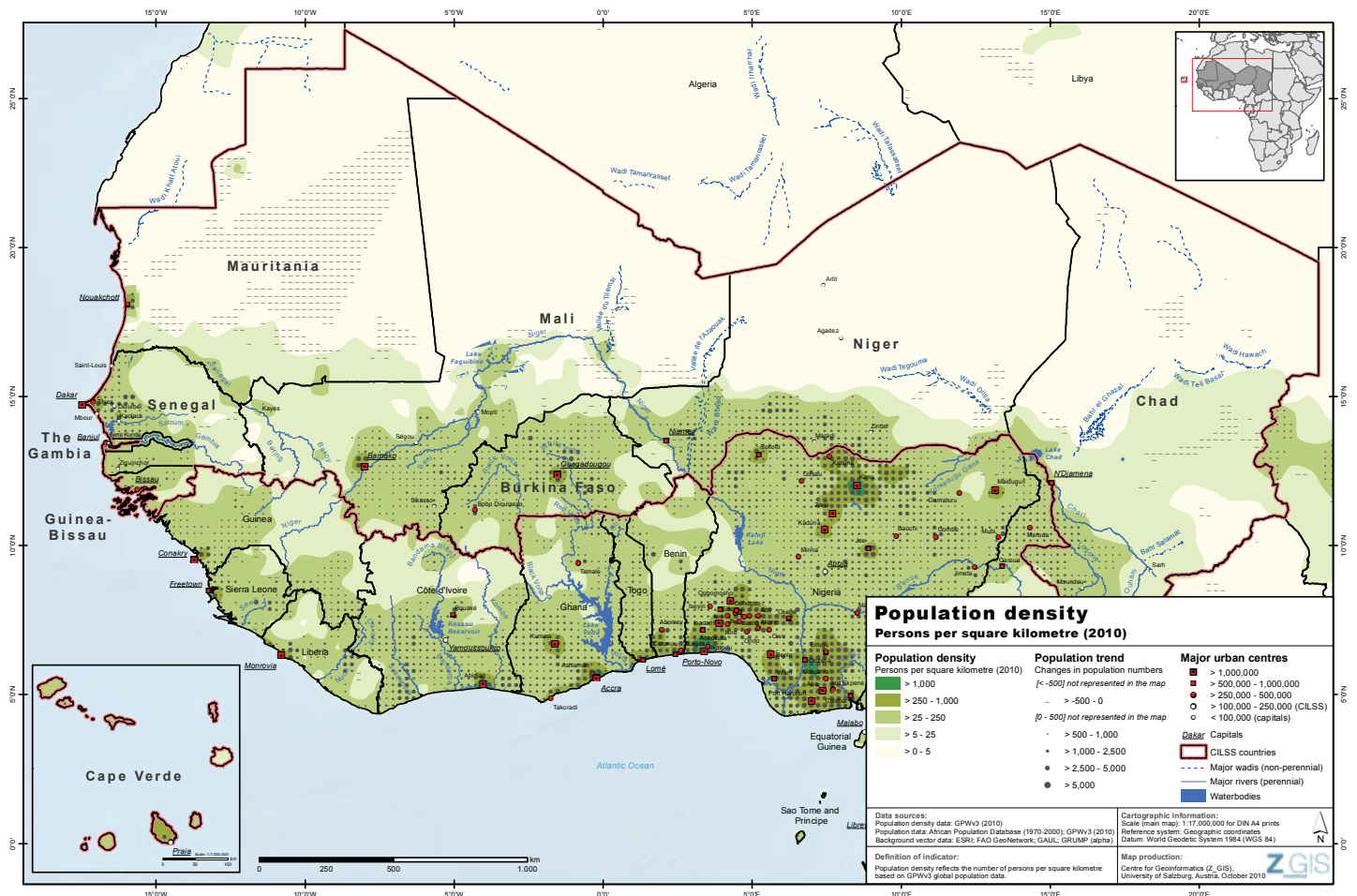
### 2.1 Socio-economic conditions

#### Population

The 17 countries covered in this study are home to a population of over 309 million, a majority of which

is rural – over 70 per cent in the nine CILSS countries and approximately 60 per cent in the broader region.<sup>16,17</sup> While population density varies across the region, it has increased faster than in the rest of the world in the past decades, from 25 persons per square kilometre (km<sup>2</sup>) in 1970 to 41 persons per km<sup>2</sup> in 2010,<sup>18</sup> as compared to the global average rise from 27.1 persons per km<sup>2</sup> in 1970 to 33.7 in 2010.<sup>19</sup> The most rapid increase in population in recent years (2001-2010) has occurred in Niger and Liberia, with an average yearly growth rate of 3.7 per cent, closely followed by Burkina Faso, Sierra Leone, Benin and Chad, with a yearly population increase of more than 3 per cent.<sup>20</sup> The average population growth rate in the region was 2.8 per cent per year, while the global average was 1.2 per cent.<sup>21</sup> With some 42 per cent of the population under the age of 14,<sup>22</sup> the “youth bulge” affecting the countries

Map 2. Population density and dynamics





*A young boy tills the soil in Mali, where rain-fed agriculture is one of the main livelihoods despite harsh seasonal fluctuations and erratic crop yields*

in the region is an additional concern, indicating that the population will continue to grow rapidly in the decades to come.

Map 2 shows population density and dynamics in the study region. Population density is based on data from 2010, while population dynamics is based data from 1970 to 2006 and is calculated on the basis of the absolute population change during this period, with areas of higher population density undergoing greater absolute change in population than lower density areas. A more detailed discussion of the methodology and findings can be found in Annex 3.

## Economic conditions

The region covered in this report is characterized by pervasive poverty and low development. Within the CILSS countries, the average *per capita* gross domestic product (GDP) in 2009 was US\$ 903, ranging from US\$ 350 in Niger to US\$ 3,000 in Cape Verde, with some 69 per cent of the population earning less than US\$ 2 per day. *Per capita* GDP in the broader region covered by this report is US\$ 800.<sup>23</sup> In 2008, remittances made up approximately five per cent of GDP in CILSS and the wider region.<sup>24</sup> Of the 17 countries included in this study,

only four are not classified as Least Developed Countries (LDCs): Cape Verde, Côte d'Ivoire, Ghana and Nigeria.<sup>25</sup>

An estimated 50 per cent of the population in the region derives its income from agricultural activities (mainly farming, herding and fishing). The total contribution to GDP from these sectors is 28 per cent in CILSS countries, and 32 per cent in the broader region.<sup>26</sup> As noted above, the population is largely rural, in particular in the CILSS countries where more than 70 per cent of the population lives in rural areas and relies mostly on subsistence agriculture for its livelihood. However, given the rapid urbanization that has taken place in the region over the last decades, the informal urban sector, including small-scale merchants, artisanal craftsmen and services – is now estimated to employ approximately 30 per cent of the working population in the broader region.<sup>27</sup>

Within the formal economy and in respect to foreign investments, the mining and oil industries dominate, with the manufacturing industry only playing a very limited role.<sup>28</sup> Based on figures from 2009, the region as a whole experiences a trade deficit (meaning a larger amount of goods is imported than exported): exported goods and services



account for 31.4 per cent of GDP, while imported goods and services are equal to 54.9 per cent.<sup>29</sup>

## 2.2 Environmental and climatic conditions

With an area of 7.4 million km<sup>2</sup>, the study region is comprised of the transitional zone between the arid Sahara and the tropical forest that borders the maritime coast. Desert and semi-desert in the northern parts of the region gradually give way to tall grass savannah, followed by savannah woodland, while the southernmost and coastal parts of the region are dominated by a semi-humid and humid tropical climate with equatorial and tropical-zone rainforest.<sup>30</sup> Although the landscape is relatively flat, mountains in the northern reaches of the Sahel, including in Mali, Mauritania, Niger and Chad, reach upwards to 3,400 m in elevation.<sup>31</sup>

The main water basins in the region are Lake Chad and the Niger, Senegal and Gambia Rivers. The Niger River basin is Africa's third largest after the Nile and Congo, and is shared by no less than 11 countries. Major lakes in the region include Lake Faguibine in Mali, Kainji Lake in Nigeria, Lake Volta in Ghana and Lake Chad, which borders Chad, Nigeria, Niger and Cameroon. Groundwater resources range from shallow aquifers that are refilled seasonally to ancient sedimentary water basins, which are non-renewable and difficult to access, reaching depths of up to 2,000 m.<sup>32</sup>

Both surface and groundwater are highly dependent on seasonal rainfall, which is characterized by strong variability and irregularity across the region. With the majority falling in only three months of the year, between July and September, rainfall can vary by more than 1,000 millimetres (mm) over a north-south distance of 750 km, from the arid zones in the north to the humid and sub-humid zones on the coast.<sup>33,34</sup> The desert-like climate in the far north receives an average of only 200 mm<sup>35</sup> per year, while the more humid climate in the southern part of the Sahelian semi-arid belt receives an annual average of some 600 mm. Halfway between these values – at approximately 350 mm – is the limit at which rain-fed agriculture can be practiced,<sup>36</sup> which has shifted southward in recent years.<sup>37</sup> In addition, a variation of more than 30 per cent in the length of the rainy season can be experienced

from one year to the next.<sup>38</sup> This cycle of dry years and wet years is a typical feature of this climate.

Desertification and sand intrusion, finally, are a threat in the arid northern regions, where sand encroachment compromises the growth of seeds and renders some production areas sterile.<sup>39</sup> Sand intrusion from desertification also threatens major water courses in the region, such as the Niger River, as well as roads and other development infrastructure.

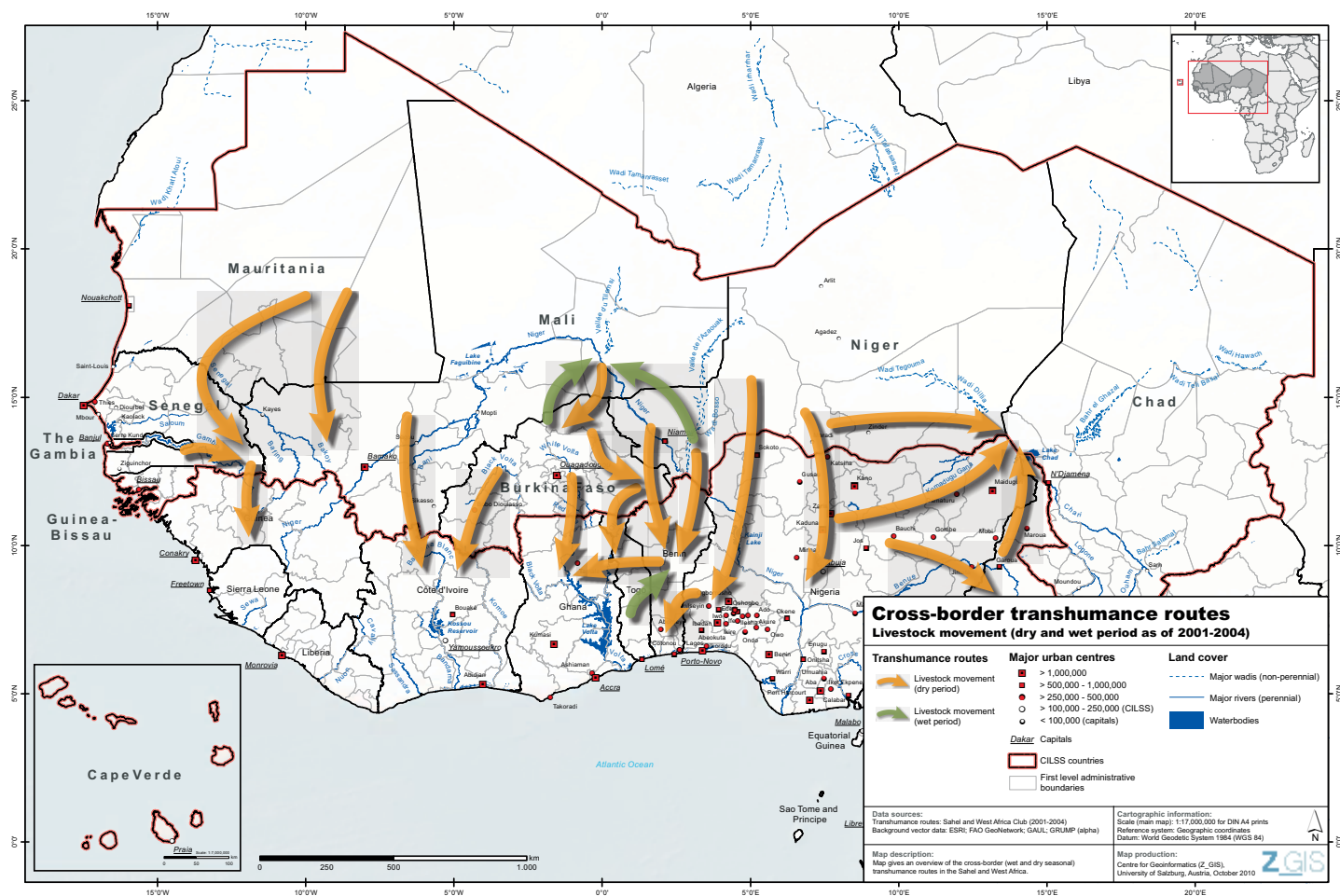
## 2.3 Livelihoods: Farmers, herders and fishermen

Despite significant seasonal fluctuations in rainfall, erratic crop yields, poor soil, and depleted fish stocks, farming, herding and fishing remain the dominant livelihoods in the region. In 2008, 46 per cent of the land area of the countries covered by this study was categorized as agricultural land – defined as arable lands under permanent crops and pastures – by the Food and Agriculture Organization (FAO).<sup>40</sup> Farming accounts for more than 50 per cent of the part of GDP that is derived from agricultural practices,<sup>41</sup> closely followed by pastoralism, which accounts for approximately 40 per cent.<sup>42</sup>

Rain-fed agriculture is the dominant method used by both farmers and herders at the subsistence level, with few mechanical inputs to enhance production, and low monetary income.<sup>43</sup> However, rain-fed agriculture can only be practiced in the region up to the 350 mm rain belt, which varies between 14 and 17 degrees latitude, from east to west (see Map 7).<sup>44</sup> North of this fluctuating line, farming gives way to pastoralism as the main livelihood.

Only a small proportion of arable land in the region<sup>45</sup> – an estimated 5 per cent of the total land area – is irrigated.<sup>46</sup> The Markala dam, along the Niger River in Mali, and Senegal's Manantali and Diama dams, at the mouth of the Senegal River, facilitate large-scale irrigation.<sup>47,48</sup> In addition, flood recession agriculture occurs along some rivers and lakes, allowing farmers to grow crops in the soil moistened by the inundations of the rainy season.

Map 3. Cross-border transhumance routes (2001-2004)



Farmers typically live in permanent settlements, growing millet, maize, rice and sorghum, and raising domestic animals to provide supplementary income. The main cash crops in the region are groundnuts and cotton.<sup>49</sup> Herders, conversely, raise livestock and cultivate crops along various seasonal nomadic routes,<sup>50</sup> generally moving from northern to southern pastoral areas during the dry season (October to June), and back north during the wet season.<sup>51</sup> Main transhumance corridors can be seen in Map 3. With 60 million cattle and 160 million small ruminants, the Sahel, together with West Africa, is one of the dominating regions for livestock-rearing on the continent, corresponding to 25 per cent of the cattle, 33 per cent of the sheep and 40 per cent of the goats in all sub-Saharan Africa.<sup>52</sup>

The fishing industry employs 7 million people and contributes up to 15 per cent to GDP in some of the coastal countries included in this study.<sup>53</sup> For instance, fishery exports represent 86 per cent and 46.9 per cent of agricultural exports in Senegal and

Mauritania respectively.<sup>54</sup> Major freshwater fishing takes place along the Niger and Senegal rivers and Lake Chad. Coastal fisheries are found along 3,500 km of coast spanning Cape Verde, the Gambia, Guinea-Bissau, Guinea, Mauritania, and Senegal, including the Saloum Delta. The delta generates some US\$ 400 million in revenue annually and is an important source of foreign investment through negotiated fishing agreements with foreign fleets, mainly from China, the European Union and Japan. Fish is also a key food source across the region, particularly for communities living near lakes, rivers, and the coast.

Alongside farming, fishing, and herding, much of the population also depends on the collection of and direct access to raw natural resources for daily subsistence, much of which come from forest areas. In 2010, forests accounted for 25 per cent of the land area in CILSS countries, and 26 per cent in the broader region.<sup>55</sup> The role of forests





© UN Photo/Evan Schneider

*Fishing is a key source of income and food in the region, particularly in coastal states such as Senegal, Cape Verde and Mauritania*

in contributing to livelihood security is discussed in further detail in Box 1.

## 2.4 Natural resource governance

The region covered by this study is characterized by complex natural resource governance systems that combine customary structures with rules and laws inherited from the colonial era, as well as reforms undertaken by governments during the 1980s-90s. The disconnect and overlap among these three elements, as well as a lack of capacity and resources to implement reform, have posed serious challenges for the effective governance of natural resources in the region, and contributed to further environmental degradation, as well as tension and local-level conflict. This is particularly the case for land tenure, a critical issue for natural-resource based livelihoods.

Indeed, a brief look at the history of statutory governance systems shows that after their independence, most countries in the region continued

to manage their land through the rules and laws inherited from the colonial era. Starting in the 1990s, however, many States attempted to reform their land and natural resource laws to address the failures of former policies, particularly through initiatives of decentralization.<sup>61</sup>

Decentralization was seen as a way to promote local-level development, but limited technical capacity and insufficient financial resources at the local level have largely prevented effective management of common property resources, such as land.<sup>62</sup> In addition, although enhanced participation at the local level was one of the major goals of decentralization, national political authorities have often continued to hold ultimate influencing power. Further challenges observed by CILSS include problems of implementation due to the fact that many new laws lack a mechanism for application, or are not known or followed by relevant stakeholders. In many cases, both customary and statutory systems continue to exist and overlap, leading to confusion over land rights, ownership, and access.

## Box 1. Forest-based livelihoods

Many people in the region depend on forest resources to supplement their main livelihood of farming, herding or fishing. While forest-based livelihoods are not discussed in depth in this report, it is important to highlight the key role that forests play in the countries at hand.

Fuelwood, including charcoal, is the main source of energy in the region. In West Africa, it is estimated that fuelwood makes up 85 per cent of total energy consumption.<sup>56</sup> Forests also support livestock during the dry season by providing woody fodder, which is high in water content.<sup>57</sup>

Non-wood forest products also are critical for livelihoods and food security. According to the FAO, dependence on forest products generally increases when agricultural production is low, during droughts or other natural disasters. Food products such as fruits, roots, leaves, and bushmeat are traded and consumed at the local level.<sup>58</sup> Medicinal plants are also traded in both rural and urban markets. More than 80 per cent of the population in Burkina Faso, Ghana, Niger, and Nigeria depend on the use of medicinal plants.<sup>59</sup> Finally, other non-wood forest products are increasingly being traded at the international level, including shea butter, rattan and gum Arabic.<sup>60</sup>

Finally, “hybrid” livelihoods strategies combining farming and livestock rearing have increasingly been adopted as a means of mitigating climate-related uncertainties,<sup>63</sup> undermining the traditional complementarity and interdependency between farmers and herders, and increasing competition for suitable land.

Complementing initiatives for decentralization, an increasing number of policies have formally recognized pastoralists’ rights to key resources. For example, in 1993, Niger adopted the Rural Code, which stipulated that pastoralists had priority rights to use natural resources in designated pastoral zones.<sup>64</sup> Pastoral laws have also been implemented in Guinea (1995), Mauritania (2000),<sup>65</sup> Mali (2001) and Burkina Faso (2003). However, while provisions to support pastoralism are an improvement on past policies, implementing legislation that is not sensitive to changes in climate and resource availability can hinder pastoralists from effectively adapting to the extremely unpredictable Sahelian environment.

These issues have been further compounded by the highly sectoral approach that is generally taken to manage natural resources, which has resulted in competition and confusion between differing government institutions and failed to account for multiple uses of the land by livelihood groups such as agro-pastoralists.<sup>66</sup> Lastly, national land policies and reforms have also largely failed to take into account transboundary or regional dimensions of land and natural resource management, such as



*Populations across the region remain highly dependent on fuelwood for their household energy needs. In Burkina Faso, hundreds of carts and trucks piled high with wood travel throughout the night from areas outside of the capital Ouagadougou to reach the markets by morning*



water resources management, and the mobility of people and their belongings, including cross-border transhumance.

To date, this lack of effective national and local-level natural resource governance has undermined the development of effective responses to changing climatic conditions. Likewise, the disconnect between customary and statutory laws and institutions could further challenge the development of sustainable adaptation policies in the region, as discussed in more detail in chapter 5.<sup>67</sup>

However, a number of regional governance initiatives have recently been adopted that hold promise for addressing the challenges posed by climate change in a more coherent and harmonized way. For example, the Africa Ministerial Conference of Environment Ministers (AMCEN) highlighted the challenges faced by the continent as a result of climate change in the Joint Statement resulting from its 12th session held in 2008,<sup>68</sup> while the Economic Com-

munity of West African States (ECOWAS) recently committed to adopting a new regional programme of action to reduce vulnerability to climate change in West Africa.<sup>69</sup> The African Union, finally, adopted a policy framework for pastoralism in Africa in 2011, aiming to “secure, protect and improve the lives, livelihoods and rights of African pastoralists” while also recognizing the role such a policy could have on consolidating peace and security.<sup>70</sup>

## 2.5 Migration in the region

### A way of life for farmers, herders and fishermen

Seasonal and circular migration can be considered as traditional positive adaptation strategies to climate variability in the region.<sup>71,72</sup> Herders typically graze their livestock in the North during the wet season and move South during the dry months.<sup>73</sup> The Fulani ethnic group in West Africa, for example, have long used migration and the nomadic herd-



© UN Photo/John Isaac

*Seasonal migration of herders and their livestock is a traditional livelihood strategy in the Sahel. However, droughts and changes in rainfall have modified these traditional movements*



© UN Photo/John Isaac

*Adverse changes in the environment, such as drought, can lead to migration when natural resource-dependent livelihoods are undermined. During the 1980's large numbers of Chad's rural population moved to the capital N'Djamena in search of alternative opportunities for income*

ing of cattle, goats and sheep as an adaptation strategy against seasonal climate variability.<sup>74,75</sup>

Some farmers and herders in the region also move in search of short-term employment to supplement incomes and diversify their skills.<sup>76</sup> Seasonal labour migration occurs, for example, from the arid parts of Mali, Mauritania and Niger to plantations and mines on the coast of Côte d'Ivoire, Ghana, Nigeria and Senegal. In the delta region of Mali, a third of the rural workforce migrates each season from rural areas to cities in search of a job. In Senegal, much of the male farming population works in large towns or cities during the dry season, before returning to the countryside for the rainy season.<sup>77</sup>

Many fishermen in the region – both coastal and inland – have also long used migration as an adaptation response, moving in search of better catches, higher market prices and seasonal work opportunities. The labour migration of young men from Nigeria's Jola fishing community to Dakar has taken place since the 1950s.<sup>78</sup> Young men leave for months, sometimes years, hoping to return with savings earned in cities – highlighting the difficulty of living purely on a fishing-related income. These

remittances are a major source of income for many poor rural families, and as such, an important element in their resilience to economic and environmental shocks and stresses.<sup>79</sup>

This seasonal labour migration creates income diversification through the transfer of funds, knowledge and skills to recipient communities. To encourage open borders and the free movement of people and goods, ECOWAS eliminated short-term visas through the 1979 Protocol on the Free Mobility of Persons, Residence and Establishment.<sup>80</sup> To further develop this policy, ECOWAS introduced regional passports in 2000, which 9 of the 15 member States have started issuing. The lack of implementation by other States has been due to financial and logistical difficulties.<sup>81,82</sup> While the passport aims to facilitate the movement of people, the challenge remains that those most vulnerable to climate change are frequently the most disadvantaged and least able to move.<sup>83</sup> For instance, an IOM publication reports that in Burkina Faso "food scarcity during drought was found to lead to increased prices, forcing people to spend more money on their basic needs rather than on long-distance migration."<sup>84</sup>



Migration is largely regional in nature – generally along a north-south axis – rather than from the region to other parts of the world. Indeed, there is a strong relationship between coastal West African countries and Sahelian countries, as traditional transhumance routes cover the whole West African region. Over two-thirds of emigrants from Burkina Faso, Ghana, Guinea, Mali, Mauritania, and Niger remain within West and Central Africa.<sup>85</sup> For example, prior to the post-election violence in 2010, there were nearly four million Burkinabe and three million Malian migrants in Côte d'Ivoire.

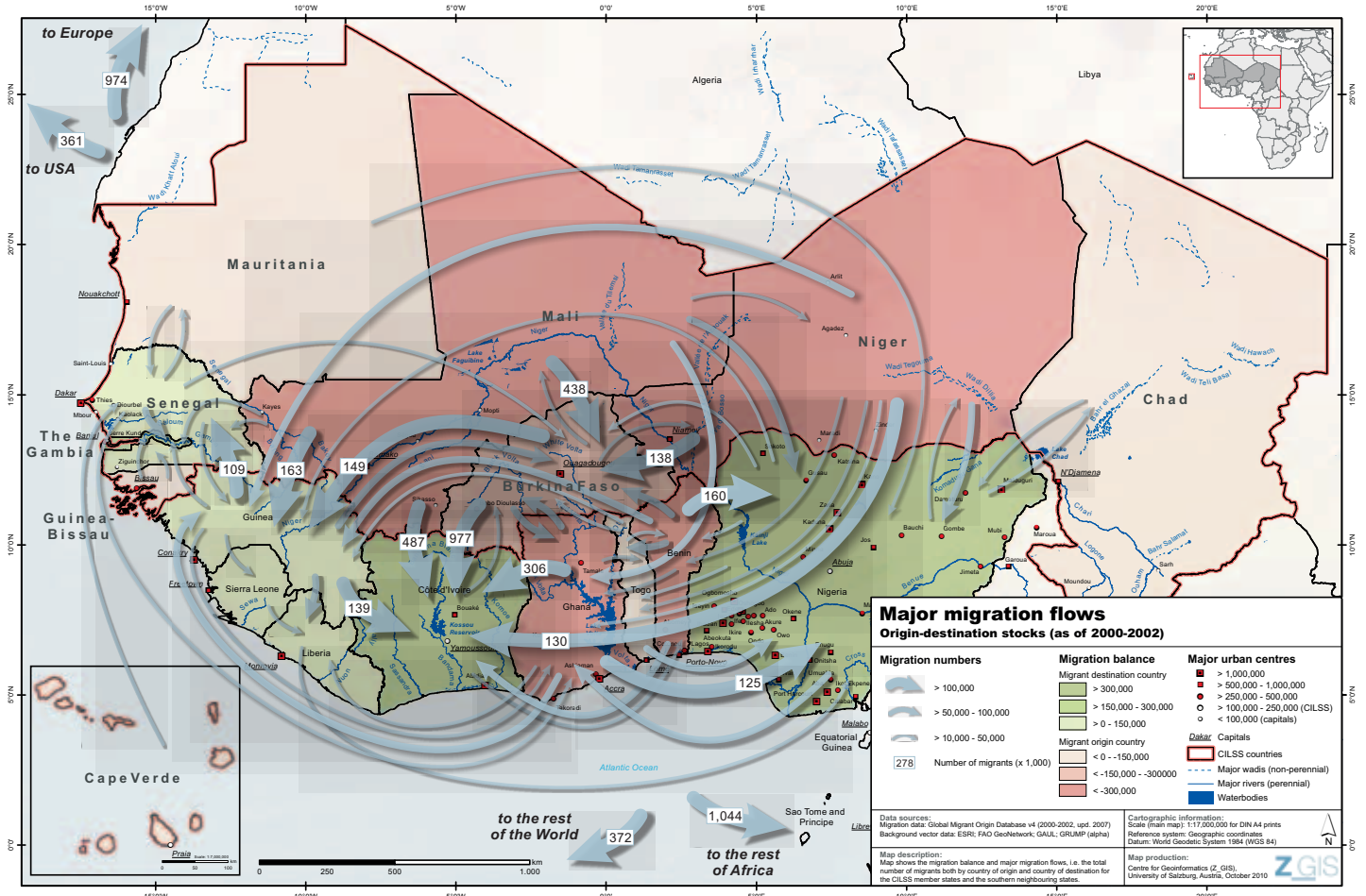
Map 4 shows the main migration trends in the region for the period 2000 to 2002. This data is the latest available, highlighting how poorly documented migration dynamics in the region are. During the time the data was collected, Côte d'Ivoire was a destination country while Mali and Nigeria were major source countries. These movements, particularly when observed over a short time frame, are often tied to political and economic situations within the country or region. Côte d'Ivoire, for

example, attracted many immigrants due to its strong economy. This situation changed drastically when the post-election violence erupted in 2010. Annex 4 provides greater detail on the migration data used in Map 4.

## Climate and environmentally induced migration

For the reasons discussed above, it is difficult to isolate the role of climate change from socio-economic motives in the assessment of migration decisions.<sup>86</sup> The working definition of “environmental migrants” used by IOM is useful in framing the parameters: environmental migrants are “persons or groups of persons who, for compelling reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad.”<sup>87</sup>

Map 4. Major migration flows in the region (2000-2002)





© UN Photo/Eskinder Debebe

*Conflicts in the region have resulted in large numbers of refugees and internally displaced persons (IDPs). At mid-2011, for example, there were over 130,000 IDPs in 38 camps in Eastern Chad, due to intermittent conflict in the country since 1965*

This broad definition encompasses different forms of migration, from traditional adaptation to changing environmental conditions, to forced migration as livelihood groups fail to adapt. Research conducted by EACH-FOR, a project of the European Commission, identified and investigated links between migration and environmental change. Case studies were completed in 23 countries around the world, involving empirical research conducted with individuals and communities who were migrating, or may migrate, due in part to environmental reasons. Among the project's findings was that "migration occurs when livelihoods cannot be maintained, especially when agriculture or herding is severely affected by environmental degradation or extreme events."<sup>88</sup>

## 2.6 Conflict in the region

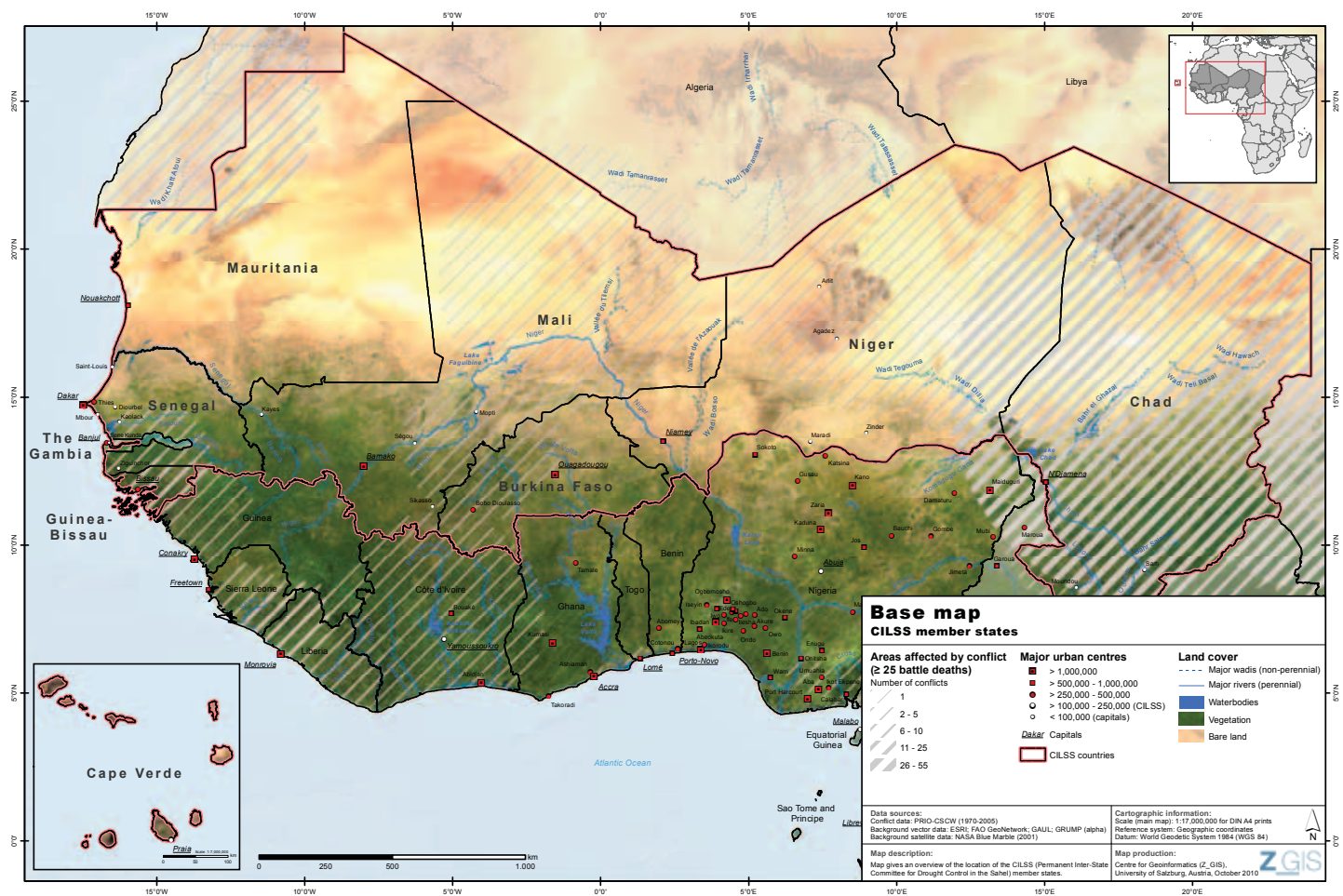
Since the start of decolonization, the region has experienced a significant number of conflicts, including large-scale interstate wars, civil wars and localized fighting. In the CILSS countries, Burkina Faso and Mali fought a protracted interstate war (The Agacher Strip War) in 1974 and 1985, primar-

ily over land thought to contain substantial natural resources, such as natural gas and minerals. Other countries have experienced internal conflict, including Chad (intermittently since 1965), Guinea-Bissau (1998-1999) and Senegal (ongoing since 1990). Military coups have also taken place in Chad, Guinea-Bissau, Mauritania, Niger and Senegal. In the ECOWAS countries, there have been civil wars in Côte d'Ivoire (2002-2007), Liberia (1989-1996 and 1999-2003) and Sierra Leone (1991-2002), and the movement of rebels into non-civil war States has destabilized regional security. More recently, the political crisis following the 2010 elections in Côte d'Ivoire led to several months of unrest and violence.

Factors contributing to the large number of conflicts in the region over the last decades have included historical tensions between ethno-linguistic groups and the legacy of colonial power, poor governance, marginalization of various social groups and corruption. The proliferation of guns and non-state militaries has also played an important role, despite the 2006 ECOWAS Convention that formally bans the sale of small arms and light weapons.<sup>89</sup>



Map 5. Conflict occurrences



Map 5 identifies the location of conflicts in the region for the period 1946 to 2005. This map uses the Peace Research Institute Oslo (PRIO) and the Centre for the Study of Civil War (CSCW) “conflict site” database, drawing on the Uppsala Conflict Data Project. The Data Project defines armed conflict as “a contested incompatibility that results in at least 25 battle-related deaths.” Conflict zones are established based on coordinates for the location of the conflict, and a radius of area that estimates the extent of the conflict.

A limitation of this map, however, is its exclusion of small-scale localized conflicts that occur between and among livelihood groups, which are of particular interest to this study. Indeed, these small-scale conflicts are often the first to occur in relation to changes in environmental factors sustaining livelihoods. Detailed data on small-scale conflicts in the region has not been systematically collected to date, though efforts are now being made to compile these incidents. The Social Conflict in Africa

Database produced by the Robert S. Strauss Center for International Security and Law<sup>90</sup> has compiled a list of social conflicts that have occurred in Africa since 1990. This data has been generated by gathering Associated Press and Agence France Presse news wires on events such as strikes, protests, riots, and outbreak of violence. The database further specifies topics of unrest, including food, water and environmental degradation. While this project has begun the process of systematically collecting information on social conflicts, it is currently limited to those tensions that receive international media attention. As such, this database is not necessarily a comprehensive listing of small-scale social conflicts and tensions relating to natural resources.

Small-scale conflicts among individuals and groups who depend on natural resources for their livelihoods are a consequence of several factors that relate to access, control and ownership of land and natural resources. These factors include: unclear land tenure systems, demographic growth,

successive droughts, greater rain variability, and the ill-adapted responses by governments and societies to these changes.<sup>91</sup> Land issues, in particular, are a central concern for communities, states and international institutions. In many of the countries discussed in this report, land ownership is synonymous with uncertainty.<sup>92</sup> Additionally, cross-border migration is a source of tension between transhumant livestock breeders and inhabitants in pastoral areas.<sup>93</sup> These conflicts remain a threat to social peace and impede development in the region.

## 2.7 Livelihood vulnerability

The vulnerability of herders, farmers and fishermen to the impacts of climate change stems from a range of climate and non-climate factors, resilience and capacity for preparedness at the local, national, and regional levels. This report focuses on four specific indicators of climate change:

slow-onset changes in temperature, rainfall and drought, and occurrences of sudden-onset and extreme flood events. In addition, this report looks at the potential impact of sea-level rise in the region. These changes in climate can act as threat multipliers to a number of existing vulnerabilities faced by these three types of livelihoods.<sup>94</sup>

First, however, it is important to note that the region has long been subject to considerable climate variability unrelated to anthropogenic climate change. As discussed in section 2.2, rainfall varies sharply across the region, with differences of more than 1,000 mm over a north-south distance of 750 km.<sup>95</sup> There can also be a variation of more than 30 per cent in the length of the rainy season from one year to the next.<sup>96</sup> Specific livelihood strategies have developed in the region in response to this variability.



*In the Sahel, women often travel great distances daily to collect water from scarce sources such as seasonal waterholes. Changes in climate affect the availability of natural resources and increase vulnerabilities, such as food and water insecurity*



## Box 2. The role of non-climate factors in migration and conflict

Migration and conflict are most often the result of a broad range of complex issues. Changes in climate, and their effects on natural resources, are just one such factor. A combination of economic, social and political factors contributes to any decision to migrate and similarly influences conflict-related outcomes.

**Migration:** Economic opportunities have long been recognized as an important contributor to migration. Cities are often the location for job prospects, and along with other social factors, contribute to a “pull factor” influencing migration decisions. These social factors include access to health care, education and greater infrastructure. Other external factors can also have a significant influence. In the case of coastal fisheries, the existence of international fishing fleets has strongly affected the local population’s catch. It has been estimated that Guinea, Liberia and Sierra Leone are losing approximately US\$140 million per year to illegal fishing by foreign vessels.<sup>100</sup> This loss translates into depleted fish stocks and a direct economic loss for fishermen, as well as an impact on food and nutritional security for much of the population that depends on fish as their main source of protein. Likewise, dam construction has affected freshwater fisheries, with a 90 percent drop between the 1970s and the early 2000s in the Senegal River Valley, following the construction of the Manatali and Diama dams.<sup>101</sup> On the other hand, political instability and weak governance can be “push factors.” Current conflicts in North and West Africa provide a timely illustration of the role that politics play in contributing to the movement of people. Indeed, due to the 2011 conflict in Libya, over 190,000 West African nationals left the country, with 121,000 crossing over the border into Chad and Niger.<sup>102</sup> In Côte d’Ivoire, the 2010 post-election crisis led to the displacement of hundreds of thousands of people, including some 150,000 Ivorian refugees in neighbouring Liberia.<sup>103</sup> Additionally, local and national governance influence migration decisions. For example, changes in land tenure systems or restricting access to resources can affect livelihood security, with migration being used as a coping mechanism.

**Conflict:** Natural resources are rarely, if ever, the sole cause of conflict. Rather, availability and access to natural resources can contribute to triggering conflict in already tense situations. Economic disparity between the affluent and poor, weak state institutions and capacity and cultural or ethnic marginalization by one group over another can all contribute to the risk of conflict.<sup>104</sup> Further, the lack of dispute resolution mechanisms for small-scale conflict also blocks the ability for such disagreements to be addressed.

Changes in climate, such as greater rainfall variability or rising temperatures, affect the availability of natural resources and increase vulnerabilities, such as food and water security. Other effects include negative health impacts due to malnutrition and favourable conditions for disease transmission.<sup>97</sup> Further, ineffective governance compounds these challenges through vague or contradictory land policies and poor natural resources management capacity. This may in turn contribute to environmental degradation.<sup>98</sup>

Of course, non-climate change-related factors also play a critical role. Political, economic and social factors are all paramount in understanding vulner-

abilities. Box 2 provides a brief overview of how these factors interact with conflict and migration. Underlying all of these factors is the role of governance in planning and regulating development, ensuring access to land, providing infrastructure support to mitigate risks from sudden onset disasters and promoting livelihood diversification.<sup>99</sup>

Livelihoods in the region have long adapted to high rates of climate variability, using migration as an effective coping mechanism. In some instances, however, climate variability has led to conflict due to limited resource availability and access. The following section analyzes changes in climatic conditions over the last 20 to 40 years in the region.

### 3. Mapping historical climate trends in the Sahel

The objective of this chapter is to analyze historical climate trends in the region, identify hotspots, and discuss how these trends could impact natural resource-dependent livelihoods, potentially resulting in migration, conflict, or a combination of the two. It presents the findings of a mapping process undertaken in collaboration with the University of Salzburg, aimed at determining the nature and location of the changes that have taken place.

By focusing on historical changes in climate trends rather than future climate projections, the analysis avoids the well recognized challenges and uncertainties of climate modelling in the Sahel (see Box 3).

#### 3.1 Mapping historical climate trends in the region

The mapping approach illustrated in Figure 2 was selected on the basis of the availability of climate data for the entire study region. Limitations of the data used for mapping are discussed in Box 4.

The mapping process focused on analyzing four climate indicators over time: Map 6 and Map 7 respectively show long-term average conditions of temperature (1970-2006) and rainfall (1970-2006), while Map 8 and Map 9 respectively present the frequency and severity of extreme events such as droughts (1982-2009) and flooding (1985-2009).

#### Box 3. OECD climate projections and recommendations for the Sahel<sup>105</sup>

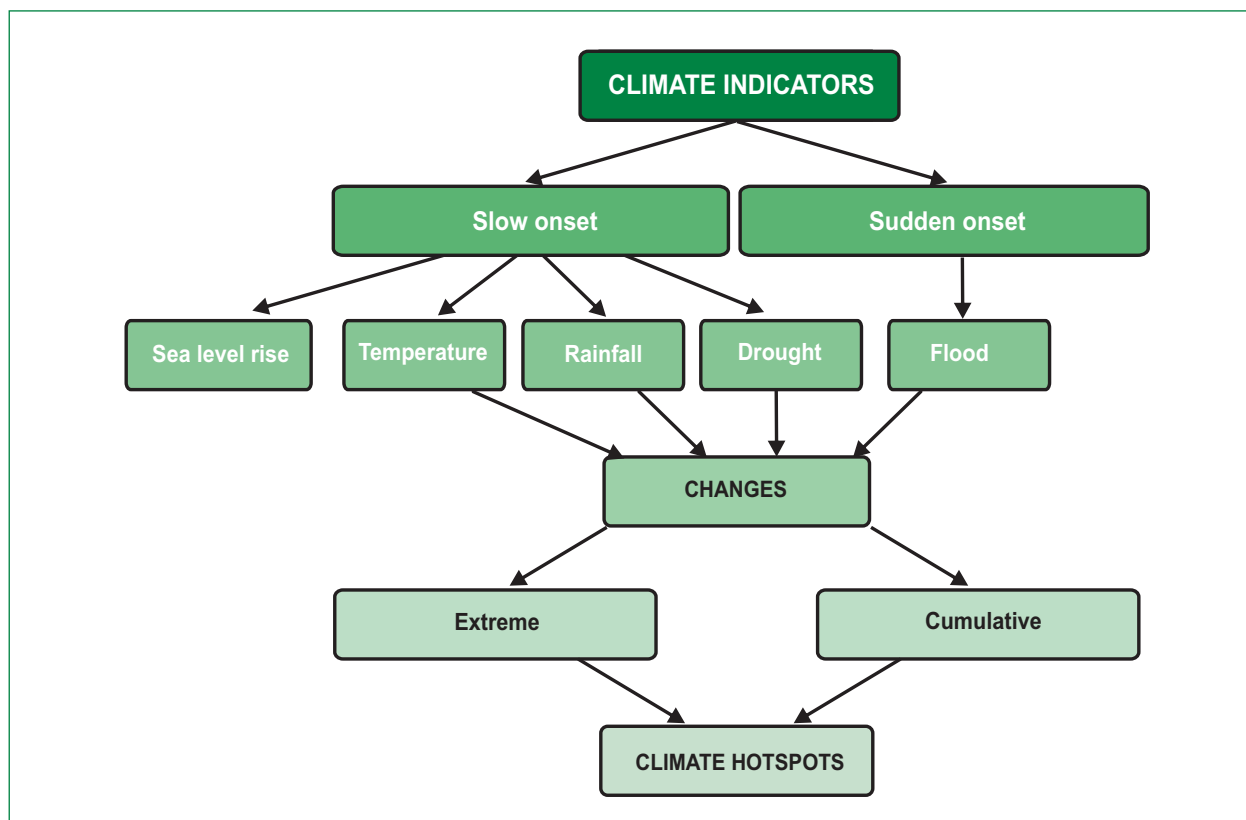
A recent study by the OECD's Sahel and West Africa Club concludes that existing climate models are in significant disagreement over projected changes in the region, particularly over the general trend for precipitation – whether the region will become wetter or dryer in the coming years.

Models tend to agree, however, on temperature projections that suggest an increase in temperature, particularly during summer months. This projected increase is likely to be greater than the global average, with estimates showing a 3-4 degree Celsius (°C) increase by 2100. In addition to rising temperatures, projections also indicate greater frequency of extremely hot seasons.

To identify where past droughts caused the largest difference in precipitation between drought and non-drought years, the OECD study also conducted sensitivity analyses based on historical observations. Three particularly sensitive areas were identified: the western parts of Senegal and Mauritania, the region stretching between Mali and Niger, and the region along the eastern fringe of Ethiopia that extends north towards Sudan.

The OECD study highlights acute vulnerabilities to climate variability in the region due to the population's high dependence on agricultural activities and limited opportunities for alternative income generation, and provides a number of policy recommendations for the region. According to the study, investments in improved water management and enhancing national and international famine early warning systems can be critical tools for mitigating the potential impacts of food crises. Establishing national and regional policies that consider the long-term features of climate change – including improving long-term and seasonal forecasting, and enhancing population resilience to climate variability – is also suggested to manage uncertainties. Promoting the emergence and adoption of new sources of livelihoods, as well as encouraging open and constructive dialogue through regional African institutions like the African Union, ECOWAS or the Intergovernmental Authority on Development (IGAD), is recommended to help facilitate improved coordination and enhance effectiveness.

Figure 2. Mapping climate hotspots in the Sahel



The datasets used for each of the indicators are described in detail in Annex 5. Coastal areas vulnerable to inundation based on potential sea-level rise are shown in Map 10. Also calculated using mapping data is the land area and the percentage of the population in CILSS countries affected by the four climate indicators (see Annex 6).

Two synthesis maps combine the data to identify “hotspots.” Map 11 depicts the areas where the most *extreme* changes have taken place in the four individual climate indicators. Map 12 considers the four climate indicators together, showing the areas affected by the most *cumulative* change over the last 40 years. The hotspots identified in these two synthesis maps are of specific interest for follow-up activities, including specific adaptation policies and programmes.

Included on each of the maps are two additional layers showing population trends and large-scale conflict occurrences during the same time periods. The conflict layer highlights areas with higher insecurity and often more fragile governance structures. The population data is of interest in order to understand where populations are most at risk from climate-related factors.

### 3.2 Changes in temperature

Map 6 depicts the absolute changes in mean seasonal temperature in degrees Celsius (°C) between 1970 and 2006. The data is aggregated from weather stations located in the region with readings taken annually from May to October. This period includes the rainy and cropping season months of July to September, as well as “buffer” months to capture natural variance. This period has been chosen because it is the most critical time period for agriculture-based livelihoods. Six colour categories represent seasonal temperature ranging from a decrease in mean temperature of -0.5°C to an increase of greater than 2.0°C.

The data shows that there has been an overall rise in mean seasonal temperature in CILSS countries from 1970 to 2006 of approximately 1° C (see Figure 3).

The only area to experience a decrease in seasonal temperature is in southern Mali near Bamako, and small adjoining parts of Burkina Faso and Guinea. There have been very significant increases (between 1.5°C and 2°C) in the north of the region, including in far eastern Chad and the northern regions of Mali and Mauritania. Increases in temperature of



#### Box 4. Data limitations

A major challenge in mapping historical climate trends as well as factors associated with migration and conflict is the limitation in data. There is a lack of reliable and complete data beyond the last 40 years. Some of the key limitations are:

**Precipitation and temperature:** Data measuring precipitation and temperature depends on the information gathered by weather stations. One limitation is the low number of weather stations within the region that regularly collect information. As such, an analysis of the variability in rain intensity, for example, is limited by the data available.

**Drought and flooding:** The earliest data available for droughts and floods is from 1981 and 1985, respectively. Similar to the other datasets used, the relatively recent data does not allow for the analysis of long-term trends.

**Conflict:** Data is only recorded for conflicts that have 25 battle deaths or more. It therefore does not cover small-scale localized conflicts that occur between and among livelihood practitioners, which is of particular interest to this study, as these small-scale conflicts are often the first to occur in relation to changes in environmental factors sustaining livelihoods. Detailed data on small-scale conflicts in the region has not been collected systematically.

**Migration:** Very little data exists in the region on migration flows, with surveys conducted only in 1976-1980, 1988-1992 and 2000-2002. In addition, the data on migration is static, showing one period, rather than a trend over time, which can be highly influenced by political events in the region. As such, it is not possible to draw generalizations on patterns of migration from the data.

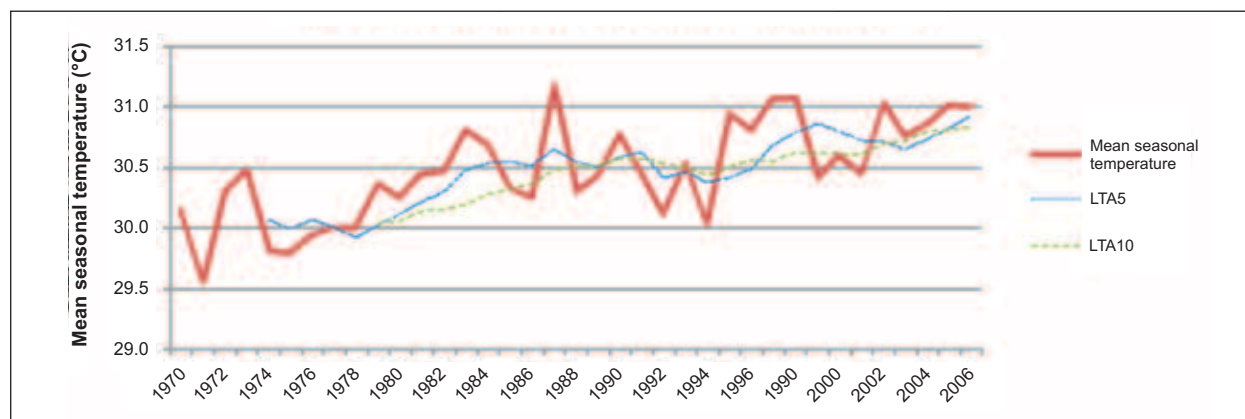
For more detailed information on the datasets and methodologies used, see Annexes 3 and 5.

1°C to 1.5°C are observed across Mauritania, Mali, Chad and the very northern portions of Niger, along the border with Algeria and Libya, while increases between 0.5°C and 1.0°C are found along the Atlantic coast from Senegal to Togo, in certain parts of Cape Verde, in most of Niger, in southern and central Burkina Faso and in western Chad. Finally, less marked increases of up to 0.5°C have occurred

in much of southern Mali, northern and western parts of Burkina Faso, northern Guinea and Côte d'Ivoire, coastal Liberia, pockets of Senegal, south-western Niger and most of Nigeria.

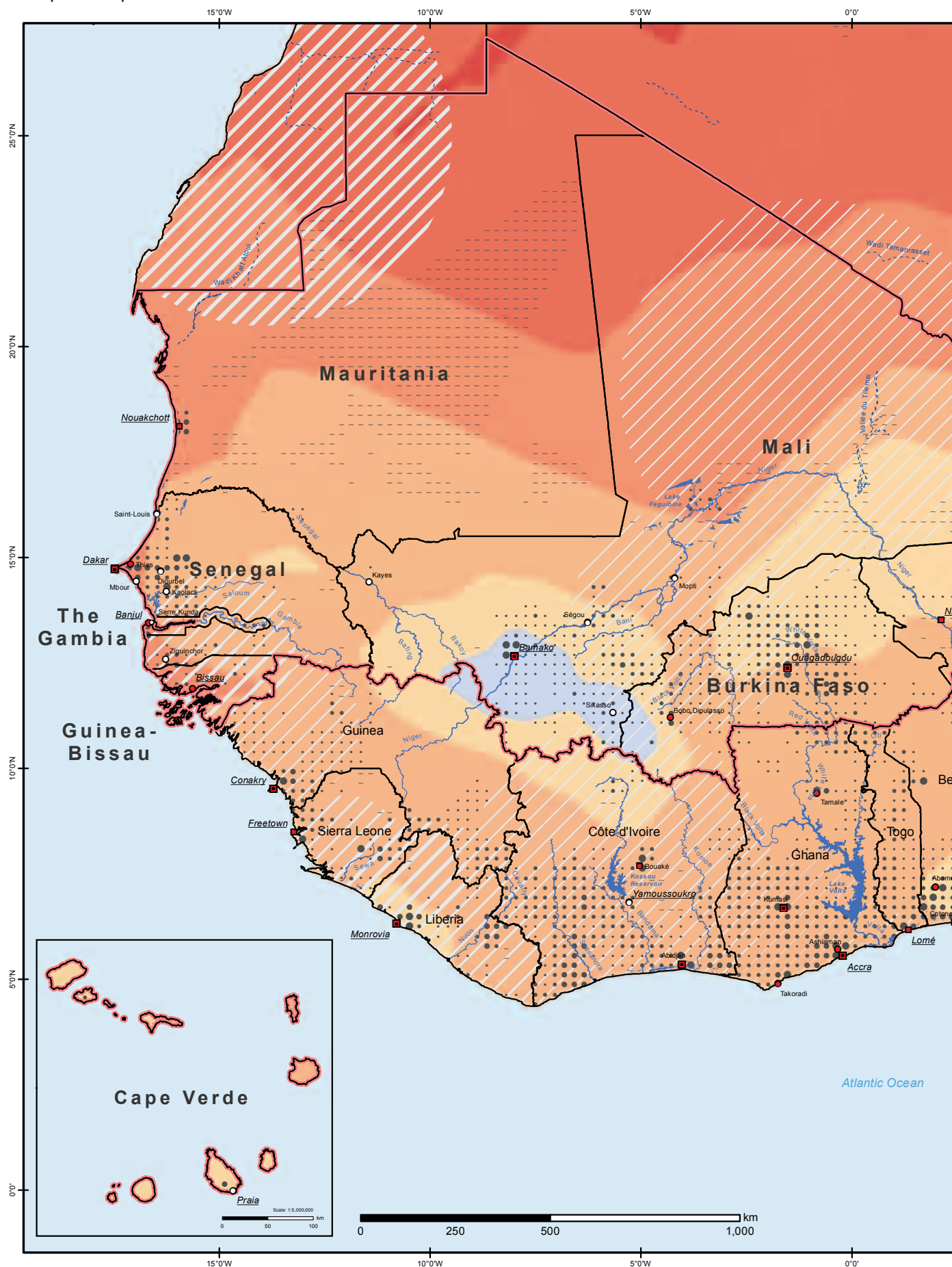
The data also shows that from 1976 to 2006, nearly 50 per cent of the total area and almost 50 per cent of the total population of the CILSS countries

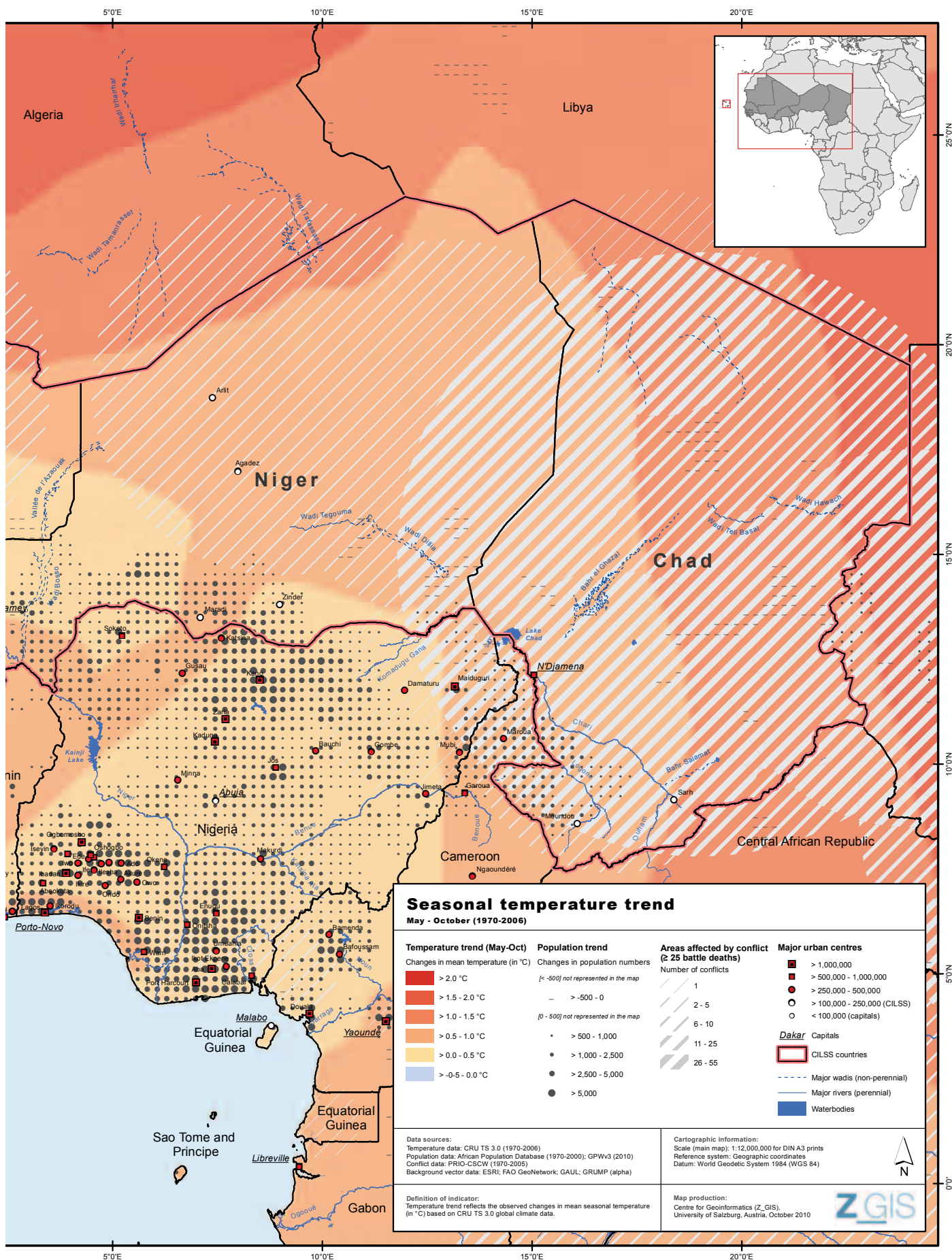
Figure 3. Mean seasonal temperature in the CILSS countries (1970-2006)



Source: Climate Research Unit Time-Series (CRU TS) 3.0 climate data. Includes the five year long-term average (LTA5), and the ten year long-term average (LTA10)

Map 6. Temperature







experienced a 0.5°C to 1°C increase. Some 15 per cent of the population experienced a more significant increase of 1.0°C to 1.5°C, representing approximately 30 per cent of the total geographical area of the CILSS countries.

## Impacts of temperature rise on livelihoods

While secondary sources do not currently single out temperature rise as a factor directly affecting livelihoods in the region, it is expected to have a very significant impact in years to come, including on food production. According to ECOWAS and OECD, further increases in temperature will affect pastoral and agropastoral areas the most.<sup>106</sup> A recent study shows for example that an increase of more than 2°C could result in a decrease of 15-25 per cent in the yields of millet and sorghum in Burkina Faso and Niger by 2080.<sup>107</sup> Similarly, it is estimated that with an increase of 2°C, maize yields will drop by 5 per cent.<sup>108</sup> On the other hand, rice yields are expected to grow in the short term by 10-35 per cent, given sufficient water availability, as rice plants benefit from higher concentrations of CO<sub>2</sub> in the atmosphere, which helps to fertilize the plant.<sup>109</sup> In the long term, however, rice yields will be reduced

to below normal levels as a result of further increasing temperatures.<sup>110</sup>

Using average data from 1961 to 1990 as a baseline, FAO has predicted significant decline in global cereal production by 2050, with a 20-50 per cent decrease in cereal productivity in the Sahelian belt from Niger to Senegal.<sup>111</sup> In addition, increased temperatures are expected to change the spread and occurrence of various diseases and pests, such as locusts, with potentially serious consequences for the health of plants and animals, as well as human health.<sup>112</sup> However, many factors influencing how an increase in temperature affects livelihood practices in the region remain uncertain, such as potential changes in evapotranspiration rates and water availability.

## 3.3 Changes in rainfall

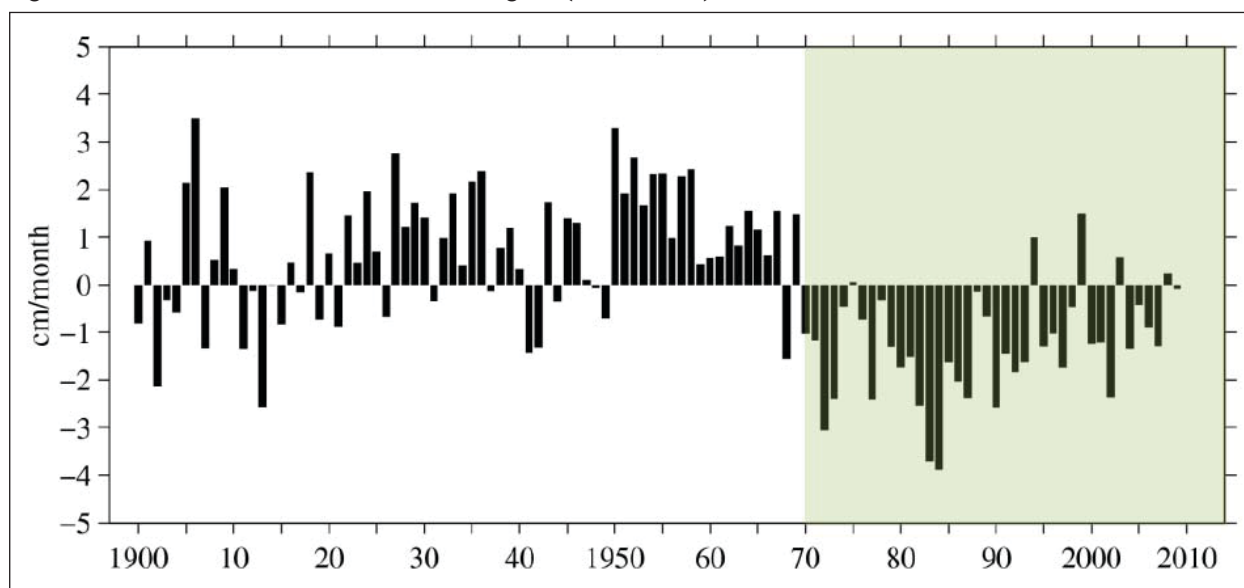
Map 7 shows seasonal rainfall in millimetres (mm) from 1970 to 2006, using data recorded annually between May and October. These months were chosen due to the importance of rainfall during the cropping season. The map shows absolute changes in rainfall rather than the actual amount



© UNU/Julie Shorek

*Seasonal lakes, such as this one in Tekashuwart, Niger, provide both humans and animals with drinking water during the rainy season. Changes in rainfall can affect the availability of water and fodder for cattle, leading to alterations in the migratory patterns of pastoralists*

Figure 4. Mean seasonal rainfall in the region (1900-2009)



Source: National Oceanic and Atmospheric Administration's National Climatic Data Center (NOAA NCDC) Global Historical Climatology Network data, 1900-2009. Averages over 20°-10°N, 20°W-10°E

of rainfall in the region. Absolute seasonal rainfall is represented in six colour categories, ranging from a decrease of more than 100 mm to an increase of more than 250 mm. Rainfall patterns are deemed as constant within a range of minus 50 mm to plus 50 mm.

Overall, seasonal rainfall has increased during the 36-year period under review. Only three areas experienced declines in seasonal rainfall of more than 50 mm: Bobo Dioulasso in Burkina Faso, the Burkina Faso and Ghana border, and the southern coast of Ghana, stretching into Côte d'Ivoire. Constant levels of rainfall are observed in northern parts of Chad, Mali, Mauritania, and Niger; most of Ghana; central Nigeria; Côte d'Ivoire; Cape Verde; a large area spanning northern Guinea and south-western Mali; and southern Burkina Faso.

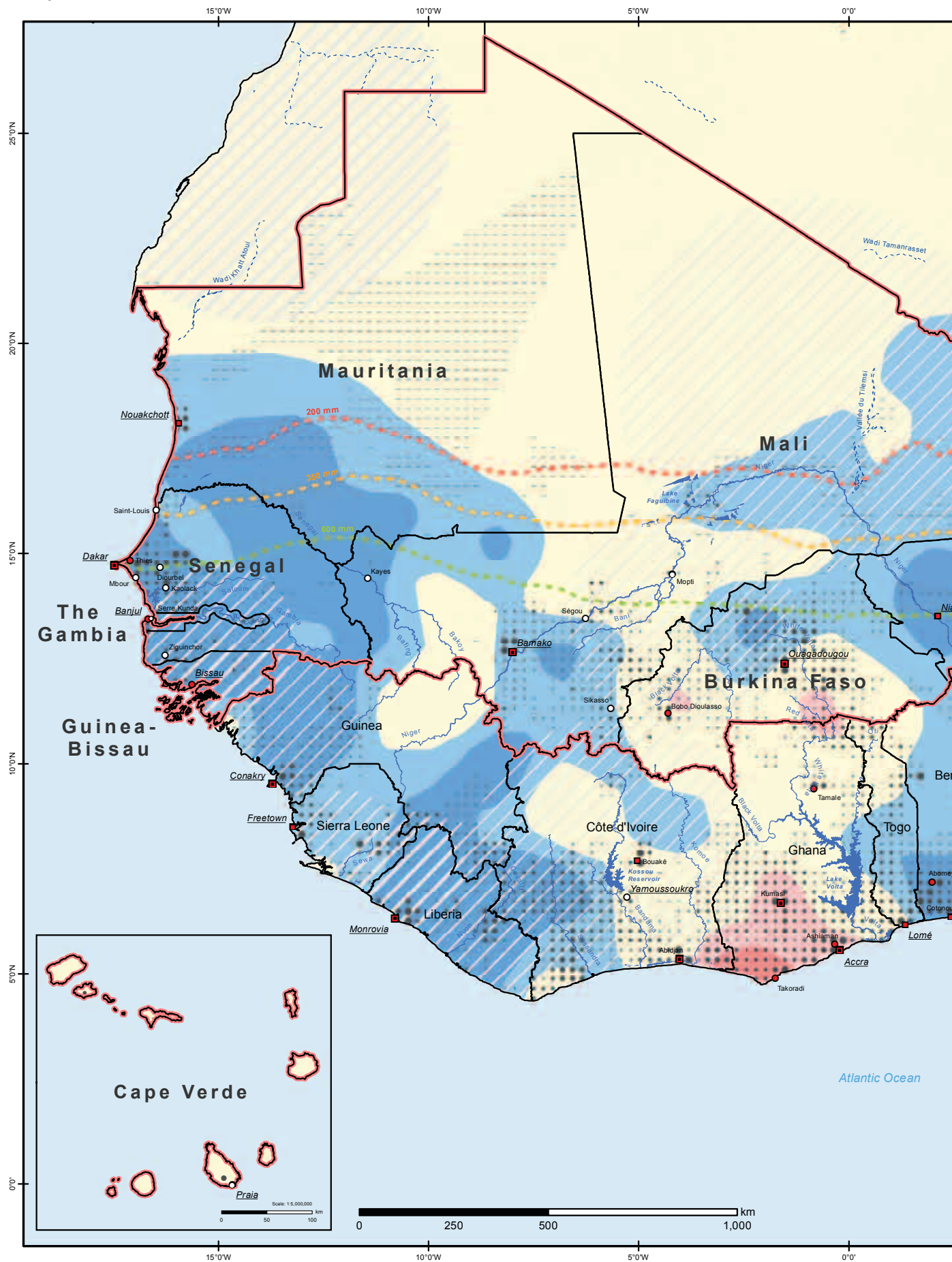
Much of the remainder of the coast has experienced increases in rainfall. The area around Kano, Nigeria, is unique in that it is the only area to have experienced an average increase of more than 250 mm. The next highest average increases of 100 to 250 mm occurred in parts of Benin, Togo, Burkina Faso, Nigeria, Chad, the Gambia, Guinea-Bissau, Guinea, Liberia, Côte d'Ivoire, Mali, Mauritania, Niger and Senegal. With the exception of Benin, Liberia and Nigeria (which are not CILSS countries), these areas represent 17 per cent of the region and contain almost 42 per cent of the population.

Seasonal rainfall increases of 50 to 100 mm occurred in northern and western Côte d'Ivoire, parts of Guinea and Guinea-Bissau, Togo, Benin, southern Mauritania, parts of Senegal, Sierra Leone and southern Nigeria; and in the central Sahel region that encompasses parts of northern Burkina Faso, Mali and Niger. In sum, data from 1970 to 2006 reveals a 50 to 100 mm increase in average rainfall across 30 per cent of the CILSS countries, affecting an estimated 35 per cent of the population.

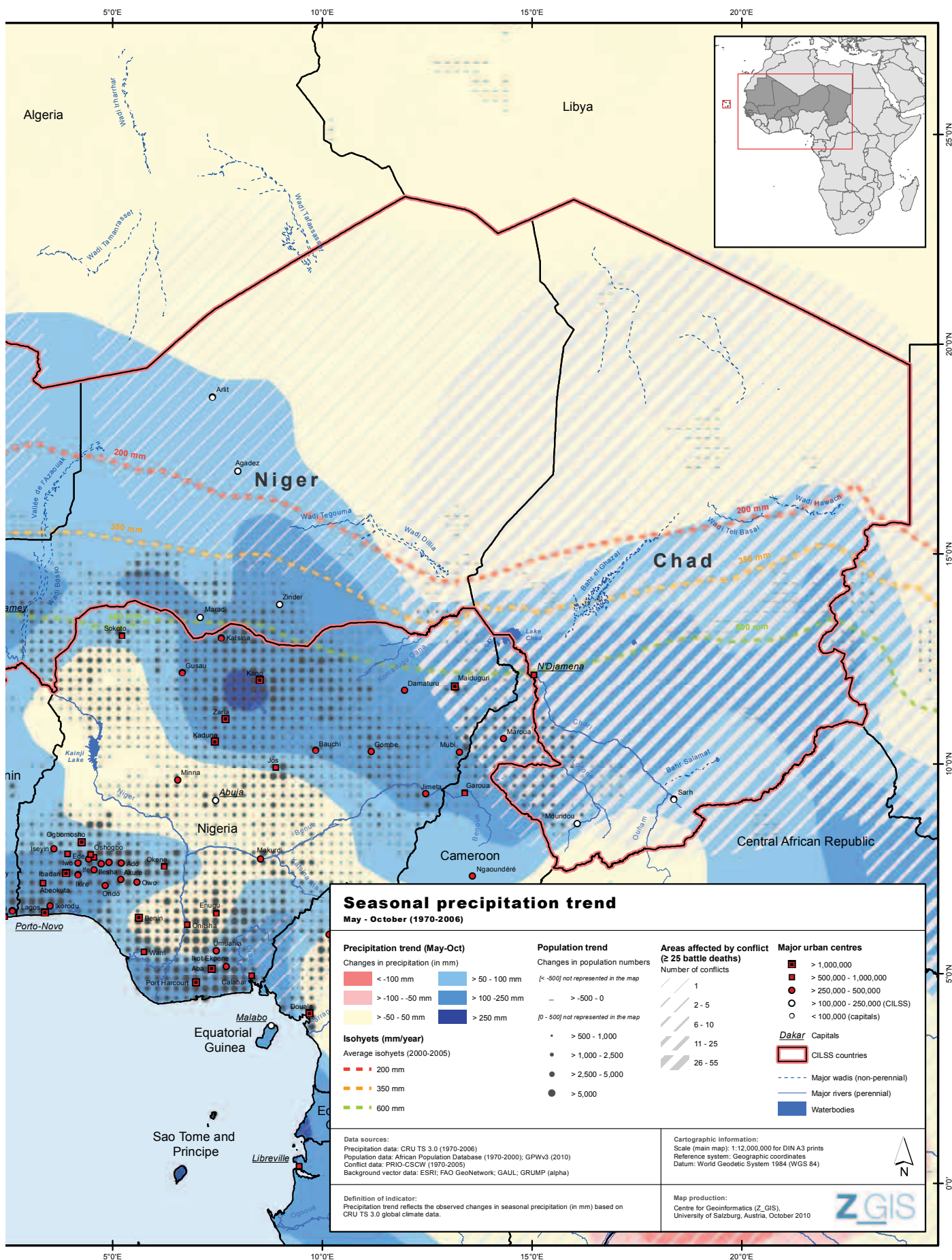
As noted in section 2.2, the 350 mm rain belt represents the general limit at which rain-fed agriculture can be practiced. To highlight this zone, in which livelihoods are the most vulnerable to changes in rainfall, the 200, 350 and 600 mm of rain per year markers (isohyets) are also shown on Map 7, based on mean rainfall values from 2000 to 2005.<sup>113</sup>

The observed seasonal rainfall patterns support the findings of the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC), which analyzed rainfall data from the beginning of the 20<sup>th</sup> century. While the data collected prior to 1970 is less detailed and less suitable for a regional analysis such as this one, it shows that rainfall has been increasing in some parts of the region since the early 1970s, although the mean seasonal rainfall is still below the long-term average from 1900 to 2009 (Figure 4).

Map 7. Rainfall







It is acknowledged that the findings of this mapping process leave a number of questions regarding the duration, variability and intensity of rainfall in any one season unanswered, as the available data and sparse network of weather stations do not allow for such an analysis. These factors can have significant impacts on livelihoods, for example when a large proportion of the seasonal rainfall is received in a small number of intensive events rather than evenly over the cropping season, causing erosion of topsoil and destruction of crops.

## Impacts of changes in rainfall on livelihoods

The main issue of concern from a livelihood perspective in respect to rainfall is related to changes in rainfall variability and their effects on food security.<sup>114</sup> The livelihood most affected by these changes is farming, due to loss of soil from intensive rain events and poor crop yields from changes in the timing of the rainfall. Changes in rainfall also affect the prevalence of crop pests, as improved ecological conditions such as soil moisture and vegetation cover can promote their development.<sup>115</sup> However, increases in rainfall can also create more favourable conditions for agricultural practices. Pastoralists are mainly affected by changes in rainfall that occur in the arid and semi-arid areas of the Sahel and influence the availability of shrubs, grasses and water sources for livestock. Where rainfall is reduced, water availability for cattle and fodder production is affected, leading to changes in migratory patterns for pastoralists. When traditional patterns are disturbed, CILSS-AGRHYMET's studies have shown a weakening of the social fabric and a loss of confidence, as well as increased mistrust within and between communities.<sup>116</sup>

## 3.4 Occurrence of drought

The region has experienced three major drought periods during the last century: 1910-1916, 1941-1945 and a longer period starting in the 1970s, which can be considered to be still ongoing despite some interruptions due to one-off seasons with adequate rainfall.

Map 8 shows vegetative drought measured in terms of the health and stress conditions of vegetation due to adverse changes in the climate system

and hydrological cycle between May and October for the period 1982 to 2009. It is important to note that the dataset used for this map thus falls within a recognized period of major drought in region, highlighting the difficulty of identifying particular trends for this specific time period.

Vegetative drought is represented in four colour categories reflecting the total number of drought-affected seasons during this period. The most severe category includes regions with 11-15 drought-affected seasons over the last 27 years. The map demonstrates that most countries in the region have experienced vegetative drought, with a higher number of droughts in the northern parts of the region.

Large areas of Chad, Mali, Mauritania and Niger faced between six and ten drought seasons between 1982 and 2009, with smaller pockets experiencing between 11 and 15. Smaller areas of Burkina Faso, Liberia, Senegal, Ghana and Nigeria – as well as all the islands of Cape Verde – have also been affected by a high number of drought seasons. The incidence of drought across central and southern Sahel has generally been lower, with eight additional countries (Senegal, the Gambia, Guinea-Bissau, Guinea, Sierra Leone, Côte d'Ivoire, Ghana and Benin) experiencing between three and five drought seasons, and Togo between one and two.

When cross referenced with population and area data, less than one per cent of the CILSS population experienced 11-15 drought seasons during the study period. However, nearly eight per cent of the population faced 6-10 drought seasons, covering almost 35 per cent of the area of CILSS countries. Since 1971, over 62 million people in the broader region (CILSS and ECOWAS countries) have been affected by drought, requiring emergency assistance.<sup>117</sup>

## Impacts of seasonal drought on livelihoods

Seasonal droughts, which are recognized as a primary cause of food insecurity, have long affected the Sahel.<sup>118</sup> Between 1969 and 1974, for example, drought across the region led to the displacement of millions of farmers and herders in search of alternative livelihoods, mainly towards cities.<sup>119</sup>



These events undermine crop yields and lead to reductions in food availability within individual households, as well as at the national level. This decline also impacts the income of farmers – and that of States – who depend on the sale of agricultural goods.<sup>120</sup> This was exemplified in Niger's 2005 food crisis, where drought combined with an invasion of locusts led to both a reduction in food availability and an inability of poor households to purchase food.<sup>121</sup> In combination with changing rainfall patterns, seasonal droughts have already contributed to changes in livelihoods. Agropastoralism, for example, has become increasingly popular. This livelihood combines both farming and livestock breeding and is considered to be a strategy used to mitigate increasing climate uncertainties.<sup>122</sup> This has decreased the interdependency between farmers and herders, but increased the competition for suitable land.

### 3.5 Occurrence of flooding

Map 9 depicts the areas affected by flooding from 1985 to 2009. Unlike the data for Map 7, which is limited to the seasonal rainy period, flood data is

based on annual information. Historical data from the Dartmouth Flood Observatory was used to calculate when a flood had occurred and whether the frequency had increased over the 24-year period.

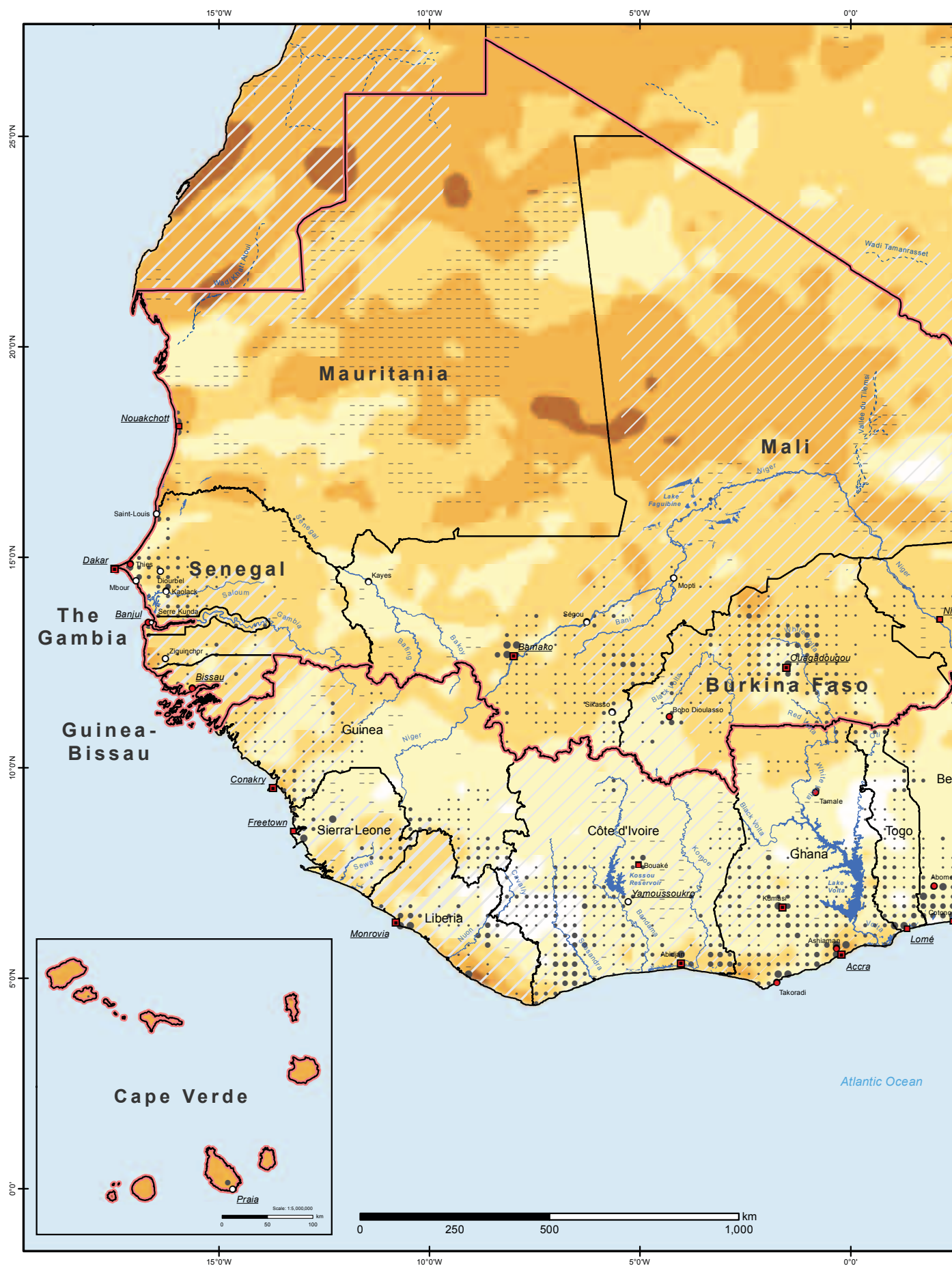
The map shows that central Sahel was most affected by flooding during the study period, with significant areas of southern Burkina Faso, northern Nigeria and south-western Niger experiencing between nine and ten floods, and the border between Benin and Niger, as well as small pockets of Nigeria facing up to twelve. Virtually the entirety of Burkina Faso, most of Southern Niger, northern Ghana, Benin and Togo, as well as northern Nigeria and southern Chad experienced between seven and eight floods, representing 36 per cent of the population and more than 11 per cent of the land area of the CILSS countries. Over the same period, large parts of Mali, Ghana, Senegal, Benin, Niger, Nigeria and Chad – including an estimated 18 per cent of the population and 15 per cent of the land area of the CILSS countries – saw five to six floods. The remainder of the region experienced a smaller incidence of flooding, with zero to two floods in most of the countries along the Atlantic coast, from the Gambia to Côte d'Ivoire.

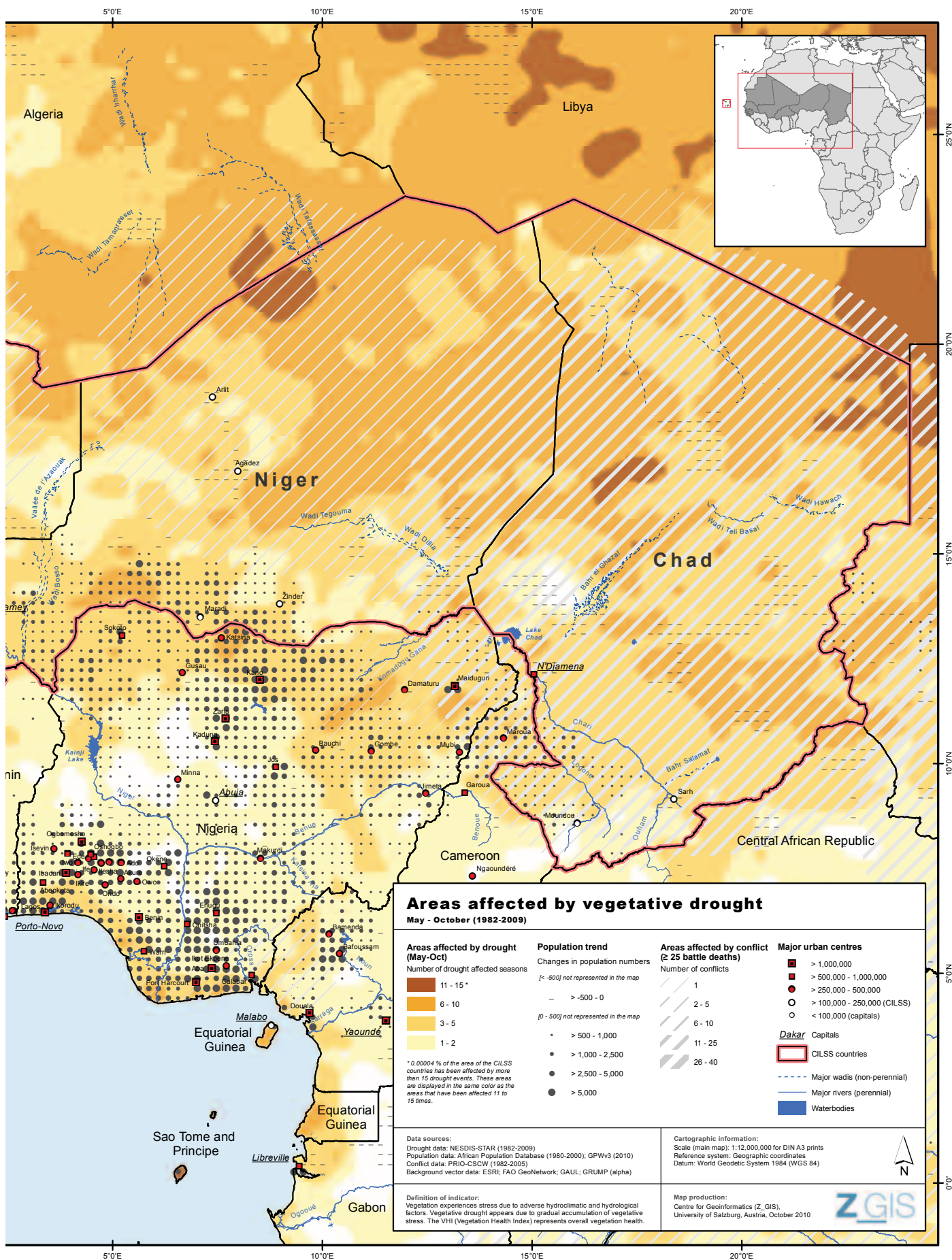


*Flooding has had a significant impact on livelihoods in the region, destroying infrastructure and crops, and often leading to massive displacement. In recent years, the region has experienced an increase in the frequency and severity of flooding*

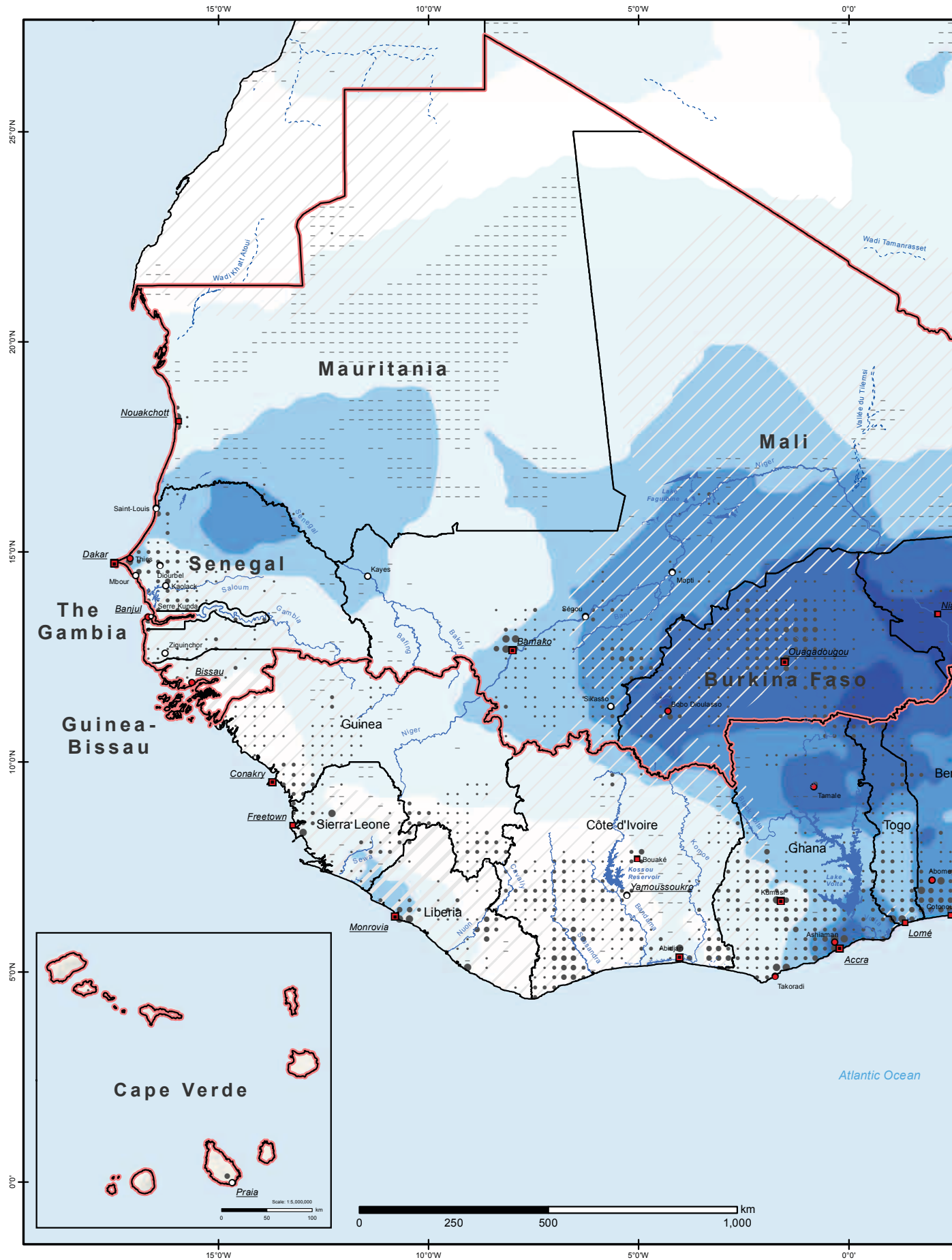


Map 8. Drought

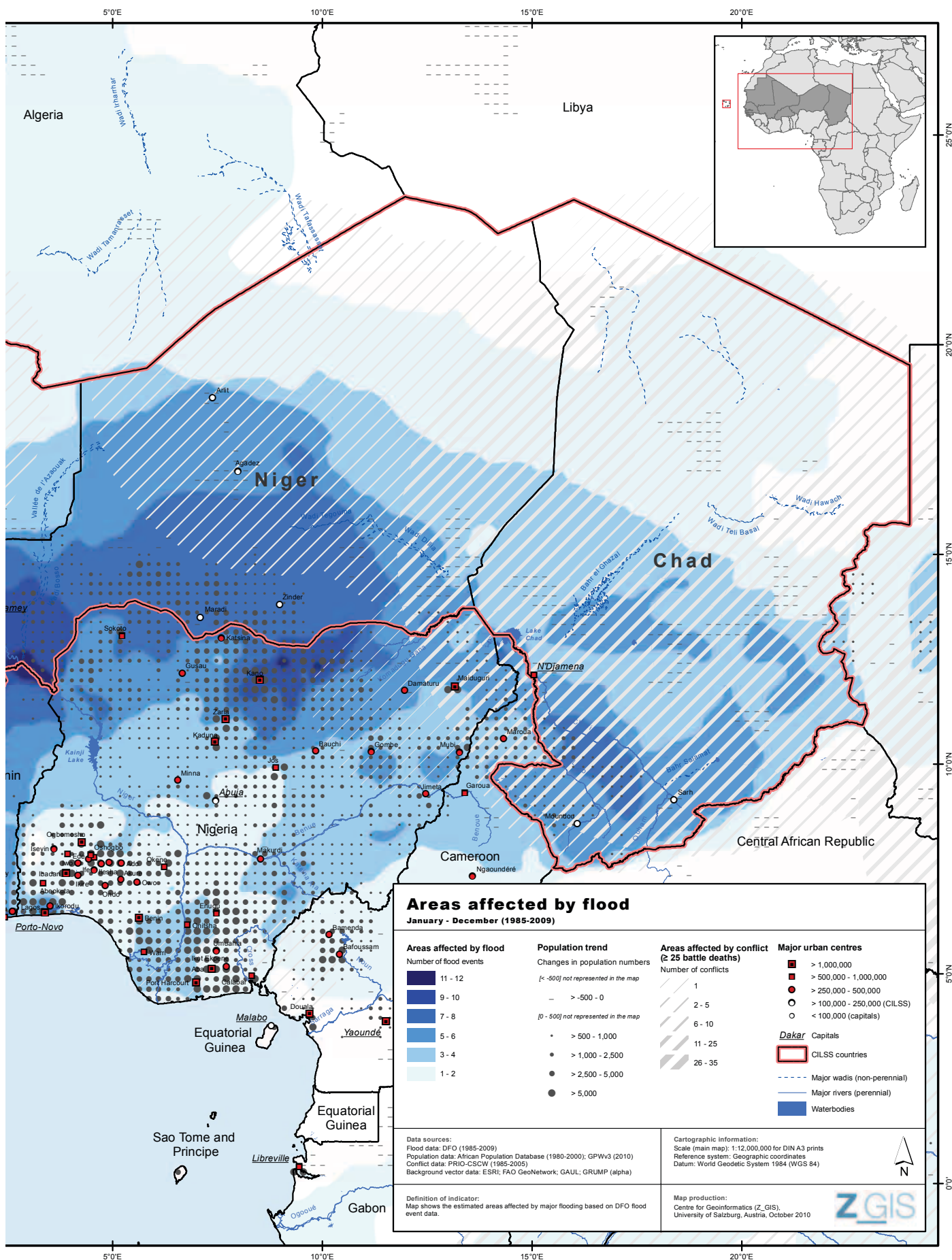




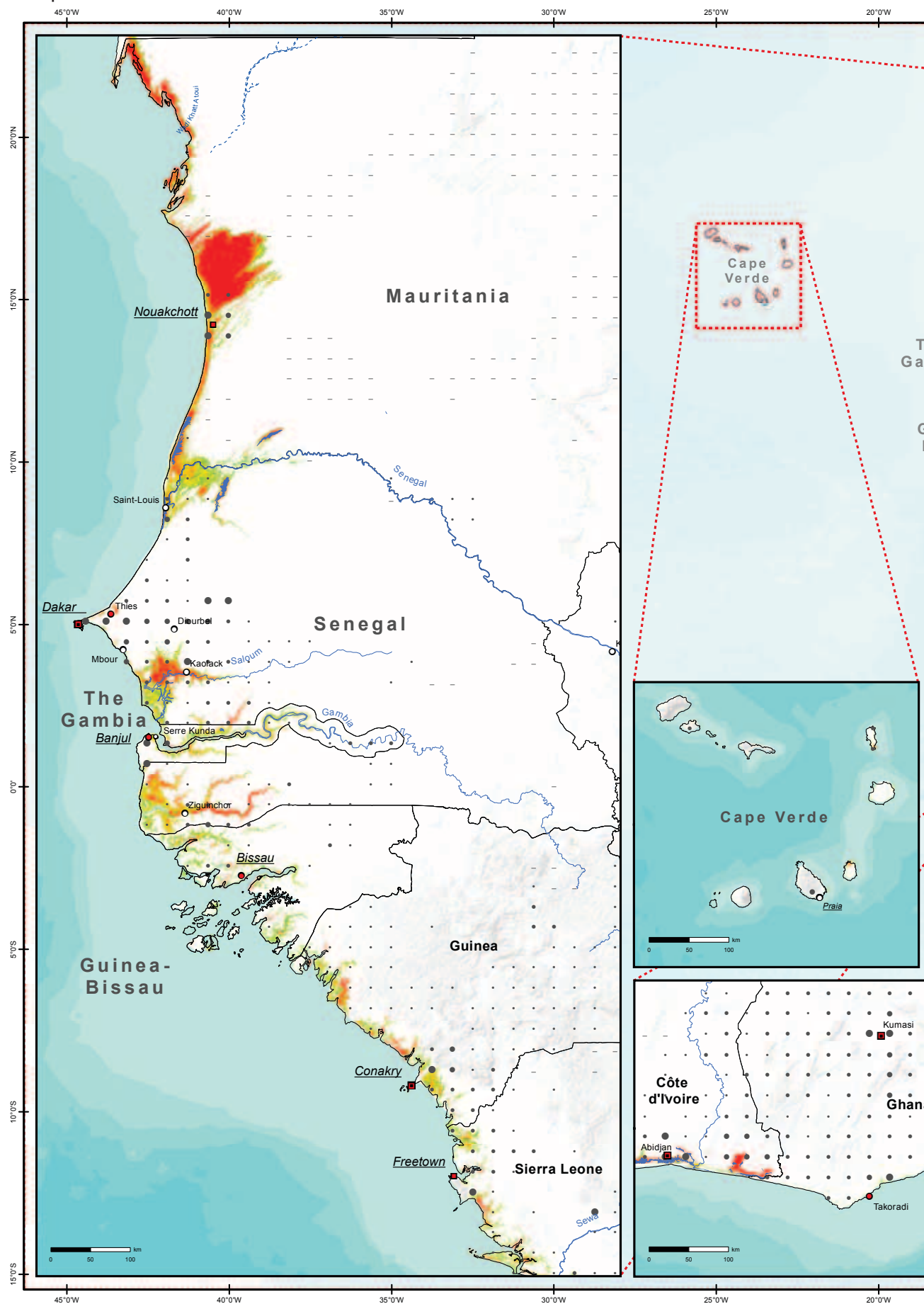
Map 9. Flooding







Map 10. Sea-level rise



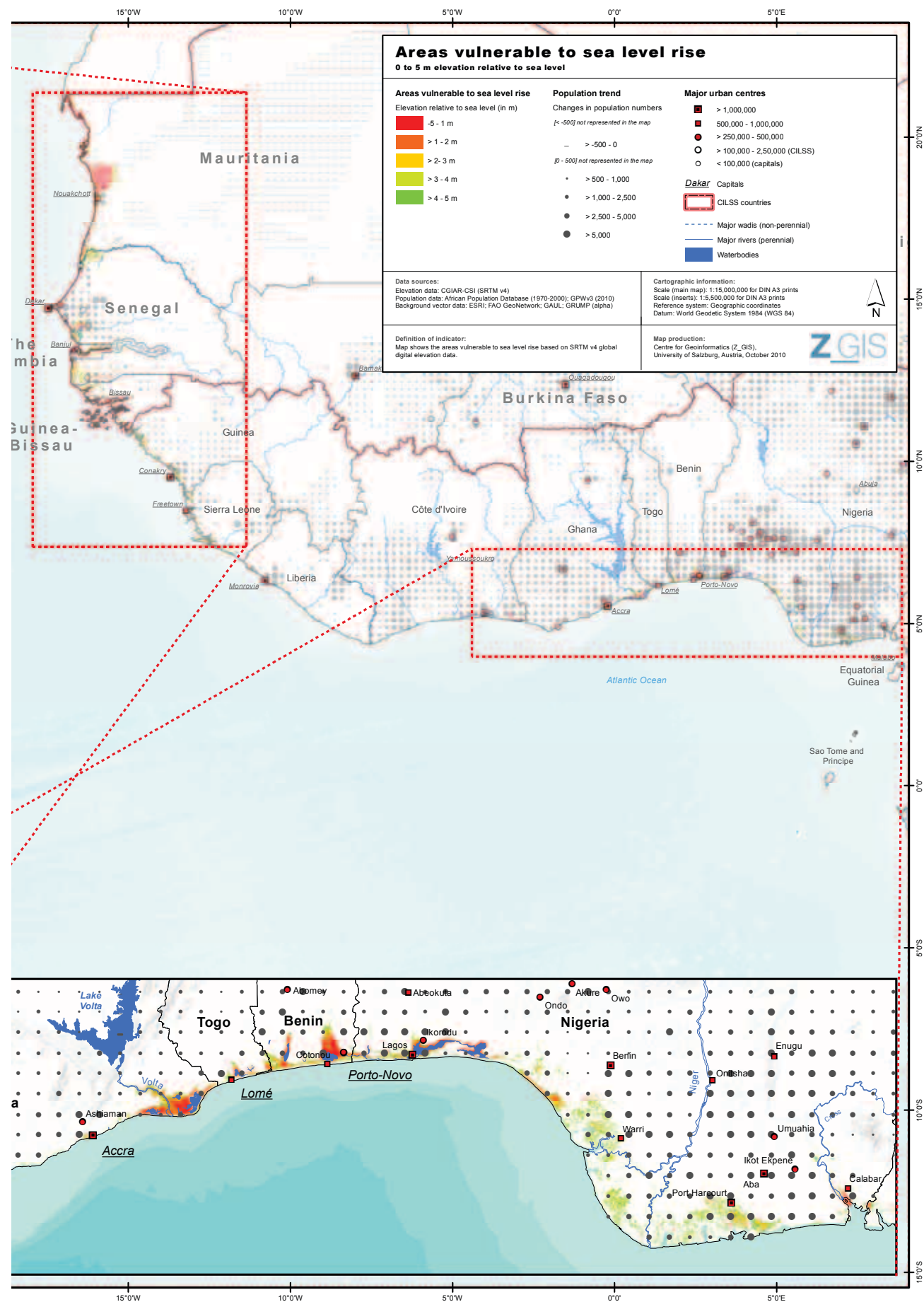




Figure 5. Frequency and land area covered by flooding in areas that have experienced 9-10 floods

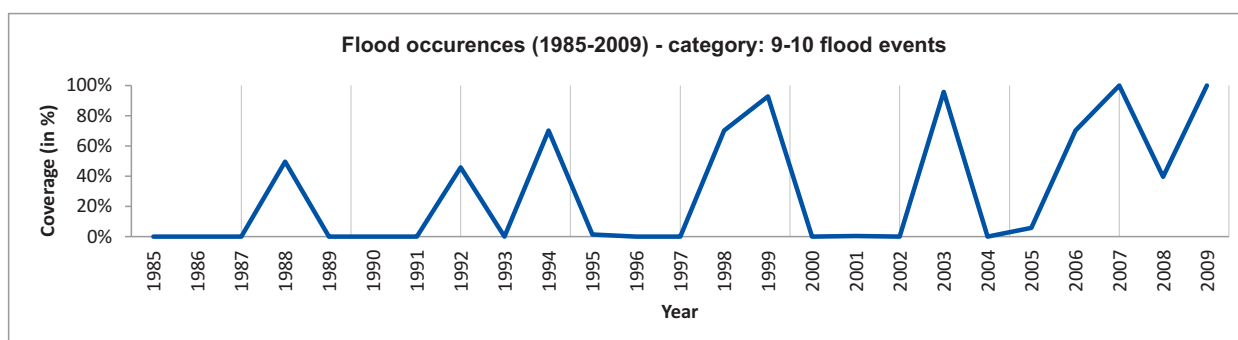
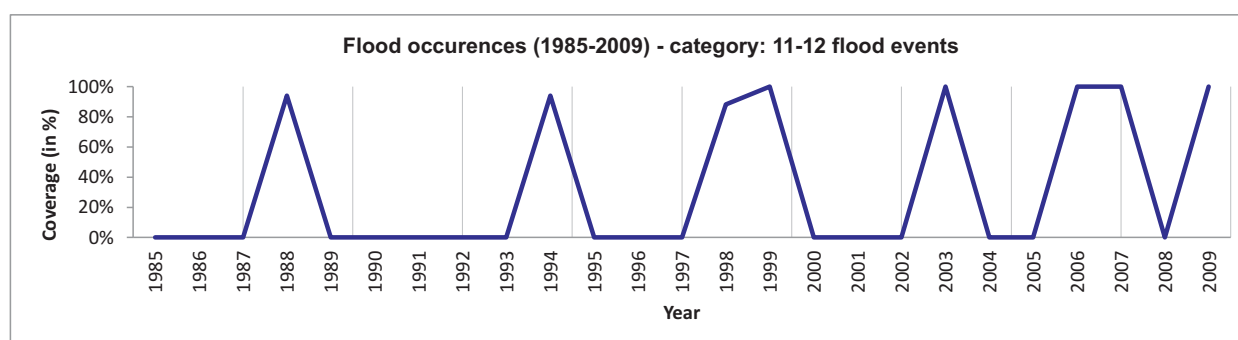


Figure 6. Frequency and land area covered by flooding in areas that have experienced 11-12 floods



In addition, the frequency of flooding and the land area affected were graphed over time. Figures 5 and 6 show the results for the two highest categories – nine to ten floods and eleven to twelve floods respectively. In Figure 5, it can be observed that both the frequency and area covered by the flooding events have increased. When floods occurred in the first half of the time period (1985-1995), approximately 50 per cent of the area experienced flooding during any one year. By contrast, when flooding has occurred in the past 15 years, nearly 100 per cent of these areas have been affected, illustrating a wider and more severe inundation. Moreover, both Figures 5 and 6 show that the gaps between the peaks and troughs have shortened, indicating a greater frequency of flooding. There have also been wider peaks, indicating more extended periods of inundation. Figure 6 also shows a greater frequency of flooding in areas affected by 11-12 floods during the last 15 years, with only two occurrences between 1985 and 1995 compared to four between 1995 and 2009.

It can be noted that of the 17 States included in the study region, twelve endure regular flooding, which not only represents a danger for human health

and lives, but also leads to localized decreases in agricultural production and cattle losses.

## Impacts of flooding on livelihoods

Flooding in the region causes many deaths and can lead to massive displacement, notably due to the lack of preparedness and infrastructure to address intense rainfall. The floods that devastated Burkina Faso in 2009 and southern Benin in 2010, for example, led to the displacement of hundreds of thousands of people. These risks are likely to become more acute if the frequency and severity of flooding increases. Additionally, floods in 2010 led to major crop losses: Nigeria had an approximate loss of 180,000 hectares (ha) of crops due to inundation (in Sokoto, Kebbi, Zamfara, Jigawa), while Benin experienced a total loss of approximately 140,000 ha of crops (in Lanville, Karimana and the region of Cotonou). In addition, Chad lost approximately 110,000 ha (in Lac, Guéra, Logone, Tandjilé); the Gambia lost 15,000 ha (in Upper River Region, Western Region, Lower River Regions, North Bank Region, Central River Region); and Burkina Faso (in Centre West, North, Boucle du Mouhoun, Centre South et Upper basins) lost some 20,000 ha.

In combination with volatile global commodity markets, exchange rate fluctuations and availability of food aid, such drops in production risk compounding the rise in the price of staples such as rice, corn and wheat.<sup>123</sup> Rises in food prices affect the poorest and most vulnerable population groups the most, and can lead to suffering and social unrest.

### 3.6 Areas vulnerable to sea-level rise

Map 10 shows coastal areas vulnerable to future sea-level rise. Five colour categories are used to illustrate levels of risk relative to elevation, with the most vulnerable zones being areas with an elevation of minus 5 metres (m) below sea-level (land surface only) to 1 m above sea-level. All coastal regions of up to 5 m in elevation have been identified as potentially at risk because of increased coastal erosion, saltwater intrusion, and seawater inundation. Cross-referenced population data indicates that a 0-1 m rise in sea-level could affect over 3 million people in this region. More information on the land area and percentage of the population at risk from future sea-level rise in the study area can be found in Annex 7.

The IPCC predicts an 18-59 cm sea-level rise globally by the year 2100. However, more recent reports point to likely global sea-level rise of close to a metre or more by the end of the century as a result of, for example, faster melting of the ice sheets in Greenland.<sup>124</sup> In the region covered in this report, this rise is expected to have a major effect on some coastal areas.

The most vulnerable areas shown on the map are near Nouakchott in Mauritania (709,000 inhabitants), which is located 2-3 m below sea-level, and parts of the coastline east of Accra in Ghana to Porto-Novo in Nigeria, including Benin. Much of the western coastal zone of the Sahel, including parts of Senegal, the Gambia, Guinea-Bissau, Guinea, as well as further south all the way to Sierra Leone, is also vulnerable due to its low elevation (0-1 m above sea-level). Furthermore, six of the largest cities of the region – Lagos (10.5 million inhabitants), Abidjan (4.1 million), Dakar (2.8 million), Accra (2.3 million), Conakry (1.6 million) and Lomé (1.6 million) – could be affected as they are located on the coast, as would smaller cities such as Cotonou,

Banjul, Bissau and Porto Novo, and dense urban areas close to the Senegal River, the Saloum Delta, and the Volta Delta.<sup>125</sup> Sea-level rise could also have an impact on agricultural production that occurs on or near the coast, and cause saltwater intrusion into freshwater lagoons and lake systems.

### 3.7 Synthesis maps

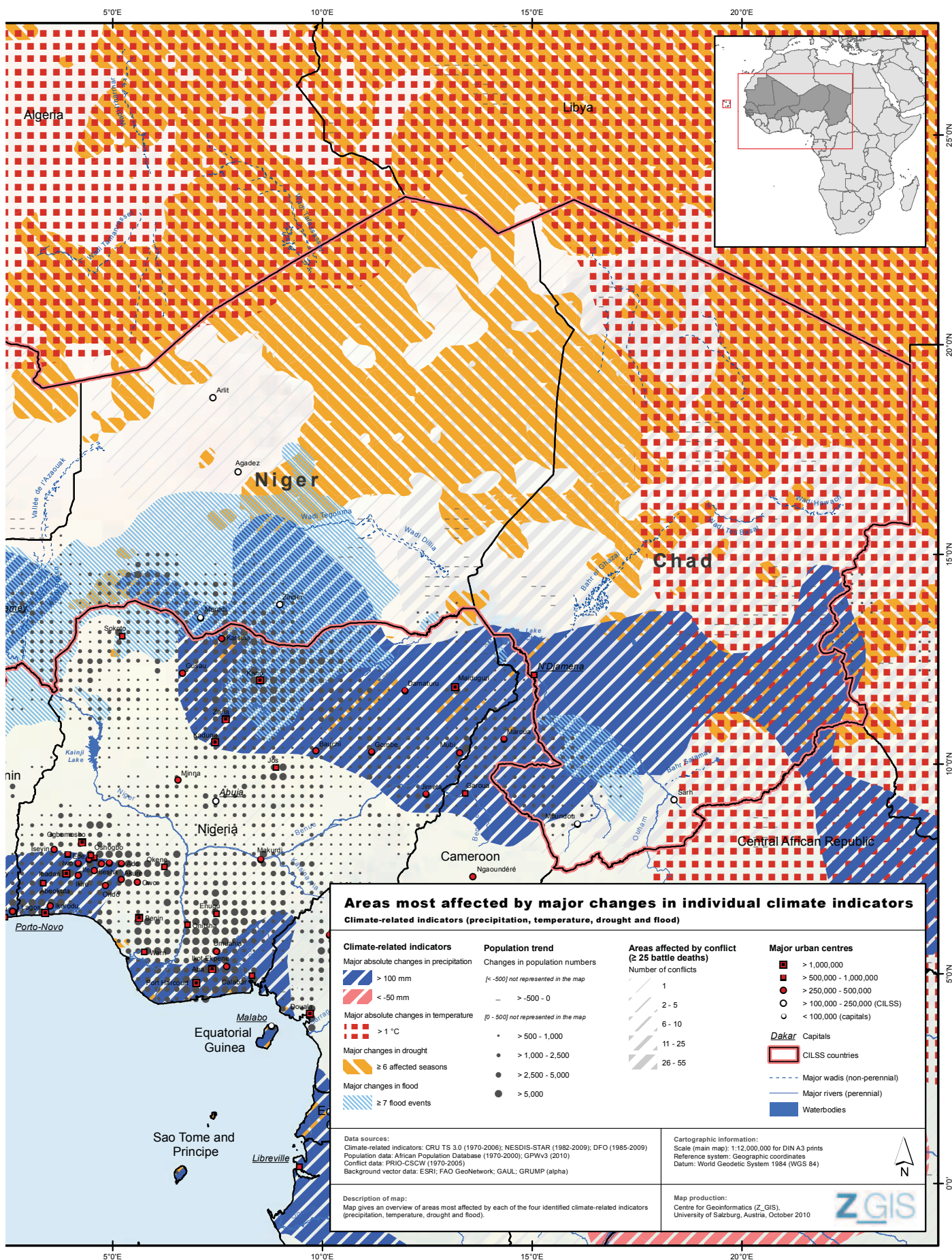
Maps 11 and 12 synthesize the information presented in the four maps showing changes in temperature, precipitation, drought and flooding (Maps 6-9), with a view to identifying “hotspots.” Map 11 depicts the areas where the most *extreme* changes in these individual climate indicators have taken place, while Map 12 considers the four climate indicators together, highlighting the areas affected by the most *cumulative* change over the last 40 years. Data on population dynamics and conflict is also overlaid on these maps.

Map 11 shows clear general trends in climate for the study region, with the north experiencing the most extreme increases in temperature and highest number of droughts, and the central areas facing a high frequency of flooding. The most significant changes in precipitation are found along parts of the coast, as well as along a belt stretching from northern Nigeria into southern Chad. In addition, the map shows areas where major changes in individual climate indicators overlap, in particular in western Mauritania, some areas in Burkina Faso, Niger and southern Ghana, as well as in the northern parts of Nigeria and southern Chad. A more nuanced analysis of areas affected by cumulative changes in the climate indicators is presented in Map 12.

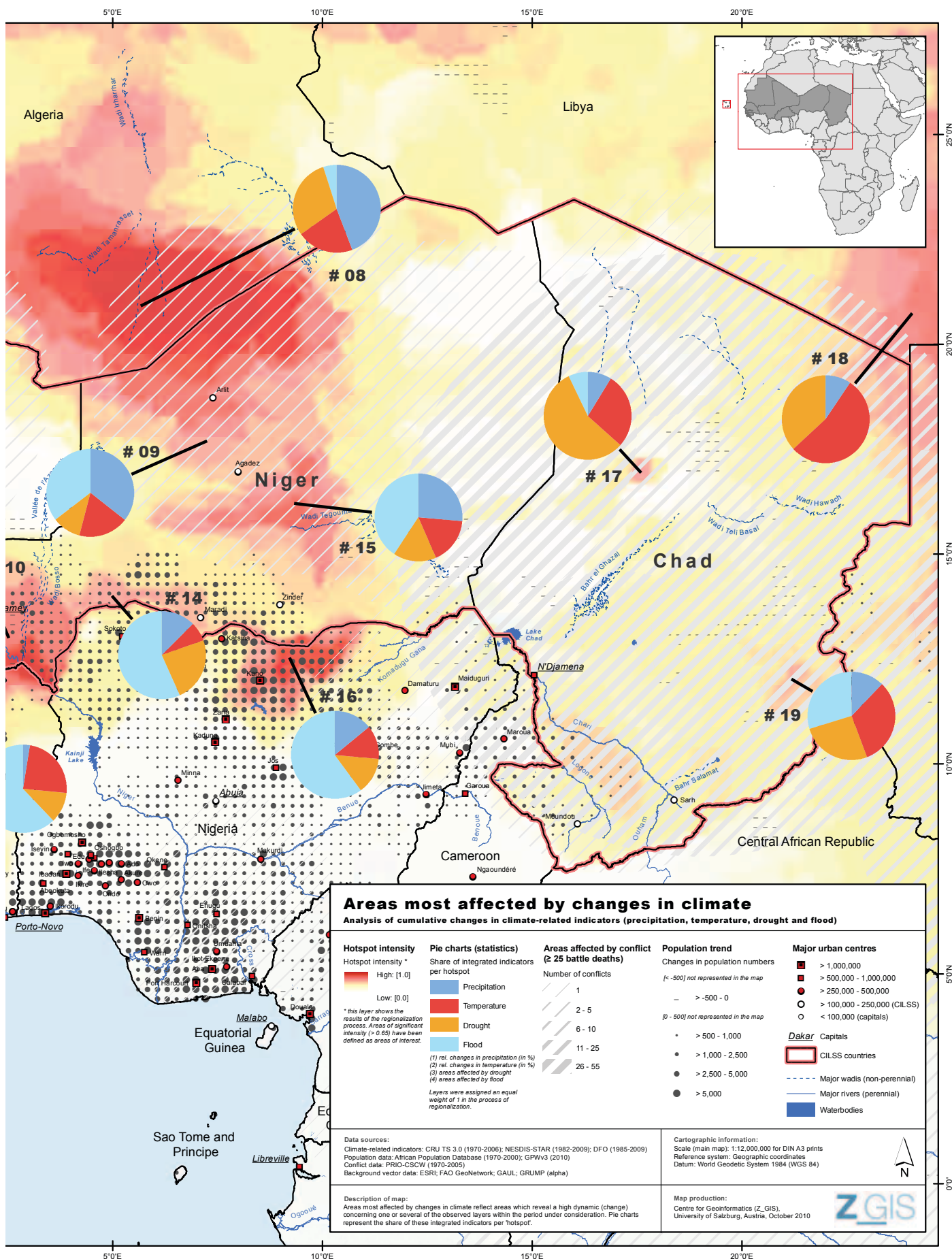
The “hotspots” identified in Map 12 were determined by “normalizing” the data for the individual indicators – i.e. standardizing their values in order to make them comparable to one another. Further, the four climate indicators were given equal weight in order to analyze their combined occurrences and cumulative impact (for more information on the methods used, please refer to Annex 3). The colour coding used in the pie charts for each hotspot represents the approximate proportional influence of each climate indicator for the specific area. While this simplified methodology does not incorporate population and conflict variables,

This map of West Africa illustrates the distribution of three major vegetation types: Sahelian (represented by diagonal lines), Sudanian (represented by dots), and Guinean (represented by a cross-hatch pattern). The map covers the region from 15°0'W to 0°0'W and 0°0'N to 15°0'N. Key countries shown include Mauritania, Mali, Senegal, The Gambia, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Burkina Faso, Ghana, and Togo. Major cities such as Nouakchott, Saint-Louis, Dakar, Banjul, Bissau, Conakry, Freetown, Monrovia, Bamako, Ségou, Mopti, Ouagadougou, Koudougou, Bobo Dioulasso, Yamoussoukro, Bouaké, Kossou, Kumasi, Ashaman, Accra, and Lomé are marked. Rivers like the Niger, Benue, Volta, and Senegal are depicted. The Atlantic Ocean is to the west. An inset map shows the Cape Verde islands, with Praia as the capital. A scale bar indicates distances up to 1,000 km.





This map of West Africa displays 13 sampling locations, each marked with a pie chart. The locations are numbered #01 through #13. The map includes country borders and names: Mauritania, Mali, Burkina Faso, Ghana, Togo, Côte d'Ivoire, Liberia, Sierra Leone, Guinea, Senegal, The Gambia, Guinea-Bissau, and Cape Verde. Major cities and towns are labeled, such as Nouakchott, Saint-Louis, Dakar, Banjul, Bissau, Conakry, Freetown, Monrovia, Yamoussoukro, Abidjan, Lomé, and Accra. Rivers and lakes are also shown, including the Niger, Senegal, and Volta rivers, and Lake Faguibine. The Atlantic Ocean is labeled to the west. A scale bar at the bottom indicates distances from 0 to 1,000 km. An inset map shows the Cape Verde archipelago. The pie charts at each location represent different data series, with colors ranging from red to blue. The map is overlaid with a grid of latitude and longitude lines.





nor provides an analysis of the underlying socio-economic factors, it enables the identification of those areas that have already been cumulatively impacted by the four climate indicators, which are of specific interest for targeted adaptation policies and programmes.

The quantitative analysis presented in this map is illustrated by the “hotspot intensity” gradient. Areas

that have experienced the greatest cumulative impact are shown in red. Based on this analysis, hotspots occur in three main areas: (i) the north-western part of the study area, including Mauritania; (ii) the centre of the study area, including Niger, Burkina Faso and the northern parts of the coastal States of Ghana, Togo, Benin and Nigeria; and (iii) Chad. It is to be noted that the analysis also highlighted three hotspots that fall outside of the study



© UN Photo/John Isaac

*Changes in rainfall and occurrences of drought and flooding have a direct impact on crop yields and food supplies, as well as income for those who depend on natural resources for their livelihoods. Prolonged drought combined with a locust invasion led to a major food crisis in Niger starting in 2005*

area of this report (hotspots 3, 7, 8 and 18), which are not discussed in further detail here.

In the western parts of the region (hotspots 1, 2 and 4), the main influencing factors are changes in precipitation, increasing temperature and the occurrence of drought. Hotspots near the coast (hotspot 4) have seen a greater change in precipitation than areas further inland, where drought has had a more significant role (hotspots 1 and 2).

The majority of hotspots are found in the central part of the study area (hotspots 5 and 6, and 9-16), namely in Niger, Burkina Faso, northern and coastal Ghana, as well as northern Togo, Benin and Nigeria. Common to all of these hotspots is that they have been most heavily affected by flooding. Most, however, have also experienced slow-onset changes, in particular in temperature and occurrence of drought.

Finally, two hotspots can be identified in Chad (hotspots 17 and 19). The first has been chiefly affected by changes in temperature and the occurrence of drought, while for the second, located in the southeast of the country, flooding has played a greater role.

Population trends and conflict data are also overlaid on this map, showing that a number of areas identified as hotspots have experienced an increase in population – most notably hotspots 10, 13 and 16. In addition, major urban centres such as Accra, Kano, Niamey, Nouakchott and Ouagadougou are located within areas most affected by the observed changes in climate. Further, the densely populated southern parts of the region – which appear not to be particularly affected by the observed changes in climate – are potentially vulnerable to sea-level rise (see Map 10). Finally, the data on conflict reveals that the areas affected by large-scale conflicts, particularly Chad and northern Niger, have also been affected by changes in climate.

This chapter has presented the main findings of the mapping process undertaken to analyze historical climate trends in the Sahel over the past decades, providing an overview of the variety of climate-related challenges faced in the region. There is unquestionably a need, however, for further field-level analysis to better understand the actual effects of these changes on livelihoods in these areas.

Specifically, field-level assessments are needed within the identified hotspots to collect quantitative data on conflict and migration pressures caused by changes in the regional climate, as well as on the livelihood adaptation strategies that are being put in place.

Given the multifaceted challenges that changes in climate can pose, successful adaptation will need to integrate traditional adaptation strategies with other risk management initiatives. These include early warning systems, awareness-raising and in some cases physical infrastructural interventions that may help to reduce risks associated with sudden onset changes, such as flooding.<sup>126</sup> The additional data presented on population trends, conflicts and potential sea-level rise should also be considered in the design and implementation of adaptation policies in the region.



## 4. Understanding climate-related conflict and migration trends in the Sahel

The trends observed over the last 40 years show that overall in the region covered in this report, temperatures have risen, droughts have been recurrent and severe, rainfall has generally increased, and floods have occurred more frequently and with more intensity. These changes, in turn, have already impacted livelihoods in the region by increasing vulnerability and affecting the availability of natural resources. This chapter aims to examine the linkages between the livelihood impacts caused by changing climatic conditions and behavioural responses, namely conflict and migration. Based on a wide range of existing literature, as well as case studies and field observation, the chapter discusses three main behavioural trends: (i) southward migration to cities and coastal regions, (ii) environmentally induced migration caused by rapid-onset disasters, and (iii) conflict over fertile land and water resources.

As noted previously in this report, it is difficult to isolate climate-related factors contributing to migration and conflict from the economic, social, cultural, demographic and political factors involved. However, it is important to highlight and understand the exacerbating effect of changes in climate on population dynamics and conflict in the region, in order to ensure that these risks are considered and addressed as part of adaptation policies and strategies.

### 4.1 Southward migration to cities and the coast

Rural to urban migration is a global phenomenon of massive proportions – for the first time in 2009, the number of people living in urban areas surpassed those in rural areas worldwide. For the



© UN Photo/Christopher Hewig

*Urbanization, partly due to rural-urban migratory flows, is a defining trend in the region. Monrovia, Liberia's capital city, houses approximately 880,000 people. It is estimated that it is home to 20-30 per cent of the country's population*



countries covered in this report, the United Nations Population Division projects a 25 per cent increase in the urban population by 2050.<sup>128</sup> Indeed in the Sahel, the traditional temporary and seasonal migration patterns of many farmers, herders and fishermen in the region are increasingly being replaced by a more permanent shift southward and to urban areas. Nearly half of the West African population now lives in largely overcrowded coastal cities, including 12 townships of over one million inhabitants along the coastline from Senegal to Nigeria.<sup>129,130</sup> In addition, it is predicted that the 500 km coastline between Accra and the Niger delta will be an urban megalopolis of 50 million people by 2020.<sup>131</sup> These new, more permanent migration patterns are a result of a combination of push

and pull factors to which changes in climate have contributed, as illustrated in Case study 1.

Many agricultural areas in the region are characterized by low productivity and already degraded natural resources.<sup>132</sup> Changes in climate further compound these challenges.<sup>133,134,135</sup> Increasing variability of rainfall and recurring drought have been cited as major push factors in the migration of many farming and other natural resource-dependent communities.<sup>136</sup> For example, during the long period of drought that lasted from the 1960s to 1990s, an estimated one million people left Burkina Faso, mostly resettling in urban areas throughout West Africa.<sup>137</sup>

### Case study 1: What business does a herder have in town?

Increasingly, Tuareg and Wodaabe Fulani pastoralists in northern Niger cannot find enough available pasture, water or land to sustain their traditional livelihood. Though some have tried adaptation mechanisms, such as planting fields in the marginal land of the pastoral zone or buying supplemental fodder to sustain their animals, many have lost their herds and migrated to urban areas in search of alternative livelihood options.<sup>139</sup>

The inhabitants of the town of Abalak, situated just 185 km north of the official agropastoral dividing line, are primarily former herders who do not have the means to travel to Libya or Nigeria to find work, and eke out a living in town. As traditional stewards of the land, these former pastoralists describe the reasons contributing to their exodus as: significant variability of rainfall, the disappearance of the vitamin-rich grasses that once supported their livestock, irregular distribution of pasture and the increasing cost of the cereals required to supplement their animals' insufficient milk production.<sup>140</sup>

As the desert has encroached from the north and southern farmers have expanded their plantations into traditionally pastoral areas, a general lack of governance has exacerbated these constraints. Yet, despite political and ecological failures, the former herders of Abalak commonly reiterate the desire to return to herding. Echoing many a fellow pastoralist, a man who lost his entire herd during the drought of 2005 asks: "What business does a herder have in town?"



*After having lost all their animals as a result of changes in the natural environment, this family had to give up its traditional pastoral lifestyle and seek alternative livelihoods in the town of Abalak, Niger*

Drought also has a significant negative impact on pastoralist livelihoods. The 1982-1984 drought in Niger, for instance, led to a nearly 60 per cent decline in the cattle population in the country due to a combination of southward migration and the direct loss of animals,<sup>138</sup> while the 2005 food crisis, discussed in Case study 2, resulted in an early southward movement of agropastoralists to coastal areas in search of grazing land. In Nigeria, a survey

of 100 herdsmen taken in 2010 found that nearly a third had permanently migrated southeast and that the overall number of southern pastoralists had been increasing since the 1990s, due to changes in the natural environment.<sup>141</sup>

Drought and rainfall changes have also contributed to a decline in water bodies and the subsequent migration of fishermen to a dwindling number of

## Case study 2: Food crisis causes pastoralists to migrate south

Over 80 per cent of Niger's 12 million inhabitants depend on agriculture and livestock for their subsistence; the national poverty rate is 63 per cent.<sup>142</sup>

The 2005-2006 food crisis centred in the pastoral and agropastoral regions of northern Maradi, Tahoua, Tillabéri and Zinder. A number of events in 2004 conspired to cause the crisis, including an early end to the rains, desert locust damage to pasture lands, high food prices and a population living in chronic poverty.<sup>143</sup> The drought and locust damage resulted in the largest fodder deficit in Niger's history, a shortfall of 4.6 million tons, forcing herders to move south to the coast and dry season grazing grounds in Nigeria earlier than usual. Such early movements can result in increased competition for resources and the destruction of crops before they have been harvested in the receiving areas, and lead to conflicts with local farming communities further south.<sup>144</sup> In addition, high cereal prices and low livestock prices in pastoral and agropastoral areas forced some households to liquidate assets, increasing their vulnerability for future years.

A joint food security assessment conducted by the Government of Niger, the Food and Agriculture Organization, the World Food Programme and the Famine Early Warning Systems Network in April 2005 estimated that 2.4 million of the 3.6 million people living in agropastoral areas were highly vulnerable to food insecurity. Of those, 874,000 faced extreme food insecurity conditions and 1.2 million were judged to require some level of food aid.<sup>145</sup>



*Due to a lack of available pasture during droughts, herders in Niger are forced to come to towns to buy imported fodder. Merchants come from as far away as Nigeria, Togo, and Benin to sell fodder at inflated prices to desperate herders*

© UNU/Julie Shorek

lakes, rivers and coastal regions where fish can still be found. Indeed, diminished rainfall and elevated temperatures, in combination with irrigation schemes, have contributed to evaporative losses and reduced runoff into water bodies. Flows in the region's main watercourses – the Gambia, Niger,

and Senegal Rivers – have dropped by 25 to 60 per cent over the last 30 years. Drought has also reduced vegetation cover and contributed to greater sand deposits in the Niger River basin, the Senegal River, Lake Chad, the Logone/Chari River system, and their respective tributaries.

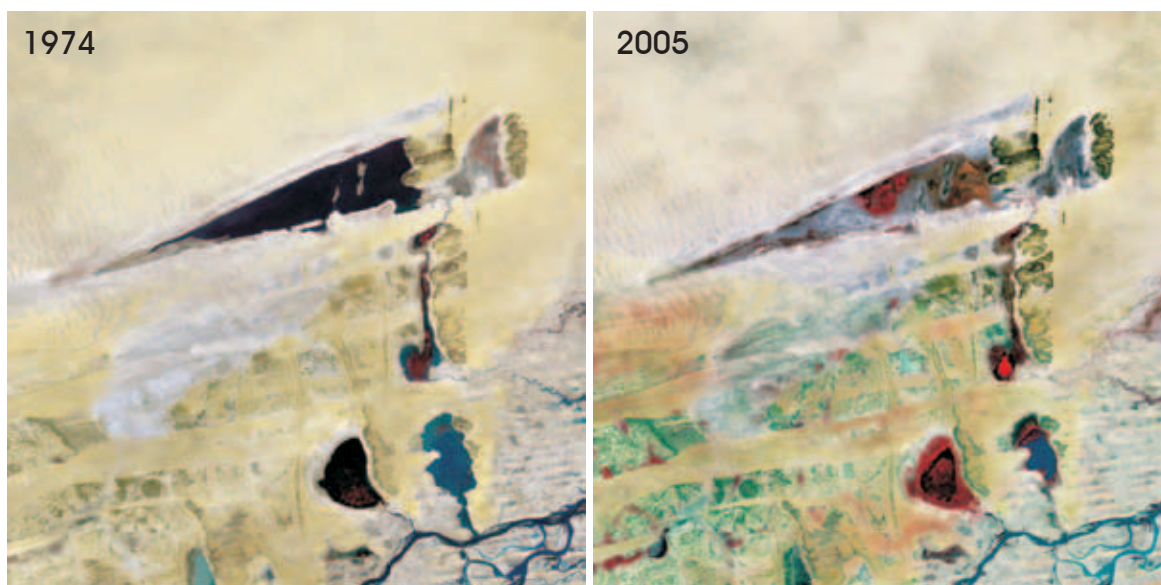
### Case study 3: Lake Faguibine

Like its neighbours in the region, Mali has endured severe droughts since the 1970s. These extreme climate conditions, in combination with increased use of water resources upstream, have notably contributed to the gradual decline of Lake Faguibine. Between 1976 and 2004, the lake was completely dry for 21 of 28 years.<sup>148</sup> More generally, the region has suffered constant reductions in water levels, including in groundwater, reduction and degradation of pastures, shrinkage of farmable lands and silting of water bodies, which can result in desertification.<sup>149</sup>

As a result of these conditions, more than 200,000 people have been forced to abandon their traditional livelihoods of agriculture, forestry and fishing, and move to urban areas in search of alternative income options.<sup>150</sup> Migration in the region has also been spurred by more structural issues, such as poverty.<sup>151</sup> A study by IOM found that those interviewed said they would continue to leave and not return so long as Lake Faguibine was dry.<sup>152</sup>

These movements have had a significant impact on the social structures of the main livelihood groups in the region. Traditional society has been dislocated and social status redefined around new figures, such as women heads of household. Likewise, the economy has been transformed by the loss of traditional sharecropping systems.<sup>153</sup>

Projects to rehabilitate and restore the “crucial ecosystem services that form the base for fisheries, biodiversity, recession agriculture, and eco-tourism”<sup>154</sup> are being undertaken and should contribute to improving livelihoods in the region.



*Lake Faguibine in Mali experienced a severe decline in water levels between 1974 and 2005, due to extreme drought conditions and increased water use upstream. For 21 years during this period, the lake was completely dry*



An example of these dramatic changes is found in the drying of Mali's Lake Faguibine in the 1970s, which forced more than 200,000 farmers and fishermen to abandon their traditional livelihood practices. Lake Faguibine is discussed in greater detail in Case study 3. Similarly, fishermen in Nigeria's Hadejia-Jama'are floodplain have been compelled to migrate to other flood plains, river-basins, dams and lakes.<sup>155</sup> One such destination point has been Burkina Faso's Lake Bagre, to which more than 10,000 people have migrated since 1994, bringing the population to an estimated 162,000 inhabitants in 2009. It is now the most populated zone in the country and continues to receive a high rate of migrants.<sup>156</sup>

While the environment and natural resources can act as push factors, cities and urban areas provide strong pull factors, with economic opportunities playing a major role in labour migration. Specifically, cocoa farms in Côte d'Ivoire, coffee plantations in Ghana and the oil industry in Nigeria have all drawn in migrants from across West Africa. Recent figures show that about three per cent, or 7.5 million, of the population in West Africa are migrants, compared to two per cent in all of Africa.<sup>157</sup> Further, as centres of information exchange and technological advancement, urban areas can be drivers of innovation and efficiency. People routinely migrate to cities for better job opportunities, education, health care, shelter, access to information and cultural diversity.

In the Sahel, however, urban migration represents a particular challenge to both large cities, often located near or on the coast, and to intermediate sized cities closer to migration source areas. Regardless of their size, these cities are frequently ill-equipped to absorb new populations, particularly in terms of access to water, sanitation, health care, education and employment,<sup>158</sup> and struggle with issues of infrastructure, housing and larger challenges associated with integration and inequality.<sup>159</sup>

## 4.2 Environmentally induced migration due to rapid-onset disasters

Extreme weather events, such as floods, often have devastating consequences for natural resource-

dependent livelihoods. Floods can result in the loss of livestock, farmland and crops, homes and critical infrastructure, including water supply systems and irrigation networks.<sup>160</sup> Furthermore, the impact of flooding is exacerbated in the region by the poor absorption capacity of the soil: water runoff can be 15-40 per cent of total rainfall due to the hard, crusted terrain and limited vegetation, increasing the inundation of water catchments, river plains, and low-lying areas,<sup>161</sup> degrading land and washing away topsoil. As a result, floods can have both immediate and lasting effects on food security, lead to significant losses of income for both farmers and herders and act as triggering events, contributing to migration by destroying homes and critical infrastructure.

In 2009, intense flooding in the region affected some 700,000 people and killed more than 150.<sup>162</sup> Some 150,000 people lost their homes in Burkina Faso alone, after 35 percent of the annual 750 mm rainfall average fell in just 12 hours in the area of Ouagadougou.<sup>163</sup> Case study 4 discusses a similar event in northern Ghana in 2007, which caused the displacement of over 330,000 people.

While sudden-onset events can cause very large-scale movements of population – over 20 million people were displaced by sudden-onset climate-related disasters in 2008 alone, according to IDMC and OCHA<sup>164</sup> – these movements tend to be relatively short-term and localized, with most people returning as soon as possible to rebuild their homes.<sup>165</sup> In addition, slow-onset events, including sea-level rise, can also act as triggers and are predicted to cause the majority of environmentally induced migration.

However, Map 9 and the accompanying Figures 4 and 5 show that both the frequency of floods and the area covered by flooding when it occurs have increased in some of parts of the region over the last 24 years, and that some 42 per cent of the population in CILSS countries has been affected by at least seven floods since 1985. This increase in frequency and coverage allows for less recovery time for farmland and pastures between flooding events. Over time, this recurrent and more severe flooding could lead to more permanent migration away from flood-prone areas.

## Case study 4: Flooding and migration in Ghana

In August 2007, Ghana experienced unprecedented flooding that devastated the nation's crops and infrastructure and led to the displacement of over 330,000 people, as well as the death of 56.<sup>167</sup> The damage occurred primarily in the three northern regions of the country, where a substantial portion of the nation's crops are grown.<sup>168</sup> Estimated losses from cereals and food items amounted to nearly 260,000 metric tons and with a number of irrigation dams and wells destroyed, many farmers were forced to migrate to other farming regions or seek new economic opportunities.<sup>169</sup> Leaving their crops untended, those who returned several months later found their lands barren and in need of new cultivation.<sup>170</sup> These devastating floods and resulting economic losses further aggravated food insecurity in a region already plagued with chronic malnutrition and famine.

Perennial flooding, which typically occurs toward the beginning (May-June) and end (September-October) of the rainy season, has been a major source of temporal migration.<sup>171</sup> Those residing in settlements along river bodies or lower landscapes are typically more vulnerable to the sudden onset of floods. According to a study conducted by the Center on Migration, Citizenship and Development, respondents indicated that flooding had led to extreme loss of farmlands and livestock as well as the loss of human life, and had induced migration in places along the White Volta in Northern Ghana.<sup>172</sup>

While the 2007 floods struck the northern region with unprecedented force, a number of coastal regions as well as plains situated along the major rivers remain vulnerable to sudden-onset flooding. Poor planning and urban waste management issues in coastal settlements such as Accra and Tema further exacerbate the adverse impacts of floods, particularly when drains are blocked in low-lying areas.<sup>173</sup> Flooding in urban areas can lead to serious environmental and social consequences, including pollution from solid and industrial waste, and can have particularly pervasive impacts in poor areas. As a rapidly developing coastal city, Accra has faced a number of challenges from the combination of persistent flooding, a high population growth rate and inadequate infrastructure. Currently, there are some 172,000 residents at risk of a major flood, of which 33,000 are located in slums or substandard housing units.<sup>174</sup>

Given the widespread damages flooding has caused across the country, the Government of Ghana has been working to develop policies that can help reduce the resulting socio-economic impacts. Specifically, the government has provided the equivalent of US\$ 7 million "towards the mitigation of the impacts of floods on the people of the three northern regions and Keta of Ghana."<sup>175</sup> Despite these concerted efforts, many of the factors, such as poor urban planning, that exacerbate flood impacts remain unaddressed today.

### 4.3 Climate-related conflict over scarce resources

Studies have found that the recurrence of drought, in combination with social and economic factors, has contributed to conflicts between rural populations in the region.<sup>166</sup> Changes in the natural environment have led northern pastoralists to push further southwards into regions used by sedentary farmers. At the same time, increasing demand for food has meant that farmers have expanded cultivation into lands used primarily by pastoralists.

Such changes have led to greater competition, tensions and violent conflict between livelihood groups, as illustrated in Case study 5.

Climate trends such as those mapped in Chapter 3 can indirectly contribute to unrest by exacerbating tensions over natural resource availability, most notably fertile land and water. Indeed, a key response to changes in natural resources availability by many farmers, herders and fishermen has been a diversification into other livelihood practices. Without enough fish to catch, some fishermen have sought land to raise cattle and grow crops,

## Case study 5: Farmer-herder conflict in Niger and Nigeria

Conflict between Niger's pastoral and agricultural populations is concentrated along a contested "dividing line" that separates the pastoral zone in the north from the cultivated land in the south.<sup>177,178,179</sup> Established by Niger's Rural Code in 1961,<sup>180</sup> the unmarked border was meant to protect the pastoral zone and delineate the two land use activities.

However, with unprecedented population growth in the south and a dearth of land management in the north, agriculturalists are spreading their fields into this contested pastoralist space, while during periods of drought, pastoralists move south into the agricultural areas seeking water and pasture for their herds.

Although pastoralists have traditionally migrated southwards along established livestock pathways, agriculturalists often spread their cultivation onto these pathways, preventing the safe passage of herds. Some studies have found that such planting can be considered a deliberate act of "claiming" the space and diverting pastoralists.<sup>181</sup> Often with the same deliberation, pastoralists will "ignore" their animals, allowing them to graze within the claimed farmland.<sup>182</sup> Together with factors such as poor land management, the observed climate trends now risk aggravating this age-old scenario by further impacting the already insufficient resource base.

Similar conflicts have been observed in neighbouring Nigeria, where Fulani herders from the north are remaining in the south for longer periods, or even becoming sedentary. This has led to increased pressures on farmlands and local resources, resulting in violent conflicts with local farming hosts in the south.<sup>183</sup>



© UNU/Anika Rissalamin

*During periods of drought, it is common to find large numbers of dead animals in pastoral areas. In such times, pastoralists often move into agricultural areas to find water and pasture for their herds, leading to conflict over land and local resources*



farmers have become livestock-keepers or fisher-farmers, and some herders have moved to southern pastoral lands to take up sedentary farming. These changes have placed groups in direct competition with each other over land and water. The farming Soninke and the herding Toucouleur communities in Mali, for example, have long cooperated in trading manure and grain. When the Toucouleur established a village in the region, the Soninke also started raising livestock. Reduced rainfall increased competition for feedstock and the greater number of animals started crowding farming land. There has

since been a growing low-level conflict between the two groups.<sup>184</sup>

Likewise, competition for freshwater and coastal resources amongst traditional fishermen and newly arrived migrants is increasing, and in some cases leading to heightened tension and small-scale conflict. Within the study region this is most evident in Lake Chad, which has seen significant population growth and decreasing availability of fresh water, arable land and fish. Lake Chad is discussed in greater detail in Case study 6.

## Case study 6: Environmental conflicts in Lake Chad

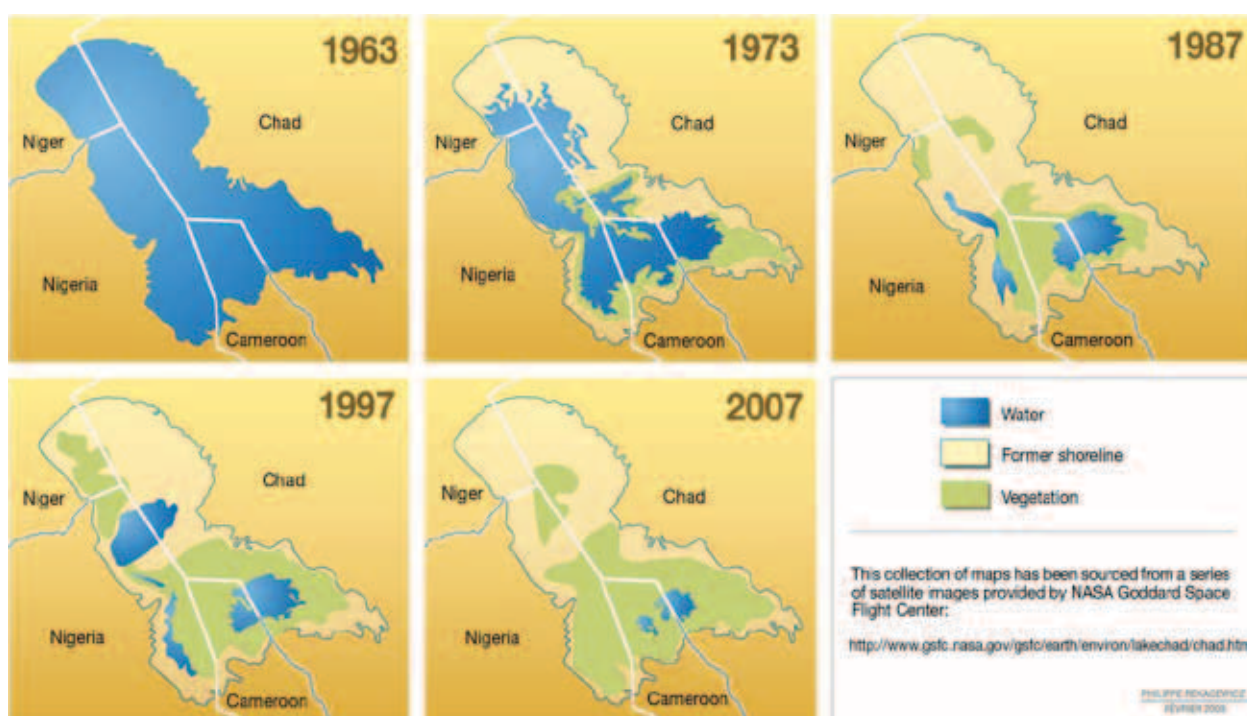
Since 1963, Lake Chad has contracted by 90 percent, down to 1,350 km<sup>2</sup> from its original size of 25,000 km<sup>2</sup> (see Figure 7). In addition to changing climatic conditions, resource misuse and overuse as well as population growth explain this massive contraction. Between 1983 and 1994, the volumes of water used for irrigation were four times larger than during the previous 25 years.<sup>186</sup> The population in the region furthermore increased from 13 million in 1960 to more than 35 million in 2007, and is expected to continue to grow by another 75 percent by 2025.<sup>187</sup> These changes have impacted both aquatic and terrestrial ecosystems, and the quantity and quality of available freshwater.<sup>188</sup>

As a result, water scarcity, health issues, food insecurity and poverty have increased dramatically in the area. Due to the lack of freshwater, water-related diseases like diarrhoea, cholera and typhoid have become common.<sup>189</sup> Populations not directly dependent on natural resources for their livelihood have also been affected, as explained by a migrant from the Difa region: "I used to live in the Lake Chad region. My activities were not directly related to the lake, as I used to be a merchant. However, when the lake dried out, people depending on it left for other countries, affecting my business negatively. I had to leave for Nigeria."<sup>190</sup>

This region, which is home to over 300 ethnic groups, as well as migrant workers from other African countries, such as Burkina Faso and Ghana, has seen heightened tensions over water access between different communities and livelihood groups resulting in both migration and increasing territorial disputes. According to a recent study, the shrinking of Lake Chad has contributed to conflicts in two notable ways: "First, by intensifying the frequency of contact between and among the major livelihood systems, thereby making them more competitive rather than complementary. Second, it intensifies the pattern of migration as a response to the contraction of the lake."<sup>191</sup>

Disputes focused on access to and use of water, on land and on fish catches have been occurring regularly.<sup>192</sup> According to the Nigerien Minister of Water, numerous conflicts have broken out among pastoralists and farmers, and between different ethnic groups in Niger, as a result of the loss of the lake and its resources.<sup>193</sup> Similarly, a director at the Lake Chad Basin Commission said that the area was "already experiencing some conflicts between fishermen and pastoralists, and between fisherman and farmers, and vice versa."<sup>194</sup> As the receding waters expose new islands, land ownership issues are also causing problems between Cameroon, Chad, Niger and Nigeria. Furthermore, the incapacity of existing political institutions to resolve these competing claims increases the likelihood of violent conflicts over resources.<sup>195</sup>

Figure 7. Changes in the surface area of Lake Chad (1963-2007)



Source: NASA Goddard Space Flight Center (2008) <sup>196</sup>

Changes in climate and their effect on natural resources can also lead to greater food insecurity. The rising cost of food in the region has been a source of tensions and protest in the past.<sup>185</sup> In combination with global commodity prices, climate change threatens local production and the availability of staples, further increasing the risk of tensions and conflict. The landlocked countries in the region produce the majority of the region's cereals, comprising more than 87 per cent of the overall production in the CILSS countries: Burkina Faso (4,358,519 tonnes in 2008), Chad (2,018,649 tonnes), Mali (4,814,961 tonnes) and Niger (4,854,494 tonnes). The coastal States, on the other hand, produce few cereals and import much more, with the exception of Nigeria, which produces more than 50 per cent of all the cereal produced in West Africa.<sup>197</sup> Changes in temperature and rainfall, and an increased frequency in the occurrence of drought and flooding have been observed in each of these countries, and there have already been instances of food shortages in nearly all of these countries. Niger, for example, was assessed in 2005 as having 2.4 million people highly vulnerable to food insecurity, including nearly 900,000 facing extreme food insecurity and 1.2 million requiring food aid.<sup>198</sup> Food shortages, in combination with increasing global prices of food commodities, have

led to unrest and even conflict, as seen in the 2008 food riots in Burkina Faso, Côte d'Ivoire, Mauritania and Senegal.

#### 4.4 Other responses to changing climatic conditions in the Sahel

In addition to the three trends discussed in this chapter, other behavioural changes relating to changing climatic conditions can also be observed in the region. Studies have found, for example, that as the environment becomes unliveable due to cases of extreme drought or environmental degradation, unplanned, short-term migration that develops into a pattern of movement known as "creeping migration" tends to occur.<sup>199</sup> One such case can be found in Niger, where the village of Caré is inhabited by farmers from another village, which had to be abandoned due to rainfall shortages and soil degradation.<sup>200</sup> As the recipient village is experiencing similar problems today, the migrants are now considering moving onwards to a new location.

Of course, conflict and migration – forced or otherwise – are not the only possible outcome. Even as institutions at the international, regional and national levels grapple with understanding

## Case study 7: Best practices in adaptation – Association Zoramb Naagtaaba

The livelihoods of over 80 per cent of the population in Burkina Faso are based in the agricultural sector, including livestock rearing; farming millet, groundnuts, sorghum and cotton; and fisheries. This strong dependency on natural resources makes communities particularly vulnerable to land degradation, desertification, frequent occurrence of drought and erratic rainfall.

In 1989, a pilot farm in Guiè, some 60 km outside of the capital of Ouagadougou, was established with the goal of restoring desertified land in the region. The project began with the participation of five villages in the area, and has since expanded to ten villages with a combined population of approximately 10,000. The initial farm has become part of a larger non-governmental organization, known as the Association Zoramb Naagtaaba (AZN), which provides a number of social services to the ten communities, including health and education services.

The farming is conducted through the establishment of a *bocage*. A *bocage* is defined as a rural landscape of grasslands and/or fields that is surrounded by hedges and forest. The AZN project has established three *bocage* areas of 100 hectares each. Each *bocage* supports 36 families and uses simple soil and water conservation farming technologies. Along the edges of the *bocage* are infiltration ponds that capture rainwater and are used to replenish groundwater. Changes have also been made to address the changing environment and weather patterns. For example, as rain has become increasingly erratic and winds more prominent, trees have been planted around the periphery of the *bocage* to help prevent the loss of top soil.

The use of Zai has also led to significant increases in the output of harvest. Zai, which originated in Mali, is a technique that involves placing a pit around the seedling (approximately 10-20 cm in depth, 20-40 cm in diameter), to which organic matter is added. The ridged circle around the plant helps improve water retention, as well as prevent the loss of soil and erosion. In addition, each plot within the *bocage* is fallowed every fifth year to protect from degradation by overplanting. At certain points in the year, livestock are brought in to fertilize the area and eat the fodder that remains after harvest. As a result of these unique soil and water conservation strategies, *bocage* production has had approximately four times the output than that of traditional farming practices in the area. In the most recent drought, production remained stable as opposed to that in areas outside of the *bocage*, which were negatively impacted by the lack of rainfall.

Furthermore, this case illustrates cooperative management between the farmers in the ten villages. Cooperation has been critical to the success of AZN. A local council made up of representatives from the ten villages agrees on all the actions taken by the association. For example, the construction of a new road requires agreement, as well as assurance of ongoing maintenance by all communities.

This endeavour is being coordinated through a non-governmental organization and is supported mainly through international funding. However, there is significant demand: many more villages in the surrounding area are requesting to become part of the association and more farmers would like to participate and farm in the *bocage*.



*In Guiè, Burkina Faso, farmers have been able to harvest up to four times the output generated by traditional farming practices in the area, thanks to the use of unique but simple soil and water conservation techniques*





*In marginal pastoral areas, some herders have begun farming the land in order to survive, such as here in Kijari, Niger*

and planning for the potential impacts of climate change, many communities on the ground are already seeking to adapt to the changes around them. Indeed, innovative small-scale adaptation initiatives can be found in various parts of the region. One such example is the work of the Association Zoramb Naagtaaba in Burkina Faso, discussed in Case study 7. Furthermore, Annex 8 lists a number of additional adaptation measures developed by various local communities with respect to managing floods and drought, as well as a number of integrated adaptation strategies that can be drawn upon to enhance resilience in the face of cumulative changes in climate indicators.

This chapter has sought to explore the exacerbating effect that changing climatic conditions are having on population dynamics and conflict in the region, in order to better inform both national and regional climate change adaptation policies and make the case for considering migration and conflict in the design and implementation planning of these policies. The following section takes a closer look at how adaptation policies can provide an opportunity for minimizing threats from climate change through conflict prevention, migration planning and improved governance.

## 5. Improving adaptation planning in the Sahel

Policies that spell out strategies for climate change adaptation and regulate the use and management of natural resources can have both positive and negative impacts on the livelihoods that depend on those resources. While little is known to date about the long-term effects of adaptation policies in the region, some studies suggest that policies and interventions that focus on reducing specific climate sensitivities can benefit some interests while negatively affecting other groups or creating social inequity.<sup>201</sup> In some cases, this could lead to tensions between competing groups or to the involuntary displacement of the disadvantaged. In other words, neglecting the factors that can trigger conflict and migration can result in adaptation policies that compound the risks posed by the climatic conditions they aim to mitigate.

This chapter presents a cursory examination of existing adaptation plans in the region, highlighting different approaches and gaps with respect to conflict and migration risk, and explores how considering these factors can reduce forced migration and conflict, help prioritize adaptation investments and strengthen climate adaptation capacity.

### 5.1 Reducing conflict and migration risk through sound adaptation planning

Sustainable development strategies have long sought to be sensitive to migration and conflict risks, recognizing that these phenomena can have a major impact on the achievement of development goals.<sup>202</sup> Climate adaptation strategies also need to incorporate these considerations in order to ensure that related policies and projects maximize conflict prevention opportunities and positively influence migration dynamics.<sup>203,204</sup>

A number of adaptation planning documents in the region already recognize the linkages between changing climatic conditions and behavioural responses such as migration and conflict, but few have so far included provisions addressing these risks. Box 5 provides an overview of National Adaptation Programmes of Action (NAPAs) in the region, which serve as the primary adaptation planning tools for Sahelian countries.

#### Box 5. Overview of National Adaptation Programmes of Action in the region

In 2002, the United Nations Framework Convention on Climate Change (UNFCCC) initiated the National Adaptation Programmes of Action (NAPAs). NAPAs are processes that allow Least Developed Countries to “identify priority activities that respond to their urgent and immediate needs to adapt to climate change”.<sup>205</sup> Since 2004, 14 of the 17 countries covered in this study have submitted their NAPAs to the UNFCCC: Benin, 2008; Burkina Faso, 2007; Cape Verde, 2007; Chad, 2010; the Gambia, 2008; Guinea, 2007; Guinea-Bissau, 2008; Liberia, 2007; Mali, 2007; Mauritania, 2004; Niger, 2006; Senegal, 2006; Sierra Leone, 2007; and Togo, 2009.

While these NAPAs do not have comprehensive treatment of conflict or migration, several countries do acknowledge these phenomena as potential responses to changes in climate. Some examples include:

- Burkina Faso’s programme proposes a regional approach to securing pastoral zones and mitigating farmer and herder conflicts over land;
- The Gambia’s programme mentions conflict as a “side effect” of climate change;
- Mauritania’s programme notes “massive” migration of farmers to urban areas because of declining rainfall and proposes an 18-month monitoring and assessment of water-related conflicts;
- Guinea-Bissau’s programme considers population displacement to be a consequence of climate change and highlights the need to resolve conflicts between cattle raisers and farmers; and
- Cape Verde’s programme points out the need to address increasingly frequent water-related conflicts.<sup>206</sup>

While it is essential to address the potential conflict implications of climate change when developing adaptation strategies, oversimplifying the security dynamics is counter-productive. Adaptation policies should be rooted in a sound analysis of how changes in climate can exacerbate local conflicts by impacting access to and availability of natural resources for different livelihoods. They should also assess what forms of power each group holds and what local or national dispute resolution mechanisms are available. Policies should furthermore ensure that they respond to the actual needs of the community, involve local stakeholders in the development process, and are sensitive to the existing social order and distribution of power. Finally, it is important to consider that climate change,



Women work to pound and terrace the soil in drought-stricken Burkina Faso to control erosion and manage water in the rainy season

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governance, poverty, and the risk for conflict are interrelated issues and should not be addressed in isolation.<sup>207</sup> The African Union's policy framework for pastoralism in Africa provides a good example of this in recognizing that its objective is "not simply the improvement of living and working conditions of the pastoral communities in Africa, but the deepening and consolidation of peace, security and democracy".<sup>208</sup>

Adaptation policies should also consider whether specific adaptation projects might trigger or intensify migration and how push and pull factors for migration can be mitigated.<sup>209</sup> Furthermore, while adaptation policies often acknowledge that migration is a coping strategy for dealing with the impacts of climate change, few recognize and treat migration as an adaptation strategy in itself. More explicitly incorporating migration into adaptation policies, such as NAPAs, can help prevent forced migration and facilitate voluntary migration. The IOM study *Migration, Environment and Climate Change: Assessing the Evidence* notes that "attention needs to be given to both sides of the environment and migration nexus: 1) identifying adaptation strategies that enable people to remain where they currently live and work, and 2) identifying resettlement strategies that protect people's lives and livelihoods when they are unable to remain."<sup>210</sup> Finally, in working to avoid the threats associated with involuntary resettlement programmes, lessons from previous experiences should be systematically taken into account in adaptation plans and policies.

In addition to integrating conflict and migration sensitivities into adaptation policies, coordination with new and existing development policies and programming is paramount. Indeed, considering the broader consequences of climate change in national and regional adaptation plans would enable policies to more effectively advance development goals while enhancing resilience to climate variability.<sup>211</sup> Further, ensuring that climate change adaptation policies are in line with and reinforce national-level policies on natural resources, such as land, water and agriculture, can help both sets of policies be more effective in general, and mitigate the risk of conflict or involuntary migration in particular.<sup>212</sup>

Lastly, it is critical that adaptation policies do not reinforce existing social inequalities, for example



with regards to ethnicity or gender. Rather, adaptation policies should address the disproportionate impacts that climate change, migration and conflict have on vulnerable groups, and meaningfully integrate their perspectives and participation in these policies.<sup>213</sup> Gender inequalities related to climate change impacts, migration and conflict are discussed in further detail in Box 6.

In sum, adaptation policies that reduce livelihood vulnerability, promote alternatives, improve the quality and quantity of natural resources, and decrease resource competition can reduce forced migratory pressures and minimize the threat of conflict.<sup>214</sup> Adaptation measures that are blind to such dynamics may, on the other hand, unknowingly aggravate certain situations.<sup>215</sup> Burkina Faso provides a positive example of the integration of conflict management considerations into national adaptation policies, as discussed in Case Study 8.

## 5.2 Using conflict and migration considerations to prioritize adaptation

Incorporating conflict and migration sensitivities into adaptation policies can help prioritize the most vulnerable areas for targeted adaptation programming and investment of adaptation funding. Identifying priority areas for investment is particularly timely given the large amounts of donor funding becoming available to address this issue in Africa: the newly created UNFCCC Green Fund, for example, is expected to mobilize up to US\$ 100 billion per year by 2020, alongside many other multilateral organizations, such as the Africa Adaptation Programme, which has been granted US\$ 92 million from the Government of Japan.<sup>222</sup> Funding is also becoming available for large-scale projects, such the Great Green Wall initiative

### Box 6. Gender inequalities related to climate change impacts, migration and conflict

Gender inequalities, such as women's lack of access to financial resources and limited involvement in decision-making, tend to compound the impacts of changing climatic conditions on their livelihoods and increase their vulnerability.<sup>216</sup> These inequalities are unfortunately not reflected in the majority of adaptation policies and programmes.

**Climate change:** Both slow and sudden-onset disasters, which are recognized to be increasing in frequency in the Sahel, have significant impacts on women. Within the countries in this study, women make up 50 per cent of the agriculture labour-force.<sup>217</sup> Women's high dependence on fertile land and regular rainfall for agriculture make them vulnerable to changes in precipitation, temperature and the occurrence of sudden-onset disasters, such as floods. Given their lack of access to financial resources, such as credit or formal land holdings, women are less able to recover from floods or poor harvests.

**Migration:** Women are more likely to stay behind as men migrate in search of alternative income and seasonal employment. This out-migration of men can give women greater decision-making power,<sup>218</sup> but also bring additional difficulties. Due to social taboos, women may not be able to access the same tools or resources as their male counterparts, or participate in certain agricultural tasks. Thus, rural women can become more vulnerable to poverty when males migrate.

**Conflict:** Conflict places women in danger of direct violence, including intimidation, sexual violence and abduction.<sup>219</sup> They also experience indirect harm.<sup>220</sup> In many countries, for example, neither traditional nor modern law permit women to inherit land or other assets when their husbands or male family members die.

**Adaptation programming:** Women are not systematically involved, nor considered, in climate change adaptation planning. Further, women are less able to access the financial and technical resources made available for adaptation programming.<sup>221</sup> Despite their traditional role in collecting water and fuel, and securing food for their families, adaptation plans rarely consider women's rich knowledge of natural resources.

## Case study 8: Burkina Faso's National Adaptation Programme of Action (NAPA)

Burkina Faso's first NAPA, which was adopted in 2007, identifies needs in four main sectors: agriculture, water, forestry and livestock. The national Government has successfully used its NAPA to leverage funds and implement projects, including the following three key initiatives addressing livelihood impacts as well as conflict and migration risks, which are being implemented by the Ministry of Environment together with the UN Development Programme's (UNDP) Energy and Environment Unit:

- **Strengthening national capacities for early warning and prevention, in order to ensure food security and improved access to water resources in the context of climate change:** This project looks at adaptation best practices, with a particular focus on agriculture, forestry and livestock. A community-based adaptation programme has been set up in each of the country's three climate zones that face particular challenges related to changes in climate: Mouhoun in the west, Namentenga in the east and Oudalan in the north.

- **Raising awareness of climate change and reinforcing the capacities of adaptation in order to reduce vulnerabilities to climate change:** This project seeks to raise awareness of climate change and its impacts among decision-makers at national, regional and local levels. Administered by UNDP through the Permanent Secretariat for Environment and



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*Rain-fed agriculture is one of the main livelihoods in Burkina Faso. The country's NAPA has been instrumental in leveraging funds to address the impacts of climate change for livelihoods, including conflict and migration risk*

- Sustainable Development of the Ministry of Environment and Sustainable Development, as well as with civil society organizations such as the International Union for Conservation of Nature (IUCN), the project aims to work with a pilot village and surrounding villages on the management of conflict over the use of natural resources, in the same areas where the above community-based adaptation programmes are carried out.
- **Modifying the development process to address risks and opportunities associated with climate change:** This project aims to build capacity for long-term development planning with significant focus on local governments and the municipalities' right to request and manage a budget. As part of this project, a simulation study is being conducted to determine the potential risks from climate change for agriculture, livestock, energy, housing, natural disasters, health, forestry and land degradation using a small scale of analysis of 25-50 km<sup>2</sup>. Based on the multi-sector simulations, an analysis of vulnerability, evaluation of cost of adaptation, and economic impact will be conducted for each sector.

Lessons learned in the field will be instrumental to the development of Burkina Faso's new NAPA in 2012.

(discussed in Box 7). In 2010 alone, the European Union's financial aid for the Sahel was €74 million, of which a large part was directed towards food assistance.

In addition to helping to prioritize funding decisions, conflict and migration considerations can inform adaptation policy development and lead to more concrete programming. The uncertainty over climate models and future environmental changes has meant that many adaptation policies have been designed to accommodate as broad a range of scenarios as possible. With stronger data on local-level conflicts and migration, the focus can be sharpened.

For example, this report has highlighted increasingly permanent migration to urban centres, coastal areas and some inland lake areas by farmers, herders and fishermen. These migration destinations require priority adaptation action over the arid northern parts of the region that have experienced a decline in population. Conversely, the arid northern areas may be targeted for adaptation projects to improve agricultural opportunities and slow the rate of migration to cities and coastal areas that lack the capacity to provide adequate conditions and services for the migrants.

### 5.3 Capitalizing on conflict and migration management to strengthen adaptation

Given the transboundary nature of many climate-related challenges, regional cooperation is critical to adaptation planning. Where appropriate, existing regional structures with conflict prevention and migration management mandates can help improve regional cooperation for adaptation policy-making and implementation. In addition, regional platforms addressing disaster risk reduction, as outlined in Box 8, also provide appropriate fora for considering conflict and migration in adaptation planning. In other words, building on existing capacity for conflict and migration management – rather than setting up parallel structures – can strengthen adaptation capacity and improve efficiency, which is important in light of the capacity constraints of many countries in the region.

#### Box 7. The Great Green Wall Initiative for the Sahara and the Sahel

The CEN-SAD (Community of Sahel-Saharan States) Summit of Leaders and Heads of State adopted the Great Green Wall initiative as one of its priority programmes in 2005. The project envisages a belt of trees that would be 15 km wide and 7,775 km long, stretching from the Atlantic coast to the Indian Ocean across 11 countries. The initiative, aimed at halting the advance of the Sahara Desert, was slow to start due to a lack of funding. The project has since slightly changed its approach, focusing more holistically on integrated natural resource management, and is now backed by the African Union. The Global Environment Facility (GEF) has also pledged funds to support the initiative.

#### Box 8. Integrating climate change adaptation and disaster risk reduction strategies

The Bali Action Plan of the UNFCCC calls for greater integration between climate change adaptation and disaster risk reduction strategies. At the regional and continental levels, the number of disaster risk reduction policies and plans has been steadily increasing in Africa. The African Union Commission has supported the Africa Regional Strategy for Disaster Risk Reduction, as part of the New Partnership for Africa's Development. This regional strategy recognizes the importance of coordination across agencies for proactive disaster prevention and response strategies. In West Africa, ECOWAS adopted a policy for disaster risk reduction in 2007, recognizing the role that climate change can play in triggering disasters, including floods and droughts. The policy provides strategic guidance for member States, and facilitates the implementation of sub-regional strategies and programmes that are in line with the Africa Regional Strategy.

This inclusion of migration and conflict sensitivity in adaptation governance is already occurring in some organizations in the region. The ECOWAS mandate, for example, includes the promotion of improved resource management in conflict prevention strategies. The organization is also working on adaptation strategies to address the impact of climate change on agriculture, water resources and





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*In an effort to prevent the desert from reaching fertile land, eucalyptus saplings, resistant to extreme conditions, have been planted to stabilize sand dunes*

energy, and has adopted a new strategic guideline on the “Reduction of Vulnerability to Climate Change in West Africa.”<sup>223</sup>

Policy partnerships for climate change adaptation, however, need to be broadened to involve organizations with specific expertise in natural resources issues. River basin authorities in the region – most notably the Senegal River Basin, Niger Basin Authority and the Lake Chad Basin Commission – can have an important role in strengthening adaptation governance and capacity. These authorities have long promoted activities that are central to adaptation plans, including diversified income-generating activities, improved water management and the modernization of agricultural techniques.

## 6. Conclusions and recommendations

This report has analyzed historical climate trends across the 17 countries included in the study region and examined how these changes have exacerbated existing vulnerabilities. In particular, the study has sought to examine the link between the impacts of changing climatic conditions on livelihoods in the region and behavioural responses such as conflict and migration. On the basis of the findings of the mapping process and information gathered from existing literature, case studies and field observation, as well as an overview of existing adaptation plans in the countries of concern, this report reaches five main conclusions, summarized below. As a result, seven principal recommendations are presented to national, regional and international policy and decision-makers, as well as adaptation practitioners in the region. The UN system can also address many of the issues highlighted in the recommendations through its specialized agencies and programmes.

### 6.1 Conclusions

1) *Climatic change trends can be observed over the last 40 years in the Sahel in temperature, rainfall, and occurrence of flooding across the study region. In addition, the recurrence of drought and the potential severe impacts of sea-level rise are increasing livelihood vulnerability:*

- There has been a general increase in mean temperature in the region of 1°C. Nearly 50 per cent of the population in the CILSS countries has experienced an increase of between 0.5-1°C and 15 per cent of the population has seen an increase of more than 1°C.
- Flooding has increased in frequency and severity in terms of the size of the impacted land area, affecting large numbers of people in the region. The area has also experienced more extended periods of inundation. Since 1985, 54 per cent of the CILSS population has been affected by five or more floods.

- Precipitation has increased in many parts of the region. Data, however, is lacking in respect to the intensity and duration of the rainfall.
- The area has experienced recurrent and severe drought since the 1970s, which has had a very significant impact on livelihoods.
- Estimated sea-level rise of up to 1 m would affect over 3 million people in the region.

2) *Changes in climatic conditions are exacerbating issues linked to the availability of natural resources essential to livelihoods in the region, as well as food insecurity. Along with important social, economic and political factors, this can lead to migration and conflict:*

- Changing climatic conditions most impact livelihoods that are directly dependent on the environment, for example through the decrease in agricultural yields, gradual unsuitability of traditional grazing grounds, drying of important water bodies or the increase in various diseases.
- The landlocked countries in the study region (Burkina Faso, Chad, Mali and Niger) produce the majority of the region's cereals and export to neighbouring countries. Increasing uncertainty about rainfall and the recurrence of droughts and flooding threaten food production in the region. For example, Niger was assessed in 2005 as having 2.4 million people highly vulnerable to food insecurity, including nearly 900,000 facing extreme food insecurity and 1.2 million requiring food aid.
- Livelihood vulnerability is linked to many non-climate factors, such as unequal land distribution, insecure land tenure, poorly developed markets, existing trade barriers and inadequate infrastructure. Underlying all of these factors is the role

of governance in planning and regulating development, ensuring access to land, providing infrastructure support to mitigate risks from sudden-onset disasters, and promoting livelihood diversification.

- While research does not support a direct causal link between climate change, migration and conflict in the region, the combination of livelihood vulnerabilities exacerbated by changing climatic conditions and the non-climatic factors described above can result in behavioural responses such as conflict and migration.

3) *The migration and movement of people and livestock are an integral part of ancestral livelihood strategies in the region. However, migration also occurs as a result of traditional and non-traditional livelihoods no longer being viable, due to changes in the natural environment:*

- Seasonal and circular migration can be considered as traditional adaptation strategies to climate variability in the region, offering opportunities for trade and the exchange of ideas. Herders typically graze their livestock in the North during the wet season and move South during the dry months.
- However, the traditional temporary and seasonal migration patterns of many farmers, herders and fishermen in the region are increasingly being replaced by a more permanent southward shift.
- In addition, increased occurrences of climate-related disasters – particularly floods and droughts – are likely to result in large-scale population movements and the loss of livelihood options. Floods in northern Ghana in 2007, for example, caused the displacement of over 330,000 people. Over time, recurrent and more severe climate-related disasters could lead to more permanent migration.
- Urbanization, partly due to rural-urban migratory flows, is also a defining trend in the region. While unmanaged urbanization can increase the vulnerability of new migrants,

remittances and other assets transferred by the migrants to their rural community of origin often comprise an important source of resilience to environmental hazards.

- Migration movements are principally confined to the region – generally along a north-south axis – rather than from the region to other parts of the world.

4) *The impacts of changing climatic conditions on the availability of natural resources, coupled with factors such as population growth, weak governance and land tenure challenges, have led to increased competition over scarce natural resources – most notably fertile land and water – and resulted in tensions and conflicts between communities and livelihood groups:*

- Changes in the natural environment, in combination with social, economic and governance factors, has contributed to conflicts between rural populations in the region. Northern pastoralists, for example, have pushed further southwards into regions used by sedentary farmers, while increasing demand for food has meant that farmers have expanded cultivation into lands used primarily by pastoralists. Such changes have led to greater competition, tensions and violent conflict between livelihood groups.
  - Livelihood diversification, a key response to environmental changes that have affected the viability of traditional livelihoods, has also placed different groups in direct competition with each other over land and water, leading to local-level tension and conflict.
  - Changes in climatic conditions affect food security by impacting local food production and the availability of staples. In combination with rising commodity prices, food insecurity increases the risk of social unrest and conflict.
- 5) *A number of adaptation policies in the region recognize the linkages between changing climatic conditions and behavioural responses such as migration and conflict, but few so far have included provisions addressing these risks. Systematically considering these issues in adaptation planning can reduce conflict and migra-*



tion risk, help prioritize adaptation investments and strengthen climate change adaptation capacity:

- Neglecting the factors that can trigger conflict and migration can result in adaptation policies that compound the risks posed by the climatic conditions they aim to mitigate and threaten development gains. Conversely, adaptation policies that reduce livelihood vulnerability, promote alternatives, improve the quality and quantity of natural resources, and decrease resource competition can reduce migratory pressures and minimize the threat of conflict.
- Incorporating conflict and migration sensitivities into adaptation policies can help prioritize the most vulnerable areas for targeted adaptation programming and investment of adaptation funding. Identifying priority areas for investment is particularly timely given the large amounts of donor funding becoming available to address this issue in Africa.
- Where appropriate, existing regional structures with conflict prevention, migration management and disaster risk reduction mandates can help improve regional cooperation for adaptation policy-making and implementation. Building on existing capacity for conflict and migration management – rather than setting up parallel structures – can strengthen adaptation capacity and improve efficiency, which is important in light of the capacity constraints of many countries in the region.

## 6.2 Recommendations

- 1) **Conduct follow-up field assessments in the hotspots identified in this study, using a livelihoods approach.** Livelihoods provide a clear stepping stone between climate change and conflict risk, as well as between climate change and migration. A livelihoods approach is therefore well suited for follow-up field assessments that should determine how resource availability is changing, how livelihoods are being affected, and if incidences of conflict or migration are increasing. In order to better

inform adaptation strategies and interventions, follow-up studies should focus on answering the following questions:

- Is *per capita* availability of key natural resources being affected by changes in regional climatic conditions?
  - How are livelihoods and food security being impacted by these changes and what coping strategies or adaptation measures are being adopted?
  - Is competition between livelihood groups over scarce resources increasing, and is this a contributing factor in local-level conflicts or migration decisions?
  - Are traditional natural resource management and dispute resolution practices breaking down as a result of increasing resource scarcity or factors such as population growth?
  - How are the existing institutions, policies and processes supporting or undermining livelihood adaptation measures, resource rights, dispute resolution mechanisms and migration management?
  - What specific technical and financial support would be needed to increase livelihood resilience to changing climatic conditions in the region, thereby reducing conflict risk and forced migration?
- 2) **Adopt adaptation policies that are migration and conflict-sensitive:** Adaptation policies and programmes that aim to reduce livelihood vulnerability, promote alternatives, and improve the availability and access to natural resources can mitigate the drivers of migration and conflict and help secure development gains. Specific actions that can be taken include the following:
    - Migration and conflict considerations should be systematically included in all revisions of National Adaptation Programmes of Action (NAPAs) in the region. Insofar as possible, NAPAs should be coordinated at a regional level for these issues, in order to maximize benefits and avoid inconsistencies between neighbouring countries.

- A comprehensive conflict analysis should be conducted before designing and implementing climate change adaptation strategies, in order to fully understand local and regional conflict dynamics.<sup>224</sup> Engagement of affected local communities is paramount in this process as local communities are usually best placed to identify conflict risks and potential solutions, and to provide feedback on the impact of interventions on these conflict dynamics.<sup>225</sup>
  - The positive role of migration should also be considered as part of adaptation strategies. For example, temporary and circular labour migration schemes can be developed for environmentally vulnerable communities – particularly those at less advanced stages of environmental degradation.
  - The benefits of climate change adaptation policies should be carefully considered across social groups so that they do not reinforce inequalities, for example with regard to ethnicity or gender. Rather, adaptation policies should address the disproportionate impacts that climate change, migration and conflict have on vulnerable groups, and meaningfully integrate their perspectives and participation.
- 3) **Root national adaptation strategies in the “green economy” and promote the creation of “green jobs”:** A green economy aims to improve human well-being and social equity, while significantly reducing environmental risks and ecological scarcities.<sup>226</sup> Employment opportunities and enhanced food security resulting from improved agricultural productivity based on sustainable practices, for example, could increase resilience to climate stressors and reduce local tensions and forced displacement.
- Adaptation policies should consider “green farming” practices, including “climate proofing” agricultural practices and integrating traditional farming methods with resource-efficient techniques.<sup>227</sup> Such practices have been shown to increase yields, especially on small farms.<sup>228</sup> It is furthermore important to prioritize investments that benefit the local environment and improve ecosystem services, as it is these services on which the poorest people rely on for their livelihoods.
  - Small landholder production should also be increased, diversified and commercialized, thereby creating local job and market opportunities. One example is organically produced cash crops that can be sold for a premium on international markets.
  - Bringing energy options to the rural poor in least developed countries has long been a challenge. Renewable energy technologies that provide off-grid solutions can not only help meet this challenge, but also open up new possibilities for job creation, such as local manufacturing, installation and maintenance of equipment, while reducing the dependence on biomass.<sup>229</sup>
  - Renewable energy systems, rainwater harvesting and efficient waste management should also be promoted to address the challenges posed by rapid urbanization and reduce the vulnerability of urban populations to changes in climate and the declining availability of natural resources.<sup>230</sup>
  - New employment opportunities should focus on increasing the use of local labour, thus diversifying options for income and reducing vulnerability to changes in natural resource availability.
- 4) **Promote regional environmental cooperation in addressing climate change, migration and conflict:** Issues of climate change and migration are regional in nature, and as such should not only be managed at the national level, as is most commonly the case today. Likewise many cases of conflict in the region are transboundary, as competition for scarce natural resources pushes various groups beyond national borders in search of improved livelihood conditions.
- The transboundary nature of climate change, migration and some conflicts should increasingly be addressed through regional cooperation, including through regional institutions like CILSS and ECOWAS, as well as the African Union. Climate change adaptation programmes in the Sahel should

focus on the most vulnerable groups, such as pastoralist societies, and build upon existing policies, such as the African Union's policy framework for pastoralism in Africa.

- International organizations, including UNEP, IOM, OCHA and UNU, should strengthen their cooperation with these regional structures, for example through joint programmes and projects for conflict prevention and disaster management related to environmental factors and the increasing displacement of communities due to environmental change.
- National laws and policies on natural resources and environmental issues should be harmonized across the region, in order to avoid inconsistencies or discrepancies between neighbouring countries that could lead to increased pressure on natural resources in areas with weaker legislation.
- The UN system should additionally gather lessons learned on best practices in adaptation policy in order to better support transboundary cooperation and regional approaches. It should also assist in capacity-building for national and regional governance, facilitating linkages between different governance levels, and the harmonization of national laws and policies to address the interlinked issues covered in this report.

5) **Strengthen preventive action, resource rights and dispute resolution:** Early action on the environmental drivers of crises can help prevent and defuse both imminent issues and broader instability. Traditional conflict mediation practices should also be adapted to the new realities on the ground resulting from changes taking place in the climate and natural environment.

- Dispute resolution should be promoted by building local, national and international capacity to conduct mediation between conflicting parties where tensions are linked to natural resources. The deployment of "stand-by teams" of environmental experts as part of conflict prevention efforts, for example, is one option.
- Clarifying resource rights, land tenure and access to justice is a prerequisite for effective

national and local-level governance. When doing so, national or regional authorities need to consider potential conflicts between national and local/traditional governance structures and, where possible, build on existing and accepted dispute resolution mechanisms.

6) **Prioritize systematic data collection and early warning systems:** One of the considerable challenges faced in this study was the significant lack of data on climate indicators, migration and local-level conflict in the region. These issues have already been highlighted in a number of publications on the Sahel, most recently by the OECD.<sup>231</sup> The collection of this data should preferably be mandated under one specific regional organization, building on existing structures within CILSS (such as INSAH and AGRHYMET) or ECOWAS, for example, and supported by the international community. The UN system can also support improved data collection by providing scientific tools, global transboundary databases and long-term funding. Specific recommendations to address these gaps include:

- Systematic collection of data of rainfall, temperature and the occurrence and severity of droughts and floods should be established and improved throughout the region, notably through weather stations set up to track these indicators within the various microclimates. Improved climate-related data for the region should be integrated with the work of national meteorological institutions and the recently launched Climate for Development in Africa Programme (ClimDev-Africa),<sup>232</sup> in cooperation with the World Meteorological Organization (WMO).
- Indicators should be identified and mechanisms established to systematically collect data on small-scale and localized conflicts in the region, capturing the various causes and triggers, including the availability of fodder and the movements of people and their animals. When conflicts are identified as being related to natural resources, continued monitoring and appropriate mitigation activities should be undertaken. Such activities can include mediation activities, improved natural resources management,



livelihood diversification and the elaboration of dispute resolution mechanisms.

- Migration profiles prepared by IOM highlight that migration patterns have been shifting over the last two decades, but systematic censuses have not taken place.<sup>233</sup> Surveys should also be conducted directly with migrants in order to better understand reasons behind the decision to migrate. Data collection should distinguish between short-term and permanent migration, as well as areas of origin and destination.
- Remote sensing should be used to monitor land use changes, changes in water flows, and agro-pastoral seasons in order to understand large-scale trends and assess factors affecting the vulnerability of livelihoods.
- Establishing and using early warning systems can help mitigate livelihood insecurities by providing the information required to mitigate disaster risk, food insecurity and related conflict and migration outcomes. This report recommends that the checklist developed by the UN International Strategy for Disaster Reduction (ISDR) be followed.<sup>234</sup>
- Environmental and natural resource issues should be included in international and regional conflict early warning systems in order to support preventive action and encourage environmental cooperation.

7) **Use conflict and/or migration risk to prioritize investments and build donor commitment to long-term engagement in the Sahel:** Addressing climate change impacts on livelihoods in the Sahel requires long-term financial commitment and improved coordination of investments. Identified conflict and migration risks from climate change impacts on livelihoods and food security can help prioritize programme and funding. To ensure the most efficient use of donor support, the following should be considered:

- Focus adaptation programmes on core capacity-building for conflict prevention, dispute resolution and migration management, as well as technology transfer for data collec-

tion and analysis and green technology, and agree on performance-based financing.

- Forced displacement can be minimized by investing resources in disaster risk reduction and climate change adaptation to increase the resilience of affected communities while at the same time bolstering humanitarian action to meet the growing challenge of climate change. This includes measures to ensure adequate assistance and protection for people migrating as a result of environmental factors.
- Funding should also be prioritized for regional organizations such as ECOWAS and CILSS to support transboundary projects addressing the regional dimensions of climate change, migration and conflict.
- Existing climate change adaptation and mitigation funding sources – such as the UNFCCC's Green Climate Fund, the Adaptation Fund, and the Clean Development Mechanism (CDM) – should adopt clear policy guidelines on the need to address conflict and migration risks. These facilities should also enable regional organizations to access funding, in addition to national entities.
- The estimated cost of the immediate next steps recommended in this study is USD 12 million. This includes capacity-building for national and regional authorities in integrating migration and conflict sensitivities into adaptation planning (US\$ 1.5 million); establishing and maintaining international stand-by mediation capacity (US\$ 1 million); establishing weather stations and related maintenance activities to ensure reliable and systematic data collection (US\$ 3.5 million for onetime investments + US\$ 1.5 million per year for maintenance and data collection); focused follow-up studies and interventions to better understand the realities on the ground in the hotspots identified in this study (ten separate projects with a budget of US\$ 250,000 each); and resources to collect migration and conflict data systematically and down to the local level (US\$ 2 million).

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## Annex 1. Acronyms

|                 |                                                                                                                                                |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| ACMAD           | African Centre of Meteorological Application for Development                                                                                   |
| AGRHYMET        | Centre Régional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle (specialized institute of CILSS)                |
| AMCEN           | African Ministerial Conference of Environment Ministers                                                                                        |
| AZN             | Association Zoramb Naagtaaba (Burkina Faso NGO)                                                                                                |
| °C              | Degrees Celsius                                                                                                                                |
| CDM             | Clean Development Mechanism                                                                                                                    |
| CEN-SAD         | Community of Sahel-Saharan States                                                                                                              |
| CILSS           | Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (the Permanent Interstate Committee for Drought Control in the Sahel) |
| EACH-FOR        | Environmental Change and Forced Migration Scenarios (EU Project)                                                                               |
| ECA-WA          | Economic Commission for Africa, office in West Africa                                                                                          |
| ECOWAS          | Economic Community of West African States                                                                                                      |
| EU              | European Union                                                                                                                                 |
| FAO             | Food and Agriculture Organization of the United Nations                                                                                        |
| GDP             | Gross domestic product                                                                                                                         |
| GEF             | Global Environment Facility                                                                                                                    |
| IDMC            | Internal Displacement Monitoring Centre                                                                                                        |
| IDPs            | Internally displaced persons                                                                                                                   |
| IGAD            | Intergovernmental Authority on Development                                                                                                     |
| INSAH           | Institut du Sahel (the Sahel Institute)                                                                                                        |
| IPCC            | Intergovernmental Panel on Climate Change                                                                                                      |
| IOM             | International Organization for Migration                                                                                                       |
| ISDR            | International Strategy for Disaster Reduction                                                                                                  |
| IUCN            | International Union for Conservation of Nature                                                                                                 |
| km              | Kilometre                                                                                                                                      |
| km <sup>2</sup> | Square kilometre                                                                                                                               |
| LDC             | Least developed country                                                                                                                        |
| m               | Metre                                                                                                                                          |
| mm              | Millimetre                                                                                                                                     |
| NAPA            | National Adaptation Programme of Action                                                                                                        |
| NASA            | National Aeronautics and Space Administration (US)                                                                                             |
| NCDC            | National Climatic Data Center (US)                                                                                                             |
| NGO             | Non-governmental organization                                                                                                                  |



|           |                                                                                           |
|-----------|-------------------------------------------------------------------------------------------|
| NOAA      | National Oceanic and Atmospheric Administration (US)                                      |
| OCHA      | Office for the Coordination of Humanitarian Affairs                                       |
| OECD      | Organisation for Economic Co-operation and Development                                    |
| PRIO-CSCW | Peace Research Institute Oslo – Centre for the Study of Civil War                         |
| REDD      | Reducing Emissions from Deforestation and Forest Degradation (UN collaborative programme) |
| UN        | United Nations                                                                            |
| UNDP      | United Nations Development Programme                                                      |
| UNEP      | United Nations Environment Programme                                                      |
| UNFCCC    | United Nations Framework Convention on Climate Change                                     |
| UNU       | United Nations University                                                                 |
| WAEMU     | West African Economic and Monetary Union                                                  |
| WMO       | World Meteorological Organization                                                         |
| Z_GIS     | Centre for Geoinformatics, University of Salzburg                                         |

## Annex 2. Glossary

|                           |                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Adaptation                | Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation. (IPCC, 2007)                                                                                                                                        |
| Climate change            | Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. (IPCC, 2007)                                                                                                                                                                                                                                                                                             |
| Climate change indicators | Climate change indicators are benchmarks that help to understand changes in climate. The indicators used in this report are change in temperature, change in rainfall, occurrence of drought and occurrence of floods. (UNEP, 2011)                                                                                                                                                                                                     |
| Conflict                  | A dispute or incompatibility caused by the actual or perceived opposition of needs, values, and interests. Conflicts can be a positive force for change if they are managed and resolved in a peaceful manner. If tensions turn violent, conflicts will always have negative repercussions. (UNEP, 2011)                                                                                                                                |
| Environment               | The environment is the sum of all external conditions affecting the life, development and survival of an organism. In the context of this report, environment refers to the physical conditions that affect natural resources (climate, geology, hazards) and the ecosystem services that sustain them (e.g. carbon, nutrient, and hydrological cycles). (UNEP, 2009)                                                                   |
| Ecosystem services        | Ecological processes or functions having monetary or non-monetary value to individuals or society at large. There are (i) supporting services such as productivity or biodiversity maintenance, (ii) provisioning services such as food, fibre, or fish, (iii) regulating services such as climate regulation or carbon sequestration, and (iv) cultural services such as tourism or spiritual and aesthetic appreciation. (IPCC, 2007) |
| Food insecurity           | A situation that exists when people do not have secure access to sufficient amounts of safe and nutritious food for normal growth, development and an active and healthy life. Food insecurity may be caused by the unavailability of food, insufficient purchasing power, inappropriate distribution, or inadequate use of food at the household level. (IPCC, 2007)                                                                   |
| Food security             | A situation that exists when people have secure access to sufficient amounts of safe and nutritious food for normal growth, development and an active and healthy life. (IPCC, 2007)                                                                                                                                                                                                                                                    |
| Forced migration          | General term used to describe a migratory movement in which an element of coercion exists, including threats to life and livelihood, arising from natural or man-made causes (e.g. movements of refugees and internally displaced persons as well as people displaced by natural or environmental disasters, chemical or nuclear disasters, famine or development projects). (IOM, 2004)                                                |
| Livelihood                | A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. It is considered sustainable when it can cope with and recover from stresses and shocks, and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resources base on which it relies. (UNEP, 2009)                                |

|                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Livelihood security | Livelihood security refers to the absence of objective threats to livelihood preservation and/or subjective fears that livelihood preservation may be undermined. It requires maintaining the conditions under which each livelihood group can live from their activities. (UNEP, 2011)                                                                                                                                                                                                                                                  |
| Migration           | A process of moving, either across an international border, or within a state. It is a population movement, encompassing any kind of movement of people, whatever its length, composition and causes; it includes migration of refugees, displaced persons, uprooted people, and economic migrants. (IOM, 2004)                                                                                                                                                                                                                          |
| Natural resources   | Natural resources are actual or potential sources of wealth that occur in a natural state, such as timber, water, fertile land, wildlife, minerals, metals, stones, and hydrocarbons. A natural resource qualifies as a renewable resource if it is replenished by natural processes at a rate comparable to its rate of consumption by human or other users. A natural resource is considered non-renewable when it exists in a fixed amount, or when it cannot be regenerated on a scale comparable with its consumption. (UNEP, 2009) |
| Resilience          | The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change. (IPCC, 2007)                                                                                                                                                                                                                                                                                                   |
| Scarcity            | Scarcity describes a situation where renewable resources – such as water, forests or productive land – are degraded or decreasing, in the sense that the resource is used faster than it is replenished. (UNEP, 2011)                                                                                                                                                                                                                                                                                                                    |
| Vulnerability       | Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity. (IPCC, 2007)                                                                                                                                                                         |



## Annex 3. Map methodologies

### Data pre-processing

#### DOWNLOAD AND CONVERSION (DATA FORMAT)

As an initial step the datasets were downloaded and, where necessary, converted and re-scaled to a data format and range that enabled the integration and subsequent analysis of the datasets in a GIS environment.

#### SPATIAL REFERENCE/GEOREFERENCING

In the next step a spatial reference was defined for all datasets: the World Geodetic System 1984 (WGS 84) was set to define both the coordinate frame (geographic coordinates) and the dates of the datasets.

#### OBSERVATION PERIOD AND SEASONAL FOCUS

Based on the constraints of the datasets, an individual observation period was defined for each of the climate-related drivers. Moreover, as livelihoods in the target region are often highly dependent on natural resource availability, which in turn is (among other factors) also a function of rainfall and temperature, the rainy season was chosen as a critical season to be observed in the target region. Consequently, the seasonal focus for the observation of driver 1 (precipitation and temperature) and driver 2 (drought) was set to the months from May to October in order to cover not only the actual rainy season, but also a few weeks before and after the rainy season.

### Data processing and analysis

#### ESSENTIAL CLIMATE VARIABLES (TEMPERATURE / PRECIPITATION)

##### *Temperature data*

After data download and re-scaling (values were scaled by a factor of 10), a subset of the dataset, covering the entire target region, was created. With the period of observation and the seasonal focus in mind, mean temperature was calculated for each season (May-October) of the years 1970 to 2006. Based on these values a seasonal temperature trend was calculated for each grid cell of the subset (5,387 grid cells of 0.5 degree resolution), making use of linear regression (ordinary least squares).

##### *Precipitation data*

A similar approach was applied for the analysis of the overall precipitation trend. Instead of mean seasonal precipitation values, however, the actual precipitation amount (sum) was calculated for each season (May-October) for the period 1970 to 2006.

#### NESDIS-STAR – VEGETATION HEALTH DATA (VHI)

As the data is provided in 'hierarchical data format' in the NESDIS-STAR server, the first step was to convert the data to a common raster format. Consequently, each of the weekly VHI datasets from 1982 to 2009 (5,740 files) was converted to 'tagged image file format.' In a next step the datasets were re-scaled to a new range of 0 to 100 (datasets were scaled by a factor of 100), where a VHI value of 0 indicates extreme drought conditions and a VHI value of 100 indicates excellent vegetation health conditions. Then, the seasonal (May-October) mean vegetation health (VHI) value was calculated from the weekly gridded VHI datasets (weeks 18-44 of each year). Next, a subset of the seasonal VHI layers was cre-

ated to increase processing time. Building on a critical VHI threshold (VHI values < 35 indicate severe drought conditions), the datasets were reclassified in a subsequent step. Based on these reclassified layers (0: VHI > 35; 1: VHI < 35), finally, the number of drought affected seasons was calculated for each cell (16 x 16 km) for the period 1985 to 2009.

#### **DFO - FLOOD DATA**

As the data is provided in Mapinfo Interchange Format on the DFO website, the first step was to convert the data to a common vector format. In a next step a subset of the data was created, showing the major flood events in the region of interest as polygons. Finally, a net of artificial cells was created in order to calculate the number of flood events per cell for the years 1985 to 2009.

#### **CSI-CGIAR – SRTM v4 ELEVATION DATA**

As the SRTM v4 global digital elevation model (GDEM) is provided in 5 degree resolution tiles, the first step – after downloading the tiles - was to mosaic the tiles covering the target region.

#### **APD & GPWv3 - POPULATION DATA**

Population count data was acquired from different sources. Data from 1960 to 2000 was acquired from the UNEP African Population Database (APD) website, while data from 1990 to 2010 was downloaded from the Gridded Population of the World (Version 3) portal. To determine if the GPWv3 data could be utilized to update the available time-series of population data as provided by UNEP-APD, Pearson's correlation of both datasets (UNEP-APD and GPWv3) was calculated for three larger test areas. Following this approach the overall population trend was calculated for two periods: 1) 1970-2010 and 2) 1980-2010.

#### **PRIO-CSCW – CONFLICT SITE DATA**

After the dataset was downloaded from the PRIO-CSCW website, a subset of the data for the region of interest was created. Then, based on the given centre-point coordinates and the radius variable, the estimated spatial extent of the conflicts in the target area were calculated. In order to have additional information on the number of conflicts a dissect (number of overlaps) was calculated based on the subset.

### **Cartographic representation**

Following analysis of the data, the resulting geospatial information layers were cartographically refined in order to obtain a more intuitive and appealing characterization of the results, making both interpretation and communication easier. Depending on the quality and format of the dataset different approaches were applied:

- Angular polygon layers were smoothed making use of Bezier interpolation techniques.
- Coarse grids, such as the temperature or precipitation trend dataset (0.5 degree resolution), were converted to point layers in order to apply spatial interpolation techniques (ordinary kriging) to create a continuous surface of finer resolution (i.e. 0.1 degree resolution). Where necessary, a low-pass filter was utilized to further smooth the entire raster. In a next step the refined grids were re-converted to polygons. Finally, the polygons were smoothed making use of Bezier interpolation techniques.
- Finally, where necessary, representation tools were utilized to enhance the visual representation of the resulting geospatial information layers.

## Annex 4. Migration data used (2000-2002)

Migration flows (origin-destination stocks)

Vertical: migrant origin countries; horizontal: migration destination countries

|                     | BEN    | BFA     | CPV   | TCD    | CIV       | GMB     | GHA     | GIN     | GNB    | LBR     | MLI    |
|---------------------|--------|---------|-------|--------|-----------|---------|---------|---------|--------|---------|--------|
| Benin (BEN)         | 0      | 73'069  | 5     | 66     | 61'103    | 88      | 29'828  | 56'533  | 40     | 137     | 4'231  |
| Burkina Faso (BFA)  | 2'701  | 0       | 11    | 154    | 977'421   | 204     | 69'218  | 148'791 | 93     | 486     | 11'136 |
| Cape Verde (CPV)    | 71     | 4'596   | 0     | 22     | 1'658     | 29      | 9'890   | 4'480   | 437    | 37      | 335    |
| Chad (TCD)          | 56     | 3'612   | 2     | 0      | 2'459     | 21      | 2'448   | 3'893   | 9      | 49      | 291    |
| Côte d'Ivoire (CIV) | 11'584 | 34'847  | 1     | 20     | 0         | 27      | 9'123   | 9'542   | 12     | 4'751   | 714    |
| Gambia (GMB)        | 41     | 2'671   | 0     | 6      | 422       | 0       | 2'518   | 2'625   | 911    | 12      | 196    |
| Ghana (GHA)         | 8'608  | 93'320  | 8     | 112    | 305'648   | 157     | 0       | 83'236  | 72     | 21'655  | 6'230  |
| Guinea (GIN)        | 1'008  | 65'176  | 5     | 66     | 138'550   | 38'362  | 29'618  | 0       | 4'844  | 70'689  | 4'812  |
| Guinea-Bissau (GNB) | 115    | 7'448   | 788   | 14     | 1'024     | 17'130  | 6'107   | 7'326   | 0      | 30      | 548    |
| Liberia (LBR)       | 52     | 3'381   | 1     | 10     | 753       | 13      | 4'485   | 3'321   | 6      | 0       | 249    |
| Mali (MLI)          | 2'965  | 437'921 | 13    | 183    | 486'604   | 13'078  | 82'403  | 162'921 | 111    | 4'286   | 0      |
| Mauritania (MRT)    | 139    | 8'981   | 1     | 12     | 904       | 5'566   | 900     | 8'838   | 570    | 30      | 661    |
| Niger (NER)         | 14'680 | 138'293 | 4     | 4'110  | 130'387   | 76      | 25'611  | 53'625  | 35     | 177     | 4'013  |
| Nigeria (NGA)       | 29'911 | 26'572  | 8     | 12'134 | 8'913     | 158     | 53'486  | 25'885  | 72     | 5'207   | 1'937  |
| Senegal (SEN)       | 215    | 13'908  | 206   | 54     | 3'992     | 98'608  | 23'896  | 13'594  | 9'829  | 529     | 1'017  |
| Sierra Leone (SLE)  | 65     | 4'217   | 1     | 11     | 793       | 1'574   | 4'724   | 4'147   | 6      | 17'285  | 310    |
| Togo (TGO)          | 25'826 | 19'233  | 2     | 22     | 1'650     | 29      | 9'867   | 18'953  | 13     | 545     | 1'418  |
|                     |        |         |       |        |           |         |         |         |        |         |        |
| Total               | 98'037 | 937'245 | 1'056 | 16'996 | 2'122'281 | 175'120 | 364'122 | 607'710 | 17'060 | 125'905 | 38'098 |

|                     | MRT    | NER     | NGA     | SEN     | SLE    | TGO     | Europe  | USA     | Rest of Africa | Rest of the World | Overall total |
|---------------------|--------|---------|---------|---------|--------|---------|---------|---------|----------------|-------------------|---------------|
| Benin (BEN)         | 585    | 9'682   | 159'683 | 1'497   | 127    | 71'780  | 24'823  | 2'717   | 59'272         | 21'066            | 576'332       |
| Burkina Faso (BFA)  | 132    | 10'426  | 7'583   | 3'793   | 17     | 717     | 27'996  | 4'303   | 35'320         | 48'154            | 1'348'656     |
| Cape Verde (CPV)    | 19     | 11      | 2'891   | 12'583  | 3      | 103     | 97'315  | 27'606  | 30'238         | 7'320             | 199'644       |
| Chad (TCD)          | 57     | 727     | 18'321  | 163     | 3      | 153     | 8'490   | 766     | 242'941        | 18'870            | 303'331       |
| Côte d'Ivoire (CIV) | 209    | 4'782   | 3'036   | 314     | 36     | 94      | 76'038  | 8'076   | 5'110          | 8'376             | 176'692       |
| Gambia (GMB)        | 5      | 3       | 4'367   | 7'945   | 0      | 26      | 20'348  | 6'178   | 1'347          | 2'082             | 51'703        |
| Ghana (GHA)         | 222    | 4'569   | 125'052 | 2'345   | 633    | 37'898  | 114'004 | 69'995  | 27'089         | 57'030            | 957'883       |
| Guinea (GIN)        | 3'274  | 34      | 4'891   | 109'109 | 35'950 | 307     | 27'930  | 6'741   | 20'261         | 22'020            | 583'647       |
| Guinea-Bissau (GNB) | 1'271  | 7       | 3'316   | 32'628  | 12     | 64      | 39'752  | 777     | 5'554          | 4'317             | 128'228       |
| Liberia (LBR)       | 9      | 5       | 12'909  | 121     | 2'171  | 47      | 9'563   | 41'136  | 2'361          | 5'165             | 85'758        |
| Mali (MLI)          | 8'073  | 33'673  | 91'150  | 23'642  | 945    | 2'675   | 75'752  | 7'157   | 87'250         | 57'893            | 1'578'695     |
| Mauritania (MRT)    | 0      | 6       | 12'068  | 39'984  | 69     | 56      | 19'653  | 2'525   | 9'909          | 6'016             | 116'888       |
| Niger (NER)         | 162    | 0       | 59'043  | 1'379   | 78     | 16'719  | 13'040  | 2'425   | 14'933         | 17'983            | 496'773       |
| Nigeria (NGA)       | 102    | 41'379  | 0       | 1'225   | 1'024  | 18'695  | 185'001 | 143'054 | 422'124        | 64'397            | 1'041'284     |
| Senegal (SEN)       | 40'670 | 817     | 3'326   | 0       | 357    | 249     | 181'380 | 12'119  | 55'815         | 18'934            | 479'515       |
| Sierra Leone (SLE)  | 9      | 5       | 2'605   | 138     | 0      | 49      | 29'410  | 21'594  | 2'681          | 4'796             | 94'420        |
| Togo (TGO)          | 124    | 1'542   | 77'353  | 452     | 21     | 0       | 23'558  | 3'490   | 22'495         | 7'709             | 214'302       |
|                     |        |         |         |         |        |         |         |         |                |                   |               |
| Total               | 54'923 | 107'668 | 587'594 | 237'318 | 41'446 | 149'632 | 974'053 | 360'659 | 1'044'700      | 372'128           |               |



## Annex 5. Summary of datasets used

### Data sources

This table presents the actual datasets and sources that were utilized in the mapping process.

| Topic                                         | Map_ID    | Resolution  | Start date                  | End date | Data source                           |
|-----------------------------------------------|-----------|-------------|-----------------------------|----------|---------------------------------------|
| <b>Climate-related indicators</b>             |           |             |                             |          |                                       |
| Temperature                                   | 1.1       | 0.5 degree  | 01/1901                     | 12/2006  | CRU TS 3.0                            |
| Precipitation                                 | 1.2       | 0.5 degree  | 01/1901                     | 12/2006  | CRU TS 3.0                            |
| Vegetation health                             | 2.0       | 16 × 16 km  | 08/1981                     | 08/2010  | NESDIS-STAR (VHI data)                |
| Flood event                                   | 3.0       | Polygon     | 01/1985                     | 08/2010  | DFO                                   |
| Elevation                                     | 4.0       | 90 m        | -                           | -        | SRTM v4                               |
| <b>Additional information layers</b>          |           |             |                             |          |                                       |
| Population                                    | All       | 2.5 minutes | 1960                        | 2010     | 1970-2000 (UNEP-APD);<br>2010 (GPWv3) |
| Conflict                                      | All       | Polygon     | 01/1946                     | 12/2005  | PRIO-CSCW                             |
| <b>Background vector data</b>                 |           |             |                             |          |                                       |
|                                               |           |             | <b>Reference year</b>       |          |                                       |
| World physical                                | 1.1 - 3.0 | -           | -                           | -        | ESRI Resource Centre                  |
| World terrain                                 | 4.0       | -           | -                           | -        | ESRI Resource Centre                  |
| Major rivers                                  | All       | Line        | 2006                        |          | FAO GeoNetwork                        |
| Major wadis                                   | All       | Line        | 2006                        |          | FAO GeoNetwork                        |
| Waterbodies                                   | All       | Polygon     | 2000; updated by Z_GIS 2010 |          | FAO GeoNetwork                        |
| GAUL (Global Administrative Unit Layers)      | All       | Polygon     | 2008                        |          | FAO GeoNetwork                        |
| Settlements                                   | All       | Point       | 2004; 2008 (estimated)      |          | GRUMP (alpha)                         |
| <b>Station-based daily precipitation data</b> |           |             |                             |          |                                       |
| Precipitation                                 | -         | Point       | 01/1929                     | 09/2010  | NOAA-NCDC                             |

### Description of the datasets

#### CRU TS 3.0 – GRIDDED GLOBAL CLIMATE DATA (PRECIPITATION/TEMPERATURE)

The CRU TS 3.0 dataset (TS = time series) comprises 1,224 monthly grids of observed climate for the period 1901-2006, covering the global land surface at 0.5 degree resolution.

*Strengths of the datasets:*

- continuous in time and space (global coverage)
- time-series enables retrospective change analysis (available time-series: 1901-2006)
- data is freely available via CRU/BADC data portal (restricted to BADC users only)

*Weaknesses of the datasets:*

- datasets are based on climate stations → sparse net of stations in the region of interest
- available time-series ends in 2006 → up-to-date climate data not available

## NESDIS-STAR – GRIDDED GLOBAL VEGETATION HEALTH DATA (VHI)

The NOAA NESDIS-STAR vegetation health index (VHI) dataset has global coverage at 16 km resolution. It comprises 7-day composite, validated vegetation health data.

*Strengths of the dataset:*

- based on measurements of the Advanced Very High Resolution Radiometer (AVHRR) onboard the NOAA satellite → objective, up-to-date and reliable data source
- dataset is continuous in space and time (global coverage)
- time-series enables retrospective change analysis (available time-series: 1981 to date)
- high temporal resolution (weekly dataset)
- freely available via NESDIS-STAR data portal

*Weaknesses of the dataset:*

- dataset dates back only to 1981 (week 35)
- from week 36 of 1994 to week 3 of 1995 data is not available due to sensor problems

## DFO – MAJOR FLOOD EVENT DATA

DFO (Dartmouth Flood Observatory) major flood event data comprises a global time-series (1985-2010) of major flood events which are represented as approximated polygons. The polygons reflect the estimated areas affected by flood rather than the actual inundated areas. According to DFO, the flood-affected areas (polygons) are delineated based on various sources, such as online news reports, governmental and international relief agency websites and satellite imagery.

*Strengths of the dataset:*

- global, up-to-date dataset
- time-series enables retrospective change analysis (available time-series: 1985 to date)
- freely available at DFO website

*Weaknesses of the dataset:*

- dataset does not reflect the actually inundated areas
- time-series dates back only to 1985

## CSI-CGIAR – SRTM v4 GRIDDED 90 m ELEVATION DATA

The SRTM 90 meter Digital Elevation Model (DEM) has a resolution of 90 m at the equator, and is provided in mosaics of 5 degree resolution tiles.

*Strengths of the dataset:*

- continuous in space (global coverage)
- high spatial resolution (90 m)
- vertical accuracy (< 9 m) is much higher than the vertical accuracy of the ASTER GDEM (+/- 20 m)
- high quality coastline
- freely available at CGIAR-CSI SRTM website

*Weaknesses of the dataset:*

- vertical accuracy (< 9 m) is not sufficient to delineate small changes in sea level (cm)

## AFRICAN POPULATION DATABASE (APD) – GRIDDED AFRICAN POPULATION DATA

The population figures of the UNEP African Population Database (APD) represent estimated totals for the standardized years 1960, 1970, 1980, 1990 and 2000 (10-year intervals). Data sources vary by country (censuses, national statistical offices, etc.). The African Population Database provides population count and population density information at a spatial resolution of 2.5 arc minutes.

*Strengths of the dataset:*

- high spatial resolution (2.5 arc minutes)
- time-series enables retrospective change analysis (available time-series: 1960-2000)
- high correlation (Pearson) with the Gridded Population of the World (GPWv3) dataset → GPWv3 dataset can be utilized to extend the time-series to 2010
- freely available via UNEP-APD data portal

*Weaknesses of the dataset:*

- data is only available for the African continent (no weakness within the context of this project, however could be a weakness for other projects)
- accuracy of the data as it is partly census-based and there is a lack of available census information in the region of interest
- dataset ends in the year 2000 (no up-to-date data available)

## **GRIDDED POPULATION OF THE WORLD (GPWv3) – POPULATION DATA**

Gridded Population of the World (GPWv3) is the third edition of a large-scale data product that demonstrates the spatial distribution of human populations across the globe. The output is unique in that the distribution of human population is converted from national or sub-national spatial units (usually administrative units) of varying resolutions, to a series of geo-referenced quadrilateral grids at a resolution of 2.5 arc minutes.

*Strengths of the dataset:*

- dataset is continuous in space (global coverage)
- high spatial resolution (2.5 arc minutes)
- time-series enables retrospective change analysis (available time-series: 1990-2015)
- dataset comprises a population count/density forecast until 2015
- high correlation (Pearson) with the UNEP-APD population dataset → GPWv3 dataset can be utilized to extend the available population time-series from 1960 to 2010
- freely available at the GPW/GRUMP data portal

*Weaknesses of the dataset:*

- the 1990 population and population density estimates are missing from all countries in Africa
- accuracy of the data (data is partly census-based → lacking census data in the region of interest)

## **PRIO-CSCW – CONFLICT SITE DATA**

The Uppsala Conflict Data Project (UCDP) defines armed conflict as 'a contested incompatibility that concerns either government or territory or both, where the use of armed force between two parties results in at least 25 battle-related deaths.' The PRIO-CSCW 'conflict site' dataset is an extension to the UCDP/PRIO 'Armed Conflicts Dataset' that provides coordinates for the conflict zones and lists of countries in which the conflicts were located from 1946 to 2005. Following the procedure of earlier versions of the UCDP/PRIO data, the conflict zones are coded with centre-point coordinates, plus a radius variable to denote the estimated spatial extent of the conflicts.

*Strengths of the dataset:*

- global dataset
- time-series enables retrospective change analysis (available time-series: 1946-2005)
- data reflects the estimated area affected by conflict (radius variable)
- freely available at PRIO-CSCW website

*Weaknesses of the dataset:*

- areas affected by conflict are represented by an estimated conflict radius → high degree of generalization
- dataset ends in 2005 (no up-to-date information on conflicts available)
- small-scale conflicts are not captured in the dataset

#### **NOAA-NCDC – STATION-BASED CLIMATE DATA**

The input data used in building these station-based global daily summaries are the 'Integrated Surface Data' (ISD), which includes global data obtained from the USAF Climatology Center, located in the Federal Climate Complex with NCDC (National Climatic Data Center). The online data files are now at the Version 7 software level. Globally, data from over 9,000 stations is available.

*Strengths of the dataset:*

- large number of stations globally available
- daily climate statistics
- time-series enables retrospective change analysis (available time-series: 1946-2005)
- freely available via NOAA-NCDC data portal

*Weaknesses of the dataset:*

- sparse net of stations in the target region
- high number of missing values in the data



## Annex 6. Land area and population affected by changes in the four climate indicators used

Seasonal precipitation trend (1970-2006). Area and population of the precipitation zones per country (CILSS countries)

|               | < -100 mm               |   |              |   | > -100 – -50 mm         |      |              |      | > -50 – 50 mm           |        |              |        | > 50 – 100 mm           |       |              |       |
|---------------|-------------------------|---|--------------|---|-------------------------|------|--------------|------|-------------------------|--------|--------------|--------|-------------------------|-------|--------------|-------|
|               | Area                    |   | Population   |   | Area                    |      | Population   |      | Area                    |        | Population   |        | Area                    |       | Population   |       |
|               | abs. (km <sup>2</sup> ) | % | abs. (thsd.) | % | abs. (km <sup>2</sup> ) | %    | abs. (thsd.) | %    | abs. (km <sup>2</sup> ) | %      | abs. (thsd.) | %      | abs. (km <sup>2</sup> ) | %     | abs. (thsd.) | %     |
| Burkina Faso  | -                       | - | -            | - | 9,830                   | 3.57 | 767          | 4.87 | 151,842                 | 55.21  | 8,288        | 52.66  | 104,033                 | 37.82 | 5,570        | 35.39 |
| Cape Verde    | -                       | - | -            | - | -                       | -    | -            | -    | 4,079                   | 100.00 | 450          | 100.00 | -                       | -     | -            | -     |
| Chad          | -                       | - | -            | - | -                       | -    | -            | -    | 655,513                 | 51.33  | 1,396        | 13.01  | 316,797                 | 24.81 | 3,448        | 32.14 |
| Gambia, The   | -                       | - | -            | - | -                       | -    | -            | -    | -                       | -      | -            | -      | -                       | -     | -            | -     |
| Guinea-Bissau | -                       | - | -            | - | -                       | -    | -            | -    | 512                     | 1.50   | 11           | 0.79   | 2,808                   | 8.22  | 78           | 5.73  |
| Mali          | -                       | - | -            | - | -                       | -    | -            | -    | 738,550                 | 58.69  | 5,281        | 34.66  | 473,230                 | 37.61 | 9,086        | 59.63 |
| Mauritania    | -                       | - | -            | - | -                       | -    | -            | -    | 746,163                 | 71.46  | 443          | 12.45  | 179,413                 | 17.18 | 1,635        | 45.96 |
| Niger         | -                       | - | -            | - | -                       | -    | -            | -    | 609,444                 | 51.20  | 371          | 2.39   | 409,673                 | 34.42 | 5,950        | 38.32 |
| Senegal       | -                       | - | -            | - | -                       | -    | -            | -    | -                       | -      | -            | -      | 29,942                  | 15.13 | 843          | 7.74  |
| total         | -                       | - | -            | - | 9,830                   | 0.20 | 767          | 1.02 | 2,906,103               | 57.93  | 16,240       | 21.68  | 1,515,896               | 30.22 | 26,610       | 35.52 |

|               | > 100 – 250 mm          |        |              |        | > 250 mm                |      |              |      |
|---------------|-------------------------|--------|--------------|--------|-------------------------|------|--------------|------|
|               | Area                    |        | Population   |        | Area                    |      | Population   |      |
|               | abs. (km <sup>2</sup> ) | %      | abs. (thsd.) | %      | abs. (km <sup>2</sup> ) | %    | abs. (thsd.) | %    |
| Burkina Faso  | 9,344                   | 3.40   | 1,103        | 7.01   | -                       | -    | -            | -    |
| Cape Verde    | -                       | -      | -            | -      | -                       | -    | -            | -    |
| Chad          | 304,824                 | 23.87  | 5,879        | 54.79  | -                       | -    | -            | -    |
| Gambia, The   | 10,862                  | 100.00 | 1,428        | 100.00 | -                       | -    | -            | -    |
| Guinea-Bissau | 30,857                  | 90.27  | 1,283        | 93.94  | -                       | -    | -            | -    |
| Mali          | 46,670                  | 3.71   | 872          | 5.72   | -                       | -    | -            | -    |
| Mauritania    | 118,664                 | 11.36  | 1,489        | 41.86  | -                       | -    | -            | -    |
| Niger         | 171,123                 | 14.38  | 9,183        | 59.14  | -                       | -    | -            | -    |
| Senegal       | 167,983                 | 84.87  | 10,076       | 92.61  | -                       | -    | -            | -    |
| total         | 664,680                 | 44.44  | 24,240       | 14.44  | 197,926                 | 1.99 | 10,881       | 0.66 |

Note: There are no zones in the CILSS countries with a change in precipitation of less than -100 millimetres (MM) or more than 250 millimetres (MM)

Seasonal temperature trend (1970-2006). Area and population of the temperature zones per country (CILSS countries)

|               | -0.5 – 0.0°C |            |              | > 0.0 – 0.5°C |            |              | > 0.5 – 1.0°C |            |              | > 1.0 – 1.5°C |            |              |
|---------------|--------------|------------|--------------|---------------|------------|--------------|---------------|------------|--------------|---------------|------------|--------------|
|               | Area         | Population |              | Area          | Population |              | Area          | Population |              | Area          | Population |              |
|               | abs. (km²)   | %          | abs. (thsd.) | abs. (km²)    | %          | abs. (thsd.) | abs. (km²)    | %          | abs. (thsd.) | abs. (km²)    | %          | abs. (thsd.) |
| Burkina Faso  | 10,565       | 3.84       | 439          | 118,215       | 42.98      | 6,875        | 146,270       | 53.18      | 8,415        | -             | -          | -            |
| Cape Verde    | -            | -          | -            | 3,221         | 78.96      | 425          | 858           | 21.04      | 24           | -             | -          | -            |
| Chad          | -            | -          | -            | -             | -          | -            | 491,744       | 38.50      | 7,883        | 689,345       | 53.98      | 2,769        |
| Gambia, The   | -            | -          | -            | -             | -          | -            | 9,953         | 91.63      | 731          | 909           | 8.37       | 721          |
| Guinea-Bissau | -            | -          | -            | -             | -          | -            | 16,737        | 48.97      | 455          | 17,445        | 51.04      | 934          |
| Mali          | 69,190       | 5.50       | 4,767        | 305,599       | 24.28      | 5,542        | 338,226       | 26.88      | 3,994        | 396,362       | 31.50      | 867          |
| Mauritania    | -            | -          | -            | -             | -          | -            | 304,055       | 29.12      | 2,391        | 377,230       | 36.13      | 1,084        |
| Niger         | -            | -          | -            | 223,406       | 18.77      | 9,262        | 913,228       | 76.73      | 6,208        | 53,607        | 4.50       | 35           |
| Senegal       | -            | -          | -            | 10,083        | 5.09       | 123          | 176,445       | 89.15      | 6,595        | 11,398        | 5.76       | 4,294        |
| total         | 79,755       | 1.59       | 5,206        | 660,524       | 13.17      | 22,227       | 2,397,516     | 47.79      | 36,696       | 1,546,296     | 30.82      | 10,704       |

|               | > 1.5 – 2.0°C |            |              | > 2.0°C    |            |              |                             |                                     |
|---------------|---------------|------------|--------------|------------|------------|--------------|-----------------------------|-------------------------------------|
|               | Area          | Population |              | Area       | Population |              |                             |                                     |
|               | abs. (km²)    | %          | abs. (thsd.) | abs. (km²) | %          | abs. (thsd.) | total area of country (km²) | total population of country (thsd.) |
| Burkina Faso  | -             | -          | -            | -          | -          | -            | 275,049                     | 15,739                              |
| Cape Verde    | -             | -          | -            | -          | -          | -            | 4,079                       | 450                                 |
| Chad          | 96,045        | 7.52       | 73           | -          | -          | -            | 1,277,143                   | 10,730                              |
| Gambia, The   | -             | -          | -            | -          | -          | -            | 10,862                      | 1,428                               |
| Guinea-Bissau | -             | -          | -            | -          | -          | -            | 34,182                      | 1,366                               |
| Mali          | 149,072       | 11.85      | 71           | -          | -          | -            | 1,258,413                   | 15,238                              |
| Mauritania    | 354,935       | 33.99      | 89           | 8,020      | 0.77       | 1            | 1,044,184                   | 3,558                               |
| Niger         | -             | -          | -            | -          | -          | -            | 1,190,209                   | 15,528                              |
| Senegal       | -             | -          | -            | -          | -          | -            | 197,926                     | 10,881                              |
| total         | 600,053       | 11.96      | 233          | 8,020      | 0.16       | 1            | 5,292,047                   | 74,918                              |

### Areas affected by drought (1982-2009). Area and population of the drought-affected areas per country (CILSS countries)

|               | 1 – 2 drought affected seasons |       |                    | 3 – 5 drought affected seasons |        |                    | 6 – 10 drought affected seasons |       |                    | 11 – 15 drought affected seasons |      |                    |
|---------------|--------------------------------|-------|--------------------|--------------------------------|--------|--------------------|---------------------------------|-------|--------------------|----------------------------------|------|--------------------|
|               | abs. (km²)                     | %     | Population (thsd.) | abs. (km²)                     | %      | Population (thsd.) | abs. (km²)                      | %     | Population (thsd.) | abs. (km²)                       | %    | Population (thsd.) |
| Burkina Faso  | 74,694                         | 27.16 | 4,910              | 194,301                        | 70.64  | 10,326             | 5,981                           | 2.17  | 487                | -                                | -    | -                  |
| Cape Verde    | -                              | -     | -                  | -                              | -      | -                  | 3,953                           | 96.93 | 441                | 125                              | 3.07 | 8                  |
| Chad          | 87,951                         | 6.89  | 1,787              | 655,131                        | 51.30  | 7,577              | 476,753                         | 37.33 | 1,065              | 41,164                           | 3.22 | 15                 |
| Gambia, The   | -                              | -     | -                  | 10,862                         | 100.00 | 1,428              | -                               | -     | -                  | -                                | -    | -                  |
| Guinea-Bissau | 3,593                          | 10.51 | 130                | 30,461                         | 89.11  | 1,242              | 129                             | 0.38  | 7                  | -                                | -    | -                  |
| Mali          | 207,090                        | 16.46 | 2,497              | 688,367                        | 54.70  | 12,281             | 344,871                         | 27.41 | 447                | 7,587                            | 0.60 | 4                  |
| Mauritania    | 108,624                        | 10.40 | 292                | 432,223                        | 41.39  | 1,784              | 481,919                         | 46.15 | 1,482              | 21,417                           | 2.05 | 9                  |
| Niger         | 134,147                        | 11.27 | 2,069              | 529,189                        | 44.46  | 11,668             | 508,652                         | 42.74 | 1,754              | 18,221                           | 1.53 | 17                 |
| Senegal       | 32,768                         | 16.56 | 4,538              | 157,420                        | 79.53  | 6,230              | 7,738                           | 3.91  | 248                | -                                | -    | -                  |
| total         | 648,866                        | 12.26 | 16,223             | 2,697,954                      | 50.98  | 52,536             | 1,829,996                       | 34.58 | 5,931              | 88,514                           | 1.67 | 53                 |

|               | > 15 drought affected seasons |      |                    |                             |                                     |  |
|---------------|-------------------------------|------|--------------------|-----------------------------|-------------------------------------|--|
|               | abs. (km²)                    | %    | Population (thsd.) | total area of country (km²) | total population of country (thsd.) |  |
| Burkina Faso  | -                             | -    | -                  | 275,049                     | 15,739                              |  |
| Cape Verde    | -                             | -    | -                  | 4,079                       | 450                                 |  |
| Chad          | 195                           | 0.02 | 0                  | 1,277,143                   | 10,730                              |  |
| Gambia, The   | -                             | -    | -                  | 10,862                      | 1,428                               |  |
| Guinea-Bissau | -                             | -    | -                  | 34,182                      | 1,366                               |  |
| Mali          | -                             | -    | -                  | 1,258,413                   | 15,238                              |  |
| Mauritania    | -                             | -    | -                  | 1,044,184                   | 3,558                               |  |
| Niger         | -                             | -    | -                  | 1,190,209                   | 15,528                              |  |
| Senegal       | -                             | -    | -                  | 197,926                     | 10,881                              |  |
| total         | 195                           | 0.00 | 0                  | 5,292,047                   | 74,918                              |  |

Note: As only 0.000037 per cent of the area of the CILSS countries have been affected by more than 15 drought events, this category (> 15 drought affected seasons) is displayed in the same colour in the map as the areas that have been affected 11 to 15 times.

Areas affected by flooding (1985-2009). Area and population of the flood-affected areas per country (CILSS countries)

|               | 1 – 2 flood events |        |              |        | 3 – 4 flood events |       |              |       | 5 – 6 flood events |       |              |       | 7 – 8 flood events |       |              |       |
|---------------|--------------------|--------|--------------|--------|--------------------|-------|--------------|-------|--------------------|-------|--------------|-------|--------------------|-------|--------------|-------|
|               | Area               |        | Population   |        | Area               |       | Population   |       | Area               |       | Population   |       | Area               |       | Population   |       |
|               | abs. (km²)         | %      | abs. (thsd.) | %      | abs. (km²)         | %     | abs. (thsd.) | %     | abs. (km²)         | %     | abs. (thsd.) | %     | abs. (km²)         | %     | abs. (thsd.) | %     |
| Burkina Faso  | -                  | -      | -            | -      | 122                | 0.04  | 4            | 0.03  | 20,590             | 7.49  | 579          | 3.68  | 223,850            | 81.39 | 14,214       | 90.31 |
| Cape Verde    | -                  | -      | -            | -      | -                  | -     | -            | -     | -                  | -     | -            | -     | -                  | -     | -            | -     |
| Chad          | 426,159            | 33.37  | 588          | 5.48   | 349,926            | 27.40 | 3,024        | 28.18 | 237,883            | 18.63 | 5,574        | 51.95 | 36,054             | 2.82  | 1,329        | 12.39 |
| Gambia, The   | 10,862             | 100.00 | 1,428        | 100.00 | -                  | -     | -            | -     | -                  | -     | -            | -     | -                  | -     | -            | -     |
| Guinea-Bissau | 19,252             | 56.32  | 798          | 58.46  | -                  | -     | -            | -     | -                  | -     | -            | -     | -                  | -     | -            | -     |
| Mali          | 612,974            | 48.71  | 2,201        | 14.44  | 374,376            | 29.75 | 5,876        | 38.56 | 224,472            | 17.84 | 6,634        | 43.54 | 17,807             | 1.42  | 514          | 3.37  |
| Mauritania    | 595,411            | 57.02  | 1,483        | 41.67  | 229,006            | 21.93 | 1,834        | 51.53 | 2,404              | 0.23  | 108          | 3.03  | -                  | -     | -            | -     |
| Niger         | 258,333            | 21.70  | 136          | 0.88   | 171,185            | 14.38 | 112          | 0.72  | 231,952            | 19.49 | 686          | 4.42  | 297,138            | 24.97 | 11,111       | 71.55 |
| Senegal       | 115,024            | 58.11  | 5,854        | 53.80  | 50,418             | 25.47 | 4,726        | 43.43 | 32,490             | 16.42 | 440          | 4.04  | -                  | -     | -            | -     |
| total         | 2,038,014          | 40.62  | 12,488       | 16.67  | 1,175,033          | 23.42 | 15,576       | 20.79 | 749,792            | 14.95 | 14,021       | 18.72 | 574,848            | 11.46 | 27,168       | 36.26 |

|               | 9 – 10 flood events |       |              |       | 11 – 12 flood events |      |              |      |                             |                                     |
|---------------|---------------------|-------|--------------|-------|----------------------|------|--------------|------|-----------------------------|-------------------------------------|
|               | Area                |       | Population   |       | Area                 |      | Population   |      | total area of country (km²) | total population of country (thsd.) |
|               | abs. (km²)          | %     | abs. (thsd.) | %     | abs. (km²)           | %    | abs. (thsd.) | %    |                             |                                     |
| Burkina Faso  | 30,534              | 11.10 | 934          | 5.93  | 112                  | 0.04 | 5            | 0.03 | 275,049                     | 15,739                              |
| Cape Verde    | -                   | -     | -            | -     | -                    | -    | -            | -    | 4,079                       | 450                                 |
| Chad          | -                   | -     | -            | -     | -                    | -    | -            | -    | 1,277,143                   | 10,730                              |
| Gambia, The   | -                   | -     | -            | -     | -                    | -    | -            | -    | 10,862                      | 1,428                               |
| Guinea-Bissau | -                   | -     | -            | -     | -                    | -    | -            | -    | 34,182                      | 1,366                               |
| Mali          | 91                  | 0.01  | 0            | 0.00  | -                    | -    | -            | -    | 1,258,413                   | 15,238                              |
| Mauritania    | -                   | -     | -            | -     | -                    | -    | -            | -    | 1,044,184                   | 3,558                               |
| Niger         | 61,312              | 5.15  | 3,106        | 20.00 | 4,570                | 0.38 | 324          | 2.09 | 1,190,209                   | 15,528                              |
| Senegal       | -                   | -     | -            | -     | -                    | -    | -            | -    | 197,926                     | 10,881                              |
| total         | 91,937              | 1.83  | 4,040        | 5.39  | 4,682                | 0.09 | 329          | 0.44 | 5,292,047                   | 74,918                              |



## Annex 7. Population vulnerable to sea-level rise

Area and population of the defined elevation zones per country (coastal countries in the study region)

|               | -5 – 1m elevation relative to sea level |      |                            | -5 – 2m elevation relative to sea level |      |                            | -5 – 3m elevation relative to sea level |      |                            | -5 – 4m elevation relative to sea level |       |                            |
|---------------|-----------------------------------------|------|----------------------------|-----------------------------------------|------|----------------------------|-----------------------------------------|------|----------------------------|-----------------------------------------|-------|----------------------------|
|               | abs. (km <sup>2</sup> )                 | %    | Population<br>abs. (thsd.) | abs. (km <sup>2</sup> )                 | %    | Population<br>abs. (thsd.) | abs. (km <sup>2</sup> )                 | %    | Population<br>abs. (thsd.) | abs. (km <sup>2</sup> )                 | %     | Population<br>abs. (thsd.) |
| Cape Verde    | 26                                      | 0.65 | 1                          | 47                                      | 1.15 | 4                          | 71                                      | 1.75 | 4                          | 98                                      | 2.39  | 7                          |
| Gambia, The   | 162                                     | 1.49 | 78                         | 495                                     | 4.56 | 98                         | 932                                     | 8.58 | 133                        | 1,363                                   | 12.55 | 300                        |
| Guinea-Bissau | 260                                     | 0.76 | 12                         | 476                                     | 1.39 | 20                         | 919                                     | 2.69 | 34                         | 1,791                                   | 5.24  | 64                         |
| Mauritania    | 7,310                                   | 0.70 | 228                        | 8,909                                   | 0.85 | 295                        | 10,424                                  | 1.00 | 542                        | 11,812                                  | 1.13  | 636                        |
| Senegal       | 1,017                                   | 0.51 | 140                        | 1,688                                   | 0.85 | 318                        | 2,485                                   | 1.26 | 451                        | 3,207                                   | 1.62  | 665                        |
| Benin         | 694                                     | 0.60 | 397                        | 917                                     | 0.79 | 478                        | 1,112                                   | 0.96 | 647                        | 1,294                                   | 1.11  | 693                        |
| Cameroon      | 84                                      | 0.02 | 8                          | 116                                     | 0.02 | 9                          | 174                                     | 0.04 | 18                         | 276                                     | 0.06  | 41                         |
| Côte d'Ivoire | 1,010                                   | 0.31 | 389                        | 1,070                                   | 0.33 | 462                        | 1,351                                   | 0.42 | 481                        | 1,483                                   | 0.46  | 532                        |
| Ghana         | 728                                     | 0.30 | 129                        | 971                                     | 0.40 | 161                        | 1,210                                   | 0.50 | 229                        | 1,446                                   | 0.60  | 295                        |
| Guinea        | 514                                     | 0.21 | 23                         | 936                                     | 0.38 | 65                         | 1,465                                   | 0.59 | 122                        | 2,044                                   | 0.83  | 190                        |
| Liberia       | 57                                      | 0.06 | 15                         | 225                                     | 0.23 | 117                        | 301                                     | 0.31 | 164                        | 394                                     | 0.41  | 176                        |
| Nigeria       | 1,294                                   | 0.14 | 1,584                      | 1,965                                   | 0.21 | 1,751                      | 3,234                                   | 0.35 | 2,501                      | 3,638                                   | 0.40  | 3,406                      |
| Sierra Leone  | 395                                     | 0.54 | 12                         | 765                                     | 1.05 | 33                         | 1,369                                   | 1.88 | 74                         | 2,084                                   | 2.86  | 242                        |
| Togo          | 116                                     | 0.20 | 28                         | 158                                     | 0.28 | 60                         | 207                                     | 0.36 | 70                         | 261                                     | 0.46  | 173                        |
| total         | 13,667                                  | 0.36 | 3,044                      | 18,738                                  | 0.49 | 3,871                      | 25,256                                  | 0.66 | 5,470                      | 31,192                                  | 0.81  | 7,420                      |

|               | -5 – 5m elevation relative to sea level |       |                            | total area of country (km <sup>2</sup> ) | total population of country (thsd.) |
|---------------|-----------------------------------------|-------|----------------------------|------------------------------------------|-------------------------------------|
|               | abs. (km <sup>2</sup> )                 | %     | Population<br>abs. (thsd.) |                                          |                                     |
| Cape Verde    | 122                                     | 3.00  | 7                          | 4,079                                    | 450                                 |
| Gambia, The   | 1,700                                   | 15.65 | 324                        | 10,862                                   | 1,428                               |
| Guinea-Bissau | 2,839                                   | 8.31  | 161                        | 34,182                                   | 1,366                               |
| Mauritania    | 13,167                                  | 1.26  | 701                        | 1,044,184                                | 3,558                               |
| Senegal       | 3,791                                   | 1.92  | 870                        | 197,926                                  | 10,881                              |
| Benin         | 1,467                                   | 1.26  | 990                        | 116,335                                  | 8,232                               |
| Cameroon      | 430                                     | 0.09  | 85                         | 469,364                                  | 18,400                              |
| Côte d'Ivoire | 1,643                                   | 0.51  | 777                        | 324,000                                  | 19,341                              |
| Ghana         | 1,668                                   | 0.69  | 320                        | 240,305                                  | 23,478                              |
| Guinea        | 2,620                                   | 1.06  | 225                        | 246,411                                  | 9,920                               |
| Liberia       | 508                                     | 0.53  | 250                        | 96,507                                   | 4,631                               |
| Nigeria       | 5,086                                   | 0.56  | 5,202                      | 915,225                                  | 146,462                             |
| Sierra Leone  | 2,757                                   | 3.79  | 376                        | 72,788                                   | 6,133                               |
| Togo          | 320                                     | 0.56  | 179                        | 57,405                                   | 5,677                               |
| total         | 38,119                                  | 1.00  | 10,467                     | 3,829,573                                | 259,957                             |

## Annex 8. Adapting to change: Lessons from local best practices

The following examples highlight traditional adaptation measures utilized by various local communities with respect to floods and droughts, as well as a number of integrated adaptation strategies that can be drawn upon to enhance resilience in the face of cumulative changes in climate. The list is not meant to be exhaustive, but rather aims to highlight the types of local measures that should be taken into consideration as national and regional adaptation strategies are formalized. Although many of these strategies are highly context-specific, these experiences can help inform adaptation policies for regions facing similar changes in climate.

### Floods

The sudden onset of floods can have severe consequences for communities, particularly in urban areas that have relatively high population density. In Ilorin, Nigeria, a region prone to flooding, an analysis was conducted on ways to reduce the risks associated with flood damage.<sup>235</sup> Specific recommendations highlighted in the study include:

- Establishing laws and effective enforcement mechanisms that prohibit development in flood plains;
- Mandating changes in urban and housing designs that can better withstand the sudden onset of flooding;
- Investing in appropriate infrastructure such as appropriate drainage systems;
- Promoting the construction of canals and dykes to protect the riverbank; and
- Incorporating the development of flood shelters and assistance shelters, as well as the provision of emergency housing and drinking water into community emergency preparedness programmes.

### Drought

Over the last 100 years, the region has faced severe recurrent drought.<sup>236</sup> In response, local farmers have developed a number of adaptation strategies, including the use of agroforestry, drought resistant crops and infiltration ponds. Agroforestry is an integrated approach that balances the cultivation of food crops and forests. This approach has been increasingly used in areas where drier conditions and higher population densities are prevalent.<sup>237</sup> As agroforestry techniques are further developed, both scientific research and local knowledge should be considered:

- Specifically, baobab and acacia trees have been identified by researchers as valuable species that can be used for agroforestry in drier areas of the region.<sup>238</sup>
- Local knowledge on which tree species thrive under varying ecological conditions can help to inform more diversified agroforestry practices. For example, in south-western Nigeria, a 1988 study revealed a similar practice, in which local populations grew shade-tolerant crops such as *Dioscorea spp.* and cocoyam in an essentially permanent forest setting.<sup>239</sup>
- The cultivation of drought-resistant crops can enable farmers to better withstand dry seasons. In particular, using the early maturing varieties of these crops<sup>240</sup> can also have positive benefits for dryland communities especially during the period prior to harvest when food reserves run dry.<sup>241</sup> Pearl millet has been identified as one of the most drought-tolerant crops of all the major staples. Sorghum and millet are prominent cereal crops grown in dryland regions and are essential for food, as well as feed for livestock. Additionally, a variety of millet known as Okashana 1 has been widely used by farmers in Namibia due to its early maturation cycle.<sup>242</sup> Furthermore, multipurpose grain legumes have been identified as a source of low-cost protein that can also help to restore soil fertility. Of these, the cowpea is most widely grown in the dry regions of Africa. Scientific research supported by the International Institute of Tropical Agriculture has enabled the usage of improved cowpeas in over 60 countries.

- In addition to agroforestry and the usage of drought-resistant crops, infiltration ponds have also been constructed to improve rainwater infiltration and moisture retention in soil, as well as to enhance a plant's water uptake capacity.<sup>243</sup>

### Integrated adaptation strategies

As indicated on Map 12 a number of areas in the Sahel face combined changes in multiple climate indicators. The following strategies can be utilized to enhance resilience in the presence of multiple slow-onset changes in climate:

- *Zai method*: This technique (see Case Study 7), sometimes known as the “water pockets” method, is a longstanding technique that was revived in the Yatenga Province of northern Burkina Faso by which small microreservoirs are dug out, enriched with fertilizer and covered with another thin layer of soil.<sup>244</sup> This enables water to collect in the reservoirs, providing seeds with humid soil. This technique also helps to minimize runoff.
- *Stone contour bunds*: Farmers in Burkina Faso, with the assistance of Oxfam staff, have also begun building stone contour bunds to harvest rainwater and improve soil fertility and structure.<sup>245</sup> Oxfam helped the community acquire a simple and low-cost tool that enabled the precise measurement of water levels. Since then, Zai and stone contour bunds have been used jointly for food crops, tree planting and fodder production. The combination of these tactics has led to the rehabilitation of 200,000-300,000 hectares of farmland in the Central Plateau of Burkina Faso.<sup>246</sup>
- *Half-moon technique*: The half-moon technique is a modulation of the Zai method built on forward slopes. It involves the digging of a basin and the formation of an arched dyke with the excavated soil, which collect runoff water and that then seeps into the soil.<sup>247</sup> The half-moon technique is used to enhance farm productivity through improvements in soil fertility and humidity.<sup>248</sup>
- *Natural mulches*: Natural mulches have been integrated into farming practices in order to moderate soil temperatures and extremes, suppress diseases and harmful pests, and conserve soil moisture.<sup>249</sup>
- Further efforts to improve ecosystem management through measures such as crop pollination, decomposition of wastes and regulating nutrient cycles can also help to enhance ecosystems leading to more resilient, productive and sustainable land.<sup>250</sup>

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## Annex 10. Acknowledgements

### Primary authors

Dennis Hamro-Drotz, UN Environment Programme  
David Jensen, UN Environment Programme  
Bessma Mourad, UN Environment Programme  
Patrice Quesada, International Organization for Migration  
Jenty Kirsch-Wood, Office for the Coordination of Humanitarian Affairs  
Koko Warner, United Nations University, Bonn

### Other contributors

Tamer Afifi, United Nations University, Bonn  
Philippe Boncour, International Organization for Migration  
Edwige Botoni, Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS)  
Jenny Clover, UN Environment Programme  
Mahalmoudou Hamadoun, Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS)  
Alexis Kabore, UN Development Programme, Burkina Faso  
Dr. Hamadé Kagone, West and Central African Council for Agricultural Research and Development  
Aki Kogachi, UN Development Programme, Burkina Faso  
Alina Narusova, International Organization for Migration  
Maximilien Pardo, UN Environment Programme  
Renard Sexton, UN Environment Programme  
Julie Snorek, United Nations University, Bonn  
Andrew Thow, Office for the Coordination of Humanitarian Affairs  
Baba Traore, Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS)/Institut du Sahel (INSAH)

### Research assistants

Julien Aguzzoli, UN Environment Programme  
Sarah Bieber, UN Environment Programme  
Kathryn Chelminski, UN Environment Programme  
Matthias Chesley, UN Environment Programme  
Lucas de Muelenaere, UN Environment Programme  
Lucile Maertens, UN Environment Programme  
Sophie Maisonnier, UN Environment Programme  
Andrew Tomita, UN Environment Programme  
Cassidy Travis, UN Environment Programme

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United Nations Environment Programme  
P.O. Box 30552 Nairobi, Kenya  
Tel: +254 (0)20 762 1234  
Fax: +254 (0)20 762 3927  
Email: [unep@unep.org](mailto:unep@unep.org)

