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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 urban areas of West Africa

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About *AfricaInteract*

AfricaInteract (http://africainteract.coraf.org/en/) is a platform enabling research-to-policy dialogue for adaptation to climate change among a broad range of African stakeholders in sub-Saharan Africa. These include civil society, researchers, policy-makers, donors, and the private sector working on adaptation to climate change in the agriculture and health sectors as well as urban areas with water and gender as cross cutting issues. The overall objective of AfricaInteract is to develop a platform for the effective and efficient transfer of information to policy makers, with the ultimate aim of enhancing the resilience of vulnerable populations.

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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Table of Contents

Lists of tables

List of boxes

List of figures

Abbreviations and Acronyms

AAS	African Academy of Sciences
ACMAD	African Centre of Meteorological Applications for Development
ATPS	African Technology Policy Studies
CAPA	City Adaptation Programme of Action
CSAG	Climate System Analysis Group of the University of Cape Town
ECOWAS	Economic Community of West African States
GEF	Global Environment Facility
ICTP	International Centre for Theoretical Physics
IDRC	International Development Research Centre
IPCC	Intergovernmental Panel on Climate Change
NACETEM	National Centre for Technology Management
NAPA	National Adaptation Programme of Action
NGO	Non-governmental organisation
START	Global Change System for Analysis, Research and Training
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UN-HABITAT	United Nations Human Settlements Programme

Executive Summary

There has been an unprecedented increase in human population and urban development in recent times. The West African sub-region is no exception. The sub-region's population is growing at an average annual rate of three percent, and could reach 430m by 2020. Climate change will increase existing urban system challenges in the sub-region. Against this background, the West and Central African Council for Agricultural Research and Development (CORAF/WECARD) commissioned a review of literature on climate change impacts and adaptation in urban areas of West Africa. This was with a view to enhancing the knowledge base and to supporting research-based policy formulation for climate change adaptation in urban areas of West Africa. This review was carried out using peer-reviewed journals and conference proceedings, grey literature, policy documents, technical reports, relevant government and non-governmental organisation (NGO) documents and libraries over the past 15 to 20 years.

Urban areas will experience the same exposure to climate change as their surrounding environments. However, the urban setting has particular characteristics which could affect its exposure as well as the impacts of climate change at the local scale. Some of the impacts of climate change in the urban areas of West Africa include heat waves, sea level rise, flooding, coastal erosion, increased incidence of extreme events and changes in the level and variability of rainfall. Climate change will not only affect the high concentration of city-dwellers along the coastline of West African countries but also the capital assets, and the critical role of ports in the national economies. The urban poor will also be greatly affected by climate change impacts in the sub-region. Climate change could amplify the vulnerabilities of residents in resource-constrained cities, most especially where women and girls are primarily farmers and manage fuelwood and water resources. This has a lot of implications for climate change adaptation, as differences between male and female roles and responsibilities affect individuals' capacity for climate change adaptation strategies. Importantly, the scale of risk from these impacts will be influenced by the quality of housing and infrastructure, the effectiveness of urban planning and land-use management, the level of preparedness among the city's population and key emergency services in these cities. However, there are lots of uncertainties in the climate projections for West Africa which make some of the projections rather challenging to use for policy decision. Meanwhile, adaptation efforts should not be limited by the lack of reliable, accurate and precise foresight about future climate conditions. Stakeholders should rather use a range of plausible representations of future climate to help decision-makers better understand where vulnerabilities may lie so that appropriate policies can be made.

To date, few studies have been carried out specifically on climate change adaptation in the urban areas of West Africa. Most findings are on coastal cities, and there is little information on inland cities, with a few exceptions such as studies conducted on Aba in Nigeria and Ouagadougou in Burkina Faso. There is still a deficit of knowledge on the key interrelated processes that drive West Africa's climate. There are also weak links among the key actors on the governance, planning and implementation of climate change programmes in urban areas. In essence, most of the plans of action are either implemented without consideration for the development programmes or not considered at all because of an array of factors such as finance constraints, weak institutional structures, lack of political will and bad governance.

This review identifies a number of research priorities for the sub-region that could be carried out at the city level, including the need for a study on the vulnerability of critical city infrastructure such as transportation and water supply systems, energy supply, telecommunication and urban agriculture to climate change impacts. Also, research areas such as climate change impact risk assessment mapping, early warning systems, adaptation technology needs assessment and the strategies for strengthening institutions to effectively organise and manage city-scale adaptation strategies have not been properly addressed. In the meantime, climate change impacts on socially disadvantaged urban residents such as women, children, girls, the elderly and the urban poor have not been properly studied or incorporated into urban climate change adaptation strategies and planning.

In examining exigencies to reduce vulnerability to the impacts of climate change and increase the level of urban climate change adaptation initiatives in the West African sub-region, the evidence makes clear an urgent need to evolve policies on City Adaptation Programmes of Action (CAPA) as well as to mainstream climate change adaptation into urban planning. The people who are directly impacted are 'local', and as such, adaptation strategies to increase the resilience of the people must also be 'local'. This should be carried out within the context of urban climate change frameworks and dynamics.

Introduction

> Urbanisation is inevitable ... a positive force to be harnessed in support of social equality, cultural vitality, economic prosperity and ecological security... The battle for a more sustainable future will be won or lost in cities.
>
> *Excerpt from Manifesto for Cities - June 2012 - World Urban Campaign*

1.1 Background and motivation

Over half of the world's population now lives in urban areas (Buhaug and Urdal 2012) and the majority of the high growth trend is located in developing countries (Duh et al. 2008). The global trend has been very evident in many parts of West Africa, with far-reaching impacts. Scientific evidence suggests that global climate change will have considerable implications for urban areas in West Africa. Some of the key climate-related hazards and trends already observed include heat waves, rising sea levels and increased incidence of extreme events (Feiden 2011). For instance, analyses of rainstorms on Lagos Island between 1971 and 1995 show that in more recent years (1996–2005) rainstorms have been heavier, even though the number of rain days per annum has decreased (Adelekan 2010). Many of the impacts of climate change are projected to affect significantly the cities located around the coasts of West Africa such as Port Harcourt, Lagos, Cotonou, Lome, Accra, Abidjan, Monrovia, Freetown, Conakry and Dakar where populations, capita assets and economic activities are already at risk (Jalloh et al. 2011; Dodman and Satterthwaite 2008; Nicholls 2004).

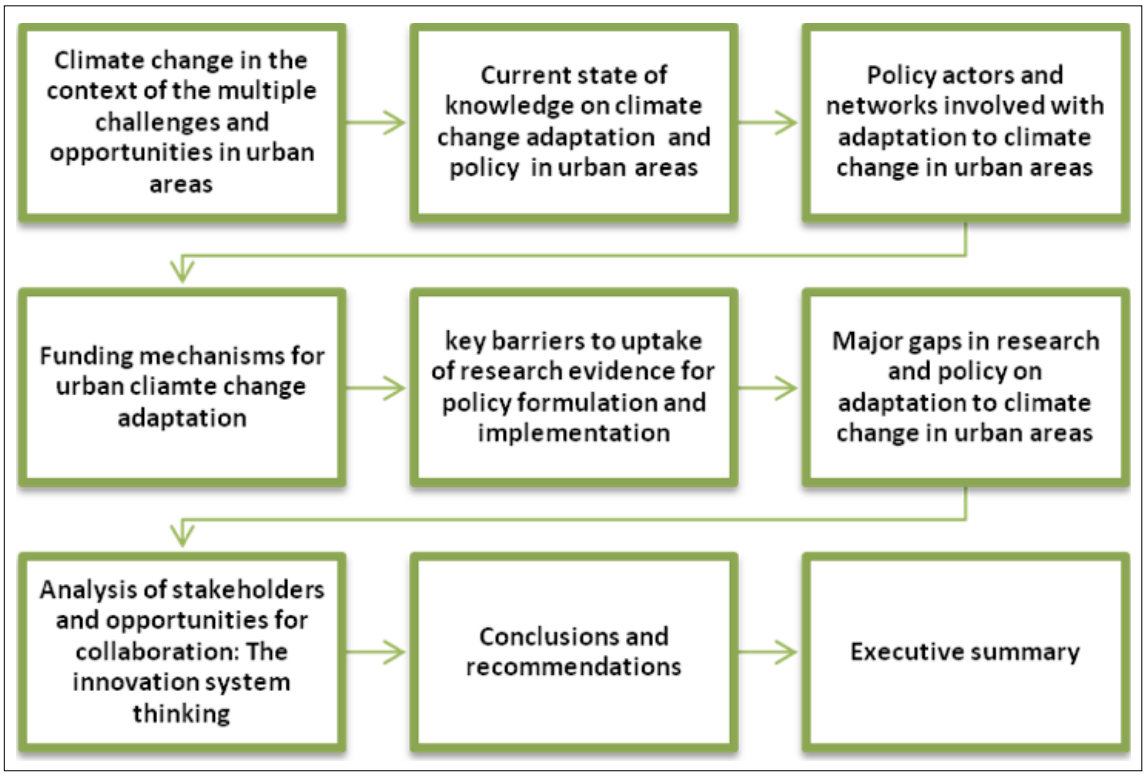
The impact of climate change is global and its complexity and scope require cities and other levels of government and stakeholders to collaborate and find innovative ways to surmount the challenge. With increasing scientific knowledge on global climate change, there are strong indications that some impacts will be unavoidable. Adaptation therefore will become a major instrument in reducing the socio-economic costs of climate change and poverty in Africa (GLCA 2009), and particularly in cities where the success of social and economic policies is crucial (World Bank 2010).

This paper was commissioned by the West and Central African Council for Agricultural Research and Development (CORAF/WECARD). The goal is to help enhance the knowledge base of researchers and to support research-based policy formulation for climate change adaptation in urban areas in West Africa, as well as identify evidence gaps and research needs. This study also aims to map out the climate change adaptation policy process, review the way research has informed policy or otherwise and identify major policy players in the region while clearly outlining the links between countries and the regional economic bodies in West Africa.

The review will seek to provide answers to the following key questions:

1. What is the role of climate change in the context of the multiple challenges and opportunities facing urban areas in the sub-region?

Figure 1. Structure of the report



2. What is the current state of knowledge on adaptation to climate change in urban areas in the region?

3. What is the current state of knowledge on whether and how research findings are integrated in urban area policies in the region?

4. What are the major gaps in research on adaptation to climate change in urban areas?

5. What is needed to ensure that research findings are better integrated into urban area policies?

6. What is the current state of knowledge on the stakeholders involved with research and policy on adaptation to climate change in urban areas in the region, and how can stakeholder involvement be improved?

This report is structured into eight parts. The first section provides the background and motivation for the report, while section two discusses the methodology. The region's urbanisation profile is discussed in section three. Studies related to climate change adaptation in urban areas are assessed in section four. The paper goes further to analyse the policies related to urban issues with regard to climate change in section five before enumerating the gaps in climate change adaptation research and policy in urban areas in section six. Section seven examines the stakeholders and opportunities for collaboration. The key conclusions and policy recommendations of the paper are outlined in the final section. The framework of the report is shown in Figure 1. This figure illustrates the issues addressed in the report as well as the flow of analysis and interconnectivities among the sections of the report.

2.0 Methodology for the Review

The scope of this report is to carry out the following tasks:

1. Review climate change adaptation research and policy pertaining to the urban sector, including the relationship with water resources and gender in the West African sub-region

2. Identify gaps in:

   a. climate change adaptation research and policy in the urban sector, and

   b. the way research informs policy making

3. Identify key stakeholders and opportunities for improving the climate change adaptation research-policy nexus in the urban sector

This study is guided by the concepts and definitions in the assessment reports of the Intergovernmental Panel on Climate Change (IPCC). Some of the main definitions are highlighted in Box 1 below.

West Africa is unique in the degree of regional economic integration efforts. The premier institution in this regard is the Economic Community of West African States (ECOWAS), a regional group of 15 countries, founded in 1975. Its mission is to promote economic integration in 'all fields of economic activity, particularly industry, transport, telecommunications, energy, agriculture, natural resources, commerce, monetary and financial questions, social and cultural matters' (ECOWAS 2012). This study focuses mainly on the climate change adaptation in urban areas of all the 15 member states of ECOWAS. These states include Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. The majority of these countries, together with Mauritania which is not yet a member, share a great part of their natural resources and face common climate change challenges. Climate change has already been recognised as a key issue, evidenced by the emergence of regional initiatives such as the formulation of the Regional Plan of Action for Reducing Vulnerability in the Face of Climate Change in West Africa. Some of the organisations in the forefront of this initiative are ECOWAS, the Permanent Interstate Committee for Drought Control in the Sahel (Comité Inter-Etate pour la Lutte contre la Sécheresse au Sahel or CILSS) and the African Centre of Meteorological Applications for Development (ACMAD) (Niang 2007). However, it has been noted that urbanisation will bring another dimension to the issue of climate change in the sub-region. Meanwhile, the growth rate of urbanisation in the sub-region has been unprecedented.

Estimates have shown that by 2020, the majority of areas in the sub-region will have at least one town of 10,000 inhabitants. The urban population of the sub-region will thus reach around 124 million inhabitants. The average distance from one agglomeration to another has decreased considerably from 111 kilometres to 33 kilometres for the whole sub-region and from 60 to 31 in urban areas (Africapolis 2009). Accessibility to towns and their services has therefore considerably increased. However, provision of transportation infrastructure is grossly inadequate. The situation is however different in most parts of Ghana, where the town network is less intense compared to the rest of the sub-region, except for areas such as Kumasi and Accra where competition for economic rents has resulted in modest densification of the coastal areas. In Senegal there is a hierarchical town network which is highly noticeable around Dakar. This has invariably raised the value of the land, leading to densification. The dynamic is different in Nigeria. For instance, the level of urbanisation in Nigeria weighs heavily on the rest of the sub-region as more than half of the population of West Africa is contained in this

country. The majority of the cities have more than 20,000 inhabitants and are more connected when compared with the overall network of the sub-region (Africapolis 2009). While Lagos maintains its supremacy in size over all other agglomerations in West Africa and indeed the entire continent, the national capitals of other countries have come to be viewed as major hubs in the West African urban landscape. Their growth has been faster than that of the old network of Nigerian cities. For instance, Lagos has grown relatively faster than Ibadan, whereas Conakry, Lomé, Cotonou, Monrovia, Ouagadougou, Niamey, Nouakchott and to a lesser degree Bamako and Abidjan have consolidated their position among the 20 largest agglomerations in West Africa (Africapolis 2009). In general, the building of nation states in the region has been accompanied by a metropolisation dynamic marked by the primacy of capital cities.

Box 1: Definition of Terms

Climate change
Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity

Climate variability
Climate variability refers to variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events.

Adaptation
Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation:

> **Anticipatory adaptation** – Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.
>
> **Autonomous adaptation** – Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.
>
> **Planned adaptation** – Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

Adaptive capacity
The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Vulnerability
Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Sensitivity
Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise).

Resilience
The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change.

Source: Glossary Section in Parry et al. (2007)

2.1 Basic Concepts

2.1.1 Urbanisation

There has been an increasing level of urban growth in West Africa since the 1950s. This growth has been attributed to both natural increase in population and urbanisation. Urbanisation is the process by which the percentage of urban population increases as a share of the total population, while the urbanisation rate is defined as the percentage of the population living in urban areas at a given moment (Hitimana et al. 2011).

Currently, the classification of towns in West African countries into urban and rural areas has changed radically due to the implementation of new demarcation criteria across different countries in the sub-region. For instance, Ghana adopted the threshold of 5,000 inhabitants based on the theory that, beyond that size, the population of localities was no longer generally rural. Meanwhile, in Nigeria the threshold population for an urban settlement was 5,000 inhabitants between 1951 and 1952, but increased to 20,000 inhabitants for the 1962, 1963, 1973 and 1991 censuses periods (Africapolis 2009; National Population Commission 2005). Meanwhile, understanding the concepts of 'urban' and 'rural' is important so as to know how much of the country is urban, or how much urbanisation is taking place, as cities are most frequently associated with having improved service delivery, more institutional facilities and infrastructure and lots of economic activities. On the other hand, cities are also associated with higher levels of unemployment, increased pressure on infrastructure and environment and high levels of greenhouse gases.

2.1.2 Vulnerability and adaptation

There is much literature with analyses and assessments of the concepts of vulnerability and adaptation (Adesina and Odekunle 2011; Leary et al. 2008; Nyong et al. 2008; 2007; Adger et al. 2007). However, the analyses of vulnerability and adaptation in this report are guided by the definitions of the IPCC (Parry et al. 2007) as seen in the glossary in Box 1. These two concepts are intricately linked within the context of the challenges of climate change. For instance, the presence of vulnerability necessitates the pursuit of adaptation. Whether adaptation is anticipatory, autonomous or planned (see Box 1), it enables the reductions of vulnerability of systems or people concerned with climate change impacts.

Putting these concepts in a proper perspective, vulnerability could be described as the propensity of people or systems to be affected by hazards or stresses (Leary et al. 2008). It is also affected by many factors such as exposure of the people or systems to hazards, their sensitivity to the exposures and their capacities to resist, cope with, exploit, recover from (show resilience) and adapt to the effects (Adesina and Odekunle 2011; Adesina et al. 2008). In the same light, vulnerability to climate change can be aggravated by the effects of other stressors such as mismanagement of resources by governments, political instability and weak implementation of socio-economic development programmes (Adesina et al. 2008). Meanwhile, the goal of adaptation to climate change is to reduce harm to the system and/or to exploit new opportunities (Baer et al. 2007; Feenstra et al. 1998). However, the choice and appropriateness of an adaptation option will depend on the peculiarity of the environment in which it is going to be implemented. Many people are of the opinion that adaptation options are 'win-win' or 'no-regrets' strategies because they offer measurable benefits whether or not there is an adverse climate change impact. For example, supposing a better water resources management system of water harvesting is developed for the cities of semi-arid areas of Nigeria because of prevailing water stress. Its benefits would remain even if the stressor, i.e. inadequate raw water, were to become weakened by an increase in rainfall in the region. Meanwhile, adaptation is very important because delaying action or creating an ill-focused adaptation agenda will only result in increased costs from climate change impacts and greater risk to humanity (Rosenberg 1996).

2.2 Data collection

The review was carried out using peer-reviewed journals, conference proceedings, grey literature, policy documents, technical reports, project documents, relevant government and NGO documents and libraries over the past 15 years. These documents helped to synthesise scientific and indigenous knowledge as well as policies related to climate change adaptation and, in effect, the possible gaps that will form the basis for further research and policy formulation.

For ease of analysis, the approach to the literature review and analysis that informed this report was broken into three distinct tasks:

- Analysis of government documents (e.g. technical reports and policy documents)
- Analysis of NGO and development agency resources (e.g. IDRC library, AGORA, HINARI)
- Analysis of content from the Internet (e.g. Google): open and closed access publications

Key informant interviews were used to complement the literature review and substantiate the facts gathered from the literature. The list of contacted researchers and colleagues is in Appendix B.

2.3 *Challenges/limitations to the study and measures adopted to mitigate them*

Although there have been numerous research activities on climate change in the last several decades, only recently has attention been focused on climate change implications for urban areas, and there has been little research to date in West Africa (Okali et al. 2012; Adelekan 2010; Ruth and Coelho 2007). Some of those that are available are not documented in the mainstream publication outlets, and some are written in other languages such as French. In order to achieve the goal of this task, relevant unpublished government documents were obtained from various agencies through their websites and phone calls (see Appendix B). The same approach was used for NGOs, particularly those that are located in Nigeria. In a bid to overcome the challenge of personally engaging with key stakeholders, assistance was sought from the focal point of the AfricaInteract project in the region, consultants for the other thematic areas and other colleagues in the sub-region. Google Translate was used in translating documents that were written in French.

3.0 Overview of the Region's Urbanisation Profile

3.1 *Dynamics of urbanisation in West Africa*

With a population of over 250m people and an estimated land area of 5m km^2, the West African sub-region's population is growing at an average annual growth rate of three percent (OHCHR 2011). The land expanse is 2.5 times the size of China and 1.8 times the size of the 27 European Union countries (Hiraldo 2011). Projections show that the population of the sub-region could reach 430m by 2020 (Cour 2001). The majority of the countries have a very young population, with over 40 percent of inhabitants being under 15 years of age (Hiraldo 2011). Estimates of population growth and some other indicators are shown in Table 1.

Table 1: Population, Health and Estimates for West African Countries for 2012

		Percent of Population Ages		Life Expectancy at Birth (years)			
Country	**Total Fertility Rate**	**<15**	**65+**	**Both sexes**	**Male**	**Female**	**Percent urban**
Benin	5.4	44	3	56	54	58	44
Burkina Faso	6.0	45	2	55	54	56	24
Cape Verde	2.5	32	6	73	69	77	62
Côte d'Ivoire	4.6	41	4	55	54	56	50
Gambia	4.9	44	2	58	57	59	59
Ghana	4.2	39	4	64	63	65	44
Guinea	5.2	43	3	54	52	55	28
Guinea-Bissau	5.1	41	3	48	47	50	43
Liberia	5.4	43	3	56	55	57	47
Mali	6.3	47	2	51	50	52	33
Niger	7.1	52	3	58	56	60	20
Nigeria	5.6	44	3	51	48	54	51
Senegal	5.0	44	2	58	57	59	42
Sierra Leone	5.0	43	2	47	47	48	40
Togo	4.7	41	3	62	60	65	37
West Africa	**5.4**	**44**	**3**	**54**	**52**	**56**	**44**

Source: Population Reference Bureau (2012)

3.2 Characteristics of urbanisation in West Africa

Africapolis (2009) presents the state of urbanisation in West Africa, its evolution and perspectives, using a geostatistical approach that combines demographic surveys and other technologies such as remote sensing and geographic information systems. According to the report, urbanisation rates in the sub-region range from 16 percent in Niger to 46 percent in Senegal. The countries in the West African sub-region vary widely in terms of their population size, from Cape Verde's 500,000 to Nigeria's over 170m people.

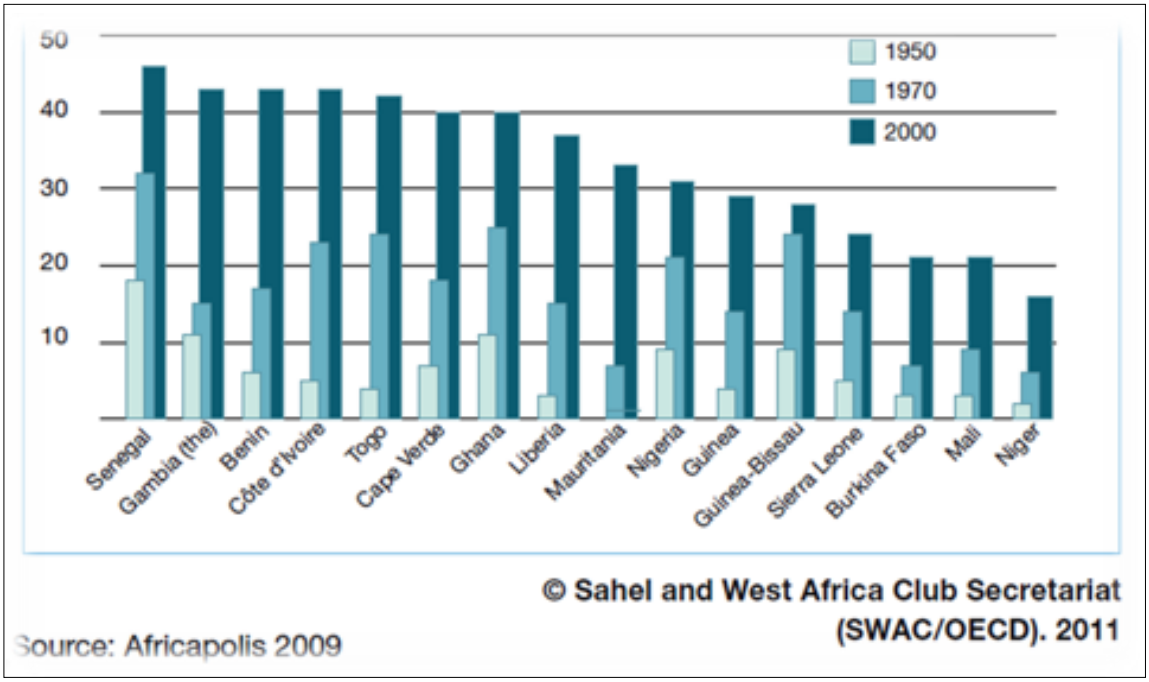
Another characteristic of urbanisation in this region is the difference between the coastal and landlocked countries. Seven coastal and four landlocked countries have urbanisation rates close to or above 40 percent and below 25 percent, respectively (See Figure 2). The dynamics of urbanisation in the sub-region have also changed dramatically since the 1950s. For instance, in the 1950s Liberia and Guinea had low urbanisation rates while Nigeria and Guinea-Bissau were among the most urbanised (Hitimana et al. 2011). This trend has changed in recent times. With respect to the level of development in West Africa, the region could not be said to be over-urbanised. As a matter of fact, in recent times, the urbanisation process in some parts of West Africa has slowed down due to structural economic adjustment programmes and political instability. For instance, actual decreases in the level of urbanisation have been recorded for Côte d'Ivoire and Mali (Potts 2009; Bryceson and Potts 2006). It is important to note however that many West African countries are still in the early phase of urbanisation with an average rate of 34 percent and 44 percent in 2000 and 2012 respectively (Population Reference Bureau 2012; Africapolis 2009). With economic growth rates of five percent in several countries and less political volatility, the urbanisation dynamic and its associated transformations are expected to continue into the future (Hitimana et al. 2011).

3.3 Vulnerabilities of urban populations in West Africa

People living in cities in developing countries, including those in the West African sub-region, are vulnerable to the impacts of climate change for many reasons. These include (Bull-Kamanga et al. 2003; Lavell 2003):

- High density of populations
- Urban populations living in informal housing
- Urban expansion on particularly risky sites
- Exposure to climate risks
- Poor urban infrastructure

Figure 2. Percentage of Degree of Urbanisation in West Africa



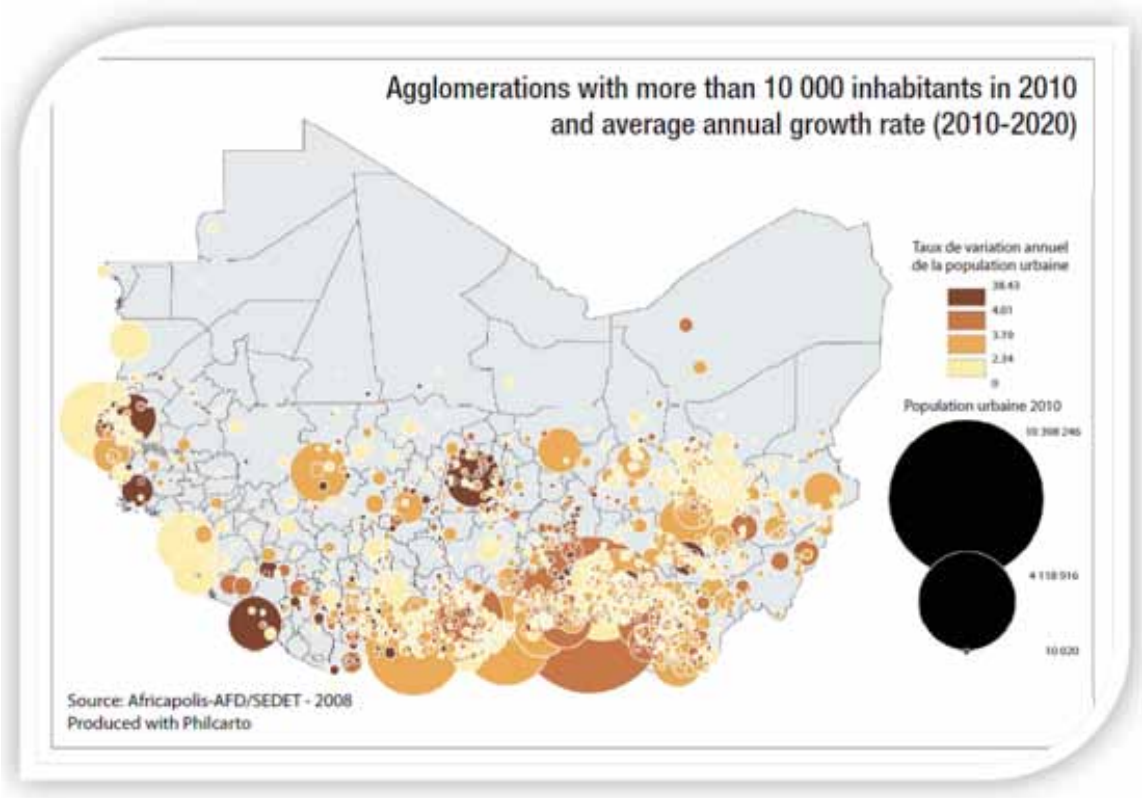
The majority of large, high density cities in West Africa are located in coastal zones where they are exposed to high tides, coastal erosion, flooding and sea level rise (See Figure 3). Lagos, for instance, has been referred to as one of the 50 cities most at risk from extreme sea level rise, and yet is projected to experience a more than 800 percent increase in population by the 2070s (Nicholls et al. 2007). The number of slums in the city was estimated at about 100 in 2010, containing almost 70 percent of Lagos's population (Adelekan 2010). The same scenario is true for most of the other West African cities along the coast. These impacts add to the challenges of providing for the urban poor and under-housed whose needs are already enormous without the additional stresses brought by climate change. These categories of people are usually the most vulnerable to the impacts of climate change, often residing in low-lying areas or on steep slopes with little to no infrastructure or basic amenities to protect them from extreme events and other vagaries of climate (Adelekan 2010; Nicholls et al. 2007; Soyombo 2006; Mabogunje 2001). For instance, urban slums with a high density of buildings are likely to experience more intense heat waves than areas that are well planned. Those built along steep slopes are also susceptible to mudslides or landslides in the event of heavy downpours or other extreme events. Issues such as these have been compounded with absence or lack of enforcement of building codes which were primarily formulated to address these concerns. Besides the vulnerability of the urban poor, social and cultural factors such as ethnicity, class, religion and gender also affect the adaptive capacity of the urban poor. For example, gender-specific roles often create structural differences between men and women through their interactions with society, work and domestic life, with consequent impacts on their abilities to adapt to climate change (Adger et al. 2007). It is from this perspective that understanding the interactions between the urban environment in West Africa and global climate change is imperative.

4.0 Research Related to Climate Change Adaptation in Urban Areas

4.1 Climate change and impacts in the West African sub-region

Climate change has been defined as the change in the state of climate that can be identified by changes in the mean and/or variability of its properties (e.g. rainfall, temperature) and that persists over an extended period of time, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity (Christensen et al. 2007). Meanwhile, climate variability implies the changes in rainfall and temperature that are recorded over a period of ten years or more (Nkuba 2011). Climate variability is no stranger to West African society. Examination of the climate of the sub-region reveals that its environment has undergone several marked climatic events. For instance, there was a wet period between 1930 and 1960, followed by the drought of 1970–1980 and the return of rainfall in the 1990s and 2000s (Perret 2008). These events could

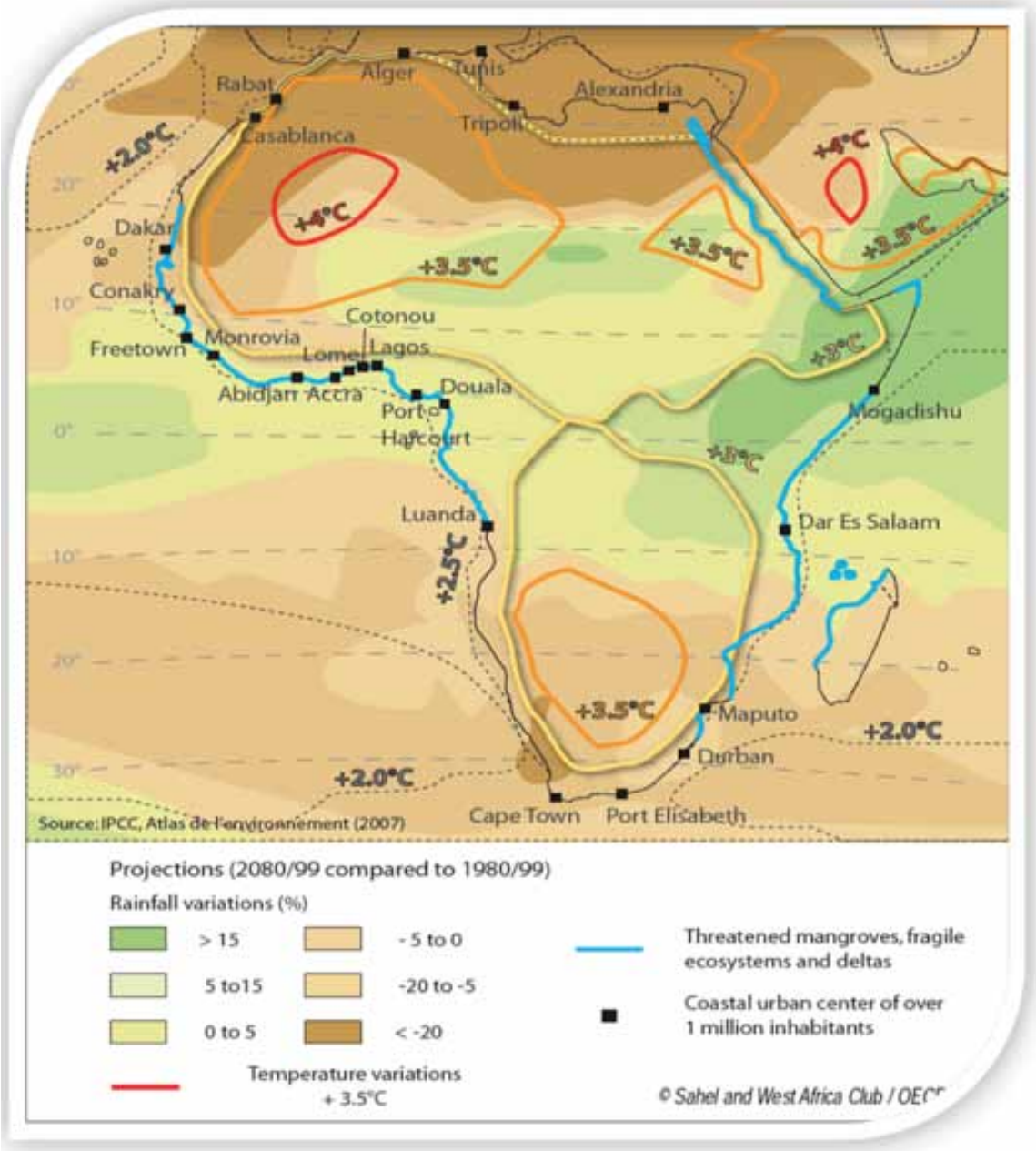
Figure 3. Spatial Distribution of Agglomerations in West Africa (2010–2020)



increase the level of exposure of people in the West African sub-region to climate change risk.

According to IPCC, some of the projected impacts of climate change in West Africa include rising temperatures, rising sea levels and changes in the variability of rainfall (Parry et al. 2007). However, there are considerable uncertainties in the climate projections for West Africa which make many of these unreliable (Perret 2008). In the meantime, over the years, there has been a significant improvement in the science of climate change and this has increased the level of accuracy of regional climate change projections. As long as estimates of some climate change impacts are based on climate projections, there will always be elements of uncertainty in decision making. This issue has generated debates on how to make decisions on climate change adaptations under uncertainty. However, there is a widely held view that adaptation efforts should not be limited by the lack of reliable (accurate and precise) foresight about future climate conditions. Rather stakeholders should use a range of plausible representations of future climate to help decision-makers appreciate where vulnerabilities may lie so that appropriate policies can be made (Dessai 2005). Meanwhile, there is a gloomy picture for Africa in terms of high intensity of global warming on the continent in the twenty-first century (Boko et al. 2007; Christensen et al. 2007). According to the IPCC Fourth Assessment Report (Parry et al. 2007), the average rise in temperature between 1980–1999 and 2080–2099 would be between 3°C and 4°C for the continent as a whole (see Figure 4), which is about the same as the global average of 4°C for the best estimates under the A1F1 scenario. With respect to rainfall, there will be impacts in the Sahel bordering the Sahara desert and the West African coast up to Dakar.

Figure 4. A Conceivable Overview of Climate Change in Africa



Source: SWAC/OECD (2007)

4.2 West African cities and climate change impacts

4.2.1 Peculiarity of cities within the context of climate change impacts in West Africa

In general, urban areas will experience the same exposure to 'new' climates as their surrounding environment. However, the urban setting has particular characteristics within the context of its form and socio economic activity which could alter its exposure as well as impacts at the local scale. For instance, built-up areas in the cities create unique microclimates due to the replacement of natural vegetation with artificial surfaces (EEA 2012). The change in this microclimate would bring about greater changes in the air temperature, wind direction and precipitation patterns, amongst others. Climate change would intensify many of these parameters and alter intra-relationships including 'factor compensation' (e.g. Odum 1971) impacts on others. Climate change impacts will not only affect the high concentrations of population along the coastline of West African countries but also the capital assets (Dodman and Satterthwaite 2008), and the critical role of ports in the national economies. The sea level along the coast of West Africa is projected to rise by 0.13 to 0.56m by the 2090s, relative to 1980–1999 sea levels (Boko et al. 2007), with Lagos likely to be impacted by tidal flooding (Boko et al. 2007; Hewawasam 2002).

4.3 Climate change adaptation in West Africa

4.3.1 Concepts of climate change adaptation

The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change is termed resilience (Parry et al. 2007). This has also been described as the ability to respond effectively to stresses such as sea level rise, floods, droughts and landslides. Box 2 elaborates on factors determining vulnerability and adaptation at the city scale. Meanwhile, adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (Parry et al. 2007). It varies according to localities or municipalities, countries and regions as well as social groups. For example, the urban poor tend to have more limited adaptive capacities with regards to climate change impacts on human settlement. Secondly, they are usually less mobile as a

Box 2: Evaluation of Vulnerabilities of Cities and Adaptation in Urban Settlements

Evaluating Vulnerability of Cities:

A list of critical factors in evaluating overall vulnerability to climate change impacts might include the following:

- Population at low elevations. This would include data on population in the Low Elevation Coastal Zone and population at lower elevation thresholds
- Geologic and development conditions that can increase or reduce the rate of local sea level rise
- Local storm patterns and anticipated changes or intensification with continual global climate change
- Economic activity in low-lying areas
- The value of local infrastructure at risk
- The value of regional or national assets at risk (e.g. power plant, port facility)
- The value of human settlements at risk
- Projected growth of areas at-risk
- Planned investment at risk

Source: (Fieden 2011)

Adaptation in Urban Settlements:

For urban settlements, the term adaptation refers to actions to make human settlement, capital, and productivity more resilient as the global climate continues to change. It might, depending on circumstances, include the following types of actions:

- Hardening of infrastructure to make it more resilient to extreme weather
- Building seawalls to reduce the impact of rising seas and extreme weather
- Improving housing quality to make it more resistant to storm events
- Land filling to raise elevations for new development
- Relocation to alternative settlement areas
- Investments in cooling technologies to improve comfort as urban heat island effects take hold
- Disaster planning to enable more effective evacuation based on improved early warning systems for storm events
- Public health measures to address changes in disease vectors
- Facilitating settlement of new urban migrants in more appropriate parts of the city and use of proper designs in new construction
- Improved enforcement of critical building and land use regulations

Source: (Fieden 2011)

result of economic or cultural constraints and this limits their ability to move to a less vulnerable environment. Finally, they are more dependent on climate sensitive sources for their livelihoods (Feiden 2011). From the foregoing, it seems clear that the risk posed by climate change to West Africa's future sustainable development objectives is quite real (Boko et al. 2007), as more than 60 percent of the population living in the cities are regarded as poor.

4.3.2 Water management adaptation strategies in West African cities

In general, it is still uncertain how climate change will impact freshwater resources in West Africa. However, it has been suggested that future availability will be affected by population growth, migration and agricultural development (deWit and Stankiewicz 2006; Mabogunje 2004). Unfortunately, many cities in the region have low capacities to cope with the additional water stress that may arise due to climate change (Afouda et al. 2007). One of the ways in which farmers in the peri-urban areas adapt to the increasing water demand in the cities is the use of urban wastewater for peri-urban irrigation of agricultural plots (Ngigi 2009). This is made possible because of the lack or inadequacy of a suitable network of sewers in most parts of sub-Saharan Africa. This lack of wastewater infrastructure has not only resulted in the pollution of the urban environment but has also affected the health of the city-dwellers who depend on peri-urban products such as dairy and vegetables raised on such wastewaters. The same system is also practiced in Kano where the city's peri-urban lands, in which gardening is mainly conducted on plots of 100-500m2, are often irrigated with industrially polluted water (Ndiaye 2012; Binns et al. 2003) or domestic and abattoir wastewater which are discharged into the same effluent (Abdu et al. 2011). However, this condition can be improved by appropriate adaptation strategies such as treating the urban wastewater to an acceptable quality for irrigation in the peri-urban areas (INERA 2008). Part of Kano is already practicing this as the Kano River Irrigation Project, located on the south and northeast of the city, serves large irrigated fields. Many small-scale farmers in the peri-urban areas have also adopted the use of shallow wells and hand-dug wells to supplement the shortfall in water supply for dry-season irrigation (Ngigi 2009). These adaptation measures will make it possible for the farmers to produce various crops (vegetables, flowers, fruit and dairy products) of interest to urban consumers. Use of recycled water has also dissuaded some of these urban farmers from using drinking and industrial water in urban areas for irrigation.

There are many other climate change adaptation strategies used across West African cities to reduce the effects of climate change on freshwater resources. Some of these strategies include: construction of infrastructure to collect, supply and store water; promotion of integrated water resources management; improvement and stabilisation of watershed management; protection of aquifers and reservoir sites; dissemination of drip irrigation technologies; and capacity building to understand surface water cycles (CV-MEA 2007; NNECSD 2006; NMEFRN 2003; GMEST 2000).

4.3.3 Adaptation measures in the coastal cities of West Africa

Climate change could impact on economic activities in the coastal cities of West Africa in various ways. Extreme events could damage infrastructure and affect the provision of electricity, water and sewerage systems necessary for socio-economic development. The rise in sea level and associated erosion threatening coastal industrial and residential areas could raise salinity levels, thereby changing the volume, timing and quality of surface water available for industrial and domestic purposes (Gasper et al. 2011). Many of the urban poor, most especially those living around the coastal cities with houses in swampy lands or dwellings built on stilts in tidewater areas, are vulnerable to increased storminess and rising sea levels. Although these impacts are not limited to the urban poor alone, the rich city-dwellers are better able to protect themselves from adversity by insuring their valuable property as well as their lives. In the West African sub-region, some of the cities most exposed to climate risk in the coastal lowland areas are Lagos and Port Harcourt in Nigeria (Abam et al. 2000), Cotonou in Benin and Banjul in The Gambia. It has been reported that Banjul could disappear in 50–60 years through coastal erosion and sea level rise, putting more than 42,000 people at risk (Jallow et al. 1999). Metropolitan Lagos is highly susceptible to flooding in the rainy season (Adelekan 2010). In Cotonou, Benin, the areas most vulnerable to climate hazards such as coastal erosion comprise the first and fourth arrondissements (districts of Tokplégbé, Finagnon, Donatin, Akpakpa-Dodomey and JAK). Around one-tenth of Cotonou's population, estimated at 94,425 from the 2002 census, is affected by coastal erosion (Dossou and Glélhouenou-Dossou 2007).

Table 2 illustrates economic impacts of climate change on some selected West African coastal cities. Many of these cities have found several ways of adapting to these impacts. However, these strategies might not be able to stand the test of time. For example, in the Alajo community in Accra, people dealt with the June and July 2006 floods in a variety of ways. Some of these include (Douglas et al. 2008):

- Use of blocks, stones and furniture to create high places on which to put their most critical valuables;
- Putting property on top of wardrobes and in the small spaces between ceilings and roofs;
- Sharing high places with others who had no similar 'safe' sites; and
- Temporarily moving away from the area to stay with friends and family.

Table 2: Impacts of 1m rise in sea level in four coastal countries of West Africa

Indicators	The Gambia	Guinea	Senegal	Sierra Leone
Land at risk (km²)	92	289-468	6042-6073	
Population at risk (x1000)	42	500	109-178	26-1220
Economic value at risk (millions US$ and % of GNP)	217 (52%)		499-707 (14%)	2315,860
Adaptation cost (millions US$)	4.4		973-2156	
GDP (millions US$)	461 (2007)	3407	4971	

Source: Adapted from Niang-Diop (2005)

Many of the urban poor in Lagos cope with flood by bailing water out of their houses with buckets or blocking water inlets with pieces of cloth to reduce the amount of water coming into the house. Other, wealthier households use mechanical water pumps to drain water from their homes (Douglas et al. 2008). Some people also build temporary plank bridges between houses across the wetlands to be able to move about during flooding. There is little government or community intervention because of the scale of floods. In some parts of Lagos, however, installation of standard drainage facilities (such as along major streets within Iwaya/Makoko) has been critical in keeping flooding at bay. Some of the slum dwellers in the city have also suggested using sand to raise the entire area to a higher level (Douglas et al. 2008).

4.3.4 Gender, social differentiation and adaptation to climate change in the urban areas of West Africa

Gender is an important aspect with regard to all the dimensions of urban climate change, including agriculture, water and energy resources, as well as climate-related natural hazards. Many studies argue that due to the culturally determined roles they often play in the household and society, women and girls have particularly important roles to play in the development of sustainable cities under the advent of climate change. For instance, women are often crucial in creating resilient urban livelihoods. They tend home gardens and produce higher value vegetable and fruit crops that help diversify agricultural production in peri-urban areas. This can become especially important to the household when a natural hazard hits. This social support system is very important in building resilience to climate change impacts among the urban poor and other socially disadvantaged city-dwellers.

Women and men have also expressed their coping strategies by diversifying their crops, investing human capital in the form of time and labour. In Niger, men, as the head of the family, regularly sell their livestock to sustain the household, while most women retain their own livestock. The women however make use of these livestock during natural hazards. The implication of this is that women use livestock as a safety net for the household during natural hazards (Kristjanson et al. 2010). This example demonstrates interconnectivity between resilience, climate change impacts and gender differentiated roles. Moreover, the effect of role differentiation between men and women, which is manifested in their access to resources, has been making women more vulnerable to hazards than men. In the management of the wetlands which most peri-urban agriculture depends on, for instance, climate-sensitive roles such as selling non-timber forest products, selling fish, producing handicrafts, extracting natron, fattening livestock, gathering water for the family and growing seeds such as okra, sesame and peppers are usually assigned to women (UNDP 2012). In order to properly address issues like this, it is important that climate risk management techniques that incorporate gender differentiated groups are brought into play for appropriate climate adaptation strategies.

4.3.5 Rural-urban dynamics and climate change adaptation in West Africa

The interaction between the rural and urban inhabitants is critical for the smooth exchange of goods and services as well as the survival of a community. This is because their exchanges could reduce the level of vulnerability of inhabitants of both rural and urban areas in terms of sustenance of livelihood and inter-community cohesion (Okali et al. 2012). These exchanges between rural and urban inhabitants can be informal exchanges of goods, natural resources, labour and services as well as movements of financial resources. However, the interactions have some downsides. For instance, challenges of political and social strife, autonomy, bad governance and mismanagement of public funds often endanger the capacity of the rural and urban communities to support livelihoods and cope with climate change impacts. The effects of these factors are considerable and do reduce resilience and benefits of rural-urban interaction to livelihoods, and as such their adaptive capacity (see Figure 5). Studies have shown that climate change impacts affect rural-urban interaction in a way that contributes to the vulnerability of populations (Okali et al. 2001). For instance, in Aba, Nigeria, rural communities surrounding the town have contributed to the increasing number of migrants within the city as a result of declining agricultural yields which could be attributed to climate change.

The south-eastern part of Nigeria where Aba is located is also susceptible to soil erosion, and this may have affected the arable lands, contributing to the movement of young men and women to the city. The effect of this has been loss of capable men and women

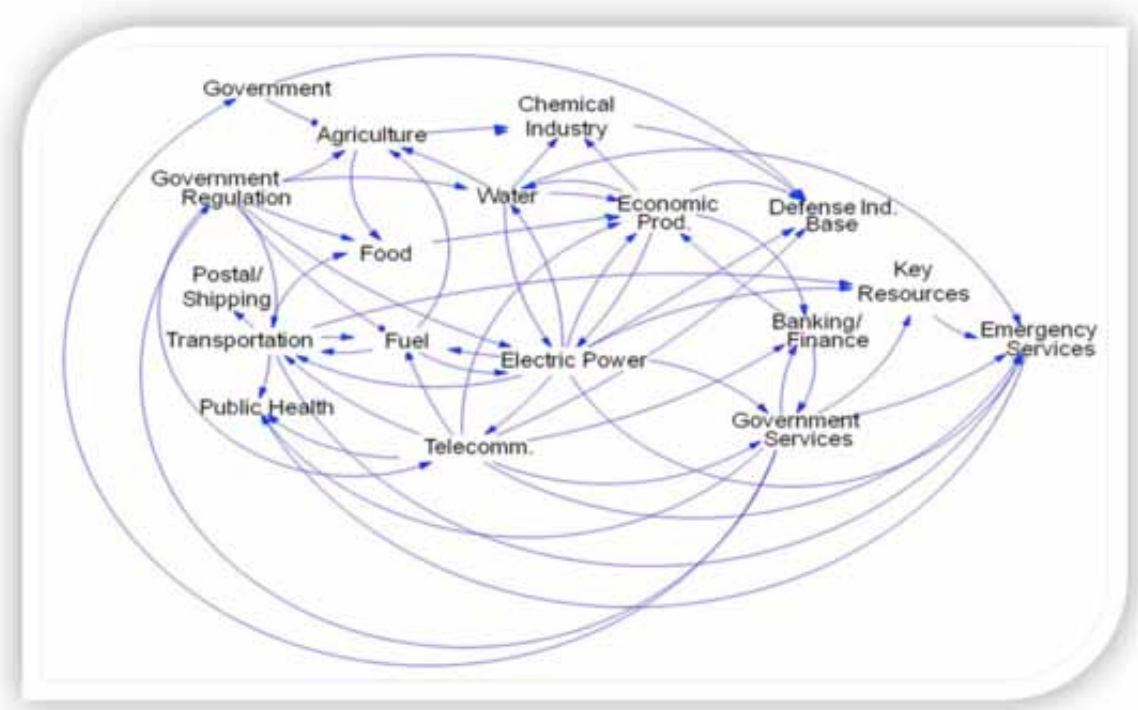
in the rural areas who could engage in agriculture and other crafts in response to climate change (Okali et al. 2012; Okali et al. 2001). This example has buttressed the fact that as climate change impacts intensify, the rate of environmentally-induced migration usually increases (Tacoli 2011). Development in the urban centres also attracts immigrants, for example in Accra (Rain et al. 2011), the majority of whom settle in the peri-urban fringe where rent is less expensive and construction of housing uncontrolled. The dynamics of interaction between the rural and urban populations has many significant effects on the already over-stressed physical infrastructure, unplanned human settlements and waste management facilities in the urban areas. The experience of the study carried out in Aba has shown how that city is usually ill-prepared to receive the migrating populations, and this often elevates the climate-related risks in the city (Okali et al. 2012).

4.3.6 Climate change adaptation and infrastructure management in cities of West Africa

Another important issue with regard to dealing with rapid urbanisation and climate change impacts in West African countries is that of building resilient urban infrastructure. Within this context, the ramifications of the impacts and disruptions of infrastructure caused by natural hazards rest on the costs associated with the clean-up, repair and/or replacement of affected infrastructure. In most cases, however, economic, social and environmental effects are also felt through the disruption of supply chains, suspension of economic activities and damage to social well-being (DOE 2012). This example is particularly true of many West African cities with sea port facilities in countries such as Benin, Ghana, Nigeria and Senegal. Another implication of climate change impacts on coastal facilities is the disruption of services rendered to relatively distant landlocked countries such as Mali and Niger through international infrastructure networks. Any disruption to the services rendered to these countries will affect their socio-economic development.

Climate change hazards such as sea level rise, storm surge and flooding could affect all infrastructure in the urban areas with resounding impacts. For instance, coastal flooding will not only affect transportation services, but also water, energy and communications, in the same geographic area (DOE 2012). In Benin, for example, many key pieces of urban infrastructure such as the fishing port, international airport and conference centre to the south of Cotonou are threatened with coastal erosion. This example illustrates the level of interdependence among different types of infrastructure that are vulnerable to climate change impacts (Kirshen et al. 2008) as depicted in Figure 6. This supports the fact that adaptation of urban infrastructure to climate change requires integration with land use and socio-economic management.

Figure 5. An illustration of infrastructure interdependencies (Source: DOE 2012)



5.0 Policies Related to Urban Climate Change Issues in West Africa

5.1 Climate change adaptation policy at city-scale level

In Ghana's National Climate Change Policy (GMEST 2012), for instance, the government is promoting energy efficiency in cities' transport sector, deregulating the railway system to permit private sector participation in urban passenger and long distance freight railway systems as well as providing incentives for the promotion of nationwide mass transit systems. The government is also planning to reduce the average wood fuel energy intensity per urban household by 30 percent by 2015 and by 50 percent by 2020. These efforts, if carried out efficiently, will increase Ghana's resilience to climate change as well as reduce vulnerability in natural and social systems in the urban centres. This is because the policy will reduce deforestation in the peri-urban fringe and as such decrease the level of heat waves in and around urban areas. Some of these trees also serve as wind breaks which could lessen damage to buildings and other infrastructure during severe storms.

5.2 Climate change adaptation policy initiatives in West African cities

One of the distinguishing features of adaptation is that it is essentially local. That is to say, the actions required to adapt are local activities the aggregate effect of which reduces vulnerabilities to the impacts of climate change; hence the need for urban climate change adaptation policy. To date, no country in West Africa has a specific urban climate change adaptation policy. Rather, what the majority of these countries have is a national climate change policy, national climate change framework, national communication to the United Nations Framework Convention on Climate Change (UNFCCC), or for the Least Developed Countries (LDCs), a National Adaptation Programme of Action (NAPA). Coming closest to urban climate change adaption policy are climate change or environmental plans of action at the level of provinces or states, as exemplified by those existing in Lagos, Bayelsa and Ondo States in Nigeria. There is also a weak link between research and policy on urban climate change adaptation in West Africa. However, studies have been carried out in countries such as Benin, Burkina Faso, Nigeria, Ghana, Sierra Leone and Cape Verde. Some of the studies conducted are shown in Table 3. A list of climate

Table 3: Examples of urban climate change adaptation research projects in West Africa

Lead Research Institution	Research Project
Institut de l'Environnement et de Recherches Agricoles, Ouagadougou, Burkina Faso	Rural-Urban Cooperation on Water Management in the Context of Climate Change in Burkina Faso
Le Centre de Recherche et d'Expertise pour le Développement Local, Cotonou, Benin	Protecting Cotonou's Urban Community in the Face of Climate Change
Nigeria Environmental Study Action Team, Ibadan, Nigeria	Implications of Climate Change on Rural-Urban Interactions: The Case Study of Aba and its Region, Southeastern Nigeria
International Water Management Institute, Accra, Ghana	Managing Water in the Rural-Urban Interface in Ghana and Ethiopia: the Key to Climate Change Resilient Cities
Institutd'applications et de vulgarisation en Sciences Ouagadougou, Burkina Faso	Building Capacities to Adapt to Climate Variability, Extreme Climate Events and Climate Change in Urban and Peri-Urban Areas of Ouagadougou
Environmental Protection Agency of Liberia (EPAL)	Coastal Defense System for the Cities of Buchanan and Monrovia: Reducing the Vulnerability of Coastal Urban Areas (Monrovia, Buchanan) to Erosion, Floods, Siltation and degraded Landscapes
Niger National Environmental Council for Sustainable Development	Promoting Peri-Urban Market Gardening and Livestock Farming in Niger
Ministry of Transport and Aviation, Sierra Leone	Improvement of the Efficiency of Existing Water Supply Systems in both Urban and Rural Areas of Sierra Leone
Action Aid International, Johannesburg, South Africa	Climate Change, Urban Flooding and the Rights of the Urban Poor in Africa (2006) (Lagos, Nigeria, Accra, Ghana, Free Town, Sierra Leone) Capacity for Sustainable Responses to Climate Change in Cities of Portuguese-Speaking Small Island Developing States, participating regional country: Cape Verde.

Sources: IDRC/DFID (2013); UNFCCC (2012); Moser and Ekstrom (2010); De Vit and Parry (2011)

change projects in urban areas of West Africa is shown in Appendix A. Countries such as Ghana, Nigeria and Senegal only have dedicated national climate change (adaptation) strategies, plans or frameworks. On 12 September 2012, the Federal Executive Council of Nigeria officially approved a National Climate Change Policy and Response Strategy document (Okali et al. 2012). A Department of Climate Change has been established in the Federal Ministry of Environment to coordinate all the activities on climate change in the country (NEST 2011; Stern 2007). Ghana has also developed a National Climate Change Adaptation Strategy and National Climate Change Policy as well as established a National Climate Change Committee (GMEST 2012). The same situation is true in Niger which now has a National Strategy and Action Plan for Climate Change and Variability.

5.3 Policy actors and networks involved in urban climate change adaptation in West Africa

Adapting to climate change impacts is challenging and actions that are required are more often than not multi-level, from local to the international, within both public and private sectors. This section of the report examines the interactions of different levels of actors within urban climate change adaptation programmes and how climate change initiatives might be promoted and facilitated through future multilateral efforts. These actors have been referred to as 'communities of practice' (De Vit and Parry 2011; Wenger 2006).

According to Wenger (2006), communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly. With respect to climate change adaptation, these groups can be classified into two types (De Vit and Parry 2011):

- **Established communities of practice**, usually defined by a sector or issue, that have begun to integrate consideration of adaptation needs and priorities into their existing knowledge sharing efforts (e.g., a community of foresters discussing methods of integrating projected climate risk into their management planning)

- **New communities of practice** established specifically due to a shared interest in adaptation to climate change (e.g. community-based adaptation experts)

Some of these actors that are actively engaged in climate change adaptation in West Africa include the International Development Research Centre (IDRC), World Bank, Global Environment Facility (GEF), United Nations Human Settlements Programme (UN-HABITAT), Global Change System for Analysis, Research and Training (START), Heinrich Böll Foundation, United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), World Food Programme (WFP) and International Fund for Agricultural Development (IFAD). Some of their networks include the AfricaAdapt Network, the Africa Partnership on Climate Change Coalition (APCCC) and the Climate Action Network – West Africa (CAN-WA). Moreover, government officials, research organisations, development specialists, sectoral experts and the business sector also participate in climate change adaptation programmes in the sub-region. Unfortunately, the West African sub-region does not have any organisations or networks specifically dedicated to urban climate change adaptation, such as exist in Asia with the Asian Cities Climate Change Resilience Network (ACCCRN) and the United States of America with the Urban Climate Change Research Network (UCCRN).

5.4 Funding urban climate change adaptation projects in West Africa

The current levels of funding earmarked for sub-Sahara Africa are likely to be inadequate to meet the region's demonstrated need for adaptation finance, estimated to at least US$18bn per year until 2050 (Schalatek et al. 2012). Meanwhile, adaptation projects have only received 28 percent of approved funds since 2003. It is within these challenges that urban climate change adaptation is competing for funds.

Some of the general funding sources that could be assessed for urban climate change adaptation include (Satterthwaite et al. 2007):

- **The Least Developed Countries Fund (LDCF)**

- **The Special Climate Change Fund (SCCF)**

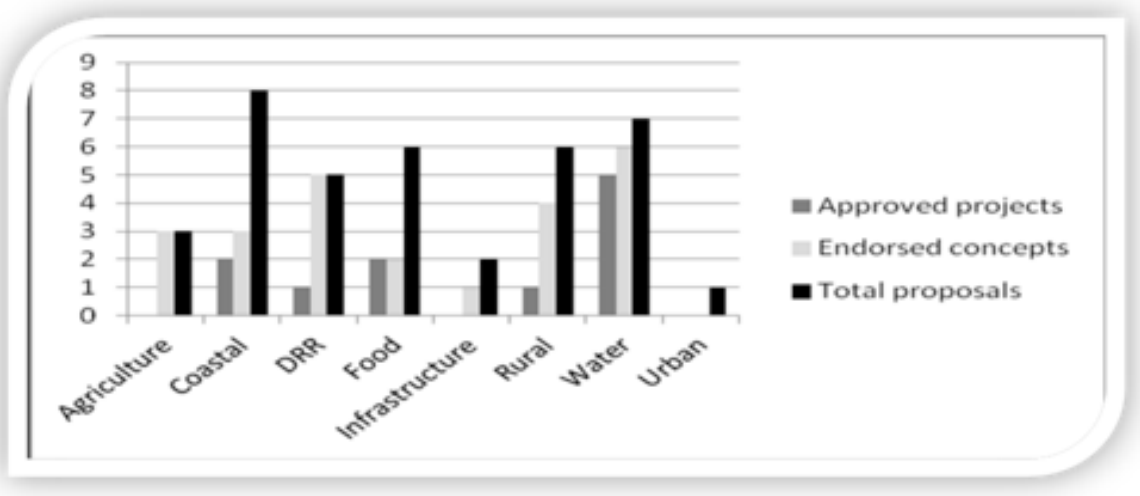
- **The Strategic Priority on Adaptation (SPA)**

The majority of the funds used in climate change adaptation are managed by GEF. Although no fund is dedicated to urban climate change adaptation in West Africa, urban climate change adaptation projects or initiatives from the sub-region are allowed to draw from the special fund called the Adaptation Fund. This funding mechanism is a good opportunity for the public institutions at the national and state levels to tap into for urban climate change adaptation initiatives.

5.4.1 The Adaptation Fund

One of the latest financial mechanisms to support climate change adaptation is the Adaptation Fund. To date, the Adaptation Fund has received over 40 conceptual and full project proposals. All the conceptual and full project proposals have an average funding request of nearly US$7m, and 18 projects have been approved as at March 2012 (Adaptation Fund Board 2011). Over the past few years, the fund has dedicated more than US$165m to increase climate resilience in 25 countries around the world, mainly in Africa, Latin

Figure 6. Proposals Reviewed by the Adaptation Fund by Sector (Source: Adaptation Fund Board 2011)



American and the Caribbean. Only Senegal has been approved for funding in West Africa. When analysed by sector, proposals submitted to the Adaptation Fund on urban climate change adaptation represent the smallest category, while those on the coastal sector constitute the largest (see Figure 7).

Although some funds seem to be available for adaptation, there exist challenges concerning access to the fund, especially for the urban sector. First, there is the requirement by GEF that project activities must have global benefits to be eligible for funding. The second challenge for fund access for urban adaption is that of bearing the full cost of an adaptation programme. Part of the operational mechanism of GEF is not to fund the full project (GEF 1995) due to the fact that some development and upgrading of systems will take place irrespective of climate change. Meanwhile, in reality the calculation of the cost of this development or upgrading is very complicated. In the same vein, most of the funds available at the state level are meagre and usually not sufficient for the running of the state, even without devoting some financial resources to climate change adaptation projects.

5.5 Review of key barriers to uptake of research evidence for policy formulation and implementation

Despite the establishment of some frameworks, strategies, funding and enabling conditions for urban climate change adaptation through national and international channels in the West African sub-region, the process of integrating climate change adaptation evidence for policy formulation and implementation is still fraught with many challenges. These include:

Technical and institutional capacities: Many state or municipal governments and their agencies in the sub-region are usually understaffed or over-burdened, especially with respect to technical members of staff. Besides, most agencies of government in the West African sub-region lack the technical capacity to interpret and use climate risk data or hydro-meteorological information in an adaptation development project. There is also the fact that most state governments have the meteorology departments in a small unit within the Ministry (OECD 2009) with little or no facilities to work with. This is coupled with the fact that there is a general weak understanding of issues associated with effective response to climate change. In the same vein, budgets at the state level are in general meagre, barely enough for the state administration let alone earmarking any money for urban climate change adaptation. In effect, most state governments do not have adequate financial and human resources to implement climate change adaptation programmes in the urban centres. The effect of this barrier could however be reduced if there is a synergy among the implementing agencies/ministries at different levels of government.

Dysfunctional institutional structures: Tedious and complicated bureaucratic processes in some state agencies are known to have hampered the integration of adaptation into community decision-making in the urban areas. A case in point is that of The Gambia where bureaucratic red tape has been identified as a key organisational barrier, delaying the delivery of climate change adaptation project outputs (GOTG 2007). Another example is that of Cape Verde where implementation of adaptation actions has been made difficult as a result of the proliferation of institutions operating without an efficient coordination mechanism; a deficiency in the functioning of the regulatory entity; overlapping of attributions among state institutions; and deficient knowledge of the law by the institutions (UNDP 2010). Meanwhile in Nigeria, the land tenure system does not allow for proper land use planning. For instance, only the Governor of a state can declare parts of the state territory governed by him or her as an urban area, through an order published in the state gazette. Lack of easy access to land could prevent people from adopting certain resilience-building strategies in the urban centres as they are not sure of their investments on such property.

Lack of technical information: As stated earlier, one of the major challenges of climate change predictions in West Africa is the ability to make projections that can be used at local levels. The absence or inadequacy of this technical information at state level could hamper adaptation development planning in the urban centres. The majority of the climate projections that are available today are regional, with little or no relevance at the city level. Although there are regional agencies and institutions that are working on downscaling global and regional climate models for use in West Africa, those that are available now still fall short of what is needed to implement city-wide adaptation initiatives. However, these regional models serve as a basis for many adaptation plans and strategies in the absence of city-scale models.

Local competing priorities/needs: Most of the West African countries are bedevilled with developmental and security challenges which are competing for the attention of both the local and national governments. It is within these challenges that climate change is competing for resources with other needs on the development agenda such as food security, job creation and access to primary education (OECD 2009). Unfortunately, in many cities of developing countries such as those in West Africa, climate change impacts are not usually perceived as issues which deserve urgent attention and as such do not get the attention of the government or policymakers who could allocate resources for climate change policy implementation.

Inappropriate channels of funding: Another important challenge affecting urban climate change adaptation research uptake for policymaking is funding. This concern is coming from the fact that the implementation agency for adaptation funds usually works with the national public institutions such as ministries of environment, science and technology or natural resources at the national level (Stern 2007). The implication of this for urban areas is that the states where most of the adaptation programmes would take place do not have access to the funds, and as such most of the projects are implemented at the national level without due consideration for the people that will be affected by climate change impacts at the city level.

Awareness: Awareness on urban climate change adaptation among government authorities, educators, trainers and business communities in various sectors and priority areas is inadequate. Although there are some awareness-raising radio programmes and jingles on clearing water channels to prevent flooding, tree planting initiatives, etc., there is still room for improvement in these areas. This is important, as lack of awareness on the part of these groups of people could impede integration of climate change adaptation considerations at the city level. Perhaps other cities could follow Senegal's initiative with an integrated approach that combines awareness raising, communication and implementation activities, as well as the reinforcement of its infrastructure in order to protect urban populations in coastal areas against erosion.

6.0 Gaps in Urban Climate Change Adaptation Research and Policy

6.1 Urban climate change adaptation research gap: the context

Scientific evidence makes clear that climate change will impact on near- and long-term development prospects in West African countries, with urban dynamics bringing a new perspective to the discourse. To this end, many adaptation plans of action at the national and regional levels have been identified and carried out to build resilient cities in the sub-region. However, as revealed by a close study of literature on the subject, there are research areas that are either not dealt with or improperly addressed. This review also identified specific gaps in the climate change adaptation plans of action and policies where certain issues are either not considered or not integrated into development plans and strategies. These issues form the basis of discussion in this section of the report.

6.1.2 Narrow scope of urban climate change adaptation research

In all, it appears that very few research activities have been carried out specifically on climate change adaptation in the urban areas of West Africa. With respect to urban areas, evidence-based research activities were carried out on particular sectors or themes. These include flooding, sea level rise and storm surge in coastal cities, droughts, food security, infrastructure damage from extreme events, sanitation, water demand and availability, urban biodiversity and air pollution. Most findings were on coastal cities and there is little information on inland cities with the exception of studies conducted on Aba, Nigeria and Ouagadougou, Burkina Faso (see Table 3). There is also a major evidence gap on the quantification of climate change impacts on urban energy usage, rural-urban migration, infrastructure (sea ports, roads, water utilities, energy utilities, waste management systems etc.) and water resources. Furthermore, very few research activities were carried out on cost-benefit analysis of such impact studies on cities in West Africa.

6.1.3 Climate change uncertainties

There are a number of uncertainties surrounding the climate change projections for the West African sub-region, especially as these relate to rainfall and low densities of synoptic stations across the sub-region. For example, it is still unclear whether the observed changes in the climate of the sub-region are part of a normal climatic cycle or an indicator of climate change (Conway 2009). However, there is general consensus in the scientific literature that the continent of Africa will warm more than the global average in the future. The uncertainties in the projection of climate change in West

Africa are largely due to the fact that most of the regional models available today cannot effectively project the climate of the sub-region for accurate forecasts of key climate parameters such as rainfall and temperature, not to mention city-scale projections. This issue is further compounded by local micro-climates and particularly urban heat island effects in the major cities across the sub-region. This goes to show that there is still a deficit of knowledge on the key interrelated processes that drive Africa's climate. Some of these processes include the regional phenomenon of tropical convection, leading to the movement of the Inter-tropical Convergence Zone and the alternation of the monsoonal winds, which influences West African rainfall patterns, along with the global phenomenon of the El Niño–Southern Oscillation (ENSO), which leads to drier conditions in the Sahel during its El Niño phase and wetter and cooler conditions in its La Niña phase (Conway 2009). However, it should be noted that there are some initiatives at some national levels which could be scaled down to city-level scales. Such initiative include Nigeria's effort in the National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN) where experts were invited from the Climate Systems Analysis Group (CSAG) at the University of Cape Town to develop climate scenarios for Nigeria.

6.1.4 Advocacy on communicating and building awareness about climate risks

More often than not, emphasis is put on general awareness about climate change at the national level, rather than communicating and building awareness of climate risks, opportunities and potential solutions as well as impact assessment analysis at the state and national levels. Also, only a few research activities include mainstreaming adaptation measures into development plans and strategies (Osman-Elasha and Downing 2007). There is no synergy among the key actors on implementation of most of the adaptation programmes. In essence, many agencies undertake exactly the same programme, duplicating and wasting resources. Most of the plans of action are also implemented without consideration for the development programmes, or else they are not considered at all because of finances and other militating factors such as ineffective leadership and lack of political will. However, efforts should also be made by the local policymakers to learn the art of making decisions in the face of uncertainties.

6.1.5 Interconnectedness among different types of infrastructure

One other clear research gap identified in this study has to do with the low level of research on the intricate interconnectedness among different types of infrastructure in the cities across the sub-region which are usually under conditions of stress and/or threat of climate change impacts. Urban centres provide a very good context within which the interdependence of infrastructure systems and the services they provide could be studied in relation to climate change conditions. Since a larger concentration of the infrastructure system is found in the urban centres, they are usually vulnerable to the same climate stressor and damage to one could mean destruction to others and similar disruption of the services they provide.

6.1.6 Gender and climate change adaptation research

Research on gender varies and is highly contextual, based on the social and cultural norms within the country of interest in the sub-region. In general, some level of research activities have been carried out on the impacts of climate change on vulnerable urban groups such as women and girls. Although the literature suggests that women seem to have suffered more negative impacts of climate change in terms of their assets and well-being, there are some exceptions where men seem to have suffered more impacts than women. As a result of this, more research is needed in this area before strong conclusions can be drawn. More importantly there is the need to expand the knowledge frontier with regards to climate change impacts on gender in the urban areas through multidisciplinary research.

6.1.7 Green Cities

Green growth has been defined as a means to create jobs and economic growth while reducing costs and environmental impacts over the long run (Hammer et al. 2011). Many industries in the urban areas of West Africa are engaged in the production of products with large carbon footprints. However, many of these are in the process of developing sustainability standards for their products so as to reduce their level of carbon emissions. Companies committed to this kind of change are very interested in tools that will help them measure the environmental benefits (reduction in footprints) of the changes they are making to their products as a result of environmental policies on climate change or organisational principles. Research is needed to develop tools which will help them measure their footprints in the cities and other areas surrounding them where their customers are concentrated. In all, there is no common protocol or methodology with which to assess a city's sustainability in the sub-region.

Besides the research gaps noted above, this review has also identified for the sub-region a number of research priorities that could be carried out at the city level, including studies on energy efficiency and climate change, municipal solid and liquid waste assessment, urban agriculture and climate change, early warning systems, climate change impact risk assessment and mapping, adaptation technology needs assessment and the need for strengthening institutions to effectively organise and manage city-scale adaptation strategies. It was also noted that there was research bias towards the urban poor while neglecting the peri-urban poor, most especially those that are involved in urban agriculture in the peri-urban areas. Also, more evidence is needed on the coping strategies of the urban poor. Most of the research surrounding urban residents dealt with housing construction and land use, rather than productive sources

of livelihood. There were few research activities on the vulnerable social groups such as children, refugees and the elderly with regards to climate change impacts in cities.

6.2 Urban climate change adaptation policy gap: the context

6.2.1 Climate change adaptation policy at the city level

Very few policy documents such as NAPAs, national communications, climate change policies, national climate change adaptation plans and frameworks address city-scale adaptation initiatives. Exceptions to this are Ghana's National Climate Change Policy (GMEST 2012) and Niger's NAPA documents. As stated earlier, these countries do not have dedicated urban climate change policies; rather what they have are national climate change adaptation plans of action that are mainstreamed around building resilience to climate change impacts in the cities. For instance, Nigeria's national plan (NASPA-CCN) laid out strategies to discourage building and urban encroachment into vulnerable areas, high risk zones and low lying areas. In the same light, Ghana's climate change policy articulated issues surrounding increased rural-urban migration that could add to the pressure on cities and urban services in a bid to find lasting solutions to these challenges (GMEST 2012).

6.2.2 City Adaptation Programmes of Action (CAPA)

While examining the exigencies available to reduce vulnerability to the impacts of climate change in the urban areas of the sub-region, adopting City Adaptation Programmes of Action (CAPAs) or the related Local Adaptation Programmes of Action (LAPAs) might be viable options (Satterthwaite et al. 2007). These frameworks are bottom-up approaches to address impacts at the local level of governance. These strategies are particularly suitable for urban climate change adaptation programmes. This is because the people who are directly impacted are local, and as such, adaptation strategies to increase resilience of the people should also be local. This framework could also be used to treat smaller scale adaptation programmes, most especially for the settlements or areas most at risk such as urban slums. These two initiatives do not have to be completely new programmes; they could be carved out of the original programmes such as NAPAs, so as to facilitate their implementation from mainstream funding mechanisms such as the Adaptation Fund.

6.2.3 Climate change and water resources management

There are many regional projects that are currently addressing some shared vulnerabilities of the West African region such as coastal settlements, fisheries and water resources management. There is the need, therefore, to formulate a policy on how to manage West Africa's trans-boundary surface and underground freshwater resources, taking into consideration dynamics of governance, diversity of purpose and primary needs in individual countries across the sub-region, most especially those that concern water demand for domestic and industrial usage (e.g. hydropower generation) in the urban centres.

6.2.4 Mainstreaming climate change adaptation into urban planning policies

As climate change impacts in the cities intensify, challenges of heat waves, coastal flooding and erosion, sea level rise, food shortages, infrastructure damage and the degradation of natural resources upon which livelihoods are based will be exacerbated. For these reasons, climate change adaptation policy is urgently needed at city-scale across the countries in the sub-region. Very few countries in West Africa have successfully integrated climate change adaptation into other sectoral policies (Osman-Elasha and Downing 2007; Satterthwaite et al. 2007) such as urban sector. Perhaps Ghana's National Climate Change Policy Framework, which later developed into the Ghana National Climate Change Policy 2012 (GMEST 2012), is a good illustration of how climate change adaptation policy could be mainstreamed into urban planning policies. For instance, this policy document is committed to a low carbon future which means improved city planning and a more modern public transport system based on high occupancy buses running in dedicated lanes. An inter-city rail service between Accra and Tema has also been inaugurated.

7.0 An Analysis of Stakeholders and Opportunities for Collaboration

Communities are usually impacted differently as a result of their different levels of vulnerability and adaptive capabilities, thereby exhibiting different adaptation needs. These issues and more necessitate the need for greater coordination to capitalise on synergies. Although there are few city-scale initiatives with respect to climate change adaptation in West Africa, rich experience exists in past interventions on climate change adaptation in general. The present and future initiatives can learn and build on past initiatives so as to realise their intended objectives. In order to ensure sustainability of urban climate change adaptation programmes, it is critical that relevant national and state government agencies and departments are brought on board from the onset. It is important that synergies are built among various stakeholders working in the same geographical area and local community so as to ensure success of the programme, as well as to avoid the duplication of efforts and repetition of mistakes (Ngigi 2009). This implies that there is the need to evolve a framework which will identify all the key stakeholders in climate change adaptation initiatives as well as their interactions within the context of urban systems in West Africa.

7.1 The innovation system thinking: A case of urban climate change adaptation

The innovation system approach started in the mid-1980s, made popular by Lundvall (1985) and extrapolated to national circumstances by Freeman (1987), Nelson (1993) and Edquist (1997). Over the years, the concept has gradually entered into policymaking processes in developing countries. The concept analyses the distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process (Metcalfe, 1995). Traditionally, the climate change adaptation systems in the sub-region are characterised by top-down, centralised and isolated structures. Linkages, interactions and learning mechanisms among the component actors are usually weak or non-existent.

The concept of innovation in this report refers to the activities and processes associated with the generation, production, distribution, adaptation and use of new technical, institutional, organisational and managerial knowledge (Hall and Yogan 2002). The agents or elements of interest include research institutes, training and education institutions (knowledge institutions), credit institutions, policy and regulatory bodies, private consultants, NGOs, insurance firms, private sector and public services delivery organisations (Agwu et al. 2011). This framework captures the complex relationships between diverse actors, processes of institutional learning and change, market and non-market institutions, public policy, poverty reduction and socioeconomic development in an urban setting. There are four key elements which are central to the functioning of the system. These include knowledge institutions, finance element, business sector and the state (local) government.

Knowledge Institutions: The role of knowledge institution in the proposed framework is to produce policy-relevant urban climate change adaptation research outputs as well as create awareness with regards to opportunities for adaptation. They should also be able to train students and support states or local governments on the issues of urban climate change adaptation. A good example in the sub-region which states or municipalities can leverage on is the African Centre of Meteorological Applications for Development (ACMAD). The organisation is based in Niamey, Niger and has the mandate to produce information for the implementation of policies to reduce vulnerability and improve adaptation to climate variability and change in the sub-region (Niang 2007). Its research focus has been on weather forecasts (including through the Seasonal Climate Outlook Forum for West Africa [PRESAO]) on different timescales (daily to monthly) and over different geographical scales (continental to national). It is also involved in weather forecast communication methods (the Contribution of Rural Communication and Climate Information [RANET] project) and training, especially continuing education, by taking in numerous interns (especially at national weather services) and students. State governments can collaborate with this organisation on capacity development of members of staff with the responsibility of urban climate change adaptation as well as training of students who might want to take up climate change management as a career. Other key institutions dealing with climate data information include the Permanent Interstate Committee for Drought Control in the Sahel (Comité Inter-Etate pour la Lutte contre la Sécheresse au Sahel or CILSS), Institut de Recherche pour le Développement (IRD), French national meteorological service (Météo France), the Agro-Hydro-Meteorology (AGRHYMET) Regional Centre and the Climate System Analysis Group (CSAG) of the University of Cape Town. These organisations, as well as local universities, could collaborate on working with urban farmers to develop synergies in building resilient urban agriculture.

States seeking to build resilient cities could further collaborate with international agricultural research institutions such as the International Institute of Tropical Agriculture (IITA), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and AfricaRice; with UN bodies such as the Food and Agriculture Organization (FAO), World Health Organization (WHO), UNEP and UNDP; and finally with international NGOs such as the World Wildlife Fund (WWF), International Union for the Conservation of Nature (IUCN), Wetlands International and Environnement et Développement pour le Tiers Monde (ENDA-TM). Conversely, civil society organisations with a focus on climate change adaptation in West Africa are very few. However, Le Réseau des Organisations Paysannes et de Producteurs de l'Afrique de l'Ouest (ROPPA) has been of help to farmers across the region (Niang 2007) and as such will be invaluable in helping urban and peri-urban farmers adapt to climate change impacts.

Financing institutions: These stakeholders provide the necessary funds for project execution as well as implementation of urban climate change adaptation projects. The main stakeholders in this category are GEF, UN-HABITAT, UNDP, START, the World Bank, commercial banks and the African Development Bank (AfDB). The challenge with this category is the accessibility of funds. To date, only Senegal has been able to access the Adaptation Fund while Ghana has just submitted a project for funding. Participation of private banks in financing adaptation programmes is still in its infancy. This brings about the need for venture capitalists who are willing to take the risk in investing in climate change adaption technologies in the sub-region. All the other key elements (knowledge institutions, private sector and state government) of the urban climate change adaptation system of innovation should interact with this element. For instance, the knowledge institutions should be able to approach the financing institutions (public and private financial institutions or international organisations such as the Adaptation Fund and GEF) for research grants. The private sector should also be able to

finance climate change adaptation goods or services (e.g. micro-insurance, desalination and wastewater treatment technologies) coming from the knowledge institutions through venture capital or other forms of investment in the urban areas. At the same time, the business sector can approach the finance element directly to borrow money so as to finance identified research outputs that are already at the prototype stage (green architecture, green building, energy efficiency technologies). Countries in the sub-region can also develop National Climate Change Adaptation Funds which the private sector can tap into for targeted adaptation actions.

Business Sector: This sector includes all firms developing, producing and providing goods and services that could help build urban resilience. This key element should relate with the knowledge institutions and also invest in knowledge input from universities, research institutes and patent documents in order to be able to create green goods and services in the cities. The ability of firms to apply new knowledge and technology in products and production processes and reduce their carbon footprints determines how competitive they are. Such ability depends on a high level of management and technical green skills (DTI 2003) which are unfortunately absent in most state governments across the sub-region. The private sector must specifically show interest in the development of the university research and development agenda, especially that relating to climate change adaptation in the urban areas. Staff exchange programmes between the industry and the universities along with Industrial Training Schemes and internships are also required to facilitate knowledge transfer to and from academia and industry. The business sector and the state government could collaborate in the provision of goods and services such as micro-insurance, low cost housing, water treatment and desalinisation technologies, disaster reduction services, affordable healthcare, water harvesting technologies, green architecture and micro-finance. These activities will help build urban resilience.

The State Government: It is the duty of governments to provide an enabling pro-poor policy environment for the knowledge institutions, businesses and financing sectors to operate. For instance, the government should ensure an enabling policy environment that will allow the business sector to recoup its capital as well as make reasonable profit. This could be achieved by allowing them to borrow at low interest rates, or by giving grants and incentives such as tax holidays. Governments should also encourage the private sector to provide certain resilient urban infrastructure while they provide critical infrastructure such as roads, water and low cost housing for the poor. This could be achieved through public-private partnerships. It is important, however, that governments make pro-poor policies which allow the urban poor to afford these climate change adaptation goods and services. This could be done by subsidising the poor in the consumption of these services (low cost housing, micro-insurance, etc.) The brokerage institutions will serve as intermediaries among the key elements in this framework by providing them with information and advice on climate change adaptation opportunities, intellectual property rights and awareness about climate change risks and impacts in the urban areas. Institutions such as African Technology Policy Studies (ATPS), African Academy of Sciences (AAS) and the National Centre for Technology Management (NACETEM) could be given the mandate by the regional body such as ECOWAS to executive this responsibility. It is believed that this framework will ensure that urban climate change adaptation activities are integrated into national and state strategies for poverty eradication and sustainable development by advancing and promoting environmentally sustainable demand-driven goods and services.

8.0 Conclusions and Recommendations

8.1 Conclusions

This study has explored urban climate change adaptation research activities and identified gaps in research and needs in the sub-region. It discussed the way urban climate change adaptation research has informed policy in the sub-region and outlined the link between countries and the regional economic bodies in West Africa. The review has provided a critical knowledge base for researchers to support research-based policy formulation for climate change adaptation in urban areas of West Africa. The study came up with the following conclusions:

8.1.1 The state of knowledge of urban climate change adaptation

Urban areas are home to over 40 percent of the people living in West Africa and are already stressed due to unfavourable socio-economic conditions. Climate change is bound to compound the extant multiple stressors of cities of West Africa through sea level rise, increased flooding, coastal erosion, storm surges, heat waves, increased frequency of droughts and inland floods which could pollute water supplies as well as other extreme events which affect critical infrastructure such as telecommunication, roads and energy supply systems. Property, ecosystems and socially disadvantaged city-dwellers are not immune to these impacts. All these issues have brought to the fore the need to strategise on how to adapt assets, people, infrastructure and investments in development objectives against the impacts of climate change on the West African cities and their inhabitants.

This review has also shown that factors such as high population density, large sections of the urban population living in slums, and urban expansion on particularly risky sites such as low-lying coastal areas

and steep slopes which are susceptible to mudslides or landslides, aggravate climate change impacts on cities in the sub-region. People living in resource-constrained communities in the urban areas where there is little or weak infrastructure or no disaster emergency response are also highly vulnerable. The climate change outlook for West Africa with respect to rainfall could be unpleasant. Among the significant impacts of climate change is the flooding of cities due to rise in sea level along the coastlines of the West African sub-region. Unfortunately, the coastline also provides the sources of livelihood for urban residents who depend on climate-sensitive economic activities such as fishing, farming and tourism for survival. Climate change will not only affect these coastal cities but also the infrastructure such as seaports, telecommunication and transportation systems.

Other consequences of climate change impacts with implications on urban areas include increased environmental pressure on rural areas; rise in rural-urban migration which adds pressure to the already-over-utilised facilities in the urban areas; increased burdens on poor and vulnerable urban residents; and stress on the capacity of governments to mainstream climate change strategies into development plans. The effect of climate change on the urban poor is likely to be more pronounced in the sub-region. This is because they are less able to move from urban areas concentrated in the coastal and riverine areas at risk of high tides and coastal erosion.

From the foregoing, adaptation to the impacts of climate change in the urban areas requires adjustments to reduce vulnerability or enhance resilience in both the natural and human systems to observed or expected changes in climate and associated extreme weather events. The study revealed that factors such as economic, social, institutional and technological conditions influence the adaptive capacity of cities to the effects of climate change in the sub-region. These factors could facilitate or constrain the development and deployment of climate change adaptation measures across the sub-region. This adaptive capacity also varies according to locality, municipality and country as well as social groups such as gender and urban wealth class. Perception of gender differentiated roles in relation to climate change adaptation is also an issue across the sub-region. For instance, men and women perceive, understand, value and respond to climate change impacts and adaptation differently. Some of the factors responsible were attributed to social structures such as social roles, religion and caste, or demographics such as age, education, wealth and size of household.

Most of the urban growth in West African countries is concentrated in informal settlements and slum areas. This is a very big challenge because these parts of the cities are not adequately equipped to cope with the present challenges and the amplified problems that could attend full scale climate change impacts. These are compounded by weak institutions, bad governance, inadequate infrastructure, shortage of safety nets and lack of social equity in a majority of the cities.

8.1.2 Urban climate change adaptation research and policy gaps

The analysis in this report shows that very few research activities have been carried out specifically on climate change adaptation in the urban areas of West Africa. It was noted that most of the research activities were based on particular sectors or themes such as flooding, sea level rise (and storm surge) on coastal cities, droughts, food security, infrastructure damage from extreme events, sanitation, water demand and availability, urban biodiversity and air pollution. Most findings were on coastal cities and there is little information on inland cities. There is also a major evidence gap on the quantification of climate change impacts on urban energy usage, rural-urban migration, infrastructure (seaports, roads, water utilities, energy utilities, waste management systems, etc.) and water resources. Cost-benefit analysis of adaptation in cities of West Africa was not thoroughly addressed.

Looking through the literature, none of the West African countries has a specific urban climate change adaptation policy. A few states or provinces such as Lagos, Bayelsa, Delta and Ondo States in Nigeria, however, have a climate change framework or plan of action. The process of integrating climate change adaptation evidence for policy formulation and implementation in the urban sector is also fraught with many challenges across the sub-region. Some of these challenges include weak technical and institutional capacities at the state level, dysfunctional institutional structures, competing priorities/needs, bad governance, inappropriate channels of funding and lack of awareness among the most vulnerable groups.

8.1.3 Key stakeholders and opportunities in urban climate change adaptation

The key stakeholders in the area of urban climate change adaptation could be broadly categorised into four: knowledge institutions, finance, business sector and governance. For a successful urban climate change adaptation strategy, all these stakeholders need to work together in a harmonious way. Unfortunately, linkages, interactions and learning mechanisms among the stakeholders are usually weak or non-existent. The majority of the climate change adaptation research initiatives in the sub-region are characterised by top-down, centralised and isolated structures. Empirical evidence from the report revealed several gaps and missing links among the actors in the urban climate change knowledge systems. An Urban Climate Change Adaptation Innovation System approach was proffered as a solution to these challenges. This framework captures the complex relationships between diverse actors, processes of institutional learning and change, market and non-market institutions, public policy, poverty reduction and socioeconomic development in an urban setting.

There are many opportunities that urbanisation could bring to the sub-region within the context of climate change adaptation. For instance, the several national adaptation plans and policies could be used by the cities as background information for their adaptation plans. High rates of agglomeration of cities and towns could help make the cities more compact in a way which could bring about smooth administration of adaptation interventions. Urbanised coastal areas in the sub-region also have very rich biodiversity and this has attracted international donors whose mandate is to reduce vulnerability of such ecosystems to climate change impacts. Other opportunities include green building, green landscaping and increased uptake of research for adaptation policy. Meanwhile, these opportunities are threatened by issues such as civil unrest and insecurity, high levels of poverty and unemployment and unplanned urban population growth. All these concerns could jeopardise urban climate change adaptation research and interventions.

The study concludes that in order to build climate change resilience in the urban areas of West Africa, state and local governments should take the lead and formulate policies that address unsustainable use of resources, shortage of technical competence, unsustainable population growth, uncontrolled environmental degradation, bad governance and corruption. A holistic and comprehensive measure to build and enhance resilience in the cities should also include policies for managing climate change risks, strengthening institutional and social organisations and enhancing the capabilities of gender-differentiated individuals as well as socially disadvantaged groups in cities: the poor, children, girls and the elderly. Such an all-inclusive strategy should integrate policies on employment, income, healthcare, water and sanitation and food price stability and rehabilitate the urban and peri-urban economy.

8.2 Recommendations

The conclusions bring out a number of policy recommendations which are relevant to cities in the sub-region. The recommendations are specific to cities in the sub-region. It is believed that the knowledge derived from research activities in these areas would be of benefit to developing urban adaptation plans in West African cities. These recommendations are structured to respond to the issues that concern the state of knowledge, research and policy gaps as well as barriers and opportunities in urban climate change adaptation strategies in the sub-region.

8.2.1 Improvement in the state of knowledge on urban climate change adaptation strategies

- Urban climate change adaptation research activities in the sub-region are very few. All the knowledge institutions and other stakeholders should identify and conduct relevant urban climate change research in areas that are of common priorities to the member states using the same protocol and indicators. These activities should be carried out in such a way that research outputs are translated to appropriate adaptation technologies and innovations that would make an impact on the most vulnerable groups in the urban areas.

- To reduce duplication of responsibility and optimise expenditures, generating data about urban climate change action should be an integral part of the existing climate change units/departments. The units or departments should also interact with and engage key stakeholders such as policymakers, knowledge institutions, the business sector, civil society and key players from different critical sectors of the economy at the national and state levels.

8.2.2 Improvement in linkages among the key stakeholders

- There is the need to further strengthen the AfricaInteract platform to serve as an effective forum for linkages and sharing of knowledge on urban climate change adaptation. The platform has already brought together key stakeholders on climate change adaptation in the region. The platform also provides the opportunity to learn from experiences in the other sub-regions in sub-Saharan Africa.

- In recent times, African diasporas are becoming increasingly important to the global scientific community. State governments could harness the potentials of these groups of people in order to increase the pool of experts in the area of urban climate change adaptation. This initiative will be of immense assistance, most especially in the area of knowledge and technology transfer.

8.2.3 Closing research and policy gaps

- This review has made clear how few studies have been carried out in the area of climate change impacts and urban agriculture despite the fact that it is key to sustainability of city-dwellers' livelihoods. In other words, more research should be carried out in the area of urban agriculture as well as integrating it into urban development policies. One other adaptation measure could be to diversify the economies in the sub-region from climate-sensitive sectors so as to increase urban resilience.

- State governments should liaise with the capacity building centres with mandates to carry out climate change adaptation research at national and international levels

on urban issues. This will allow them to build climate change competence among different categories of researchers at the local level. This can be achieved by promoting programmes and scholarship in the area of climate change adaptation, most especially as it relates to sustainable cities. Some institutions that could be part of this programme include national and state universities and research institutes such as ATPS, IDRC, AAS, NACETEM, CSAG, UNFCCC, START, ACMAD, the Inter-Governmental Authority on Development (IGAD) Climate Prediction and Application Centre (ICPAC), United Nations Institute for Training and Research (UNITAR), One UN Training Service Platform on Climate Change (UN CC:LEARN) and International Centre for Theoretical Physics (ICTP).

- One of the major challenges of making climate change predictions at the city level is that of finding reliable regional climate models that could be used to create scenarios which will be adequate for local climate model forecasts which pave the way for robust policy decisions. In essence, there is the need to improve model disaggregation to allow analysis at the city level. State governments should buy into initiatives at ACMAD, CSAG and ICTP, and more young climatologists, social scientists and other researchers from relevant disciplines with focus on urban climate change impacts in West Africa should be sponsored in PhD programmes. Governments at the state level should also develop capacity on how to make policy decisions in the face of uncertainty.

- Analysing differentiated gender roles in climate change adaptation programme is challenging. However, analysis of the review suggested that governments at the state level could mainstream gender into development plan from the beginning of the adaptation programme. Each climate change adaptation project should integrate gender disaggregated data at various stages of the project so as to understand the effect of climate change impacts on gender. However, caution should be exercised in placing more attention on the woman as the most affected when other socially disadvantaged groups are equally affected by climate change impacts.

- Practical ways of communicating climate change adaptation research outputs to policymakers at the state level have to be institutionalised. There is the need to incorporate policymakers and communication experts from the initiation of a climate change project to the period of disseminating the results. This will greatly reduce the length of time that it takes to sponsor or pass bills that relate to urban climate change adaptation. This is critical for the transformation of climate change adaptation knowledge to actual products or service.

- Climate change adaptation plans and policies at the state level across the sub-region should evolve into a single plan of action at the sub-regional level where all countries with shared vulnerabilities are classified and grouped together for funding and execution of projects to build urban resilience across the member states.

- In response to the vulnerability of the urban poor, climate change adaptation should be mainstreamed into urban land use policy. In order to make this effective, land use regulations should be enforced at all levels and penalties administered where necessary.

8.2.4 Overcoming the barriers and exploiting the opportunities

- There is the need for governments at the city level to identify and explore opportunities in climate change adaptation in urban areas. Some of the initiatives in these areas include micro-insurance, low cost housing, sanitation, affordable healthcare and microfinance. These initiatives will help vulnerable urban communities build resilience against the effects of climate change. This could be made possible by bringing in the private sector to invest in climate change adaptation plans.

- In order to curtail the urban population from growing in an unplanned fashion, areas of high population concentration with a lot of commercial activities should be decentralised. This will help reduce the pressure on infrastructure and critical utilities such as water and energy supplies. Local authorities should also pay attention to rural development so as to stem the influx of people from the rural areas to the urban centres.

- As noted above, one of the major challenges of urban climate change adaptation in the sub-region is funding adaptation projects at the city scale by the state or municipal authorities. In light of this, it is important for the state and municipal authorities to incorporate urban climate change adaptation projects into annual budgets.

- There is the need to derive and adopt a common protocol and indicators for methodology to create an urban sustainability index in the sub-region which

can be used in the development of City Adaptation Plans of Action and other policy documents. These common methodologies should be standardised across the cities in the sub-region. For instance, there may be the need to review and standardise building codes (so as to enhance the resilience of buildings and other critical infrastructure) as well as the climate data upon which those building codes and other adaptation strategies are based.

Developing urban centres should not only be focused in terms of adaptation actions, they should also be seen as strong factors for regional development. In this way adaptation actions will be enduring, being able to fulfil the purpose of reducing the vulnerability of urban residents in a robust and more sustainable manner. Urban climate change framework or policy in the sub-region should be all-inclusive, integrating policies on employment, income, healthcare, water and sanitation, food price stability and rehabilitation of the urban and peri-urban economy. This framework or plan should be carried out within an urban climate change system of innovation.

References

Abam, T., Ofoegbu, C., Osadebe, C. and Gobo, A. (2000) 'Impact of hydrology on the Port Harcourt–Patani–Warri road', *Environmental Geology*, 40:153-162

Abdu N, Abdulkadir A, Agbenin JO, Buerkert A (2011). Vertical distribution of heavy metals in wastewater irrigated-vegetable garden soils of three West African cities. Nutr. Cycl. Agroecosyst. 89:387-397.

Adaptation Fund Board (2011) *The adaptation fund project review process: Lessons learned,* presented at the Seventh Meeting of the Project and Programme Review Committee, 12 December, Durban, South Africa: Adaptation Fund

Adesina, F.A. and Odekunle, T.O. (2011) 'Climate Change and Adaptation in Nigeria: Some Background to Nigeria's Response', in *Proceedings of the International Conference on Environmental and Agriculture Engineering (ICEAE 2011)*, Singapore: IACSIT Press

Adesina, F.A., Odekunle, T.O., Ajayi, O., Eludoyin, O., Babatimehin, O., Dami, A., ... Adetiloye, O.T. (2008) *Adaptation Strategies of Action for Nigeria*. A working document prepared for the Special Climate Change Unit of the Federal Ministry of Environment, Housing and Urban Development, Abuja, Nigeria: Heinrich Böll Foundation

Adelekan, I.O. (2010) 'Vulnerability of poor urban coastal communities to flooding in Lagos, Nigeria', *Environment and Urbanization* Vol. 22 (2), pages 433-450.

Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C., O'Brien, K., Pulhin, J., ... Takahashi, K. (2007) 'Assessment of adaptation practices, options, constraints and capacity', in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge, UK: Cambridge University Press, 717-743

Afouda, A., Ndiaye, T., Niasse, M., Flint, L., Moussa Na Abou, M. and Purkey, D. (2007) *Adaptation aux changements climatiques et gestion des ressources en eaux en Afrique de l'Ouest,* Dakar, Senegal and Stockholm, Sweden: ENDA-TM and Stockholm Environment Institute

Africapolis (2009) *Urbanisation Trends 1950–2020: A Geo-statistical Approach – West Africa,* Paris, France: Africapolis

Agwu, E.A., Amadu, F.O., Morlai, T.A., Wollor, E.T. and Cegbe, L.W. (2011) *Agricultural Innovations for Climate Change Adaptation and Food Security in West Africa: The Case of Nigeria, Sierra Leone and Liberia.* Working Paper Series No. 12, African Technology Policy Studies Network

Ahmed, S. and Fajber, E. (2009) 'Engendering adaptation to climate variability in Gujarat, India', *Gender and Development,* 17(1):33-50

Akinbode, O.M., Eludoyin, A.O. and Fashae, O.A. (2008) 'Temperature and relative humidity distributions in a medium-size administrative town in southwest Nigeria', *Journal of Environmental Management*, 87:95-105

Annez, P., Buckley, R. and Kalarickal, J. (2010) 'African Urbanization as Flight? Some Policy Implications of Geography', *Urban Forum*, 21:221-234

Baer, P., Athanasiou, T. and Kartha, S. (2007) *The right to development in a Climate Constrained World.* Publication Series on Ecology, Volume 1, Berlin, Germany: Heinrich Böll Foundation

Binns, J.A., Maconachie, R.A. and Tanko, A.I. (2003) 'Water, land and health in urban and peri-urban food production: The case of Kano, Nigeria', *Land Degradation and Development,* 14(5):431-444

Bohle, H.G., Downing, T.E. and Watts, M.J. (1994) 'Climate change and social vulnerability: toward a sociology and geography of food insecurity', *Global Environmental Change,* 4(1):37-48

Bull-Kamanga, L., Diagne, K., Lavell, A., Lerise, F., MacGregor, H., Maskrey, A., ... Yitambe, A. (2003) 'Urban development and the accumulation of disaster risk and other life-threatening risks in Africa', *Environment and Urbanization*, 15(1):193-204

Boko, M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda, (2007) 'Africa', in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge, UK: Cambridge University Press, 433-467

Bryceson, D. and Potts, D. (2006) *African Urban Economies: Viability, Vitality or Vitiation?* Houndmills, Basingstoke: Palgrave Macmillan

Buhaug, H. and Urdal, H. (2012) 'An urbanization bomb? Population growth and social disorder in cities', *Global Environmental Change*, 23(1):1-10

Burton, I., Diringer, E. and Smith, J. (2006) *Adaptation to climate change: International policy options*, Arlington, VA: Pew Center on Global Climate Change

CV-MEA (2007) *National Adaptation Program of Action on Climate Change,* Praia, Cape Verde: Cape Verde Ministry of Environment and Agriculture

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menéndez, J. Räisänen, A. Rinke, A. Sarr and P. Whetton, (2007) 'Regional Climate Projections', in *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge, UK: Cambridge University Press

Conway, G. (2009) *The science of climate change in Africa: impacts and adaptation.* Discussion Paper No. 1, London, UK: Grantham Institute for Climate Change

Cour, J.M. (2001) 'The Sahel in West Africa: Countries in transition to a full market economy', *Global Environmental Change,* 11:31-47

De Vit, C. and Parry, J.-E. (2011) *Review of Current and Planned Adaptation Action: West Africa,* Winnipeg, Canada: International Institute for Sustainable Development
deWit, M. and Stankiewicz, J. (2006) 'Changes in water supply across Africa with predicted climate change', Science, 311:1917-1921

Deressa, T.D., Hassan, R.M., Ringler, C., Alemu, T. and Yesuf, M. (2009) 'Analyzing the determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia', *Global Environmental Change,* 19(2):248-255

Dessai, S. (2005) 'Robust adaptation decisions amid climate change uncertainties', PhD thesis, Norwich, UK: University of East Anglia

Dodman, D. and Satterthwaite, D. (2008) 'Institutional capacity, climate change adaptation and the urban poor', *IDS Bulletin*, 39(4):67-74

DOE (2012) *Climate Change and Infrastructure, Urban Systems, and Vulnerabilities.* Technical Report for the U.S. Department of Energy in Support of the National Climate Assessment, Oak Ridge, CA: U.S. Department of Energy

Dossou, K.M.R. and Glélhouenou-Dossou, B. (2007) 'The vulnerability to climate change of Cotonou (Benin): the rise in sea level', *Environment and Urbanization*, 19:65-79

Douglas, I., Kurshid Alam, K., Maghenda, M., McDonnel, Y., McLean, L. and Jack, M. (2008) 'Unjust waters: climate change, flooding and the urban poor in Africa', *Environment and Urbanization*, 20:187-205

DTI (2003) Innovation Report: Competing in the global economy the innovation challenge, London: DTI.

Duh, J.-D., Shandas,V., Chang, H. and George, L.A. (2008) 'Rates of urbanisation and the resiliency of air and water quality', *Science of the Total Environment*, 400:238-256

Dupar, M., Norton, A. and Lewis, P. (2012) *Women and climate change,* London, UK: Climate and Development Knowledge Network

Easterling, W., Hurd, B. and Smith, J. (2004*) Coping with Global Climate Change: The Role of Adaptation in the United States,* Arlington, VA: Pew Center on Global Climate Change

ECOWAS (2012) *ECOWAS* in Brief, Abuja, Nigeria: Economic Community of West African States / http://www.comm.ecowas.int/sec/index.php?id=about_a&lang=en [accessed 14 February 2014]

Edquist, C. (ed) (1997) *System of Innovation Approaches: Technologies, Institutions and Organizations,* London, UK: Pinter

EEA (2012) *Urban adaptation to climate change in Europe: Challenges and opportunities for cities together with supportive national and European policies.* Report No. 2/2012, Copenhagen, Denmark: European Environment Agency

Feenstra, J.F., Burton, I., Smith, J.B. and Tol, R.S.J. (1998) *Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies,* Nairobi, Kenya and Amsterdam, The Netherlands: United Nations Environment Programme and Institute for Environmental Studies

Feiden, P. (2011) *Adapting to Climate Change: Cities and the Urban Poor,* Washington DC: International Housing Coalition

Freeman, C. (1987) *Technology and Economic Performance: Lessons from Japan,* London, UK: Pinter

Gasper, R., Blohm, A. and Ruth, M. (2011) *Social and Economic Impacts of Climate Change on the Urban Environment,* Elsevier Science Direct

GMEST (2000) *Ghana's Initial National Communication,* Accra, Ghana: Ghana Ministry of Environment, Science and Technology

GMEST (2012) *Ghana National Climate Change Policy,* Accra, Ghana: Ghana Ministry of Environment, Science and Technology

GLCA (2009) *Facilitating an International Agreement on Climate Change: Adaptation to Climate Change,* Global Leadership for Climate Action

GOTG (2007) *Gambia National Adaptation Programme of Action on Climate Change,* Banjul, The Gambia: Government of The Gambia

Hall, A. and Yoganand, B. (2002) *New institutional arrangements in agricultural R&D in Africa: Concepts and case studies,* presented at the Workshop on Targeting Agricultural Research for Development in the Semi-Arid Tropics of Sub-Saharan Africa, 1-3 July, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Nairobi, Kenya

Hammer, S., Kamal-Chaoui, L., Robert, A. and Plouin, M. (2011) *Cities and Green Growth: A Conceptual Framework.* OECD Regional Development Working Papers 2011/08, Paris, France: OECD Publishing

Hewawasam, I. (2002) *Managing the marine and coastal environment of sub-Saharan Africa: strategic directions for sustainable development,* Washington DC: The World Bank

Hiraldo, R. (2011) 'Climate Change in West Africa: Key Issues', ENDA Energy, Environment and Development, Dakar, Senegal. September 2011
Hitimana, L., Heinrigs, P. and Tremolieres, M. (2011) 'West African urbanization trends', *West African Futures,* June 2011, Sahel and West Africa Club

Hope, K.R. (2009) 'Climate Change and Urban Development in Africa', *International Journal of Environmental Studies,* 66(5):643-658
IDRC/DFID (2013) *Building up climate change adaptation expertise in Africa: Lead institutions of Climate Change Adaptation in Africa research projects,* Ottawa, CA and London, UK: International Development Research Centre/Department for International Development

INERA (2008) *Responsabilsation du producteur en assainissement urbain durable au Sahel: Traitementet valorisation des dechets liquides domestiques en agriculture peri urbaine,* Ouagadougou, Burkina Faso: Institut de l'Environnement et Recherches Agricoles

Jalloh, A., Roy-Macauley, H. and Kuiseu, J. (2011) *Climate change research and development orientation framework: A CORAF/WECARD strategy for guiding climate change research and development in West and Central Africa,* Dakar, Senegal: Conseil Ouestet Centre Africain pour la Recherche et le Development Agricoles/West and Central African Council for Agricultural Research and Development

Jallow, B., Toure, S., Barrow, M. and Mathieu, A. (1999) 'Coastal zone of the Gambia and the Abidjan region in Cote d'Ivoire: sea-level rise vulnerability, response strategies and adaptation options', *Climate Research,* 6(Special Issue):137-143

GEF (1995) Revised draft: GEF Operational Strategy. GEF Council Meeting, GEF, Washington DC. October, 25-27, 1995. Kirshen, P., Ruth, M. and Anderson, W. (2008) 'Interdependencies of Urban Climate Change Impacts and Adaptation Strategies: A Case Study of Metropolitan Boston USA', *Climatic Change,* 86:105-122

Kristjanson, P., Waters-Bayer, A., Johnson, N., Tipilda, A., Njuki, J., Baltenweck, I., Grace, D., and MacMillan, S. (2010) *Livestock and women's livelihoods: A review of the recent evidence,* Nairobi, Kenya: International Livestock Research Institute / http://mahider.ilri.org/bitstream/handle/10568/3017/Discussion_Paper20.pdf [accessed 2 March 2011]

Lavell, A. (2003) *Local level risk management: Concept and practices,* Quito, Ecuador: Centro de Coordinación para la Prevención de los Desastres Naturales en América Central and United Nations Development Programme

Leary, N., Conde, C., Kulkarni J., Nyong, A. and Pulhin, J. (2008), *Climate Change Variability*, London, UK: Earthscan

Lundvall, B. (1985) *Product Innovation and User-Producer Interaction,* Aalborg, Denmark: Aalborg University Press

Mabogunje, A.L. (2001) *Nigeria and the good urban governance campaign*, presented at the First Plenary Session of the Launching of the Global Campaign in Nigeria for Good Urban Governance (GUG), Federal Ministry of Works and Housing, 10-12 April, Abuja, Nigeria

Mabogunje, A.L. (2004) *Framing the Fundamental Issues of Sustainable Development in Sub-Saharan Africa.* CID Working Paper No. 104. Cambridge, MA: Sustainable Development Program, Center for International Development, Harvard University / also published as TWAS Working Paper No. 1, Trieste, Italy: Third World Academy of Sciences

McGranahan, G., Mitlin, D., Satterthwaite, D., Tacoli, C. and Turok, I. (2009) *Africa's Urban Transition and the Role of Regional Collaboration, Human Settlements.* Urban

Change Working Paper No. 5, London, UK: International Institute for Environment and Development

Metcalfe, S. (1995), "The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives", in P. Stoneman (ed.), Handbook of the Economics of Innovation and Technological Change, Blackwell Publishers, Oxford (UK)/Cambridge (US).

Moser, S.C. and Ekstrom, J. (2010) 'A framework to diagnose barriers to climate change adaptation', *PNAS,* 107(51):22026-22031

National Population Commission (2005) *Training Reference Manual for Census,* Abuja, Nigeria: National Population Commission, Government of Nigeria

Ndiaye, M.L. (2012) 'Urban agriculture in Dakar, Senegal: Health aspects related to polluted irrigation water', in Robertson, M. (ed), *Sustainable Cities: Local solutions in the Global South,* Ottawa, Canada: International Development Research Centre

Nelson, R.R. (1993) *National Systems of Innovation: A Comparative Study*, New York, NY: Oxford University Press

NEST (2011) *Reports of Research Projects on Impacts and Adaptation: Building Nigeria's Response to Climate Change (BNRCC)*, Ibadan, Nigeria: Nigerian Environmental Study

Ngigi, S.N. (2009) *Climate Change Adaptation Strategies: Water Resources Management Options for Smallholder Farming Systems in Sub-Saharan Africa*, New York, NY: The MDG Centre for East and Southern Africa, The Earth Institute at Columbia University

Niang, I. (2007) *Climate Change Adaptation in Africa Programme: Institutional framework in relation to climate change in west and central Africa. Report on the existing institutional framework in relation to climate change in west and central Africa.* Université Cheikh Anta Diop, Dakar, Senegal.

Niang-Diop, I. (2005) 'Impacts of climate change on the coastal zones of Africa', in 'Coastal zones in sub-Saharan Africa: A scientific review of the priority issues influencing sustainability and vulnerability of coastal communities, London, 27-28 May 2003, Workshop Report 186', *ICAM Dossier,* 4:27-33

Nicholls, R.J. (2004) 'Coastal flooding and wetland loss in the 21st century: changes under the SRES climate and socioeconomic scenarios', *Global Environmental Change,* 14(1):69-86

Nicholls, R.J., Wong, P.P., Burkett, V.R., Codignotto, J.O., Hay, J.E., Ragoonaden, S. and Woodroffe, C.D. (2007) 'Coastal systems and low-lying areas', in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC,* Cambridge, UK: Cambridge University Press, 315-356

Nkuba, M. (2011) *Small holder farmers' knowledge and adaptation to climate change in the Rwenzori region,* Research Report No. 001, March 2011 Kabarole Research and Resource Centre, Fort Portal, Uganda.

NMEFRN (2003) *First National Communication on Climate Change,* Abuja, Nigeria: Nigeria Ministry of Environment of the Federal Republic of Nigeria

NNECSD (2006) *National Adaptation Program of Action (NAPA),* Niamey, Niger: Niger National Environmental Council for Sustainable Development

Nyong, A.O., Adesina, F.A. and Osman-Elasha, B. (2007) 'The value of indigenous knowledge system in integrating mitigation and adaptation to climate change', *Mitigation and Adaptation Strategies for Global Change,* 12:787-789

Nyong, A.O., Dabi, D., Adepetu, A., Berthe, A. and Ihemegbulem, V. (2008) 'Vulnerability in the Sahelina zone of northern Nigeria', in Leary, N. et al. (eds), *Climate Change and Vulnerability,* London, UK: Earthscan

Odum, E.P. (1971) *Fundamentals of Ecology,* 3rd edition, Philadelphia, PA: W.B. Saunders

OECD (2009) *Integrating Climate Change Adaptation into Development Co-operation: Policy Guidance,* Paris, France: Organisation for Economic Co-operation and Development

OHCHR (2011) *OHCHR West Africa Regional Office (2010-2011),* Geneva, Switzerland: Office of the United Nations High Commissioner for Human Rights / http://www.ohchr.org/EN/Countries/AfricaRegion/Pages/WestAfricaSummary1011.aspx [accessed 19 February 2013]

Okali, D., Okpara, E., Madu, T., Nwosu, A. and Nzegbule, E. (2012) *Triggering rural-urban interactions to cope with climate change: an adaptation experiment in Aba and its region, southeastern Nigeria.* Final technical report on IDRC climate change adaptation in Africa projectNigerian Environmental Study Action Team (NEST), Ibadan, Nigeria.

Okali, D., Okpara, E. and Olawoye, J. (2001) "Rural-Urban Interactions and Livelihood Strategies: The Case of Aba and its Region, South-Eastern Nigeria". Human Settlements Programme, International Institute for Environment and Development. Available On-line athttp://www.iied.org/

Osman-Elasha, B. and Downing, T. (2007) *Lessons Learned in Preparing National Adaptation Programmes of Action in Eastern and Southern Africa,* unpublished paper, Stockholm, Sweden: Stockholm Environment Institute

Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E. (eds) (2007) 'Summary for Policymakers', in *Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge, UK: Cambridge University Press, 7-22

Parnell, S. and Walawege, R. (2011) 'Sub-Saharan African Urbanisation and Global Environmental Changes', *Global Environmental Change,* 21:S12-S20

Perret, C. (2008) 'Climate and Climate Change', in *Atlas on Regional Integration in West Africa.* Environment series, Abuja, Nigeria and Paris, France: Economic Community of West African States and Sahel and West Africa Club

Population Reference Bureau (2012) 2012 *World Population Data Sheet,* Washington DC: Population Reference Bureau

Potts, D. (2009) 'The slowing of sub-Saharan Africa's urbanization: evidence and implications for urban livelihoods', *Environment and Urbanization,* 21:253-259

Rain, D., Engstrom, R., Ludlow, C. and Antos, S. (2011) 'Accra Ghana: A City Vulnerable to Flooding and Drought-Induced Migration', in *Cities and Climate Change: Global Report on Human Settlements 2011,* Nairobi, Kenya: United Nations Human Settlements Programme / http://www.unhabitat.org/grhs/2011

Rayner, S. and Malone, E.L. (eds) (1998) *Human Choice and Climate Change Volume 3: The Tools for Policy Analysis,* Columbus, OH: Battelle Press

Roncoli, C., Crane, T. and Orlove, B. (2009) 'Fielding climate change in cultural anthropology', in Crate, S.A. and Nuttall, M. (eds), *Anthropology and climate change: From encounters to actions,* Walnut Creek, CA: Left Coast Press

Rosenberg, N.J. (1996) *A primer of climatic change: Mechanism, trends, and projections.* RFF Paper RR86-04, Washington DC: Resources for the Future

Ruth, M. and Coelho, D. (2007) 'Understanding and managing the complexity of urban systems under climate change', *Climate Policy,* 7: 317-336

Satterthwaite, D., Huq, S., Pelling, M., Reid, H. and Lankao, P.R. (2007) *Adapting to Climate Change in Urban Areas: The possibilities and constraints in low- and middle-income nations.* Human Settlements Discussion Paper Series: Climate Change and Cities – 1. International Institute for Environment and Development, London,UK.

Schalatek, L., Nakhooda, S., Barnard, S., Caravani, A. (2012) Climate Finance Regional Briefing: Sub-Saharan Africa. Climate Fund Update. November, 2012. http://www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publicationsopinion-files/7914.pdf [accessed 31 July 2013]

Schneider, S.H., Semenov, S., Patwardhan, A., Burton, I., Magadza, C.H.D., Oppenheimer, M., and Yamin, F. (2007) 'Assessing key vulnerabilities and the risk from climate change', in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge, UK: Cambridge University Press, 779-810

Smith, B., Burton, I., Klein, R.J.T. and Street, R. (1999) 'The science of adaptation: a framework for assessment', *Mitigation and Adaptation Strategies for Global Change,* 4:199-213

Soyombo, O. (2006) *Main Report of the Lagos State Urban Upgrading Project Confirmation Survey,* Lagos, Nigeria: Lagos Metropolitan Development and Governance Project

Speilman, D.J. (2005) *Innovation Systems Perspectives on Developing Country Agriculture: A Critical Review.* ISNAR Discussion Paper 2, Washington DC: International Food Policy Research Institute

Stern, N. (2007) *The Economics of Climate Change: The Stern Review,* Cambridge, UK: Cambridge University Press

SWAC/OECD (2007) *Livestock in the Sahel and West Africa.* Policy Note No. 3, Paris, France: Sahel and West Africa Club of the Organisation for Economic Co-operation and Development

Tacoli, C. (2011) *Rural-Urban Interactions and Livelihood Strategies: Not only climate change – mobility, vulnerability and socio-economic transformations in environmentally fragile areas of Bolivia, Senegal and Tanzania.* Human Settlements Working Paper No. 28, London, UK: International Institute for Environment and Development

UNDP (2010) *Final project report: Integrating climate change in the development of Cabo Verde.* Project: Integrating Climate Change Risks and Opportunities into National Development Processes and UN Country Programming, New York, NY: United Nations Development Programme

UNDP (2012) *Sustainable Wetland Management in the Face of Climate Risks in Niger: The Case of La Mare de Tabalak,* New York, NY: United Nations Development Programme, Bureau for Crisis Prevention and Recovery

UNEP (2009) *A Preliminary Stocktaking: Organisations and Projects focused on Climate Change Adaptation in Africa,*

Nairobi, Kenya: United Nations Environment Programme, Climate Change Adaptation Unit

UNFCCC (2012) *National adaptation programmes of action,* Bonn, Germany: United Nations Framework Convention on Climate Change

Wenger, E. (2006) *Communities of practice: A brief introduction,* Wenger-Trayern website / http://www.ewenger.com/theory [accessed 30 January 2013]

Wilbanks, T.J., Lankao, P.R., Bao, M., Berkhout, F., Cairncross, S., Ceron, J.-P., ... Zapata-Marti, R. (2007) 'Industry, settlement and society', in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge, UK: Cambridge University Press, 357-390

World Bank (2010) *Cities and Climate Change: An Urgent Agenda.* Urban Development Series Knowledge Papers Vol. 10, Washington DC: The World Bank

World Urban Campaign (2012) Manifesto for cities: The urban future we want. World Urban Campaign. Nairobi: Kenya.

Appendix A: Examples of urban climate change adaptation projects in West Africa

Country	Project Title	Focus Area of Project	Adaptation Strategies Employed	Sector Affected	Impacts	Geographic Scale	Rural or Urban setting	Case Description and Web Link
Burkina Faso	Rural Urban Cooperation on Water Management in the Context of Climate Change in Burkina Faso	Building Response Capacity; Climate Risk Management	Vulnerability assessment	Disaster-risk manage-ment	Water resources manage-ment; Conflict	National	Both urban and rural	Taking the hypothesis that climate adaptation in the city depends to a great extent on climate adaptation in the country, this project aims to reinforce cooperation between cities and rural areas in order to better cope with climate change and variability. www.idrc.org/ccaa
Ghana	Capacity Development and Adaptation to Climate Change on Human Health Vulnerability	Building Response Capacity; Climate Risk Management	Institutions; Planning; Policy	Human health	Spread of Vector-Borne Diseases	National	Both urban and rural	Several organizations are collaborating to devise adaptation options in response to climate-related diseases, and to integrate adaptation into national and local health policy. http://www.acccaproject.org/evolution/modules/knowledgebox/external2/view.php?id=298&kbid=5
Multinati-onal (Burkina Faso, Cameroon, Ethiopia, Kenya, South Africa)	Advancing Capacity to Support Climate Change Adaptation: Five Pilot Projects	Addressing Vulnerability Drivers	Institutions; Awareness; Policy; Infrastructure	Disaster-risk manage-ment	Food security and water resources	Multinati-onal	Both urban and rural	This project seeks to reduce the vulnerability of poor populations in sub-Saharan Africa to climate change by mobilizing scientists and all the other actors concerned to inform political decision-making. It will do so by means of five pilot projects in rural and urban populations. The project will emphasize the generation, organization and communication of information on the risks resulting from climate change, climate variability and extreme climatic events, as well as preparation for their effects on food security (Cameroon, Ethiopia, Kenya) and water supply (South Africa, Burkina Faso). www.idrc.org/ccaa
Multinati-onal (All Africa)	Capacity Building in Analytical Tools for Estimating and Comparing Costs and Benefits of Adaptation Projects in Africa	Building Response Capacity	GCM scenario building	Agricul-ture	Cost analysis	Multinati-onal	Both urban and rural	This project seeks to reduce the vulnerability of poor populations in sub-Saharan Africa to climate change by mobilizing scientists and all the other actors concerned to inform political decision-making. It will do so by means of five pilot projects in rural and urban populations. The project will emphasize the generation, organization and communication of information on the risks resulting from climate change, climate variability and extreme climatic events, as well as preparation for their effects on food security (Cameroon, Ethiopia, Kenya) and water supply (South Africa, Burkina Faso). www.idrc.org/ccaa

Multinational (West African countries)	Food Security and Climate Change in Sub-Saharan West Africa	Addressing Vulnerability	GCM scenario building	Agriculture	Food security	Multinational	Both urban and rural	The primary objective of the project is to undertake a study of the vulnerability of food crop production to inter-annual climate variability and extreme weather events in West Africa and to assess how extended weather and climate forecasts could be employed as a basic adaptation strategy to ameliorate the impacts. www.aiaccproject.org
Multinational (West African countries)	Adapting Fishing Policy to Climate Change with the Aid of Scientific and Endogenous Knowledge	Climate Risk Management	Planning	Coastal resources	Decline in productivity of fisheries	Multinational	Both urban and rural	This project aims to improve fishing practices and policies in the face of climate change in six countries - Cap Vert, Gambia, Guinée, Guinea Bissau, Mauritanie and Sénégal. It will do so by facilitating twice-yearly meetings at three levels (subregional, national and local), bringing together political decision-makers, researchers, representatives of fisher associations and managers of projects and programs. www.idrc.org/ccaa
Niger	Niger Basin Water Resources Development and Sustainable Ecosystems Management Project	Building Response Capacity	Institutions; Resources; Infrastructure	Water resources	N/A	Subnati-onal	Both urban and rural	The Niger Basin Authority is working to improve watershed management, irrigation, hydroelectric power, and institutional coordination on water resources. http://web.worldbank.org/external/projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P093806
Nigeria	Strengthening the Capacity of Smallholder Farmers to Adapt to Climate Change through Radio Drama	Building Response Capacity	Awareness	Agriculture	Communicating adaptation strategies to the public	National	Both urban and rural	This project will support the production and test of a 26-episode radio drama featuring climate adaptation content. The episodes will be produced locally in two local languages and broadcast weekly by five radio stations over a period of six months. www.idrc.org/ccaa
Senegal	Partnership for adapting Vulnerable Populations to Soil Salinzation resulting from Climate Change in Sénégal	Building Response Capacity	Awareness	Agriculture; Water resources	Salinization and acidification of land	National	Both urban and rural	This project aims to increase the capacity of rural communities, community-based organizations, and local and national decision-makers to deal with soil salinization. www.idrc.org/ccaa

Senegal	Assessing Global and Regional Climate Change Scenarios for West Africa	Addressing Vulnerability	Vulnerability assessment	GCM scenario building		Regional	Both urban and rural	This project seeks to build capacity for assessing climate change scenarios from global and regional climate model simulations for use in impact studies in West Africa. The project will address the need to (a) Assess global circulation model (GCM) and regional climate model simulations for present and future climate states in order to examine the processes that bring about new climate states; (b) Determine whether these changes are realistic given the current understanding of the West African Climate system; and (c) Provide model output to other disciplines to examine how potential changes in climate might affect key sectors on national and regional scales in West Africa. An important component of this proposal is capacity building of West Africa institutions. www.aiaccproject.org

Source: UNEP (2009)

Appendix B: List of contacted researchers and colleagues

Name	Institution/Affiliation	Country
M Soumana Timbo	DNA-DNEF / National Ramsar Focal Point	Mali
Fuseini Issahaka	PhD Candidate at Stellenbosch University, South Africa	Ghana
Prof Chris Gordon	Director, Institute for Environment and Sanitation Studies, University of Ghana, Legon, Accra	Ghana
Chibeze Sunday Ezekiel	Executive Coordinator, Strategic Youth Network for Development Organisation	Ghana
Fall Jean Pierre Yvon	Environment and GRC Specialist	Senegal
Aliou Gory Diouf	AfricaAdapt Program Manager, Enda Energie-Environnement-Développement	Senegal
Edward Rhodes	Consultant, Agriculture and Climate Change	Sierra Leone
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Future Agricultures

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