

# CLACC

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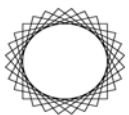
CAPACITY STRENGTHENING IN THE LEAST DEVELOPED COUNTRIES  
(LDCs) FOR ADAPTATION TO CLIMATE CHANGE (CLACC)

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CLIMATE CHANGE AND HEALTH IN WEST AFRICA

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2008



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## FOREWORD

The Capacity building in the Least Developed Countries on Adaptation to Climate Change (CLACC) programme was established by the International Institute for Environment and Development in 2003. The objectives of CLACC are capacity building and awareness raising in order to mainstream climate change into development policy and planning. CLACC targets civil society organizations such as non-government organisations and community-based organisations. This document is a synthesis of the health and climate change studies undertaken by CLACC partners in West Africa during 2008.

The drafting of health reports and organisation of workshops in each country was coordinated by national coordinators: Oumar Sango (Amadepelcode, Mali), Mady Oury Tandia (Tenmiya, Mauritania), and Krystal Dossou (Ofedi, Benin). Each national case study was produced by a research team specifically set up for the CLACC programme. Regional coordination was conducted by Dr Salimata Wade of ENDA Energie in Senegal. She provided a regional framework through which the national case studies could be considered in the context of West Africa realities.

Dr Sari Kovats provided the epidemiologic reading framework and the harmonized standards necessary to make acceptable the studies as contribution to scientific and development knowledge. Dr Kovats has provided the supervision of the English final version production of this document (made from three documents originally written in French before being translated).

In each country, the work was carried out with the help of a focus group that included experts and physicians. It should be noted that there was no tradition or process for an interdisciplinary expert group to address climate change and health. The process itself was new and the success in bringing together experts in environment and health should be considered a positive outcome of this project. The lack of inter-disciplinary working was particularly clear in the West African region of the CLACC network.

A main objective of the study was to influence the policy-makers and to raise awareness of the problem of climate change and health. This was achieved by conducting workshops in each country with a range of key stakeholders.

### *Acknowledgements*

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- Tandia Madyoury, Hydro-geologist and Coordinator of Studies and Projects at Tenmiya, CLACC Fellow
- Dr Kane Mohamed Moustapha, Dietician and Health – Climate Change focal point
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## EXECUTIVE SUMMARY

This paper describes the impacts of climate change on health in three countries in West Africa: the Republic of Benin, the Republic of Mali and the Islamic Republic of Mauritania. Three case studies reflect some of the most important and urgent public health problems in these countries.

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It is important to understand general demographic, health system, and mortality characteristics of the three countries in West Africa because the current capacity of countries to address environmental hazards and infectious disease will determine the capacity they have to cope with the health impacts of climate change. Current health indicators for Benin, Mali, and Mauritania are, therefore, described.

Climate change projections for West Africa are also described: Warming in Africa as a whole is very likely to be larger than the global, annual mean warming, with the drier subtropical regions warming more than the tropics. Annual rainfall is likely to decrease in much of Mediterranean Africa and the northern Sahara, with the likelihood of a decrease in rainfall increasing towards north Africa. It is uncertain how rainfall in the Sahel, the Guinean Coast and the southern Sahara will evolve in this century.

Although all three countries have produced a NAPA – Programme d'action national d'adaptation aux changements climatiques – these documents often do not cover climate change. In many cases, current capacity to tackle climate change in the health sector of each of the three countries is poor. For example, the government of Benin's "Roll Back Malaria" programme does not address the problem of climate change, so all efforts made under this programme could go to waste.

The Mali case study suggests that meningitis is affected by climatic factors but that these effects are dependant on the location. Rainfall and temperature seem to be the more important climatic factors, particularly rainfall, as transmission ends with the onset of the rains. As climate variability is likely to be affected by climate change in the future, the seasonal patterns of meningitis may change.

Malaria constitutes a major problem for public health in Africa in general and particularly in Benin. The economic impacts of this are enormous. Levels of malaria endemicity are high in Cotonou. The formation of many larval lodgings during rainy season favours the vectors of malaria. The highest incident rates are recorded one or two months after the rains peak. Women and children in precarious socio-economic conditions are the most vulnerable because of the high costs of malaria treatment. The long-term consequences will be considerable if no adequate prevention measures are taken to limit malaria risks. Better awareness of the roles of national (civil society) and international actors and also of existing links between adaptation to climate change and human health is necessary.

Acute Respiratory Infections (ARIs) cause 30 – 40% of hospitalization around the world. The prevalence of some ARIs is directly associated with the weather in addition to other factors such as promiscuity, malnutrition levels, water quality and poverty. When contracted during the hot season some ARIs can become particularly serious. ARIs are present throughout Mauritania and seem to be increasing in all regions of the country. It is hard to establish a formal correlation between the weather and patterns seen in ARI prevalence in Mauritania but there are indications that the number of ARIs could rise considerably with climate change. This could pose a new threat to communities, particularly children, old people and women.

These three case studies have identified a range of concerns regarding the impact of climate change on health in West Africa. Several key conclusions can be drawn:

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- That attribution to observed climate change should be made with extreme caution. Although it is tempting to attribute increases in infectious diseases to climate warming, there are many reasons why reported changes could occur. The three case studies provided interesting information on the links between climate change and health in West Africa, and correlations could be established between the two but the available data and resulting analysis regarding the links between climate change and health are not strong enough to fully assess the degree of the correlation.
  - Rainfall is very important in determining health effects, but the impacts of climate change on precipitation in this region are very uncertain.
  - There is a lack of epidemiological (health) data that is of sufficient quality to examine associations with climate factors.
  - There is also a lack of research capacity in the three countries and very little awareness of climate change. There were no existing experts available who had health and environmental knowledge. Moreover climate change experts are rare in the region and frequently focus on issues unrelated to human health.
  - Policymakers must be considered as a strategic target for research findings, because they have the power to promote better integration of climate change issues into health planning. At the local level, local authorities should also be targeted because much healthcare is decentralized to local services.
  - The importance of current environmental problems should not be overlooked. For example, in Cotonou and Bamako, poor waste and water management leads to frequent flooding, which in turn leads to increases in malaria. Increasing poverty with general reductions in the quality of life and living conditions is also important. Institutional issues and human environmental issues could be more important determinants of health than climate change effects/impacts.

These studies need extending to improve understanding of the affect of climate change on health issues in West Africa. A cross-sectoral, multidisciplinary approach is needed for such studies, with use of local human resources to ensure a deep enough understanding of the issues.

Such climate change studies are particularly useful for the Least Developed Countries. These are the most vulnerable, and thus the countries that urgently need to document the problems exacerbated by climate change and to quickly find out what responses in terms of national adaptation strategies are most important.

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### Acronyms

ARI	Acute respiratory infection
CLIPS	Services for Information and Weather Forecast
DFID	Department for International Development (UK)
DNS	National Department for Health
FNC	First National Communication (to UNFCCC)
GHG	Greenhouse gas
HIV/AIDS	Human immunodeficiency virus/Acquired Immunodeficiency Syndrome
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-tropical Convergence Zone
MARA	Malaria Risk in Africa
MDGs	Millennium Development Goals
MoH	Ministry of Health
NGO	Non-governmental Organisation
NAPA	National Action Plan for Adaptation
SMHN	National Weather and Hydrology Services
SNIS	National Health Information System Service
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization
WMO	World Meteorological Organization

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## Section I

### 1 Introduction

This paper describes the impacts of climate change on health in three countries in West Africa: the Republic of Benin, the Republic of Mali and the Islamic Republic of Mauritania. The population of West Africa inhabits a range of biogeographical zones, from humid zones to arid ones. This diversity guarantees a relevant sample of the West Africa context and its diversity. A range of diseases have been investigated in the three case studies (see Section II). They reflect the most important and urgent public health problems to treat at local community scales as well as sub regional or national scales. Institutional and community based solutions for adaptation (anticipation and reaction) could be undertaken (see Section III).

West Africa has experienced significant social, demographic and environmental change in the past decades. The OECD study of long term trends in the region considered future population growth and urbanisation as key drivers of social change (Cour and Snrech, 1998). However, this study did not consider the effects of climate change in the region, and the key issues for health was thought to be the HIV/AIDS epidemic and the challenge of fighting against high rates of mortality, especially child mortality.

### 2 Global climate change

The Intergovernmental Panel on Climate Change (IPCC) has reviewed the scientific evidence for the impacts of climate change in many sectors. Global warming is now of great concern, particularly after the conclusions of the Fourth Assessment Report (IPCC 2007). The World Meteorological Organization (WMO) and The United Nations Environment Programme (UNEP) have also supported these assessments. The IPCC makes it clear that the Earth has been warming for 150 years due to anthropogenic emissions of greenhouse gases (GHG) in the atmosphere.

In 1990, the second world conference on the environment opted for a treaty – a framework on climate change called the United Nations Framework Convention on Climate Change (UNFCCC), which was adopted on May 9<sup>th</sup>, 1992 in New York and approved on March 21<sup>st</sup>, 1994.

The main objective of the Convention is “to make fixed the concentration of greenhouse gases (CO<sub>2</sub>, CFC, CH<sub>4</sub>, H<sub>2</sub>O, N<sub>2</sub>O, NO<sub>3</sub>...) in accordance with the significant provisions of the Convention at a level which prevents any disturbance of climate system caused by dangerous human actions. It will be advisable to reach this level within a sufficient time so that the environment (ecosystems) can naturally be adapted to the climate change, that the food production is not going to be threatened and that the economic development can continue in a sustainable way”.

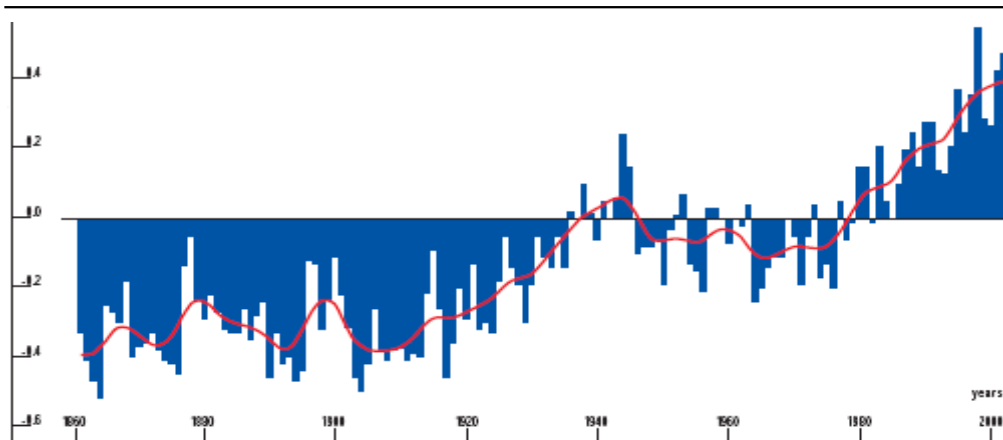


Fig 1: Global mean temperatures since 1861.  
 Source: Jones and al. (1999)

The achievement of this objective requires significant efforts on behalf of industrialized countries to reduce the GHG emissions. The Kyoto Protocol came into force on December 11<sup>th</sup> 1997 and makes it a legal obligation for some countries (i.e. developed countries and countries with economies in transition) to achieve a reduction of their emissions of greenhouse gases (GHGs) of at least 5% compared to 1990 levels, between the years 2008 and 2012.

### 3 Climate change and human health

Climate modification will affect human health. In some areas of the world, certain effects will be beneficial. However, most areas will experience negative impacts on human beings. Scientists globally estimate that the consequences are dangerous for human health. Changes in climate seen over the last few decades have already influenced human health. The World Health Organization (WHO) suggests that climate change was responsible for about 2.4% of diarrhoea cases in the world and of 6% of malaria cases in some Least Developed Countries (LDCs) in 2000 (McMichael et al. 2004). The first impacts of climate change on human health may be changes in location and seasonal distribution of some infectious diseases – included vector-borne infections such as malaria and dengue, and food borne infections (such as the salmonellas) which increase in the warmer months. An increase in average temperatures would alter the frequency of exposures of thermal extremes and their effects on health.

Climate change will have a wide range of consequences for public health, from the disturbance of natural and managed ecosystems, sea level rise, and migration due to the danger from engulfed lands, economic disruption and civil troubles (WHO, 2004).

In the Third Assessment Report, the IPCC concluded that: "Globally, climate change effects disastrous for health will be noticed particularly among poor populations, living principally in tropical and subtropical countries. Climate change can influence directly health (effects of thermal stress, loss of human being during floods and storms, for example), and indirectly after modification of vectors of the diseases (mosquitoes for example), of water borne diseases, of quality of water and air and the availability and quality of foods. The real incidences on health will largely depend on local environmental conditions and of the socioeconomic context, as well as the social, institutional, technological, behavioural measures of adaptation taken to reduce all of the sanitary risks."



The alteration of the land cover (deforestation, fragmentation of habitat) caused by drought and human activities provides evidence of environmental disturbances with harmful effects on both human and animal health (Patz, 2005). Some of these disturbances can directly or indirectly interfere with the actors of the biological cycle of a pathogenic agent: agents of diseases, such as mosquitoes or other harmful animals. For instance, rodents may proliferate in a favourable environment and transmit disease to people. Parasites and pathogenic agents (bacteria, fungus, virus, etc...) play a major role in the operation of ecosystems and their influence on communities (human, animal, and vegetation). In fact, they regulate and deregulate the balance of the ecosystems naturally established over time. In addition, a reduction or degradation of the quality of water resources has both direct and indirect impacts on human health and sanitation; the prevalence of water-borne diseases and the resurgence of endemic disease are a threat to public health.

#### 4 Current context

The current capacity of countries to address environmental hazards and infectious disease will determine the capacity they have to cope with the health impacts of climate change. It is therefore important to understand general demographic, health system, and mortality characteristics of the three countries in West Africa. Current health indicators for Benin, Mali, and Mauritania are described in Table 1.

Table 1: **Selected demographic, health system, and mortality indicators** (WHOSIS, 2008)

Indicator	Mauritania	Mali	Benin
Population total	3 044 000	11 968 000	8 760 000
Population annual growth rate (%)	2.7	3	3.1
Population living below poverty line (% living on < US\$1 per day)	25.9 <sup>C</sup>	36.1 <sup>C</sup>	30.9 <sup>C</sup>
Population proportion under 15 years (%)	40	48	44
Children <5 years of age stunted for age (%)	39.5 <sup>B</sup>	42.7 <sup>C</sup>	43.1
Children <5 years of age underweight for age (%)	30.4 <sup>B</sup>	30.1 <sup>C</sup>	18.4
Environment and public health workers density (per 10 000 population)	-	<1.0 <sup>B</sup>	<1.0 <sup>B</sup>
General government expenditure on health as percentage of total government expenditure	5 <sup>A</sup>	12 <sup>A</sup>	13.5 <sup>A</sup>
Adult mortality rate (probability of dying between 15 to 60 years per 1000 population)	288	427	327
Under-5 mortality rate (probability of dying by age 5 per 1000 live births)	125	217	148
Infant mortality rate (per 1 000 live births)	78	119	88
Deaths among children under five years of age due to diarrhoeal diseases (%)	16.2 <sup>C</sup>	18.3 <sup>D</sup>	17.1 <sup>D</sup>
Deaths among children under five years of age due to malaria (%)	12.2 <sup>C</sup>	16.9 <sup>D</sup>	27.2 <sup>D</sup>
Population with sustainable access to improved drinking water sources (%) Total	60	60	65
" " (%) Urban	70	86	78
" " (%) Rural	54	48	57
Population with sustainable access to improved sanitation (%) Total	24	45	30
" " (%) Urban	44	59	59
" " (%) Rural	10	39	11

Data from 2006 unless indicated: <sup>A</sup>2005, <sup>B</sup>2004, <sup>C</sup>2003, <sup>D</sup>2000

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## 4.1 Mauritania

Mauritania is located between the 15th and the 27th north parallels and is limited to the north by the Western Sahara, to the north-east by Algeria, to the south-east by Mali, to the south by Senegal, and to the west by the Atlantic Ocean (figure 2). 70% of its total area is desert, thus, without any doubt, Mauritania belongs to the southern part of the Sahara. Except for a small piece of land located in the south of the 16th north parallel along the Senegal River, the “Republic of Sands” as named by Daure-Serfaty (1993), has a yearly rainfall under 100 mm over most of its territory. This vast country of 1,030,700 square kilometres comprises an amazingly large range of landscapes: sand dunes fixed by a thin vegetation, moving sand dunes, rocky plateaus, oueds, and oases.

Only the valley of the Senegal River at south border of the country (about 20%) is favourable to agricultural development (Faye, 1997; Dia & Diagana 2000; Ouls Soule, 2002).

At the administrative level, Mauritania is divided into 13 wilayas, including Nouakchott and Nouadhibou, the main cities in the country. Both cities are located on the coastline; Nouakchott is the administrative capital city, and Nouadhibou the economic capital city. Mauritania is the homeland of 2,548,157 inhabitants who live in 40% of the area of the its territory. According to the 2001 census, Mauritania has a young population (50% under 18) with a growth rate of 2.6% (WHO, 2000; Niang, 2005).

The health situation in Mauritania ranks it as 111<sup>th</sup> out of 191 (country members of the WHO) and it is in the 169<sup>th</sup> position in term of the global performance of its health system. The likelihood of untimely death in the country is 378/1000 for men and 317/1000 for women (WHO report about health in the world, 2000).

The health system in Mauritania consists of centrally managed structures composed of directorates broken down into services, which in turn are divided into subdivisions. The main mission of all the different parts of the health system is to develop a national health policy and to plan, control, monitor and evaluate the social and health programmes in the country (Niang, 2005).

Health is a major concern for the government in Mauritania, so the health system has gone through a series of reforms: IV Health Plan (1981 – 1985), the first health master plan 1991 – 1994 enabled an increase in health coverage to 75%, the second master health plan 1998 – 2002, and the Medium term Budgetary Framework 2002 – 2004.

In spite of the great efforts made, the health situation in Mauritania is still of concern because of the lack of infrastructure, personnel and access to some health centres due to their remoteness. For instance, the number of health staff in the country, for all categories, is 1499 for an estimated need of 2322, which is a gap of 823. Furthermore, there is 1 physician for 18464 inhabitants (SNIS reports 2003 and 2004).

The risks related to emergencies and natural or incidental disasters and their responses have not been evaluated and there is no plan to address them.

## 5 Climate change in West Africa

The chapter on Africa in the IPCC Fourth Assessment Report indicates the following impacts of climate change in West Africa (Boko et al. 2007):

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- In general, a warming trend has been observed over the African continent. Between 1961 and 2000, there was an increase in the number of warm spells over western Africa, and a decrease in the number of extremely cold days.
  - Trends in precipitation are less consistent because of its high spatial and temporal variability. In West Africa, a decrease in annual rainfall has been observed since the end of the 1960s, with a decrease of 20 to 40% noted between the periods 1931-1960 and 1968-1990.

Future projections:

- All of Africa is very likely to warm during this century. The warming is very likely to be larger than the global, annual mean warming throughout the continent and in all seasons, with the drier subtropical regions warming more than the tropics.
- Annual rainfall is likely to decrease in much of Mediterranean Africa and the northern Sahara, with the likelihood of a decrease in rainfall increasing towards north Africa.
- It is uncertain how rainfall in the Sahel, the Guinean Coast and the southern Sahara will evolve in this century.



Figure 2: The location of Mali, Mauritania and Benin in West Africa

### 5.1 Climate zones in Benin

The climate of Benin is determined by the African monsoon. There are two rainy seasons and two dry seasons:

- A great rainy season from mid-march to mid-July
- A dry season from mid-July to mid-September
- A small rainy season from mid-September to mid-November
- A great dry season from mid-November to mid-march

Rainfall is mainly between March and July with a maximum of 300mm to 500mm in July. The monthly average temperature varies between 27° and 31° centigrade. February and April are the hottest months, July and September are the coolest ones.

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## 5.2 Climate zones in Mali

The climate of Mali is also determined by the African monsoon. Climate zones range from subtropical to arid (in the Sahel). There are three main seasons:

- rainy season - June to November
- hot and dry - February to June
- cool and dry - November to February

Most of the country lies in the southern Sahara, which produces a hot, dust-laden harmattan haze common during dry seasons. The country extends southwest through the subtropical Sahel to the Sudanian savanna zone.

## 5.3 Climate zones in Mauritania

Mauritania is located in both a tropical region with summer and autumn rains and a Mediterranean region with a few winter rains. The yearly rainfall increases from north to south, and it is more important in the southern part of the country. The rainy season lasts from July to October with its peak in August. There are three seasons in Mauritania: the rainy season /winter (mid-July – September), the cold season (October – February), and the hot season (March – mid-July). The rainy season is highly variable in timing and length.

Mauritania can be divided into four climate zones with unequal importance in regard to their area: the coastline, the Saharan zone, the Sahel zone, and the Sudanese zone. Each of these zones is characterized by its vegetation, and its climatic and biological features.

- The *coastline* zone has very scarce rains, under the influence of the Açore anticyclone, which makes a maritime trade-wind blow almost throughout the year (Gauthier-Pilters, 1969; Ould Soule, 2002).
- The *Saharan* zone covering around 70% of the country total area is located in the northern and most of the eastern part of the country. The weather is mostly hot and dry with variable daily and yearly temperatures and very low average rainfall. Nomadic pastoral practices with migrations with camels and a few livestock are the main economic activities in this zone.
- The *Sahel* zone climate varies according to the seasons; the weather is dry during the winter and rainy in the summer. The Sahel zone has considerable pastoral potential.
- The *Sudanese* zone is located in the Guidimakha region corresponding to the northern limit of the dry savanna. This zone presents a high agricultural potential and is favourable to rain crops and for pasture.

## 6 Climate change capacity

### 6.1 Benin

Benin has begun to address capacity strengthening through the following projects: CCTRAIN (1997-1999), the First National Communication (FNC) (MEHU, 2001), national strategy of UNFCCC implementation in Benin (MEHU, 2003). In the FNC, vulnerability studies focused on the following sectors: agriculture, water resources, forestry, health and others. According to the IPCC and WHO, expected climate change impacts on the

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health sector are important because of their many environmental and socio-economical implications. Diseases such as onchocerciasis, cerebrospinal meningitis and bilharzia need further study, and particularly Malaria which is a priority for follow-up strategies in the Public Health Ministry (PHM) and in need of considerable mobilisation of financial resources. At present, the government's "Roll Back Malaria" programme does not address the problem of climate change, thus all efforts presently made under this programme could go to waste by the beginning of 2025-2050.

The environment is composed of a set of factors (physical, chemical, economic, social, cultural and political) which influence one another (WHO 1992). It exerts an influence on human health. In particular, Neuvy (1991), Leroy (1994) and Pamy (1995) stress the relationship between human health and the quality of water.

The NAPA – Programme d'action national d'adaptation aux changements climatiques due Benin (PANA-BENIN) – was completed in January 2008. Although this document addresses adaptation responses to climate change impacts on the coast and water availability, it does not address the public health concerns of climate change.

## **6.2 Mali**

Mali has respected its commitments by signing and approving the UNFCCC/CCNUCC and Kyoto Protocol and taking part in most of the work of the Intergovernmental Committee for negotiation which led to the development of Convention. Activities carried out in Mali within the framework of climate change include:

- The Regional Programme for capacity building coordinated by ENDA TIERS MONDE, Programme Energie (Dakar), covering Ghana, Kenya, Mali and Zimbabwe in 1996.
- The First national communication (FNC) developed and introduced at the Conference of the Parties in the Netherlands in November 2000.
- The second national communication (SNC) is being developed to update GSE inventories in Mali and propose means for reducing greenhouse gases and for adaptation.

The Mali NAPA – Programme d'Action National d'Adaptation aux Changements Climatiques – was completed in 2007. This document addresses the impacts of climate change on health. It recommends public health responses in relation to infectious diseases such as malaria.

## **6.3 Mauritania**

The Islamic Republic of Mauritania ratified the UNFCCC in 1994 and the Kyoto Protocol in 2005. The First National Communication was submitted in 2002.

The Mauritania NAPA (NAPA RIM). Programme d'Action National d'Adaptation aux Changements Climatiques – was completed in 2004. This document did not address the impacts of climate change on health.

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## Section II

### 7 Case study: Climate and meningitis in Mali

#### 7.1 Introduction

The highest burden of meningococcal disease occurs in sub-Saharan Africa, which is known as the "Meningitis Belt", an area that stretches from Senegal in the west to Ethiopia in the east, with an estimated total population of 300 million people (WHO 2003). Mali lies within the Meningitis Belt and experiences the highest endemicity and epidemic frequency of meningococcal meningitis in Africa. Meningococcal disease is very serious, and admission to a hospital or health centre is necessary. The main treatment is with antimicrobial therapy.

The spatial distribution, intensity and seasonality of meningococcal (epidemic) meningitis is associated with climatic and environmental factors, particularly drought (IPCC 2007). Studies have shown that climate plays an important part in the year to year variability in transmission, including the timing of the seasonal onset of the disease (Sultan et al. 2005). Meningitis is conditioned by two climatic factors, which are the harmatan, which starts in dry season and rains provoked by the monsoon.

Table 2 lists the number of cases by district from 2004 to 2005. The District of Bamako registered the largest number of cases.

Table 2 Situation on meningitis in the Republic of Mali from 2004 to 2005.

	No cases 2004	No deaths 2004	No cases 2005	No deaths 2005
Kayes	109	4	6	0
Koulikoro	224	16	70	7
Sikasso	209	19	127	6
Segou	96	7	41	2
Mopti	64	4	36	1
Timbuctu	48	2	8	2
Gao	14	1	2	1
Bamako	735	4	164	1
Kidal	1	0	0	0
<b>TOTAL</b>	<b>1500</b>	<b>57</b>	<b>454</b>	<b>20</b>

Source: Ministry of Health. General Secretariat, National Direction for health: *Local Health information yearbook system*

There has been an improvement in the epidemiological monitoring system:

- Improvements in health coverage (the creation of 94 new Community Health Centres; 660 as of 31 December 2003, 699 as of 31 December 2004 and 753 as of 31 December 2005),
- Improvements in attendance of services and in the acquisition of data,
- Improvements in taking charge of cases and the pre-positioning of medicines,
- Training of agents in control of taking charge of cases,
- Participation of people in the documentation of cases.

#### *Seasonal patterns*

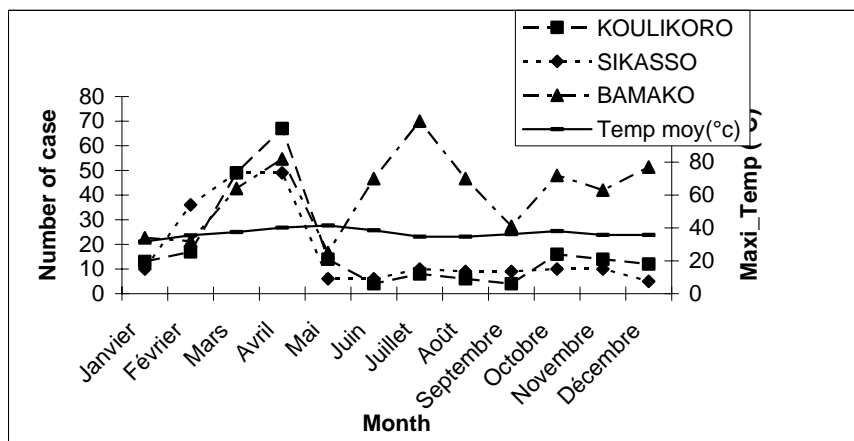
The disease is reported all the year, but most cases occur from January to May with resumption in October for the regions of Koulikoro and Sikaso (Figure 3). The district of

Bamako presents a particularity in 2004 with 4 peaks (April, July, October and December). The largest peak is situated in July (the rainy season). The maximum temperature in this period was 37°C.

In 2004 the regions of Sikasso, Koulikoro, Kayes and Ségou experienced a peak in March / April, and the others in April / May. Resumption is noticed in October for the regions of Koulikoro and Sikasso. It is only in the rainy seasons (July, August and September) that the number of cases decreases.

In the regions of Ségou, Mopti, Timbuctu, Gao and Kidal it is difficult to find a direct relationship between the climatic elements and the number of cases of meningitis.

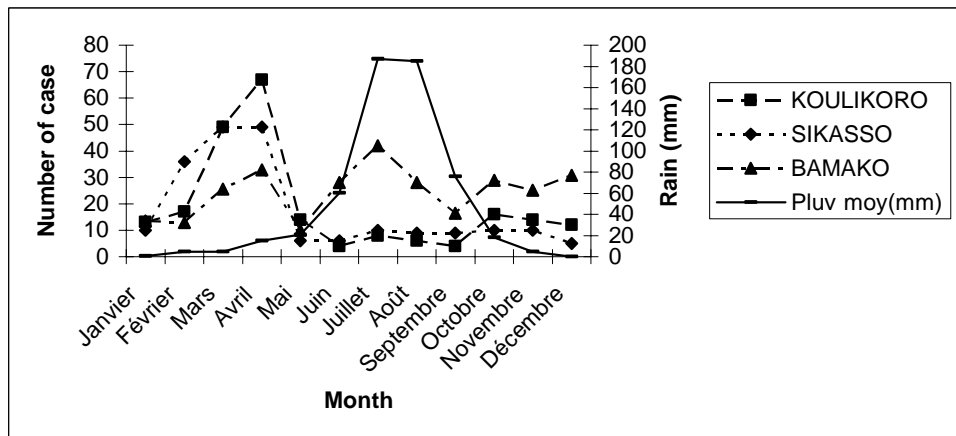
Figure 3: Number of cases of meningitis and maximum average temperature in the two regions south of Mali and the district of Bamako in 2004



Source: Local Health information yearbook system

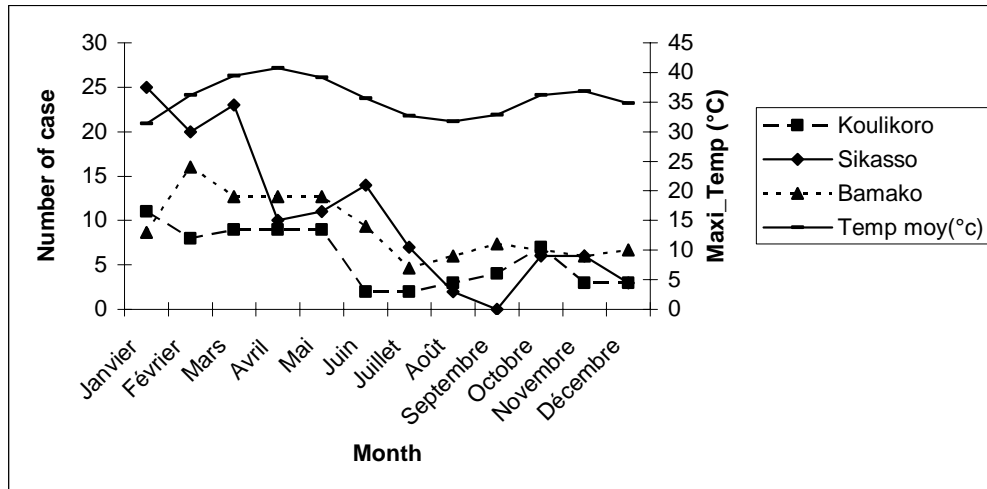
*Rainfall and temperature effects*

Figure 4a: Association between cases of meningitis and rainfall in the two regions south of Mali and the district of Bamako in 2004



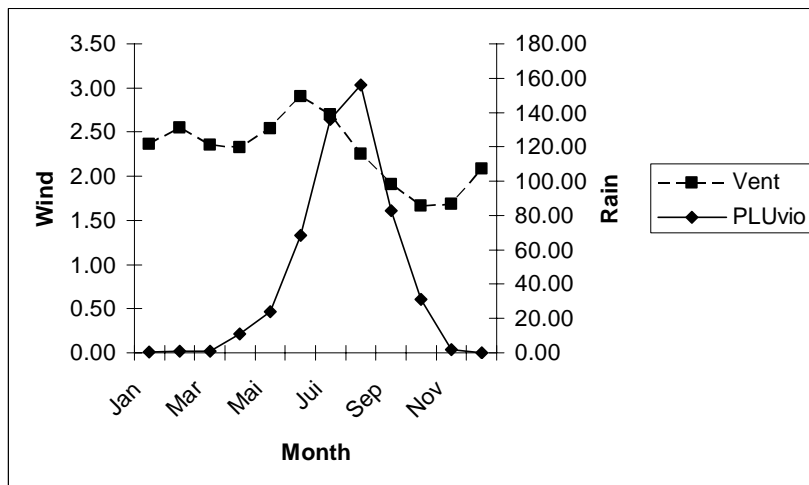
Source: Local Health information yearbook system

Figure 4b: Association between cases of meningitis and temperature in the two regions in the south of Mali and the district of Bamako in 2004



Source: Local Health information yearbook system

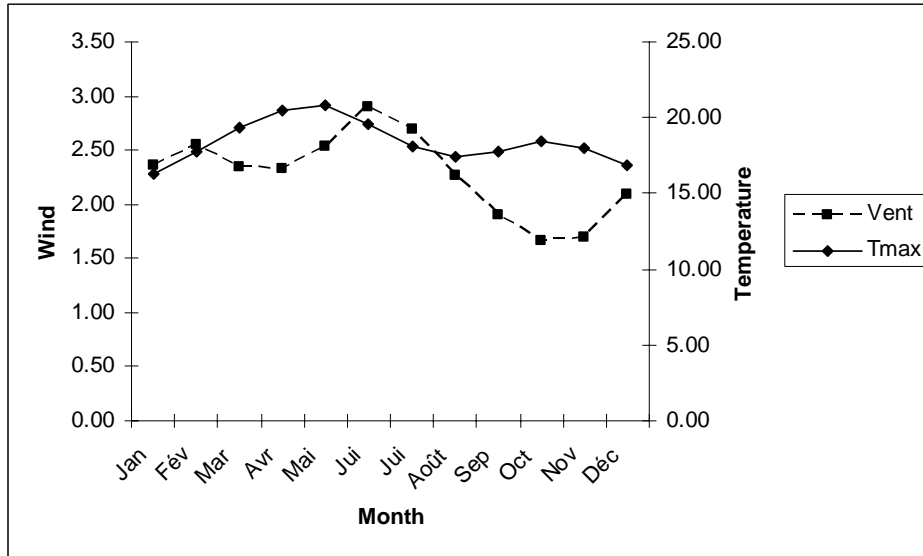
Figure 5: Variation of the wind in relation to rain from 2000 to 2005 (national average)



Source: National Direction for the Meteorology

Figure 6: Variation in the temperature in relation to the wind from 2000 to 2005 (national average)





Source: National Direction for the Meteorology

## 7.2 Conclusions

This case study suggests that meningitis is affected by climatic factors but that these effects are dependant on the location. Rainfall and temperature seem to be the more important climatic factors in this case, particularly rainfall, as transmission ends with the onset of the rains.

As climate variability is likely to be affected by climate change in the future, the seasonal patterns of meningitis may change.

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## 8 Case study: Climate and malaria in Cotonou, Benin

### 8.1 Introduction

Malaria constitutes a major problem for public health in Africa in general and particularly in Benin. The average incidence of malaria in 2001 was of 118 out of 1000 inhabitants. This incidence is much higher in children (459 per 1000 children under one year and 218 per 1000 children under 5) (Annuaire des Statistiques Sanitaires: 2001, Public Health Ministry). The economic impacts of malaria are enormous. The situation is made worse by the lack of consultation at health centres. Benin has a Strategy Plan (2001-2005) to Roll Back Malaria in Benin with the objective of halving mortality and morbidity due to malaria by 2010.

This case study examined the effects of climate variability on malaria in Cotonou (population 665,100), the economic capital of Benin. Cotonou is a low-lying coastal city, vulnerable to increases in sea level rise, floods and coastal erosion (Dossou & Dossou, 2007).

**Table 3: Indicators of poverty in Cotonou (2004)**

Population not having access to clean water (%)	Rate of illiteracy 6 years old and more (%)	Rate of mortality for less than 5 years old (for 1000 births)	Index of human poverty (IPH)	Incidence of poverty PO (%)	Depth of poverty (P1)	Severity of poverty (P2)
1,9	28,9	71,2	20,9	32,9	0,073	0,025

Source: INSAE, December 2006

The population of Cotonou has high levels of poverty (Table 3). Those without access to clean water in Cotonou number about 13,000. The incidence of poverty is estimated at nearly 219,000 inhabitants. The threshold income under which people are defined as poor is estimated to be 165,000 CFA a year in Cotonou. Environmental conditions, particularly in low-income areas, are very poor and constitute an important determinant of public health.

Cotonou has many serious environmental problems and is subject to frequent flooding, especially in the two rainy seasons (Figure 3). This flooding facilitates mosquito breeding and leads to an increase in malaria transmission.

Malaria is transmitted by several species of *Anopheles* mosquito. The transmission of malaria is sensitive to climatic factors as the duration of the sporogonic cycle varies from 10 to 40 days according to the temperature. The cycle stops when the average temperature is less than 16°C for *Plasmodium vivax* or 18°C for *Plasmodium falciparum* (Gentilini, 1993). *Plasmodium falciparum* is the most dangerous species of malaria pathogen; the one which kills. It is also the most widespread in tropical areas. The temperature in Cotonou is not a factor which serves to limit the increase in mosquito numbers causing malaria. Temperature increases may prove an asset for the expansion of mosquito-causing malaria to increasingly favourable ecological zones.

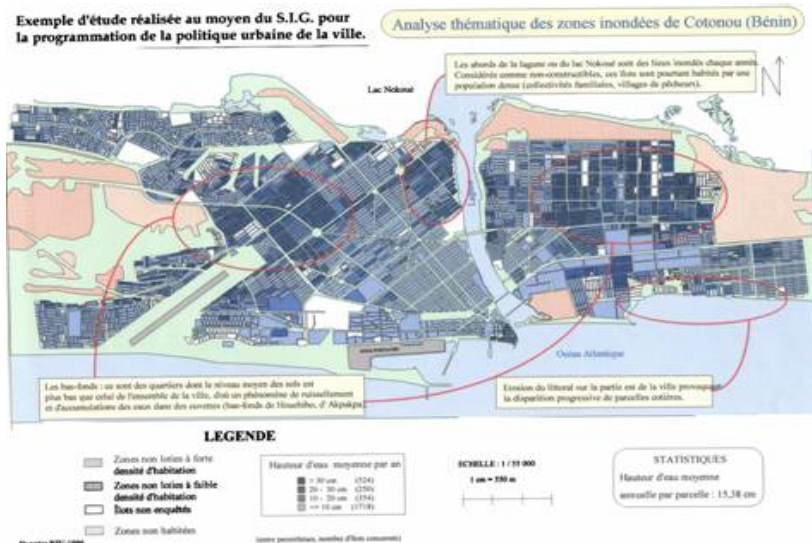


Figure 7: Map of flooded zones of the town of Cotonou

### Objectives and methods

The specific objectives of this study were to:

- Evaluate the impacts of climate and future climate change on malaria in Cotonou.
- Determine the costs related to the treatment of malaria with climate change.

The main method used is the judgment of experts associated with assessments of vulnerability to climate change. Data used are as follows:

- Climatic data come from ACECNA bases and university works
- Epidemiological data collected from the "Annuaire Statistiques du SNIGS au MSP".
- Socio-demographic data of Cotonou collected from National Institute of Statistics and Economic Analysis (INSAE).

Statistics used come from statistics directories and from different levels of the medical establishment in Cotonou. These statistics include the number of cases of patients with either simple malaria or severe malaria.

## 8.2 Results and analyses

### Analysis of malaria cases in Cotonou

In Cotonou, more than 800,000 cases of malaria have been treated between 1996 and 2004 (Table 4). There is wide variation between the 6 arrondissements in Cotonou, some of which may be due to differences in population size. The years 2003 and 2002 recorded the highest numbers of malaria cases while 1998 posted the lowest rate.

Table 4: Number of severe malaria cases in the 6 areas of Cotonou from 1996 to 2004

arrondissements	1996	1997	1998	1999	2000	2001	2002	2003	2004
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Cotonou I		9	1	1	286	237	1321	1667	968
Cotonou II	241	493	83	445	204	543	669	1135	270
Cotonou III	26	9	6	261	547	1224	1310	1373	1302
Cotonou IV	55	7	1	79	112	1565	3417	3117	1625
Cotonou V	176	155	208	993	792	1389	3711	3015	1754
Cotonou VI	600	755	259	77	465	1051	2711	2857	4272
<b>Cotonou</b>	<b>1098</b>	<b>1428</b>	<b>558</b>	<b>1856</b>	<b>2406</b>	<b>6009</b>	<b>13139</b>	<b>13164</b>	<b>10191</b>

Source: MSP/SSDRO, 2006 computations results

The greatest proportion of cases of severe malaria are in younger persons: 15 years and more (34%) and 1-4 years (30%). The reported frequencies are lower in the portion of ages 0-11 months and 5-14 years with 16% and 20 % respectively, but this may be due to higher mortality in these age groups.

The rate of health centre visits remains low in Cotonou. Not all the inhabitants of Cotonou are able to go to health centres when they are struck down by malaria. Rates of visits to health centres are fairly high in Cotonou arrondissements 1 and 6, but the rate remains low in the other areas of Cotonou.

From 1999 to 2000, a progressively increasing trend is reported. The malaria cases also have a strong seasonal pattern. Figure 8 shows that the number of malaria cases increases during rainy periods.

Overall, the increase in malaria cases shows the importance of precipitation in Cotonou. Indeed, after a period of rain, one notices a remarkable increase of malaria cases. The end of precipitation offers favourable conditions for the spreading of mosquitoes causing malaria by providing breeding sites. During this period, the temperatures are relatively low.

Figure 8: Seasonal pattern of malaria cases from 1996-2004 in Cotonou

Many parameters intervene as factors that influence malaria transmission: anaemia, severe respiratory infection, diarrhoeal diseases and malnutrition. Factors related to hygiene and waste management also affect sanitary risks. In Cotonou, one can buy waste in order to fill up the holes in swamps in order to make a home. In spite of these unconventional practises, many non-evacuated wastes (61%) still remain. The town of Cotonou produces nearly 400 tons a day.

Cotonou is a town belonging to the tropical zone and is characterized by high temperatures. It is not clear what the effect of climate change will be on the number of malaria cases. The main vector (*Anopheles* female) benefits from favourable climatic conditions. Climate change may affect both water and sanitation in Cotonou as well as its socioeconomic conditions.

Current climate conditions are favourable for mosquitoes and reported cases of malaria are increasing. The population is increasing in Cotonou. The number of malaria cases may therefore increase if nothing is done to increase public awareness and improve living conditions.

### 8.3 The future climate and impacts on malaria in Cotonou

Climate models project rates of warming in Benin. Climatic scenarios have been created for Benin (5° and 15° latitudes North) (MEHU, 2001), assuming increases in temperature from 1°C to 2.5°C. The scenarios used temperature and rainfall data from the meteorological station of Cotonou airport. Temperature change scenarios are based on results from simulations made with the model MAGICC SCENGEN. Scenarios of changes in rainfall patterns are based on the analogical scenarios of the increase of rain-gauging in Benin.

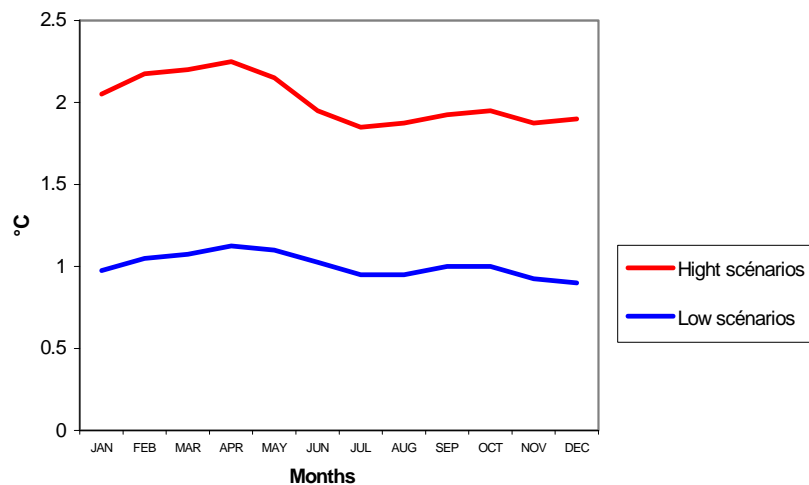


Figure 9: Change of the average monthly temperature in Beninese latitudes by 2100

Starting from the “climate normal” 1961-1990 situation, the scenarios used are of analogical types. One considers an increase of the rain-gauging from a middle analogue state to the following extreme events: either a dry or very wet analogical scenario (MEHU, 2001).

Table 5: Water heights according to the rain-gauging scenarios considered in Cotonou

Stations	Normal 1961-90	Extreme wet	Extreme dry	Increase in mm expected by scenario		Horizon of projection
Cotonou	1303 (mm)	1976 (mm)	908 (mm)	Scen. dry	- 30,3%	2100
				Scen. wet	+ 50,6%	

				Scen. wet	+ 30,0%	
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Source: MEHU, 2001

In reality, climatic scenarios are combinations of the scenarios for temperature variation with rain-gauging measurements. These are:

- Scenario 1 (Scen Tmin\_Analdry): less increase of the average temperature expected in 2100 (1°C) and the increase of the rain-gauging toward the dry analogy;
- Scenario 2 (Scén Tmin\_Analwet): less increase of the average temperature expected in 2100 (1°C) and the increase of the rain-gauging toward the wet analogy;
- Scenario 3 (Scén Tmax\_Analdry): relatively high increase of the average temperature in 2100 (2.5°C) and the increase of the rain-gauging toward the dry analogy;
- Scenario 4 (Scén Tmax\_Analwet): relatively high increase of the average temperature in 2100 (2.5°C) and the increase of the rain-gauging toward the wet analogy.

An increase in temperature of 1°C could increase the evapotranspiration from 6 to 8%. Greater increases would involve more increases in evaporation. Small increases in temperature would increase the rain deficit from 5.1% to 7.2% under a dry analogic scenario and would decrease from 3.6 to 9.6% in case of wet analogic scenarios. Cotonou seems particularly sensitive to climate variability. The strong increases in temperature expected in 2100 would cause more accentuated variations considering water evaporation rates. The deficit could increase from 6.1% to 8.2% in cases of dry analogical scenarios and decrease from 1.8% to 6.6% in the case of wet analogical scenarios.

Figure 10: Impacts on the bi-modal, average and extreme rain-gauging rating in Cotonou (6°21N)

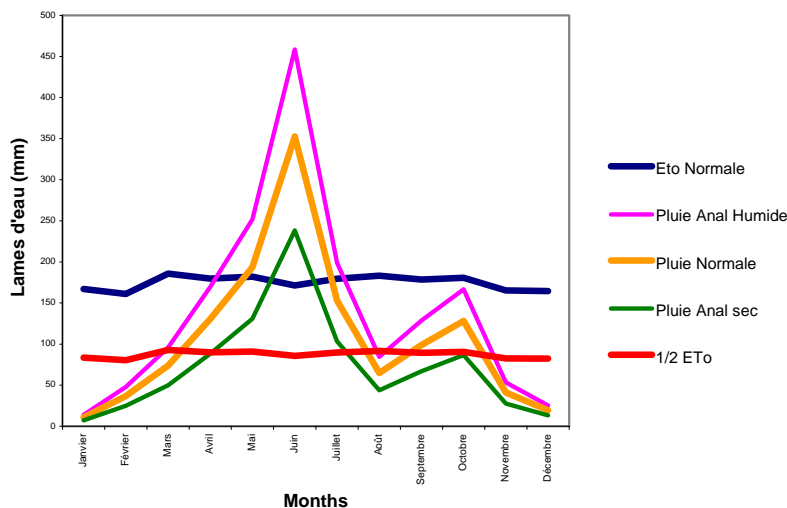


Table 6. Change in dry and wet months by 2100.

Analogical dry	Normal	Analogical wet
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Dry months	Wet months	Dry months	Wet months	Dry months	Wet months
8 months	4 months	6 months	6 months	4 months	8 months

Source: MEHU, 2001

Predicted changes in rainfall towards the dry analogical scenario show an increasing risk of more dry months (see Table 6). On the other hand, projected rainfall changes towards the wet analogical scenario would decrease the number of dry months in the year.

#### *Socio-economic scenarios*

Changes in socio-economic factors in Benin have also been modelled. These are described in Table 7. These have been adapted to consider health futures.

#### ***Pessimistic scenario***

1. Failure of strategies conducted by various programmes to fight/prevent epidemics over the last 12 years, due to bad management, corruption and disorder.
2. Increase in child morbidity rate and infectious diseases.
3. Extension of areas prone to larval lodging due to an increase in the ease with which some zones are flooded.
4. Diseases spread and health centres are badly managed.
5. Deficiency in hygiene and basic cleansing systems.
6. Resistance to current drugs grows.
7. An increase in private health centres.
8. Reduced frequentation of public health centres.
9. This situation would increase the influence of malaria and subsequently the expense of tackling it.

#### ***Optimistic scenario***

1. Optimum results from the strategies used by various programmes to fight/prevent epidemics over the last 12 years.
2. Reduced rates of child morbidity and vector-borne diseases.
3. Almost complete control of entire larval lodging zones.
4. Policies and action to reduce swamps.
5. An effective strategy from the Ministry in charge of environment and the Direction of Technical Services in the town of Cotonou.
6. Good coverage and use of impregnated mosquito nets.
7. Reduced use of chemicals to control mosquitoes.
8. Reduction in the costs of treatment at public health centres.
9. Introduction of an effective 'Ecohealthsystem'.

In this scenario, the biophysical environment, socio-economic conditions, hygiene and basic cleansing systems are controlled. Malaria vectors diminish leading to a reduction in the influence of malaria and subsequently the expenses incurred tackling it.

**Table 7: Characterization of socio-economic scenarios to 2025**

<b>Axes</b>	<b>OPTIMISTIC (ALAFIA)</b>	<b>PESSIMIST (WAHALA)</b>
Socio-cultural plan	Development of powerful social services, educational systems that respond to the needs of the market, restoration of social values	Unemployment and insecurity, corruption, popular vindication
Institutional plan	Consolidation of institutions, rooting them in democratic principles	Laxity of state, bad governorship, disastrous national situation

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Economic plan	Economic growth, formal sector development, employment promotion, increases in exports	Partnerships refused, insecurity of goods and people, no employment creation
External plan	Regain the external environment	Contempt of the diaspora, deterioration of relations with neighbours
Environmental plan	Land of hospitality, sharing the fruits of growth together	Deforestation, damage to soils, disastrous urban policies, important regional disparities
Technological plan	Modernization of agriculture and industry	Technical training schools which fail to give the required training, non-functional documentation centres

Source: Adapted from Rivertwin, 2006

## 8.4 Discussion

Methods used are based on recommendations from the IPCC, which took particular account of the case of malaria. A careful study conducted on a daily scale could be used to appreciate in more detail the daily impact of climatic and environmental parameters on malaria. Such a study is particularly suitable for the study of the lifecycle of the vector and would help us better appreciate the influence of the climate, especially during the periods of March-April and October, corresponding to the beginning and the end of the rainy season.

The sixth arrondissement – Houéoussou - shows a high risk of malaria, as do the quarters bordering Nokoué Lake located in Cotonou North (Vossa, Awansori-agué, Towéta- ladjì, Agbanto *et cetera*). It is advisable to study the vulnerability and adaptation of others areas (Sainte Rita, Houyiho, Agla *et cetera*) located in the North of Cotonou where there are swamps. Regarding observations on Nokoué Lake (Bokonon-Ganta, 1998), storms of mosquitoes rise from the lake and move to Abomey-Calavi every evening.

Mosquito nets are very efficient measures to prevent mosquito bites, but are not usually well used. The financial incapacity of parents to get many mosquito nets for their numerous children constrain them to putting all their children under one mosquito net. By doing this, the children find themselves lying next to the edge of the mosquito nets and thus exposed to mosquito bites. Mosquito nets have long been known to offer good physical individual protection, but are often badly used, especially by people sleeping on mats, most of whom are children living in the poorest quarters of Cotonou. Badly maintained and perforated, the mosquito nets do not fulfil their role and can even act as mosquito traps. Their use is not widespread because of the cost of acquiring them in spite of efforts by the government (mothers with children under five years old receive help to acquire mosquito nets).

Cotonou is a town where the level of malaria endemicity is high. The formation of many larval lodgings during rainy seasons permanently favours the vectors of malaria. The highest incident rates are recorded one or two months after the rains peak. This period corresponds to changes in the vector lifecycle patterns. Women and children in precarious socio-economic conditions are the most vulnerable to malaria because of the high costs of malaria treatment.

This study presents the current situation regarding malaria in Cotonou, its importance, the vulnerability of different groups to it, and the numerous issues related to its expansion. Long-term consequences will be considerable if no adequate prevention measures are taken to limit malaria risks. In this context, better awareness of the roles of national (civil society) and international actors and also of existing links between adaptation to climate change and human health is necessary.



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## 9 Case study: climate and acute respiratory infections in Mauritania

### 9.1 Introduction

Acute Respiratory Infections (ARIs) are infections affecting the upper and lower parts of the respiratory system. They include all the pathologies affecting the respiratory and lung systems (ear infections, pneumonia, flu, myalgia cold, rhino-pharyngitis, bronchiole infections, acute bronchitis, scarlet fever and angina). They are infections usually affecting children and they cause 30 – 40% of hospitalization around the world (Aubry, 2007; WHO, 1987). They are usually caused by a virus or a bacterium and are transmitted through direct contact with respiratory secretions (healthy carriers). Cold, bronchitis and pneumonia are more frequent during the cold and the rainy seasons in countries in the South, are directly associated with the weather (room temperature and quantity of water in the atmosphere) and indirectly associated with the way of life and promiscuity of people, but when they are contracted during the hot season they become more serious (anonymous author, 1982). The morbidity of ARIs is influenced by other factors that will not be considered in this study.

### 9.2 ARI prevalence

ARIs are present throughout Mauritania but tend to be more frequent in southeastern regions, the centre and along the river. The regions affected are: Assaba (11.64%), Hodh El Gharbi (8.63%), Tagant (8.13%), the District of Nouakchott (8.71%) and the Brakna region (7.26%). This rising tendency could be explained by the fact that some regions are more prone to malnutrition and water quality problems combined with poverty contributing to a vicious circle of disease (CSA, 2006). Furthermore, zones with high population concentrations are subject to the proliferation of transmissible diseases, such as flu, pneumonia *et cetera*. The situation in Nouakchott could be related to the heavy concentration of people in the slums and in areas around the outskirts of the city, and is worsened by the microclimate in the areas prone to ARIs (data from SNIS).

### 9.3 Evolution of ARIs in the different regions of Mauritania

The study of the prevalence of ARIs in different parts of Mauritania has been carried out using three categories ranging as follows: less than 5,000 cases, more than 10,000 cases and less than 10,000 cases. It shows that the number of cases of ARIs seems to be increasing in all regions of Mauritania.

From 1991 to 1994, and in 1996, the lowest category (less than 5 000 cases) was more prevalent all over the country, and particularly prevalent in northern and central regions. 1995 is the only time in which an equal frequency of the three categories was observed. Since then there has been a renewed outbreak of ARIs, sometimes with serious epidemics. Only the Inchiri region is spared (with a predominance of under 5,000 cases). The two other categories – more than 10,000 cases and less than 10,000 cases - were observed in all other regions. There has been a proliferation of the more than 10,000 cases category since 2005 (except in the Inchiri and the Tiris Zemmour regions). Is this the beginning of the proliferation of ARIs in Mauritania? The objective of this study is to raise awareness about and analyse the data collected and to develop efficient decision making tools to help facilitate appropriate responses.

The study of statistics related to ARIs in all the wilayas in Mauritania shows that children between 0 and 5 and adults are affected most by acute respiratory infections.

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## 9.4 Climate and ARIs in Mauritania

Climatic projections from models approved by the IPCC predict a considerable reduction of rainfall in the southern part of the country and more frequent droughts by 2020 and 2050. Reduced rainfall will affect communities in Mauritania resulting in more malnutrition with its consequences and implications for the growth and development of children.

It is hard to establish a formal correlation between the weather and patterns seen in ARI prevalence in Mauritania for two main reasons: the fragmented nature of the available data, and the inadequacy of public examination of ARIs. However, this study produced some results, which can be interpreted even though they are not perfect.

Studying the data collected showed the challenges related to looking for correlations between the two observed climate parameters (rainfall and temperature) and both the region and the year without any regard for the pathology, which would facilitate interpretation. This study looked for correlations between these two climate parameters and the relevant ARI.

Predicted climate change will probably affect the health of millions of people, mainly those with low adaptive capacity (IPCC, 2007). Understanding the ecosystems of pathogenic organisms or pests will help address many of these public health concerns and facilitate the adoption of resistance and climate change adaptation strategies (Thomas, Guegan & Renaud, 2005). It is particularly important to mobilize resources and establish adaptation capacity in Mauritania, but this is costly. It is obvious, however, that waiting for passive adaptation to climate change will have harmful public health consequences.

## 9.5 Adaptation

Adaptation solutions in Mauritania should take into account different strategies according to the category of people concerned (medical staff, political leaders, civil society, communities). There should be on-going information sharing, education and communication amongst these different stakeholders about climate change and its effects on public health as well as about vital adaptive prevention measures. This should be conducted jointly by the communities and the authorities and should cover:

- scientific achievements in the field of climate change and its consequences for, and repercussions on, human health as this is the concern of and of interest to all Mauritanian citizens; and,
- the need to establish a health sensitization and education network for communities, primarily parents, to show them the seriousness of ARIs and the influence of climatic variation on ARI pathology.

Adaptation measures should draw the attention of the authorities in Mauritania and their counterparts to efficiently fight the threat of ARIs related to climate change. These measures are related to:

- the need to prevent the spread of winter infections, mainly ARIs, and to build country capacity in the field of sanitation. This should involve sensitization campaigns to collect and dispose of domestic waste, dry waste and waste water, and to disinfect water in drinking fountains at all levels (local, regional, national). These activities should be carried out in collaboration with communities;

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- the consequences of building accommodation in risky areas (for example, in Tintane, Kaedi and Lexeiba in 2007), and of creating new threats, for example building houses in areas at risk from flooding should be avoided (depressions, former river beds, dam basins, *et cetera*);
  - the creation of a health centre well equipped to treat the most vulnerable patients (young children and people over 65) and a prevention stock of essential and specific medicines and vaccines against ARIs. This centre should hold an adequate and competent staff able to follow up with patients.

## 9.6 Conclusions

This study of climate change, the quality of the environment and human health shows that such a case study cannot analyze all the aspects of such a vast topic. It is just the starting point of a larger longer-lasting project. The creation of a focus group composed of experts in different but complementary fields is one of the challenges that the government has to address.

Climate scenarios from climate change calculation models predict weather conditions tending to deteriorate by 2020 and 2050: low rainfall, more frequent droughts all over the country and higher temperatures in all regions are likely.

In light of the outcomes of this study of the correlation between ARIs, rainfall and temperature, and considering likely future climate scenarios, there are indications that the number of ARIs could rise considerably. This could pose a new threat to communities, particularly children, old people and women.

For this reason it is recommended that political leaders get involved and play an active part in the implementation of activities required by different stakeholders and social groups in the various regions of Mauritania. These include health, economic, social and demographic groupings. Taking into consideration the likely compromises between short-term economic profits and the long-term harmful health consequences of climate change could enable decision-makers to find solutions and ways forward to ensure efficient adaptation.

Despite its imperfections, this study suggests that climate change may affect ARIs. It also draws attention to the issue and raises awareness about the effects of climate change on health amongst different stakeholders and political leaders. The work carried out is a starting point for initiating an active policy for fighting ARIs. This policy should be based on a full comprehension of the impacts of climate change, the vulnerability and sensitivity of communities to these impacts, and the different adaptation options available to efficiently minimise the threat.

Acquiring adequate knowledge about the affect of climate change on ARIs and storing this in the official data bank is vital in order to enlighten different stakeholders about the consequences of their decisions. Furthermore, this could help researchers and experts evaluate the eventual impacts of climate variability and climate change at national, regional and local levels. This will contribute to the implementation of preventive measures and consequently help vulnerable communities respond to changes in the climate.

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## Section III

### 10 Key findings

This project has identified a range of concerns regarding the impact of climate change on health in West Africa. Several key conclusions can be drawn from the three case studies.

- That attribution to climate change (observed) should be made with extreme caution. Although it is tempting to attribute increases in infectious diseases to climate warming, there are many reasons why reported changes could occur, for example improved reporting, drug resistance, vector control failures, improved access to health care *et cetera*.
- Rainfall is very important in determining health effects, but the impacts of climate change on precipitation in this region are very uncertain.
- There is a lack of epidemiological (health) data that is of sufficient quality to examine associations with climate factors.
- There is also a lack of research capacity in the three countries and very little awareness of climate change.

The importance of current environmental problems should not be overlooked. For example, in Cotonou and Bamako, poor waste and water management leads to frequent flooding, that in turn leads to increases in malaria. Unfavourable poverty trends with general reductions in the quality of life and living conditions is also important.

The process of producing the three West African case studies concerning human health and climate change was full of meaningful lessons:

- In all case study countries the original consulting teams recruited were changed for a research team with multidisciplinary profiles or were reinforced by team members with multidisciplinary profiles.
- It was a new and difficult experience to build research teams able to offer expertise on human health and climate change in Benin, Mali and Mauritania. There were no existing experts available who could combine health and environment knowledge. Moreover climate change is so new that climate change experts are rare and frequently focus on issues unrelated to human health.
- Related to the objectives and main targets of the CLACC programme, the national workshops involved strong representation from civil society in terms of number and diversity. This was requested in the terms of reference. Policymakers, however, should have been considered as a strategic target stakeholder group (and they should have had a representative on the research group) as they have the power to decide to promote a better integration of climate change and its consequences for development issues into human health planning. For instance, the Ministries in charge of planning and finances should be deeply embedded in the study process if they are expected to be interested in the results, conclusions and recommendations of these studies and then to dedicate part of the national budget to adaptation measures and strategies that integrate climate change and human health into the core of each national development programme.
- At a local level, local authorities should have been represented in the research group also because the decentralization process involves the transfer of health responsibility to the local scale as primary service.

The three case studies provided interesting information on the links between climate change and health in West Africa. Correlations could be established between the two despite the lack of sufficient and coherent data over a sufficiently long time period. The available data and resulting analysis regarding the links between climate change and

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health are not enough strong and precise enough to document the degree of the correlation between the two.

The local context seems to play a significant role: the physical environment can be affected by domestic waste management facilities, air pollution and water sanitation initiatives. Institutional issues and human environmental issues could be more important determinants of health than climate change effects/impacts. They affect the human resources available to access drinking water, healthcare, healthy nutrition, *et cetera*. The prevalence of malaria is related to increases in temperature and changes in rainfall but also possibly to water sanitation in zones with very high population concentrations and without proper prevention systems to fight malaria. Links with poverty and the prevalence of vulnerable people living in exposed areas, affected by malnutrition, with insufficient information and awareness initiatives, are also probable.

In conclusion, it would be profitable for local and national stakeholders (who are supposed to be the main targeted beneficiaries of the case study outcomes) to extend the benefits emerging from these studies. This extension could mean further studies to analyse the role of climate change in the evolution of health issues and diseases in West Africa and to consider the role of both the physical and human environment and their interfering impacts. Such an extension would be a good sign of the total appropriation of the process launched by the CLACC programme and proof that local human resources are needed to follow up with the cross-sectoral approaches necessary to ensure a deep enough analysis of the issues.

Thematic studies related to climate change effects/impacts are particularly useful for the LDCs. These are the most vulnerable countries, and thus the countries that urgently need to document the problems exacerbated by climate change and to quickly find out what responses in terms of national adaptation strategies are most important, for example in the context of their National Adaptation Programmes of Adaptation.

## **11 Recommendations for adaptation policy to national authorities in charge public health and environment:**

- A rigorous follow up of the epidemiological readings and meteorological data could help better planning of the early and simple minimum activities designed to tackle severe cases of malaria.
- Planned early and simple minimum activities designed to tackle severe cases of malaria must take into account the need for care capacity reinforcement at the level of communal and local health centres by ensuring the availability of and access to 'Therapeutic Combinations based on Artémisinine' (TCA) throughout the year.
- Planning for sever cases of malaria must include ensuring the blood bank is well supplied.
- The use of mosquito nets impregnated with insecticides must be promoted throughout the year.
- Research capacity and the provision of equipment needs reinforcing. In this context, this study must be added to and supported with more data. Reinforcement of research capacity must include capacity related to traditional medicine.
- Capacity building of non-government organisations and associations involved in adaptation to climate change and working on other development issues is needed.
- Systems for interpreting epidemiological data need improving.
- Urgent adaptation projects must be implemented as a matter of priority in order to reduce social vulnerability and help people cope better with climatic stresses or the indirect effects of climate variability and climate change.

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- Environment cleansing in poorer areas needs improving, with good management of waste, rainwater and other waste water.
  - Environmental educational messages need popularization.
  - Messages about ways to fight disease vectors need to be applied correctly, along with awareness regarding the good use of antimalarial drugs

## 12 Research needs

- Deepening of the study regarding climate change impacts on malaria in Cotonou is required, along with improved knowledge about local and national adaptation measures in Benin.
- The study zone needs expanding along with an increase in the quantity and quality of observations on climate change and health issues.
- Similar studies on other diseases such as respiratory infections, and local and endo-epidemic pathologies such as measles, cerebrospinal meningitis, cholera *et cetera*, are needed.
- Knowledge needs deepening about vulnerability and adaptation in the following sectors: agriculture and food safety, energy, water management, forestry and land use.

Faced with the impacts of climate variability on the development of malaria and meningitis, the following should be developed:

- Appropriate information programmes and sensitization of the population and of decision makers,
- Development of operational research on the relationship between health and climate,
- Health policies that take climate change into account under strategies to combat disease.

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