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AfricaInteract: Enabling research-to-policy dialogue for adaptation to climate change in Africa

Review of research and policies for climate change adaptation in the health sector in West Africa

Seydou Doumbia[1], Abdulai Jalloh[2], Aliou Diouf[3]

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Authors'Affiliations

1. Principal Consultant, Department of Public Health, Faculté de Médecine and Odontostomatology, University of Sciences, Techniques and Technology of Bamako, BP 1805 Bamako, Mali

2. Programme Manager, Natural Resources Management Programme, Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles/West and Central African Council for Agricultural Research and Development (CORAF/WECARD), 7 Avenue Bourguiba, BP 48, cp 18523 Dakar, Senegal

3. Programme Officer, Climate Change, Natural Resource Management, Rural and Urban Development ENDA Energie-Environnement-Développement, 54 rue Carnot, BP 3370 Dakar, Senegal

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AfricaInteract is funded by the International Development Research Centre (IDRC) and coordinated by the West and Central African Council for Agricultural Research and Development (CORAF/WECARD) under the auspices of the Forum for Agricultural Research in Africa (FARA). The regional focus of *AfricaInteract* is based on the Regional Economic Communities in the four sub regions of sub-Saharan Africa. Focal organizations coordinating regional activities are as follows: The Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) – East Africa; Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN) – Southern Africa; Commission des Forets d'Afrique Centrale (COMIFAC) – Central Africa; and Energie-Environnement et Developpment (Enda) – West Africa.

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Abbreviations and Acronyms

COMNAC	Comité National sur les Changements Climatiques, Senegal
ECOWAS	Economic Community of West Africa States
HDSS	Health and Demographic Surveillance Systems
HIV/AIDS	Human immunodeficiency virus / acquired immunodeficiency syndrome
IDSR	Integrated Disease Surveillance and Response
INDEPTH	International Network for Demographic Evaluation of Populations and Health
IPCC	Intergovernmental Panel on Climate Change
LDC	Least Developed Country
LDCF	Least Developed Countries Fund
LF	Lymphatic Filariasis
NAPA	National Adaptation Programme of Action
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization

Executive Summary

Aim of and motivation for the review

The African continent is the most vulnerable region in the world to the impacts of climate change. While there is undisputed evidence that the climate is changing, there is a lot of uncertainty regarding the pace and extent of the impacts on the sub-regions of Africa. This review is aimed at identifying gaps in research and policymaking for climate change adaptation in the health sector in West Africa. The purpose is to provide information and insights that can be used to bring researchers and policymakers together to improve evidence-based policymaking that can enhance food security and protect populations vulnerable to the health impacts of climate change.

Methodology and scope of the review

This report is based on a systematic review of literature on climate change and related health risks, policy and adaptation strategy over the past 15 to 20 years. The search included a broad-based review of published, peer reviewed and grey literature and interviews. Priority was given to relationships between climate change and health risks and vulnerability in West African countries, with a focus on Ghana, Senegal and Nigeria.

Overview of key findings from each of the report sections

The West African region has the highest concentration of Least Developed Countries (LDCs) in the world, and the Sahel droughts provide one of the most dramatic examples worldwide of climate variability that has been directly and quantitatively measured. Climate-sensitive infectious and parasitic diseases are the leading causes of high mortality, accounting for more than 42 percent of all deaths. Weak health systems with insufficient and unsustainable financial resources undermine efforts to reduce the burden of these diseases. Sahelian areas of West Africa have been frequently subject to heat waves, but only a few studies have documented the impact. Strong association between higher temperature and daily mortality as well as between malnutrition and stunting were established using Health Demographic Surveillance System (HDSS) time series data. Compared with other regions, the relationship between climate and meningitis has been the most widely studied in West Africa and has shown evidence of a link between epidemics and changes in climatic conditions, including dust.

For water-borne and food-borne diseases: Temporal variability of cholera incidence and epidemics was consistently associated with both local rainfall and the global climate variability in coastal West African countries.

For vector-borne diseases: Of 14 diseases meeting World Health Organization (WHO) criteria for using climate data in predicting epidemics, 6 vector-borne diseases are present in West Africa. These are malaria, African trypanosomiasis, leishmaniasis, yellow fever, dengue and Rift Valley fever. These diseases, in addition to schistosomiasis, are already major contributors to the disease burden in West Africa. Among them malaria is the most studied, particularly in Sahelian regions where the decrease in malaria prevalence and incidence associated with decline of rainfall has been demonstrated.

In the case of HIV/AIDS: The links between climate change and human immunodeficiency virus / acquired immunodeficiency syndrome (HIV/AIDS) are still conjectural but they are becoming a subject of increasing concern and study. Based on the concept of hotspots, in which climatic factors play an important role, early warning systems for HIV/AIDS have been proposed.

In terms of health policy related to climate change: The potential for climate change to exacerbate health issues and the need for prevention and response systems for climate-related diseases are acknowledged in most National Adaptation Programmes of Action (NAPAs) and national climate communications. However, very few plans are comprehensive in their health-vulnerability assessment (e.g. lack of baseline epidemiological data for climate sensitive diseases and health conditions). There are more than three dozen multi-country projects that specifically aim to support adaptation within the region, but fewer than ten percent of them have a strong focus on human health. Although the Least Developed Countries Fund (LDCF) has approved the largest volume of adaptation finance for Africa, only four percent of funds are allocated to the health sector. Among the West African countries only Ghana, Nigeria and Senegal are listed among the top ten recipient countries by amount disbursed. Gender inequity is an important factor in the relationship between climate change and disease; therefore policies should be empowering for women and gender sensitive.

Overall conclusions and recommendations

This analysis reveals evidence of climate change impacts on health and a growing awareness of vulnerability to climate change among policymakers in West Africa. However, there is still need for more empirical evidence on the health effects of climate change taking into account country specificities.

A cross-disciplinary research agenda needs to be developed to enhance understanding of the health effects of climate change in different eco-climatic settings within West African countries, linking meteorology, climatology, other relevant sectors and health. The following recommendations are proposed:

- Encourage research for the development of early warning and early response systems including climate products and services for use in national policy and decision-making.
- Undertake research on more effective methods for communicating scientific results to stakeholders, including but not restricted to the use of new technologies.

- Provide support for investments in routine observation of climate, environmental and health phenomena through HDSS for integration of climate and environmental data.

- Train public health professionals and students to understand and demand appropriate climate and environmental information.

- Strengthen health systems by integrating environmental and health surveillance.

- Determine the most appropriate indicators for climate change and develop, test and validate models for these indicators in relation to disease transmission dynamics.

- Establish the development of trans-disciplinary research-for-policy frameworks for improving management of disease risks and related health threats under climate change conditions.

Introduction

The African continent has contributed the least to global greenhouse gas emissions, yet will be more vulnerable to the impacts of climate change than any other world region (World Bank 2009). Climate projections for Africa in this century include a likely average temperature increase of 1.5 to 4°C, which is higher than the reported global average (World Bank 2009; IPCC 2007). West Africa is one of the regions most vulnerable to climate change. There is broad expectation of a greater number of extremely dry and wet years in the Sahel region throughout this century, and for more severe droughts (Boko et al. 2007). Sea levels along the coast of West Africa could also rise by between 0.13 and 0.56m over the course of the century (McSweeney et al. 2010). Food and water security, livelihoods, shelter and health are all at risk as a result of the adverse effects of climate change.

Climate change may impact on health through a number of distinct mechanisms (Thomson et al. 2004). For example, it may impact directly through heat stress, or indirectly through: a) its role in determining agricultural output and conse¬quently food security, which directly affects nutritional status; b) its role in the economy, which might affect governance, health systems and hence access to disease prevention and health care; c) its role in determining seasonal and annual de-mographic processes (e.g. migration) increasing the likelihood of individuals contracting certain infectious diseases such as HIV/AIDS; and d) its impact on the spatial and temporal distribution of climate-related infectious diseases (e.g. malaria, Rift Valley fever and meningococcal meningitis). Many of these indirect mechanisms may also interact, and when climatic anomalies concur with societal vulnerability, they will increase health vulnerability and aggravate disease outcomes.

West Africa's vulnerability to climate change is related to a high regional reliance on climate-sensitive economic activities such as rain-fed agriculture, livestock rearing, fisheries and forestry (Boko et al. 2007). This socio-economic vulnerability correlates with poor health conditions in the region. The West African region (except for Cape Verde) has a life expectancy at birth below the world average, due to high mortality rates among children under five (up to 150 per 1,000 live births in some countries). The main causes of this high child mortality are malaria, acute respiratory infections, diarrhoea and malnutrition. In addition, a dozen other climate-sensitive diseases including vector born diseases, meningitis and HIV/AIDS are highly prevalent in West Africa and constitute the major disease burden in the region. While recognising that socio-economic, demographic and immunological factors play important roles in the vulnerability of communities to these diseases, climate variability plays its own role in increasing their incidence or in 'triggering' periodic epidemics (e.g. of disease such as meningitis and cholera).

While there is undisputed evidence and increasing awareness that the climate is changing, there is a lot of uncertainty regarding the pace and extent of the change, and the health impacts in communities. This uncertainty renders policy decision-making more complex and highlights the need for Africa to build its knowledge and analytical base and to strengthen the capacity of country and regional institutions in developing the evidence base needed to address climate change adaptation issues. At present, virtually all countries in West Africa have performed some stock-taking of the variability and change in the climate and of the impact of that change on livelihoods. The Least Developed Countries (LDCs), which include many countries in West Africa, have been supported by the United Nations Framework Convention on Climate Change (UNFCCC) to undertake National Adaptation Programmes of Action (NAPAs), while all remaining countries have, to varying degrees, pursued climate change adaptation measures on their own. Besides the fact that most NAPAs are generally viewed to have been inadequately designed and implemented, a regional perspective on climate change adaptation is yet to be fully realised.

There is growing research interest in and support for adaptation to climate change in Africa. It is thus imperative that the findings emerging from relevant research are actually applied and used to inform policymaking concerning climate change adaptation. It is critical that sector policies are appropriately informed by the existing body of knowledge on climate change and climate variability generated from scientific research. These policies should enable the health sector to build resilience against climate change and climate variability through adequate adaptation strategies and contribute to mitigation of climate change through the use of improved and innovative technologies and management practices. One important lesson that may have been learnt from the tragedy of the Sahelian crisis is that it perhaps had more to do with a general lack of preparedness than declining rainfall per se. This review will help to identify gaps in current climate change adaptation research and policies and measures needed to move from current practice to best practice.

The review was commissioned by AfricaInteract, a project coordinated by the West and Central African Council for Agricultural Research and Development (CORAF/WECARD) and funded by the International Development Research Centre (IDRC). The goal of the review is to enhance the knowledge base and to support research-based policy formulation for climate change adaptation in the health sector in sub-Saharan Africa. The review will address the following questions:

- What is the role of climate change challenges in the context of the multiple challenges and opportunities facing the health sector in the region?
- What is the current state of knowledge on adaptation to climate change in the health sector in the region? (section 4)

- What is the current state of knowledge on whether and how research findings are integrated in health sector policies in the region? (section 5)

- What are the major gaps in research on adaptation to climate change in the health sector? (section 6)

- What is needed to ensure that research findings are better integrated into health sector policies? (section 6)

- What is the current state of knowledge about the stakeholders involved with research and policy on adaptation to climate change in the health sector in the region, and how can stakeholder involvement be improved? (section 7)

The review identified gaps in public health preparedness to adapt to potential adverse health impacts of climate change in West Africa. Information generated from the review can be used to bring researchers and policymakers together to improve evidence-based policymaking that can enhance food security and protect populations vulnerable to health impacts of climate change.

2. Review Methodology

The review on climate change and related health risks, policy and adaptation strategy was conducted between February and April 2013. The search included a broad-based literature review using Google and specific thematic searches in additional databases including MEDLINE (http://www.nlm.nih.gov/medlineplus/) to find key references. The search focused on reviews in the relevant areas published in peer-reviewed and grey literature covering the last 15 to 20 years. The search for evidence of the link between climate change and diseases and health risks was performed on Pubmed (http://www.ncbi.nlm.nih.gov/pubmed) using the broad term 'climate change', filtered with the addition of specific diseases and health risks as listed:

- Vector-borne diseases: 'malaria', 'leishmaniasis', 'filariasis', 'yellow fever' and 'Rift Valley fever'

- Water-borne diseases: 'cholera'

- Air-borne diseases: 'acute respiratory infection', 'meningitis'

- 'HIV/AIDS'

- Other health risks such as 'malnutrition' and 'heat stress'

A second filter was made by adding 'Africa', 'West Africa' and then individual country names ('Ghana', 'Nigeria' and 'Senegal'). A separate search was done using the geographic terms along with 'climate change' and 'adaptation' to find papers on strategies and actions related to public health adaptation to climate change in West Africa. Reports from regional forums, expert meetings, Ministries of Health and non-governmental organisations were also examined for studies on climate change and health adaptation and policy. Contacts were made with colleagues from Ghana, Senegal, Nigeria, Burkina Faso and the African Centre of Meteorological Applications for Development (ACMAD) in Niger to obtain information on unpublished documents, papers and research projects dealing with these issues. The NAPAs for Senegal, Nigeria (National Adaptation Strategy and Plan of Action on Climate Change for Nigeria, NASPA-CCN) and Ghana (National Climate Change Policy Framework, NCCPF) were examined. These and other climate change-related project or policy documents (e.g. De Vit and Parry 2011) were reviewed to search for health related adaption strategies.

Health-related information was captured as follows: (i) identified health impacts; (ii) adaptation needs and proposed adaptation actions; and (iii) the implementation framework. The following criteria were assessed: 1) Potential health impacts, whether health was listed as one of the vulnerable sectors, comprehensiveness in the health vulnerability assessment (health-vulnerability assessment was considered to be comprehensive when a full range of potential health impacts was clearly specified), coverage of health aspects and gaps in the vulnerability assessment; 2) adaptation needs and proposed adaptation actions, inclusion of health in a list of adaptation actions and proposed health interventions; and 3) assessment of implementation framework, number of project profiles focused on health and health aspects covered by project profiles.

3. Overview of the Health Situation in the Region

3.1. Key facts for the health sector in West Africa

The West African region stretches from the southern fringes of the Sahara Desert to the Atlantic Ocean along the tropical coastal areas of the Gulf of Guinea. It encompasses hot dry desert, humid forest and savannah. The region has three landlocked countries (Burkina Faso, Niger and Mali) and the small island state of Cape Verde. Of all 16 countries in the region, only Cape Verde, Côte d'Ivoire, Ghana and Nigeria are not classified as LDCs. As such, the West African region has the highest concentration of LDCs in the world – many of which are experiencing a range of economic, social, ecological and climatic stresses. West African countries can be currently characterised by high population growth, young populations and high rates of poorly controlled urbanisation. Periodic war and civil unrest plague countries which are well endowed with natural resources,

resulting in large refugee/displaced populations in some of these.

Although the health of the population has improved remarkably over the last 50 years in the West African region, average life expectancy at birth remains around 50 years compared with 68 years for the rest of the world (WHO 2009). Life expectancy (male/female) figures vary across the three focus countries of this study: 54/59 in Senegal, 58/62 in Ghana and 46/49 in Nigeria. While under-five mortality has decreased overall from 165 per 1,000 in 1990 to 118 per 1,000 in 2009 (Kynast-Wolf et al. 2010; WHO 2009), it remains high in the region, with 120 under 5 deaths per 1,000 in Ghana, 150 per 1,000 in Senegal and 212 per 1,000 in Nigeria. Infectious and parasitic diseases remain the leading causes of this high mortality, accounting for more than 42 percent of all deaths. Globally, Africa accounts for nine out of every ten child deaths due to malaria; for nine out of every ten child deaths due to AIDS; and for half of the world's child deaths due to diarrhoeal diseases and pneumonia (WHO 2009). Special attention must be paid to diarrhoeal diseases, which cause almost 800,000 deaths annually (WHO 2011a; ECOWAS-SWAC 2007).

Malaria is the primary cause of morbidity and mortality in West Africa. Over a third of reported malaria cases on the continent occur in West Africa. Their distribution indicates a very strong concentration of cases in Nigeria and Ghana, which alone account for 40 percent of malaria cases reported in West Africa. West Africa is less affected by HIV/AIDS than the continent's southern and eastern regions, but no West African country is left untouched. HIV prevalence among the three focus countries is lowest in Senegal, where less than one percent of the adult population is HIV positive; in Ghana the rate is 1.5 percent, while in Nigeria it is 4.1 percent (UNIAIDS 2012). Other serious tropical diseases include meningitis, cholera and other diarrhoeal diseases, onchocerciasis, trypanosomiasis, dracunculiasis, schistosomiasis, leprosy and yellow fever. Acute respiratory diseases and malnutrition complete the landscape of the main pathologies. Some of these diseases are present in a specific geographic environment. For instance, onchocerciasis and epidemics of meningitis are particularly prevalent in the Sudano-Sahelian region. Other diseases remain limited to a few countries, such as Lassa fever in Côte d'Ivoire, Guinea and Sierra Leone and Buruli ulcer disease in the coastal countries between Côte d'Ivoire and Ghana (ECOWAS-SWAC 2007).

Weak health systems with insufficient financial resources undermine efforts to reduce the burden of these diseases. The per capita total expenditure on health in Africa is very low and has even decreased, from US$137 in 2000 to US$86 in 2007. In the three focus countries this expenditure is even lower, from US$67 in Ghana to US$59 in Nigeria and US$56 in Senegal. The number of health workers per inhabitant is also very low in West Africa. West Africa has on average one doctor for each 8,300 inhabitants, as compared to one for 435 in the United Kingdom and one for 170 in Cuba (ECOWAS-SWAC 2007).This distribution displays wide intra-regional disparities, with 70 percent of West Africa's doctors found in Nigeria alone, which houses 45 percent of the region's population. The result is a ratio of one doctor to 4,000 inhabitants in Nigeria, and a much more critical situation in countries such as Niger, Liberia and Sierra Leone, each with less than one doctor to 33,300 inhabitants.

Access to sanitation and drinking water are also essential factors. In Africa, only 60 percent of the total population has access to improved drinking water (85 percent of the urban population and 45 percent of the rural population). In West Africa, this rate varies from 50 percent to 80 percent. In Nigeria, Senegal and Ghana, the proportion of the population with access to improved water is 60 percent, 70 percent and 80 percent respectively.

3.2. The role of climate change challenges

Climate variability and land use changes have enormous impacts on health in West Africa. In certain countries of the region which are among the poorest in the world and are also vulnerable to the impacts of climate change, these may yet undermine the potential for achieving the Millennium Development Goals. The climate of West Africa ranges from the Saharan Desert, bounded by the 100mm mean annual rainfall isohyets, through the Sahelian zone, whose southern border is demarcated by the 400mm isohyet. South of this line is the savannah zone. Further south, the 1000mm isohyet marks the start of the forest-savannah mosaic zone. The timing of the rainy season in West Africa is highly predictable and is governed by the movement of the Inter Tropical Convergence Zone (Thomson et al. 2004). Rainfall in West Africa is the most significant determinant of the landscape in terms of natural vegetation and land use activity. The amount of annual rainfall at any geographic location depends heavily on the duration of the rainy season. During the dry period from January to March, the harmattan winds blow Saharan and Sahelian dust south-westwards across the region.

West Africa provides one of the most dramatic examples worldwide of climate variability that has been directly and quantitatively measured (Thomson et al. 2004). Annual rainfall across the Sahel and savannah zones fell by 20-30 percent between the 1930s and 1950s, and the region experienced famines in the 1970s and 1980s due to drought which not only affected the Sahel but extended southward to the Guinea coast (Thomson et al. 2004). Droughts in West Africa correlate with warm surface temperatures in the tropical South Atlantic, and thus sea surface temperature variability is instrumental in determining rainfall anomalies in the Sahel. The predictability of the rainy season and the length and character of the dry season are of great significance for health in view of the potential relationship of low humidity and dust with diseases such as respiratory infections (Molesworth et al. 2002a; 2002b).

In coastal areas of West Africa, the years 2007 and 2008 were marked by heavy rains causing flooding in several countries in the region, reflecting the occurrence of weather extremes. Cotonou in Benin and other cities on the West African coast are increasingly being inundated by seawater as a result of an increase in sea levels. Sea levels along the coast of West Africa could rise by between 0.13 and 0.56 meters over the course of the century (De Vit and Parry 2011). The most evident sign of climate change is a southward shift of the climate zones, e.g. a spread of the Sahara into the Sahelian zone. After the drought period of the early 1970s and 1980s, livestock density increased, resulting in an intensification of grazing pressure that has exacerbated this shift (Mertz et al. 2012; Cecchi et al. 2009; Wittig et al. 2007). All of the above elements have shown that the West African region is currently suffering the effects of climate change.

Climate and health interactions in West Africa

There are two main aspects to the interaction between climate and health:

- *Climate change can increase health hazards*

Climate change may directly impact on health through extreme high air temperatures that may contribute to deaths from cardiovascular and respiratory disease, particularly among elderly people. Many of the major killers in the region such as diarrhoeal diseases, malnutrition, vector-borne diseases such as malaria and other infectious disease are also highly climate-sensitive and are expected to worsen as the climate changes. Other less direct impacts on health operate through a number of distinct mechanisms including a) the impact of climate on food security and nutrition; b) its role in the economy, which has an impact on the affordability of maintaining nutritional status and accessing health care and preventative tools against disease (e.g. mosquito nets); and c) its role in determining seasonal and annual demographic processes by causing seasonal labour migration, which is common in the Sahel, as well as movement of environmental refugees, increasing the vulnerability of individuals to contracting certain infectious diseases such as HIV/AIDS, malaria and respiratory infections (Findley et al. 2005).

- *The health impacts are an outcome of a large number of factors such as economic status, access to health services, demographic patterns and environmental changes*

Climate change affects the social and environmental determinants of health – clean air, safe drinking water, sufficient food and secure shelter. Rising sea levels and increasingly extreme weather events will destroy homes, medical facilities and other essential services. A large proportion of the West African population lives within 60km of the sea in coastal areas. People may be forced to move, which in turn heightens the risk of a range of health effects, including mental disorders, injuries and communicable diseases.

Increasingly variable rainfall patterns are likely to affect the supply of fresh water. A lack of safe water can compromise hygiene and increase the risk of diarrhoeal disease. In extreme cases, water scarcity leads to drought and famine. Floods are also increasing in frequency and intensity in the region and may contaminate freshwater supplies, heighten the risk of water-borne diseases and create breeding grounds for disease-carrying insects such as mosquitoes. They also cause drownings and physical injuries, damage homes and disrupt the supply of medical and health services.

The vulnerability of West Africa's population to climate change is related to a high regional reliance on climate-sensitive economic activities such as rain-fed agriculture, livestock rearing, fisheries and forestry; the presence of large population clusters (approximately 40 percent of the regional population) in coastal urban areas (De Vit and Parry 2011); the low capacity of the region's social and ecological systems to cope with climatic extremes; and existing strains on ecosystem services due to processes such as loss of productivity and deforestation.

4. Research Related to Climate Change and Health

This section examines scientific evidence of health consequences of climate change in general but specifically in the West African region, including the impact of extreme weather events such as heat waves and flooding; the effect on infectious diseases (focusing mainly on vector- and water-borne diseases, food-borne diseases and HIV); the effect of changing levels of air pollutants and allergens; and, finally, malnutrition and population displacement. The causes of vulnerability to these health risks conditions and the options for strengthening adaptive capacity are also examined. Finally, we document adaptation strategies to these health risks and conditions in the region; lessons from adaptation projects and interventions to reduce the health impact of climate change in the region; and key barriers to adaptation.

4.1. Extreme weather events and disease

These include diseases associated with heat waves and food- and water-borne diseases.

4.1.1. Heat waves

The Intergovernmental Panel on Climate Change (IPCC) predicts with high confidence that climate change will lead to an increase in the number and intensity of heat waves. Over the past few decades hot days, hot nights and heat waves have already become more frequent, as seen for example with the European heat wave of 2003. Heat waves are often associated with increases in mortality, as a result of cardiovascular, cerebrovascular and respiratory diseases (McMichael et

al. 2006). The elderly, mentally ill and children are most vulnerable. Increasing urbanisation will also lead to greater risks – the urban heat effect means that temperatures in cities are often significantly higher than in rural areas. However, it is difficult to quantify the actual mortality impact of a particular heat wave because there is often short-term mortality displacement – many of the susceptible people would have died in the near future. The 2003 heat wave in Europe demonstrated the importance of early warning systems, a coordinated response and 'heat wave plans' providing advice on behavioural measures to reduce risk (Kettaneh et al. 2010; Bulbena et al. 2009; Morali et al. 2008; Wegner et al. 2008; Johnson et al. 2005). The World Health Organization (WHO) has also identified the need to improve the understanding of factors affecting vulnerability, and to assess how other social and environmental factors influence the impact of extreme heat events.

Although the Sahelian areas of West Africa have been frequently subject to heat waves, the health impacts of these events have been rarely documented. Two studies have examined the association between weather patterns and daily mortality using Health Demographic Surveillance System (HDSS) time series in Burkina Faso and in Ghana (Azongo 2012; Diboulo 2012). These studies found strong associations between higher temperature and higher daily mortality. In Burkina Faso, the short-term direct heat effect was particularly strong on the under-five child mortality rate. The rate of cardiovascular death is highest in April during the hot dry season (March–May), and mean monthly temperature is significantly related to mortality in elderly populations (Kynast-Wolf et al. 2010). Independent coherent effects and strong associations between rainfall events and daily mortality were also found, particularly in elderly populations. In Northern Ghana, short-term weather variability was also strongly associated with mortality. The associations appear to differ among different age and sex groups. The elderly and young children were found to be more susceptible to short-term temperature-related mortality, and males to medium short-term.

4.1.2. Water-related diseases

Water-related diseases include both water-borne (transmitted by ingestion) and water-washed (caused by lack of hygiene) diseases. The IPCC predicts that the burden of both types will be altered by climate change as a result of changes in rainfall, surface water availability and water quality. There are a number of routes including: 1) higher temperatures could have an effect on the microbiological and chemical contamination of water supplies; 2) extreme rainfall events and flooding could lead to contaminated water supplies and facilitate water-borne outbreaks of disease; and 3) the incidence of diarrhoeal disease is sensitive to temperature and rainfall. It is estimated that climate change will increase the risk of diarrhoeal diseases by up to ten percent in some regions by 2030. Water scarcity may also lead to the same source of water being used for a range of purposes, increasing the likelihood of contamination.

A growing amount of work recently has attempted to understand the environmental factors that influence the distribution of cholera, and to understand the link with plankton blooms, which are triggered by warmer sea surface temperatures. The causative agent of cholera, *Vibrio cholerae,* has been shown to be autochthonous to riverine, estuarine and coastal waters along with its host, the copepod, a significant member of the zooplankton community (Constantin de Magny et al. 2008). Temperature, salinity, rainfall and plankton have proven to be important factors in the ecology of *V. cholerae,* influencing the transmission of the disease.

In West Africa, since 1970 more than a dozen cholera epidemic outbreaks have been reported in several countries from coastal to Sahelian areas (Constantin de Magny et al. 2012; 2007). A strong link was found between those outbreaks of cholera and both the local variability of rainfall and the global climate variability quantified by the Indian Oscillation Index. Large and regional scale climate variability influences both the temporal dynamics and the spatial synchrony of cholera epidemics in human populations in the Gulf of Guinea, as has been described for two other tropical regions of the world, western South America and Bangladesh (Constantin de Magny et al. 2007). Ocean and climate patterns are useful predictors of cholera epidemics, with the dynamics of endemic cholera being related to climate and/or changes in the aquatic ecosystem (Constantin de Magny et al. 2008; WHO 2004).

4.1.3. Malnutrition

Malnutrition is one of the largest health crises worldwide: according to the UN Food and Agriculture Organization, approximately 790 million people in developing countries are malnourished (Lupien and Menza 2000). Climate change is likely to create an additional pressure on food supplies. Current models suggest that crop yields will increase at high and mid-latitudes but decrease at lower latitudes. The impact is likely to be particularly severe in Africa: it is projected that a 1-2°C rise will lead to a decrease in yields of up to 50 percent (for rain-fed agricultural crops) by 2020. The increasing frequency of droughts and floods would also have a devastating effect, particularly at the local level. A framework for the analysis of climate change challenges to food and nutrition security was developed by Tirado, M.C. et al (www.sunrayafrica.co.za) adapted from the framework of UNICEF (2000) and Black et al. (2008). This framework may be used to understand the link between climate change and nutrition. Climate variability and change considerably influence shocks, trends and seasonality observed and predicted in West African countries. These shocks, trend and seasonality are recognised in this framework to have considerable effects on under-nutrition and its causal pathways, and represent sources of stresses in the lives and livelihoods of exposed communities. Most studies on malnutrition and climate change emphasise food security and the projection of malnutrition alongside climate projections (Akrofi 2012; Lloyd et al. 2011; Ramin and McMichael 2009; Haile 2005). A study examining and projecting climate and health

trends in Mali, coupling FEWS NET climate data and DHS health data, suggests links between livelihoods and each measure of malnutrition as well as a link between climate and stunting (Jankowskaa et al. 2012). A 'front-line' of vulnerability, related to the transition between agricultural and pastoral livelihoods, was identified as an area where adaptation efforts might be usefully targeted. Stunting, a chronic outcome of malnutrition, is influenced by climate in addition to livelihood, presenting a more complicated picture for intervention and underscoring the need for future research to identify aspects of this climate-stunting pathway.

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4.2. Vector-borne diseases

Climate change is expected to have a particularly strong impact on vector-borne diseases. The WHO identified 14 candidate diseases meeting their criteria for potential in using climate information in predicting epidemics (WHO 2004), including six vector born diseases present in West Africa – malaria, African trypanosomiasis, leishmaniasis, yellow fever, dengue, Rift Valley fever – along with other non-vector-borne infectious diseases such as cholera and meningitis (Connor et al. 2006, Thomson et al. 2004). These diseases, in addition to tick-borne encephalitis and schistosomiasis, already make major contributions to the global burden of disease. The vectors – mosquitoes, ticks and flies – are climate sensitive. The most recent IPCC assessment concludes that climate change has already altered the distribution of some disease vectors and predicts, with high confidence, that there will continue to be an impact. A number of climatic variables – particularly temperature, humidity, rainfall and the El Niño Southern Oscillation (ENSO) – are known to affect both pathogen and vector, for example altering reproduction and survival rates (WHO 2005; Haines and Patz 2004).

Climate change is expected to lead to a number of different changes in the distribution of vector-borne diseases:

Geographical distribution: Rising temperatures may mean that a vector becomes sustainable at different latitudes and altitudes, exposing new populations to the disease.

Seasonal transmission: Changing temperatures may alter or lengthen the transmission season for a disease. Warmer temperatures can enhance vector breeding or reduce a pathogen's maturation period; warmer winters may allow more vectors to survive from one season to the next. On the other hand, very hot and dry conditions can reduce mosquito survival.

Increased incidence resulting from changing water levels: Mosquitoes need access to stagnant water in order to breed. Increasing numbers of floods may create new breeding sites; droughts and falling water levels can also lead to stagnant pools forming as lakes recede.

However, a number of other factors also affect the transmission of vector-borne infectious diseases. These may be socio-economic – for example, increasing population movements, the use of control interventions and drug resistance (Hay et al. 2002) and malnutrition – or environmental – including changes in land use, deforestation, changing agricultural practices and water management, or increasing urbanisation. The interaction between these factors is often complex, and there is considerable controversy as to the relative impact of climate change. Despite this uncertainty, an increasing number of studies have now demonstrated evidence for the effects of climate change on vector-borne diseases. Malaria has received the most attention but other diseases, including dengue, Ross River virus and Rift Valley fever have also been linked to climatic variation (Connor et al. 2006).

4.2.1. Malaria

Assessment of the potential impact of global climate change on the incidence of malaria suggests a widespread increase of risk due to expansion of the areas suitable for malaria transmission (Tanser et al. 2003; Martens et al. 1995). This predicted increase is most pronounced at the borders of endemic malaria areas and at higher altitudes within malarial areas. The incidence of infection is sensitive to climate changes in Sahelian areas where the disease is less endemic (Ermert et al. 2012). Other studies have shown a significant association between malaria infection and climate parameters such as seasonal environmental greenness (Egbendewe-Mondzozo et al. 2011; Thomson 2010; Thomson et al. 1999), as measured using the normalised difference vegetation index derived from satellite data.

The most obvious result of rainfall decline in West Africa is the associated change in malaria prevalence and incidence across the region (Doumbia et al. 2012; Thomson et al. 2004). A greater than 80 percent decline in malaria incidence has been observed in the semi-arid areas of northern Senegal, Mali and Niger from the early 1960s to the mid-1990s. This reduction is presumably associated with a loss of vector breeding sites and a shortening or reduction in intensity of the malaria transmission season as a result of lower vector survivorship. Different cytogenetypes and molecular forms of Anopheles gambiae s.s. have been found to be highly climate sensitive (Sogoba et al. 2008; Sogoba et al. 2007). Observations of malaria incidence before and after the droughts which have occurred since the 1970s indicate that in the Sahel (Niayes region, Senegal), endemic malaria decreased drastically after the disappearance of the principal mosquito vector, Anopheles funestus, due to the destruction of its larval sites by cultivation (Mouchet et al. 1996).

A study carried out in Niakhar, Senegal on the relationship between climate variability and the number of deaths attributable to malaria (Ndiaye et al. 2001) found a strong positive correlation between monthly rainfall series and monthly mortality series at one- and two-month lag. A particular situation due to flooding for agricultural production may cause malaria epidemics in the Sahel region, which has been suffering from severe drought for the last thirty years, with large deficits in the amount of annual rainfall (Faye et al. 1998). The resulting models can be used to predict changes in malaria prevalence or incidence rates resulting from different climate change scenarios (Tonnang et al. 2010; Thomson et al. 2006a; Ceccato et al. 2005; WHO 2004). Such early warning systems have been used in response to the increasingly epidemic nature of malaria transmission (WHO 2001) due to the Sahelian drought that affected large areas of semi-arid West Africa.

4.2.2. Filariasis

Lymphatic filariasis (LF) is a vector-borne infectious disease endemic in the tropics, including sub-Saharan Africa, and is thought to present the second largest public health burden of any disease worldwide (WHO 2004). The disease is transmitted to humans by infective mosquitoes that release parasitic filarial worms into the blood stream when taking a blood meal. Many patients are asymptomatic, but infection can lead to major debilitating conditions including lymphedema, which causes swelling of arms, legs, breasts and genitalia; and hydrocele, which causes swelling of the scrotum in males. LF is one of the most widely distributed vector-borne diseases in West Africa after malaria.

The geographical distribution of human infection with LF was investigated in four West African countries (Benin, Burkina Faso, Ghana and Togo) using a commercial immunochromatographic test for filarial antigen (Thomson et al. 2004; Gyapong et al. 2002). The results revealed that prevalence in the adult population of some communities exceeded 70 percent, and that over large areas of Burkina Faso community prevalence was between 30 and 50 percent. Most of Togo, southern Benin and much of southern Ghana appeared completely free of the infection. Although there were foci on the Ghanaian coast with prevalences of ten to 30 percent, such high prevalence did not extend into coastal Togo or costal Benin. It was estimated that populations at risk of LF may range from 543m to 804m currently, and depending on the climate change scenario this could rise to between 1.65bn and 1.86bn in the future (Slater and Michael 2012). How future changes in climate and population could affect the spread and burden of LF across Africa was examined through ecological niche modelling to map the disease's potential distribution. The model predicts a broad geographic distribution of LF in Africa extending from west to east across the middle region of the continent, with high probabilities of occurrence in West Africa. The model show for the first time that predicted climate change and population growth will expand both the range and risk of LF infection (and ultimately disease) in an endemic region.

4.2.3. Onchocerciasis:

Onchocerciasis, known as river blindness and transmitted by blackfly (Simulium damnosum), was formerly a devastating vector borne disease for rural populations of West Africa living near fast-flowing rivers. The disease has been controlled through one of the continent's most successful public health campaigns, carried out by the Onchocerchiasis Control Program (OCP) in 11 countries and involving more than 20 donors. Understanding the spatial and temporal distribution of the vector has been key to its successful control. Possible roles of deforestation and rainfall on the distribution of the vector have been reported (Walsh 1993), but there is little evidence of the impact of climate change on the human risk of onchocerciasis.

4.2.4. Yellow fever

The crossover of diseases from wild animals to livestock and from livestock to humans means animal health is also increasingly a public health issue. Given the rising importance of such zoonoses, a need for improved surveillance of emerging diseases in animals has been identified. The resurgence of vector-borne diseases and zoonoses is cited as an effect of climate change. Indeed, climate change will help increase animal reservoirs and the number of insect vectors, will extend the transmission cycle and will encourage the arrival of new insects or reservoirs in some regions because of the new climate conditions (Greer et al. 2008). We have examined the most common zoonoses in West Africa: Rift Valley fever, trypanosomiasis and leishmaniasis.

4.2.5. Animal health and zoonoses

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- ***Rift Valley fever (RVF)*** is a vector-borne viral zoonosis of increasing global importance. The RVF virus is transmitted either through exposure to infected animals or through bites from different species of infected mosquitoes, mainly of Aedes and Culex genera. These mosquitoes are very sensitive to environmental conditions, which may determine their presence, biology and abundance. RVF outbreaks are known to be closely associated with heavy rainfall events in East Africa and in the semi-arid regions of West Africa (Soti et al. 2012; El Mamy et al. 2011; Fontenille et al. 1998; Zeller et al. 1997). The relationship between climate change and RVF in West Africa has mostly been studied in Senegal (Mondet et al. 2005) where the importance of rainfall on the development of Aedes vexans arabiensis populations, one of the potential vectors of RVF, has been demonstrated. Herd movements and sufficient inter-site variability in rainfall, which drives mosquito emergence, has also been described in the mechanism of transmission of the disease (Favier et al. 2006). As a result, using rainfall distribution may contribute to the implementation of a new, operational early warning system for RVF based on environmental risks linked to climatic and environmental conditions (Vignolles et al. 2010; 2009; Tourre et al. 2009; 2008).

- ***African trypanosomiasis***

The analysis of the historical evolution of outbreaks of human African trypanosomiasis (sleeping sickness) transmitted by tsetse fly in the West African region is a clear example of the effects of changing climate and human population (Cecchi et al. 2009; Courtin et al. 2005). The authors argue that today, cases of human African trypanosomiasis are no longer observed in areas with less than 1,200mm of rainfall annually, which was not the case at the beginning of the twentieth century. The authors conclude that the change in rainfall and population concentrations explain the current distribution of human African trypanosomiasis in Africa. Outbreaks in West Africa are located along mangroves and in central Côte d'Ivoire.

- ***Leishmaniasis:***

Leishmaniasis is a vector-borne disease caused by blood and tissue dwelling protozoan parasite species belonging to the genus *Leishmania*. It is basically a disease of animals that gets into the human population when humans, flies and the animal reservoirs coexist in the same environment. Leishmaniasis is present in many West African countries, predominantly in Sahelian regions (Paz et al. 2011; Senghor et al. 2011; Faye et al. 2010; Boakye et al. 2005). An epidemic of cutaneous leishmaniasis was recently reported in forest humid areas of Ghana (Boakye et al. 2005), presumably linked to climatic conditions. Precipitation and temperature have an impact on the larval substrate of *Leishmania* parasites, which can only survive in a specific 'window' of soil moisture.

The vector abundance may be associated positively with temperature. However, evidence of the actual impact of climate change on the transmission of leishmaniasis with field-based data is still weak (Fernandez et al. 2012; Fischer et al. 2010). There is a scarcity of data on the link between climate change and leishmaniasis in West Africa. The authors usually point to the need for intensified monitoring of leishmaniasis because of intra- and inter-annual variability of incidence due to changes in distribution, abundance and diversity of competent vectors. These projections are based on expert knowledge of prevalence distribution or biology and current distribution of the vector, overlapped to a region or range of climatic conditions, usually temperature. The impact of climate change on leishmaniasis, although intuitively logical and currently in an ongoing stage, requires stronger biological evidence.

4.3 Immune disorders and respiratory diseases

Climate change will cause changes in the levels of air pollutants, the main concern being that higher temperatures are likely to lead to increased levels of ground-level ozone. Ozone is associated with a wide range of adverse respiratory conditions, including non-specific respiratory effects (coughing, airway irritation), reductions in lung function, aggravation of asthma in sensitive individuals and the worsening of symptoms of existing emphysema and bronchitis. Another health consequence is meningitis. In the Sahel countries, with reduced rainfall, the concentration of dust particles in the air increases (de Longueville et al. 2013). This seems to explain the recurrent annual epidemics of meningitis in countries like Burkina Faso and Niger (Agier et al. 2013; Yaka et al. 2008).

4.3.1. HIV/AIDS

The human immunodeficiency virus (HIV) destroys certain lymph cells that defend the body against microorganisms and cancer cells, thus impairing the body's immune system. Opportunistic infectious diseases and certain cancers may then develop. When a person is affected by a series of such diseases, they are said to suffer from acquired immunodeficiency syndrome

(AIDS). HIV/AIDS in Africa has had an unprecedented devastating impact: life expectancy has fallen drastically, millions of children have been orphaned, health professionals are being decimated by the disease and economies are being destroyed. In June 2006, 6.5m persons needed antiretroviral drugs, to which only 25 percent in low and medium income countries had access. Contrary to developed countries, women and girls are the most affected in Africa and the disease is predominantly transmitted through heterosexual intercourse. West Africa is less affected than the continent's southern and eastern regions, but no West African country is left untouched, with Côte d'Ivoire being the most affected: 7.1 percent of its adult population is estimated to be HIV positive (ECOWAS-SWAC 2007). Over the last few years, the epidemic has stabilised in most of the region's countries, along with reduced HIV incidence in Burkina Faso and Togo's urban areas. A similar trend has been observed in other West African countries, especially among adults of reproductive age and sex workers, many of whom are displaying increasingly safe sexual behaviour.

The links between climate change and HIV/AIDS are still conjectural but they are becoming a subject of increasing concern and study (Ramin and McMichael 2009; Suarez 2008; Gomes 2004). No study has really demonstrated a direct link between HIV/AIDS and climate change. Most of the studies have described scenarios where in practice, individuals will face multiple stresses from climate change (i.e. floods and malaria) concomitant with other non-climate stressors (i.e. HIV/AIDS, globalisation, etc.). These multiple sources of vulnerability must be considered when designing climate change and socioeconomic development interventions.

Climate adaptation can be weakened by HIV/AIDS: HIV/AIDS already impacts on environmental protection and climate in direct ways. For example, African governments have reported to the UNFCCC that the pandemic is eroding their capacity to implement climate adaptation measures, due to a lack of staff in environmental and emergency services. Moreover, in many countries other public services, particularly health care services, are breaking down because of a shortage of qualified personnel. Yet a vicious cycle of poverty is reinforced by HIV/AIDS and climate change together. The high cost of health care is the single most significant determining factor that drives the working poor into deeper financial difficulties.

The AIDS pandemic and population migration: The IPCC (2007) has suggested that 150 million environmental refugees will exist by 2050. Migrant populations are at higher risk of contracting HIV because of their status and the situations they face, e.g. poverty, discrimination, stigma, lack of access to information and other services and separation from families and partners. Migrant populations are often subject to poor and unstable living and working conditions. Such conditions usually mean that they have limited access to reliable and culturally appropriate information on HIV/AIDS and to health services. Even if health and social service authorities are prepared to assist migrant populations, they often encounter difficulties accessing them. Irregular migrants live in an indeterminate state, having no stay or work permit in the host country. Contact with official government agencies, even if related to health matters, increases the fear of deportation. HIV/AIDS may itself be a cause of mobility. People living with HIV may be driven to leave their homes because of stigma, discrimination and the lack of health services.

HIV/AIDS and water stress: Water stresses, whether floods or droughts, cause a high burden of disease. Susceptibility to HIV, and the body's capacity to live with the virus before the onset of AIDS, are related to general levels of health and hygiene. As climate change increases the chances of droughts and dry spells, the complex relationship between food security and HIV/AIDS can make matters worse for disaster management in two ways. It can increase the nutritional requirements of people living with the disease, by up to 150 percent for protein. It can also amplify the effect of drought on nutrition. This creates a vicious cycle: the inability to provide adequate nutrition in times of drought weakens the immune system and increases susceptibility to opportunistic infections, which in turn undermine the overall nutritional status. Of particular concern is the possibility that climate change could reduce income from natural resource-intensive activities such as farming and fishing, possibly driving more women into sex work and thereby increasing HIV infection rates.

4.3.2. Meningococcal meningitis

Neisseria meningitidis (the meningococcus) is responsible for endemic and epidemic meningococcal disease in Africa. In West Africa, meningococcal meningitis often occurs as extensive epidemics with many thousands of deaths, particularly in the so-called meningitis belt of sub-Saharan Africa. This belt is defined as an area between latitudes 4°N and 16°N where high incidence and recurring epidemics of cerebrospinal meningococcal meningitis coincide with the 300-1,100mm mean annual rainfall isohyets south of the Sahara (Thomson et al. 2004). Thus, the belt comprises much of semi-arid sub-Saharan Africa, and in particular the Sahel. epidemic waves occur every five to ten years in the Sahel region, mostly due to group A meningococci.

It has been clearly shown that the Sahel bears the greatest epidemic burden of meningococcal meningitis, with over two-thirds of documented outbreaks and high attack rates (Molesworth et al. 2002b). The geographic predominance of epidemics in the belt region and their seasonal occurrence at dry, dusty times of year, ceasing with the onset of the rains (Molesworth et al. 2001), suggest that environmental conditions are important, although the mechanisms by which they may work are poorly understood (Cuevas et al. 2007; Thomson et al. 2006b; Molesworth et al. 2002b). Predictive models based

on climate/environmental information can be developed (Thomson et al. 2006). The relationship between climate and meningitis has been most widely studied in West Africa, and the evidence indicates that the distribution of the epidemics is compatible with changes in the environment, particularly dust (Agier et al. 2013; de Longueville et al. 2013; Yaka et al. 2008).

5. Health Policies Related to Climate Change

African governments have made firm commitments in various forums to address climate change with an emphasis on health adaptation. Since 2008, several initiatives involving the WHO and United Nations agencies in collaboration with Member States and other partners led to the development of a framework for health adaptation to climate change. The framework provides guidance to enable African governments to translate the commitments into action (WHO/AFRO 2011b; WHO 2011).

5.1. Policies and strategies for climate change adaptation in the health sector

In August 2008, the First Interministerial Conference on Health and Environment in Africa adopted the Libreville Declaration in Gabon and established the Health and Environment Strategic Alliance as the basis for plans of joint action. In 2010, the Second Interministerial Conference on Health and Environment in Africa that took place in Luanda, Angola, adopting a Joint Statement on Climate Change and Health. In the Statement, African countries agreed to implement an essential public health package to enhance climate change resilience of the health sector. In December 2010, the Sixteenth Conference of Parties to the UNFCCC adopted a decision to establish the Cancun Adaptation Framework, which requires all parties to intensify action on adaptation to climate change including action for health.

The UNFCCC initiated NAPAs in 2002 in LDCs to help prioritise adaptation activities. Between 2004 and 2009, 41 LDCs (including 29 from Africa, 12 of these from West Africa) developed NAPAs. These programmes were prepared with a view to not only identifying the most immediate priority needs but also developing projects in response to these needs. An Action Plan has been prepared (WHO 2011) covering the following elements: 1) baseline risk and capacity assessments; 2) capacity building; 3) integrated environment and health surveillance; 4) awareness raising and social mobilization; 5) public health oriented environmental management; 6) scaling up of existing public health interventions; 7) strengthening of partnerships; and 8) promotion of research. However, more investment will be required if these proposals are to become reality across all countries in SSA.

5.2. Climate change considerations in national government health sector policies and strategies

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5.2.1. Senegal

- ***Adaptation needs and priorities***

Based on assessments completed through the development of its NAPA, Senegal has identified salt water intrusion, coastal zone inundation, drought, low water flows, storm surge and extreme temperatures as its main climate-related hazards (MEPN 2006). Senegal identified the following adaptation priorities and needs, classified by pillars (World Bank 2010): 1) Develop knowledge on climate change impacts and encourage the transfer of appropriate technologies; 2) Reinforce actions that prevent and mitigate climate change impacts in specified sectors (including human health – needs include continuing the battle against malaria and other illnesses and improving health insurance in high-risk sectors); and 3) Promotion of the sustainable management of natural resources in specified sectors.

- ***National level policies and strategic documents***

Senegal's key government policies and reports reflecting adaptation needs, priorities and planned actions include a national adaptation strategy to climate change (Adaptation Fund 2010: 13) but no more information exists on the strategy. In addition to having developed a NAPA and its National Communications, Senegal has set up a National Committee on Climate Change (COMNAC) that reports to the Minister of State. The role of COMNAC currently is to raise awareness of different groups on climate change, including the private sector, civil society, decision makers and academics. It has been proposed that a sub-committee on adaptation be created within COMNAC (UNDP and Government of Senegal 2009).

- ***Current adaptation action***

Senegal has identified more than two dozen projects, including policy formation and integration of all funding by international donors. Only one project includes health: 'An Ecosystems Approach to Managing Water and Health in the Context of Climate Change: Adaptive Strategies to Drought and Flooding in Four West African Countries.' It is also worth mentioning that a significant number of organisations in Senegal are devoted to improving adaptation capacities and increasing adaptation networks (often through sharing and apprenticeship).

- ***Proposed adaptation action***

Senegal has proposed five adaptation projects that cover a wide range of sectors identified as priority areas for intervention in its NAPA. The project 'Climate Change Adaptation Project in the Areas of Watershed Management and Water Retention', for which Senegal has received funding from the LCDF, responds to two of these priority areas. In addition, Senegal is one of ten countries in Africa that is part of a proposal submitted to the Special Climate Change Fund.

- ***Assessment***

Compared to other West African countries, Senegal has a relatively large number of ongoing adaptation projects, many of which involve capacity building activities. Most of the ongoing and planned projects focus on agriculture and coastal zone management and integrate water supply measures, not health, as a primary focus.

5.2.2. Ghana

- ***Adaptation needs and priorities***

Ghana has a tropical climate consisting of two seasons– the wet and dry seasons – with the rains occurring from approximately March until November. Southwest Ghana is hot and humid while the north is hot and dry (CIA 2011). According to Ghana's Ministry of Environment, Science and Technology (MEST 2000), average maximum temperatures are expected to increase by 3ºC in the northern savannah region and by 2.5ºC in other areas of the country by 2100. It is projected that annual rainfall will decrease in all areas except the High Rainforest Zone of southwest Ghana. An assessment of the country's vulnerability to climate change was presented in its Initial National Communication on Climate Change to the UNFCCC, submitted in 2001. Ghana's vulnerability was evaluated taking into account its water resources, coastal resources and some agricultural crops, and an analysis of the potential effects of a temperature rise, a decrease in rainfall and a rise in sea level. Based on this analysis, negative climate change impacts in Ghana are expected to include health problems, disruption of agricultural systems, flooding of coastal areas and low water levels that will affect operation of the only hydro-generating dam in the country, which produces 80 percent of the national electricity supply (MEST 2000). More recently, in its Medium-Term National Development Policy Framework (2010-2013), Ghana identified its main challenges with respect to climate change as being: a lack of awareness regarding climate change and its potential impacts in sectors like forestry and disaster preparedness; high dependency on natural resources; poor and inadequate infrastructure; limited human resources and financial capacity; and limited control over the availability of water needed to support hydropower generation (Government of Ghana 2010).

- ***National level policies and strategic documents***

The key adaptation document in Ghana at present is its Initial National Communication on Climate Change to the UNFCCC (Government of Ghana 2011). Importantly climate change (adaptation and mitigation) has been integrated into Ghana's Medium-Term National Development Policy Framework (2010-2013) (Government of Ghana 2010). One commitment within this plan is to ensure integration of climate change impacts into sectoral and district plans.

- ***Current adaptation action***

Ghana has one of the highest numbers of adaptation projects underway in the West African region, with 24 projects focused on sectors such as human health, freshwater resources, agriculture, urban sustainability, ecosystem conservation and enhancing the capacity of government to facilitate adaptive action. Four of these are health projects: 1) 'Capacity Development and Adaptation to Climate Change on Human Health Vulnerability', 2) 'Eco-Health Approach to the Control of Onchocerciasis in the Volta Basin of Ghana', 3) 'Climate Change and Human Health in Accra' and 4) 'Piloting Climate Change Adaptation to Protect Human Health'. All projects are funded by international donors.

- ***Proposed adaptation action***

In its Initial National Communication, Ghana identified seven key actions that it would like to see undertaken to reduce its vulnerability to the impacts of climate

change. It is unclear how many of these actions have been completed in the intervening ten years.

- ***Assessment***

Ghana's Initial National Communication proposes different types of policies and programs to adapt to climate change. The regional project 'Supporting Integrated and Comprehensive Approaches to Climate Change Adaptation' may contribute to Ghana's efforts to streamline adaptation into different policies. In terms of current adaptation action, although awareness raising and research projects have started, few projects with health-focused or community-based adaptation components are being undertaken. Most of the action currently underway focuses on agriculture and freshwater sectors. Ghana is also engaged in projects that include strong gender components, and in the areas of urban adaptation and ecosystem conservation. Although Ghana's Initial National Communication highlights the vulnerability of its coastal zones, no projects underway appear to specifically address this sector.

5.2.3. Nigeria

- ***Adaptation needs and priorities***

Nigeria has a diverse climate, ranging from equatorial in the south to tropical in the centre and arid in the north. Climate change projections suggest that minimum and maximum temperatures will rise 7oC or more in some parts of the country. Sea level rise is also very likely to threaten the country's coastal zone and low-lying islands, which are currently plagued with floods and erosion.

- ***National level policies and strategic documents***

At present, Nigeria's strategy for addressing the impacts of climate change is captured in its First National Communication on Climate Change. However, Nigeria has initiated the development of a National Adaptation Strategy and Plan of Action, which includes human health (Federal Ministry of Environment 2010).

- ***Current adaptation action***

A moderate number of adaptation-focused projects are currently underway in Nigeria, relative to other countries in West Africa. However, very few of these projects are health focused. Many of these projects focus on increasing awareness of the potential impacts of climate change, understanding potential impacts and supporting the government in building its capacity to address climate change impacts. Several projects address concerns in the agriculture sector; others focus on ecosystem conservation, freshwater sectors, gender and governance.

- ***Proposed adaptation action***

In its 2003 National Communication, Nigeria identified five priority projects for implementation at the national level. These projects focused primarily on increasing the availability of meteorological information, strengthening climate change modelling and increasing public awareness of the potential impacts of climate change.

- ***Assessment***

Current adaptation initiatives in Nigeria focus on the agricultural sector, ecosystem conservation and strengthening the capacity of the government to respond to climate change adaptation needs.

6. Gaps in Climate Change Adaptation Research and Policy in the Health Sector

Although many governments have made firm commitments to adapt to climate change, most are not yet prepared to cope with the negative health consequences of climate variability and change. In most West African countries, Action Plans have been prepared covering the following elements: baseline risk and capacity assessments; capacity building; integrated environment and health surveillance; awareness raising and social mobilisation; public health oriented environmental management; scaling up of existing public health interventions; strengthening of partnerships; and promotion of research.

6.1. Key research gaps on adaptation to climate change

Our review identified the following key research gaps on adaptation to climate change in the health sector in West Africa:

Gaps in understanding of how climate change affects climate sensitive diseases in West African countries.

Although there have been a number of studies in West Africa showing that climate change affects the environment and transmission patterns of parasitic infections such as malaria, trypanosomiasis and leishmaniasis, or other diseases such as cholera and diarrhoeal infections, there is little quantitative evidence of its overall impacts on health in individual countries. Through its impacts on environmentally sensitive sectors such as water, agriculture and food production, climate change may also adversely affect human health and vulnerability to disease. More research is needed at national and regional levels to better understand these impacts, with more rigorous assessments and building of the evidence base for public health adaptation strategies in NAPAs.

Gaps in understanding how other societal and environmental changes (e.g. migration, settlement in new areas) affects the changes in health hazards and risks. How does increased urbanisation in West Africa affect health risks, for example?

There is a need for comprehensive assessments of the risks posed by climate variability and change on population health. The analysis of health considerations within NAPAs indicated that there is very weak, limited and fragmented information and understanding of the vulnerability of countries to climate change. WHO has developed guidelines and tools for assessments of risks posed by climate variability and changes. These include tools for public health vulnerability and adaptation assessments and health systems assessments as well as other tools for health risk, hazard and emergency capacity assessments. Although the baseline risk assessment is mentioned in some West African countries' NAPAs, there is limited information on its implementation. Therefore, assessments are needed to establish the baseline situation of existing population vulnerability to climate-sensitive health risks and the degree to which health systems can effectively respond and manage these risks. These assessments will serve as an important first step in the enhancement of health and health-sector resilience to climate change and will take into consideration risks posed by projected long-term climate change.

Gaps in understanding of how individuals and societies can respond to changes in hazards.

There is a research gap in understanding local and indigenous knowledge coping/adaptation strategies and assessing their value for public health strategies. As countries comprise a variety of eco-climatic zones, it is also important to undertake research to understand local coping/adaptation strategies and assess their value for public health strategies. There is need for research and development of appropriate evidence for the development of early warning and early response systems including climate products and services for use in national policy and decision-making. As stated by the WHO:

> Timely detection of cases of illness in a community or region, above the normally expected level, is vital to ensure that health authorities and policy-makers are aware of the serious and immediate threat before them and to help them make decisions on effective control measures. (WHO 2001)

Gaps in availability of data and information systems for building evidence-based early warning systems.

Countries of the West African region are implementing the WHO's Integrated Disease Surveillance and Response (IDSR) strategy. The IDSR focuses on selected diseases including epidemic and climate-sensitive diseases such as malaria and cholera. However, the IDSR implementation is facing a number of issues and challenges that include data quality and use of aggregated data, and inadequate resources at the national, district and health facility levels resulting in delayed and incomplete reporting. The IDSR is unable to provide timely data for immediate decision-making. Information and analysis that feeds into decision-making processes remains poor at the local level. There have so far been limited attempts to integrate environmental data with public health data for a comprehensive and simultaneous action on both disease determinants and their outcomes. This results in delayed epidemic detection and response.

Risk factors for vulnerable population groups need to be investigated and research should be undertaken on the mechanisms of their vulnerability and opportunities for increased resilience. Support for investments in routine observation of climate, environmental and health phenomena pertinent to decision-making for climate-sensitive diseases and public health events is necessary. This can be achieved through meteorological services and health surveillance systems like the International Network for the Demographic Evaluation of Populations and Their Health (INDEPTH).

There is limited availability, access and use of quality assured climate, environmental, social and climate-sensitive disease data for use in policy relevant analysis. A major challenge for translating climate change assessments into adaptation policies and measures is persistent and deep uncertainty about future changes in climate conditions. For example, there is little consensus between different climate models, particularly regarding crucial changes in precipitation amount, timing and intensity. Uncertainty regarding future socio-economic states may be just as profound, yet climate vulnerability assessments commonly estimate the impacts of future climate changes based upon current social and economic conditions. This can lead to distorted perceptions of risk and appropriate adaptation responses. There is also need to determine the most appropriate indicators for climate change, and to develop, test and validate models using these indicators in relation to disease transmission dynamics.

6.2. Key policy gaps in climate change adaptation

In general the section will refer to government approaches and actions that address hardships and income losses related to health impacts accruing to populations that are vulnerable to climate change.

A glaring policy gap is the failure to give climate change the attention it deserves with regards to the potential adverse effects it will have, both directly and indirectly, on the health of the population. Most or virtually all the NAPAs have laid particular emphasis on the agricultural and energy sectors. There is need to clearly address issues related to health with regards to climate change adaptation.

Building adaptive capacity – the ability of a system to respond successfully to climate variability – includes changes in mechanisms such as government transfers (whether in the form of cash or services), in financial incentives implicit in social and other fiscal policies,

and in regulations (IPCC 2007). Few governments, if any, have clear cut provisions to handle health disasters related to climate change. Potential frameworks for this include disaster assistance, safety-net programs and approaches to lower the negative impacts on stressed communities. Effective use and availability of such response mechanisms contributes to overall adaptive capacity.

Coordination among ministries with regards to climate change is another issue. Because of the cross-cutting nature of health it is imperative that proper integration of approaches and coordination will help significantly in addressing health issues related to climate change.

There is no policy related to required ratios of different categories of health workers in relation to the population in general. There is certainly no policy for the required number of health workers in case of health disasters related to climate change. Associated with the number of personnel is the provision of adequate and special training for personnel to handle health issues related to climate change.

6.3. Options and possible policy spaces for improved uptake of research findings

The foregoing has clearly demonstrated the need for informed policymaking with regards to climate change adaptation, particularly in the health sector.

Governments have the opportunity to increase funding to research through a mechanism that will ensure that there are effective linkages for the joint identification of key issues to be researched and joint decisions on how the process can be managed. This involves setting up structures that will facilitate cross-disciplinarity and cross-sectorality in government. It also involves health policy expertise, both in policy research and implementation of this expertise in real world situations through whole government and whole society approaches for policy development. This will ensure that there is a channel for reporting back on results with increased possibilities for effective sharing of research results. Through this process policymakers will be able to use scientific evidence to design policies.

In addition to funding streams, it is absolutely important that platforms like AfricaInteract are effectively used by both researchers and policymakers to interact and capitalise on synergies in climate change adaptation. The nature and coverage of AfricaInteract provides an opportunity, not only for bringing together the relevant stakeholders within a region and enabling exchange and learning; it also enables learning from other regions where the platform is operating.

7. An Analysis of Stakeholders and Opportunities for Collaboration

7.1. Key institutional actors in the region

At the regional and national levels, there is a variety of intergovernmental and national policy initiatives in West African countries to address adaptation to climate change (De Vit and Parry 2011).

At regional level, a Regional Plan of Action for Reducing Vulnerability to Climate Change in West Africa was launched in 2010 by the Economic Community of West African States (ECOWAS). The plan seeks to develop the mechanisms, stakeholders and capacity needed to support governments' and communities' efforts for adaption. If this Regional Plan can enhance adaptive capacity in West Africa, as countries share priority adaptation needs, its implementation faces barriers such as the low capacity of sub-regional institutions and organisations, and a difficulty in mobilising financial resources.

Key research institutions and networks involved in health and climate change in the region, based on published papers, include Université Cheick Anta Diop in Dakar, University of Ghana, University of Ibadan, Malaria Research and Training Center at University of Bamako, University of Ouagadougou and Centre de Recherche Médicale et Sanitaire (CERMES) in Niger. In addition to those institutions, the following constitute important resources for climate and health research and response:

- The Permanent Interstate Committee for Drought Control in the Sahel or Comité permanent inter-État de lutte contre la sécheresse au Sahel (www.cilss.bf/CILSS) is a partnership to pool resources in an effort to minimise the impacts of future droughts in Sahelian communities. CILSS has two institutions, the AGRHYMET (Agro-Hydro-Meteorological) Regional Centre (http://www.usbr.gov/pn/agrimet/wxdata.html) in charge of agriculture, hydrology and meteorology; and the Sahel Institute, specialising in the facilitation of exchange between national systems.

- The West African Health Organization (WAHO) is a specialised health institution that is part of ECOWAS. Its mandate is to help Member States to deliver a high quality of health care for their people. In the second strategic plan (2009–2013), the development of research for health is one of the ten programmes. There is little focus

on climate change in this document. The strategic objective of this programme is to facilitate health research in the ECOWAS sub-region. The expected outcomes are to establish a network of ECOWAS researchers and promote the operational research centres of excellence. WAHO intervention strategies are oriented according to four axes: stewardship, financing operational research, strengthening capacities and promoting utilisation of research for health results. Though climate change effects were addressed by ECOWAS in developing a regional plan to reduce impacts for the population, this plan is mostly agriculturally and environmentally oriented. WAHO offers an opportunity to build and strengthen a regional plan for adaptation to climate change in the health sector in West Africa and has expressed its willingness to do so.

- The International Network for the Demographic Evaluation of Populations and Their Health (INDEPTH www.indepth-network.org) is a global network of members who conduct longitudinal health and demographic evaluation of populations. INDEPTH aims to strengthen global HDSSs and to mount multi-site research to guide health priorities and policies, based on up-to-date scientific evidence.

- The Network of Migration Research in Africa (NOMRA) is a collaborative association of researchers and scholars interested in and working on migration, especially international migration, in the region. The overall aim of NOMRA is to build a regional migration research network and research capacity to carry out cross-national, multidisciplinary and innovative research on socio-cultural, economic and political aspects of international migration in the region in order to advance knowledge on migration dynamics and policymaking in the region.

- Environment and Development Third World or Environnement et développement du Tiers Monde (ENDA-TM) is focused on providing support and sharing knowledge on climate change adaptation.

- Info Climat (INFOCLIM) shares knowledge between stakeholders, with its main emphasis being on building awareness and the dissemination of data.

Projects and programs that support adaptation

A higher degree of regional climate change action is occurring through participation in shared projects and programs focusing primarily on the following sectors: agriculture, freshwater, fisheries, coastal zones and biodiversity/ecosystem conservation. Nearly all of these regional projects support research, capacity building or knowledge communication. West African countries are activity engaged in a number of projects involving other African, Asian, Latin American and Caribbean countries but none these are health related. Examples include the Climate Change Adaptation and Development Initiative involving Benin, Ghana, Senegal and Togo; the Africa Adaptation Program involving Burkina Faso, Ghana, Niger, Nigeria and Senegal; 'Enhancing the Disaster Risk Reduction Capacity in Agriculture and Rural Development' involving Burkina Faso, Niger and Senegal; and the Global Climate Change Alliance involving Mali and Senegal. These projects provide opportunities for West African countries to increase their capacities to address priority needs in a variety of sectors while also learning from the experience of others, and could be extended to the health sector.

A number of adaptation projects and programs are underway that exclusively aim to address adaptation needs in individual countries. The number varies by country, with the level of activity being very high in Ghana and Mali (which have more than 20 current adaptation projects) and very low in Côte d'Ivoire and Guinea (where fewer than five projects are currently being implemented). A number of different factors appear to be influencing the presence of adaptation projects in a country, such as competing government priorities, capacity issues, donor interest and a favourable environment for project implementation.

Key funders in the region include the Global Environment Facility, the United Kingdom, France, Canada, Denmark, Germany and the United States.

Identified or inferred missing voices in the research and policy debate

As the potentially adverse impacts of climate change on development prospects in West African countries have become clearer, a variety of actions at the national and regional levels have been implemented. These national and regional actions provide a solid start toward the implementation of actions that will reduce the vulnerability of West African communities to the impacts of climate change. However, this review suggests that greater attention could be given to the area of human health, as it has been identified as a priority area for adaptation action by nearly three-quarters of the countries in the region but little project action is occurring in this area. Finally, none of the regional programs specifically aim to understand or address the differential gender-based, migration and population displacement impacts of climate change.

Lessons from efforts to promote research policy dialogues on adaptation in the health sector

Incorporating scientific knowledge and expertise into policy dialogue on climate changes and adaptation in the health sector is a complex and multilayered task. Understanding future climate shifts requires robust and

fine-grained modelling and measurement of environmental and meteorological data. And understanding the potential impacts of such shifts requires interpretation of that information in relation to a wide range of areas, including food security and agriculture, natural resource management, ecosystems and biodiversity, infrastructure and human health. For each of these, additional scientific inputs and expertise are required in order to map not just the hazards but also the vulnerability of the physical and social systems that will be affected.

Scientific and social scientific expertise is also required to inform the discussion of potential adaptation options, such as disaster risk reduction (DRR) measures to manage hydro-meteorological risks, or the feasibility and socio-economic implications of changing practices, such as introducing climate variability information into public health interventions (Findley et al. 2005).

Overall, our review highlights the poorly institutionalised communication of information for evidence-informed policymaking. There is a general lack of awareness among health policymakers about climate change risks and how these relate to public health priorities. This is not specific to climate, as policymakers in general rarely use scientific advice or research to inform the conceptualisation, formulation or implementation of policies at the national or sub-national level.

8. Conclusions and Recommendations

This analysis reveals that the West African region is already suffering from the health impact of climate change. There is a need for health-focused institutions and organisations and other key stakeholders to join forces and bring to the attention of policymakers the serious health risks and impacts of climate change and the need for concrete and effective responses. The following recommendations are drawn from this review:

- Introduce comprehensive assessments of the risks posed by climate variability and change on population health and health systems.
- Undertake research to understand local and indigenous knowledge, coping and adaptation strategies and assess their value for public health.
- Encourage research for the development of early warning and early response systems including climate products and services for use in national policy and decision-making.
- Undertake research on more effective methods for communicating scientific results to stakeholders, including but not restricted to the use of new technologies.
- Provide support for investments in routine observation of climate, environmental and health phenomena through HDSS for integration of climate and environmental data.
- Train public health professionals and students to understand and demand appropriate climate and environmental information.
- Strengthen health systems with integrated environment and health surveillance.
- Determine the most appropriate indicators for climate change and develop, test and validate models for these indicators in relation to disease transmission dynamics.
- Establish the development of trans-disciplinary research-for-policy frameworks for improving management of disease risks and related health threats under climate change conditions.

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