

# Climate Change Adaptation Preparedness in Developing Countries: A Study of 21 Countries and Knowledge, Attitudes, and Practices Studies in Akwa Ibom and Lagos States in Nigeria

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## **ABSTRACT**

EDEMA OJOMO: Climate Change Adaptation Preparedness in Developing Countries: A Study of 21 Countries and Knowledge, Attitudes, and Practices Studies in Akwa Ibom and Lagos States in Nigeria  
(Under the direction of Dr. Jamie Bartram)

Global climate change is projected to have disproportionate adverse impacts on water quality and availability in low-resource settings. Therefore, it is essential that developing countries assess their vulnerabilities and develop strategies to improve their resilience. This thesis presents two research studies on climate change adaptation preparedness in developing countries.

In the first study, the policies and programs of 21 developing countries were analyzed to determine adaptation preparedness. In study countries, preparedness varied widely. However, in general, even those countries that have prioritized preparedness for climate change need to implement several additional policies and practices to ensure adequate adaptation.

In the second study, a knowledge, attitudes, and practices (KAP) study of policy makers and university students was carried out in Nigeria to determine the level of awareness of climate change. Study participants understood the causes of climate change but less so the effects. More awareness is needed for both study populations.

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## **LIST OF ABBREVIATIONS**

ACSM – Advocacy, Communication, and Social Mobilization

ALM – Adaptation Learning Mechanism

BNRCC - Building Nigeria's Response to Climate Change

CSIRO – Commonwealth Scientific and Industrial Research Organization

DRI – Disaster Risk Index

DRR – Disaster Risk Reduction

EPRP – Emergency Preparedness and Response Planning

FAO – Food and Agriculture Organization

GDP – Gross Domestic Product

GEF – Global Environment Facility

GHG – Greenhouse Gases

HDI – Human Development Index

INC – Initial National Communication

IPCC – Intergovernmental Panel on Climate Change

IRB – Institutional Review Board

KAP – Knowledge, Attitudes, and Practices

LDC – Least Developed Countries

NAPA – National Adaptation Programme of Action

OAGCMs – Ocean- Atmospheric General Circulation Models

UNDP – United Nations Development Programme

UNEP – United Nations Environment Programme

UNFCCC – United Nations Framework Convention on Climate Change

UNICEF – United Nations Children's Fund

UNIDO – United Nations Industrial Development Organization

# **I. Climate Change Preparedness in Developing Countries**

## **a. Introduction**

According to the Intergovernmental Panel on Climate Change (IPCC), “climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity” (IPCC 2007). However, most of the warming observed over the past fifty years is attributable to human activities. The IPCC Second Assessment Report (SAR) reports that “the balance of evidence suggests a discernible human influence on global climate (IPCC 2001).” One main anthropogenic cause of global climate change is the atmospheric build-up of carbon dioxide and other greenhouse gases (GHGs) emitted from vehicles and industrial processes. The significance of climate change lies in the dependence of several environmental factors, conditions, and resources (food production, water resources, human health, forests etc) on the climate.

Water resources (surface water and groundwater) are among the resources that have been, and continue to be, adversely affected by climate. In some regions, climate change has reduced and will continue to reduce the amount of water resources available for domestic human consumption if policies and programs are not put in place to prevent, or at least minimize, the adverse impacts of climate change on water quality and quantity. These policies and programs can either be adaptation or mitigation driven. Adaptation refers to “the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”, and mitigation refers to the “technological change and substitution that reduce resource inputs and emissions (of GHGs) per unit of output (IPCC 2007).”

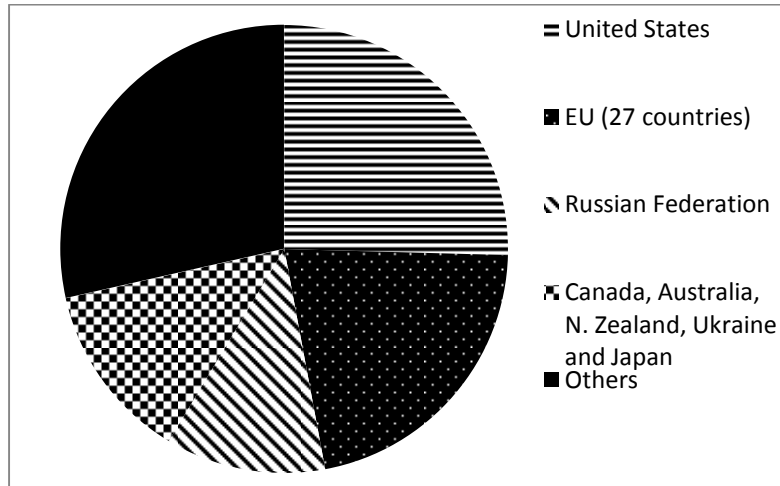
The adverse impacts of climate change on water resources occur as a result of numerous climate change effects, including sea level rise (which will lead to salinization of freshwater resources), coastal and inland flooding (as a result of storms and cyclones in coastal areas and intense precipitation in inland areas which will lead to contamination of water resources), and drought (which will lead to drying up of available water resources). These climate change effects could result in reduced water quality and availability; however, some of the effects could increase water availability if the right practices are employed. The reduction in the amount of water resources caused by climate change impacts may bring about water stress or scarcity in areas that currently don't experience water stress or scarcity by exacerbating current stresses on water resources.

An area experiences water stress when annual water supplies fall below 1,700 cubic meters per person, water scarcity when annual water supplies fall below 1,000 cubic meters per person, and absolute scarcity when annual water supplies fall below 500 cubic meters per person (UN 2011). Population growth and over-abstraction by sectors like the agricultural sector are some factors that contribute to water stress across the world, and according to the IPCC, climate change is expected to exacerbate current stresses on water resources. Experts believe that the undesirable impacts of climate change on freshwater systems outweigh the benefits (IPCC, 2007). The adverse impacts of climate change will be experienced earlier at lower latitudes, where most developing countries are located (Evans, 2009).

### ***Anthropogenic Impacts on the World's Climate***

The Earth's atmosphere is being changed at an unprecedented rate by pollutants resulting from human activities, inefficient and wasteful fossil fuel use, and the effects of rapid population growth in many regions (Gleick, 1989). This atmospheric change represents a major threat to all countries, but particularly to developing countries. Although,

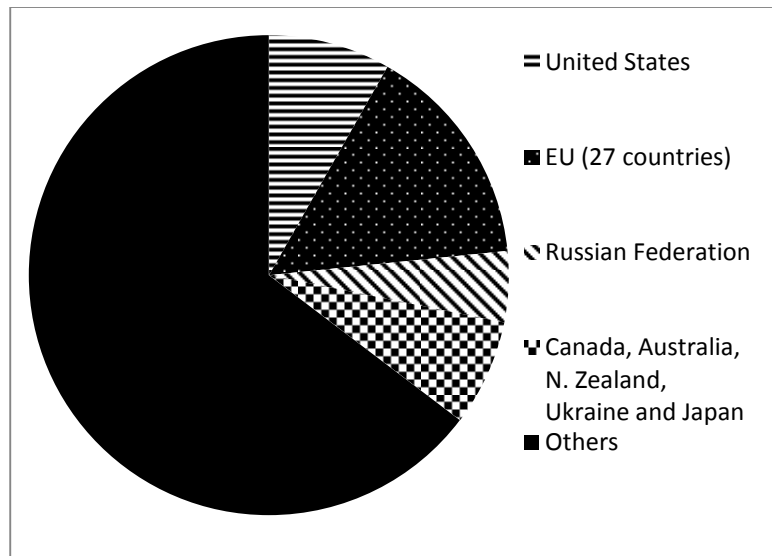
the chief responsibility for the production of GHGs lies with developed countries (as shown in Figures 1 and 2), developing countries bear the major burden posed by the risks of climate change due to a dearth of financial and institutional resources.



**Figure 1: CO2 emissions by countries in 1990.**

Source: *Climate Analysis Indicators Tool* by World Resources Institute

Note: Majority of the responsibility for CO2 emissions by EU countries falls on Germany, United Kingdom, Italy, France, and Poland. Approximately one-third of CO2 emissions for “Others” is produced by China and India but both countries ranked 88<sup>th</sup> and 118<sup>th</sup>, respectively, for emissions per capita in 1990.



**Figure 2: 1990 populations by country.**

Source: *Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2007 Revision*

### ***Effects of Climate Change on Freshwater Availability and Quality***

Temperature, precipitation, snowmelt, and sea level changes have both beneficial and adverse impacts on water availability and quality. Temperature is predicted to increase in most areas, but is mostly expected to increase more in inland areas and at higher latitudes, and an increase in rainfall variability is predicted for most regions (EPA 2011). The higher temperatures will increase loss of water through evaporation and thus reduce water availability. In arctic countries, increase in temperature will lead to reduced snow cover and increased water availability through melted snow. This melted snow could cause flooding in these countries and surrounding countries. However, the net impact on water supplies will also depend on changes in precipitation (including frequency, intensity, and timing of precipitation events). In areas where precipitation increase is projected, there may be no change or an increase in water availability. In other areas where precipitation decrease is projected, a decrease in water availability would occur, which could have adverse impacts on domestic, agricultural, and industrial use depending on amount available per capita. Increased temperature also leads to glacier melting which increases run-off. Increased annual run-off may favorably impact a variety of water users by increasing renewable water resources, but may simultaneously adversely impact communities by increasing flood risk (IPCC 2008).

Increased temperature which leads to evaporation, along with reduced precipitation in some areas, could potentially lead to reduced lake levels and reduced stream flows which will result in reduced dilution of pollutants. However, increased frequency and intensity of precipitation could transport contaminants and lead to higher pollution and sediment transport and deposition. Sea level rise will also adversely impact water quality due to saltwater intrusion into freshwater resources (EPA 2011).

### ***Climate Change Impacts on Developing Countries***

Developing countries are the most vulnerable to climate change impacts, due to the limited access to information, technology, institutions, financial, and educated human resources. Over the next decades, billions of people, particularly those in developing regions, will face water shortages, food insecurities, and greater health risks as a result of climate change. By 2020, up to 250 million people in Africa could be exposed to greater risk of water stress and over the course of the 21<sup>st</sup> century, millions of people in the catchment areas of the Himalayas and Andes face increased risk of floods from glacial melts, followed by drought as glaciers disappear (UNFCCC 2007). As of 2008, 884 million people lacked access to drinking water from improved sources, most of whom live in developing countries. Climate change is anticipated to adversely affect the ability of developing countries to improve their access to safe drinking water due to the unfavorable impacts climate change has started to have and will continue to have on water quality and availability in some parts of the world (WHO/UNICEF 2010). In other words, climate-change impacts on the timing, flow, and amount of available freshwater resources could affect the ability of developing countries to increase access to potable water.

The microbiological quality of water due to lack of sanitation and other factors is poor, and climate change effects, which could reduce the quality of water (e.g. contamination by flooding, reduced dilution during drought etc. ), could potentially further deteriorate the already poor quality of water. For example, as of 2008, open defecation was practiced by approximately 17% of the world's population, most of whom live in developing countries (WHO/UNICEF 2010). Increased frequency and intensity of precipitation could transport feces and lead to higher pollution of water sources while reduced precipitation could potentially lead to reduced dilution in contaminated water sources.

Climate change is expected to exacerbate current stresses on water resources, but population growth and other factors are likely to be more significant drivers in the near future

(Vorosmarty et al. 2000). According to the United Nations World Urbanization Prospects, world population growth rate between 2010 and 2015 (5-year growth rate) is projected to be approximately 1.1%, with growth rate in *more developed countries* being 0.2% and growth rate in *less developed countries* being approximately 1.3% (UNPD 2007). Population growth places increasing demand on limited water resources and the majority of this growth is occurring in developing regions which are most vulnerable to climate change impacts and, thus, have more stress placed on the water systems.

The flow chart below illustrates the relationships between key terms used in this paper.

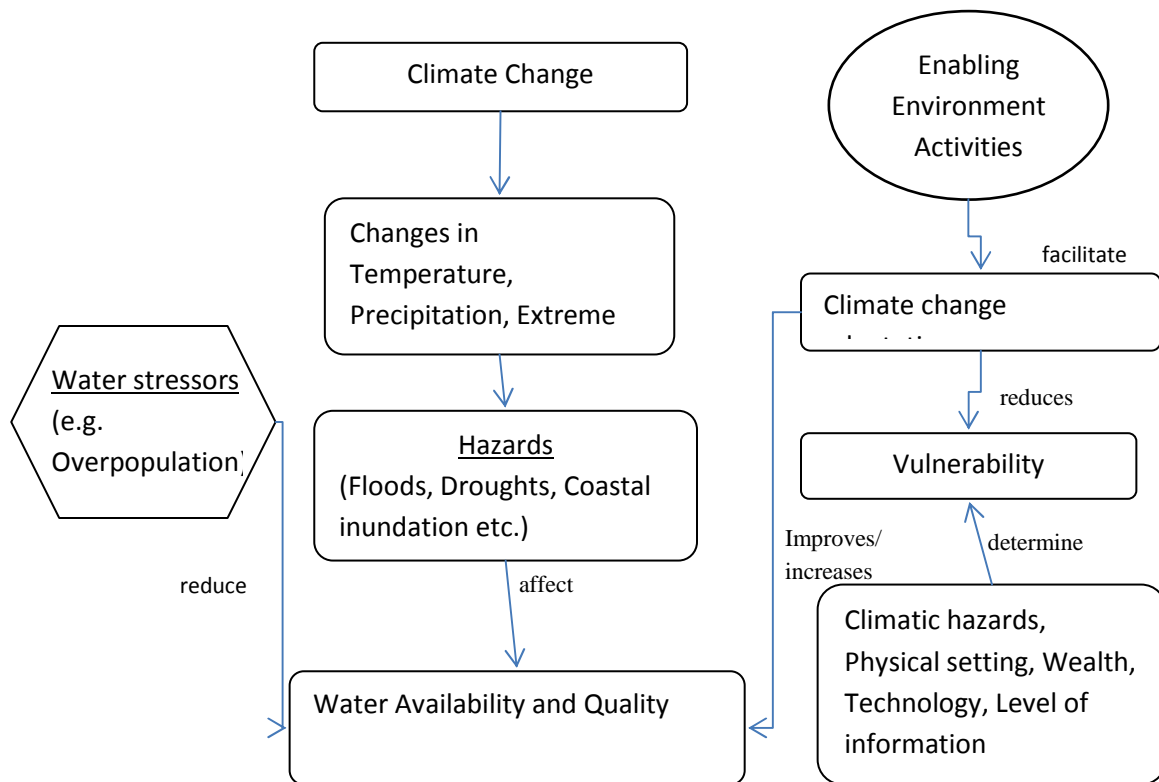


Figure 3: Relationship between key terms used in the paper

***Developing countries and their preparedness for climate change***

The IPCC Fourth Assessment Report (AR4) states that “warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average



sea level” (IPCC 2007). It is necessary that countries are prepared to take the right measures to reduce the adverse effects of climate change and exploit the favorable effects of climate change. Preparedness refers to the *presence or absence of planned and implemented policies and projects that reduce the vulnerability of a country’s water resources to climate change and the adequacy of these policies and practices when present*. 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” and “is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, the sensitivity and adaptive capacity of that system (IPCC 2007).”

Changes in extreme precipitation events which are currently occurring, as well as other extreme weather events, make it critical that developing countries are resilient enough to withstand the adverse effects of climate change and take advantage of the favorable effects. Climate change has some favorable impacts and by being prepared, countries could make the most of these impacts. For example, increased precipitation in some areas could lead to improved groundwater recharge and employing artificial recharge measures can increase volume of water recharged, thus, increasing water availability. Also, rainwater harvesting could be carried out either at the household level or at the community level or both and would improve water availability, particularly during seasons of low rainfall. Taking action early could therefore, help to not only minimize adverse impacts but also optimize benefits of climate change on the environment.

### ***Perceptions of developing countries regarding climate change***

Society’s perception of climate change is largely formed by the frequency and intensity of extremes particularly if the extreme events have large and adverse impacts on lives and property (IPCC 2007). Perceptions inform policy level decisions and influence adaptive response to climate change. In other words, the level of preparedness of a country

with regards to adapting to climate change impacts can be a function of the perception of climate change within that country. Although, developing countries are especially vulnerable to climate change impacts due to lack of adequate human, financial, institutional, and technological resources, knowledge and awareness (information) of climate change can also play a significant role in helping tackle climate change impacts. An accurate assessment of the perception of the risks of climate change by individuals of a country is only achievable by determining the current level of awareness of climate change and its potential impacts in a country. Education and awareness campaigns can then be carried out where needed.

### ***Research Objectives***

Two studies were carried out for this thesis. This paper presents information on preparedness of 20 developing countries with regards to climate change (First study) and on the level of awareness of climate change in Nigeria (Second study). Objectives of both studies are described below but the second study is presented in Chapter II.

### ***Research Study I***

Given the significance of climate change adaptation in developing countries, a study of national documents was carried out to determine the preparedness of developing countries in tackling climate change impacts on water resources. This review was the first portion of this study.

The objective of this section of the research was to:

- Determine what policies and practices are relevant in assuring sustainability of water resources in developing countries with projected climate change scenarios
- Determine credible climate change scenarios for 20 developing countries based on analysis of regional and country-level information

- Determine the preparedness of 20 developing countries with regards to reducing the vulnerability of water resources to climate change effects based on a review of national documents that describe current and planned adaptation measures

Literature review, methods, results, and discussion are presented in the sections immediately following this introduction.

### *Research Study II*

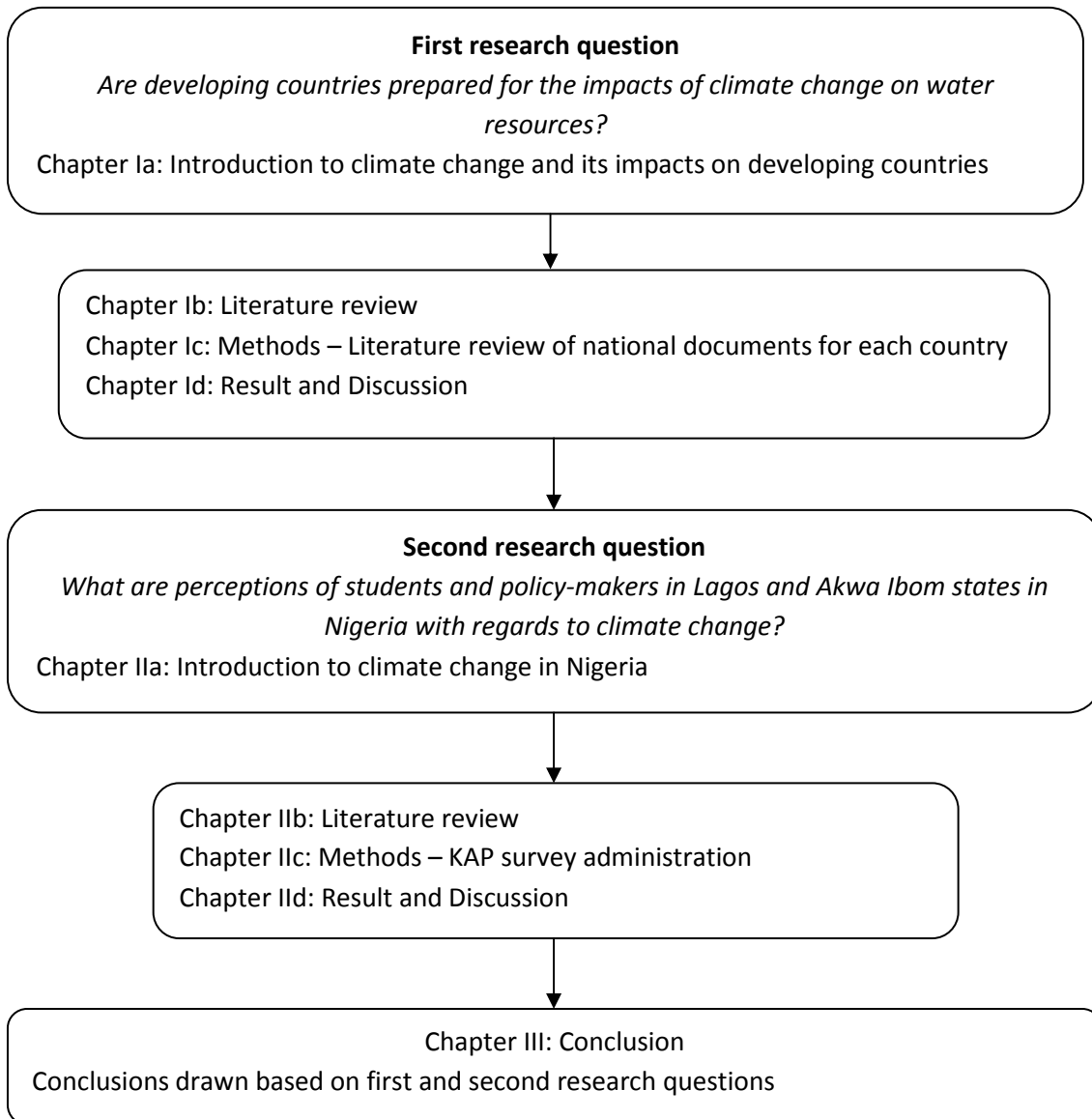
The importance of determining the level of awareness in a developing country led to research being conducted in Nigeria (one of the 21 countries studied to determine level of preparedness) for this purpose. This constitutes the second portion of this study.

The objective of this section of the research was to

- Assess the knowledge and attitudes of university students in Lagos and Akwa Ibom states in Nigeria
- Assess the knowledge, attitudes, and practices of ministry and agency officials in Lagos and Akwa Ibom states in Nigeria
- Compare knowledge and attitudes of both study populations

A thorough introduction to this research, literature review, methods, results, and discussion are presented in Chapter II – Climate Change Perceptions in Lagos and Akwa Ibom States which begins on page 69.

The flowchart below illustrates the structure of this paper.



**Figure 4: Structure of research paper**

## **b. Literature Review**

### ***Climate Change***

Climate includes patterns of temperature, precipitation, humidity, wind and seasons. Climate change refers to the long-term shifts in the statistics of weather including its averages (NOAA, 2007). Climate patterns play a vital role in shaping natural ecosystems, and the human economies and cultures that depend on them. Because many systems are tied or related to climate (agriculture, wildlife, etc.), a changing climate can affect where and how people live by influencing land and water access and use, food production and water resource availability.

### ***Global Climate Change Projections***

#### ***Temperature***

According to the IPCC (2007), an increase in global mean surface air temperature (SAT) is projected (for non-mitigation scenarios assessed) over the 21<sup>st</sup> century, and this increase is driven mainly by anthropogenic greenhouse gas concentrations. Geographical patterns of projected SAT warming show greatest temperature increases over land (roughly twice the increase in global average temperature). The multi-model mean SAT warming range for 2090 to 2099 relative to 1980 to 1999 is +1.1°C to +6.4°C for lower range of the best scenario Special Reports on Emission Scenarios (SRES) model (B1<sup>1</sup>) and higher range of the worst scenario SRES model (A1F1). In terms of temperature extremes, it is *very likely*<sup>2</sup> that heat waves will be more intense, more frequent, and longer lasting in a future warmer climate.

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<sup>1</sup> Information on all scenarios can be found in the IPCC Fourth Assessment Report

<sup>2</sup> *Very likely* as defined in the IPCC fourth assessment report means there is a greater than 90% probability that a projected occurrence or outcome will take place

### *Precipitation*

The IPCC predicts that an increase in global average temperature would in all likelihood lead to changes in precipitation, and further projects an increase in global average precipitation during the 21<sup>st</sup> century; however, changes in precipitation will vary from region to region. The intensity of precipitation events is projected to increase, particularly in tropical areas that experience increase in average precipitation. In areas where mean precipitation is projected to decrease, precipitation intensity is projected to increase, but longer periods between rainfall events would occur (IPCC, 2007). Therefore, intense and heavy precipitation would be interspersed with longer relatively dry periods (drought). Wet extremes are projected to become more severe in many areas where mean precipitation is expected to increase, and dry extremes are projected to become more severe in areas where mean precipitation is projected to decrease (IPCC, 2007).

### *Sea level rise*

Sea level is projected to rise between the end of the last century (1980 – 1999) and the end of this century (2090 – 2099) under different scenarios by a range of 0.18m (lower bound) to 0.59m (upper bound). In all scenarios, the average rate of sea level rise during the 21<sup>st</sup> century will *very likely* exceed the 1961 to 2003 average rate ( $1.8 \pm 0.5$ mm per year). Sea level rise during the 21<sup>st</sup> century is projected to have considerable geographical variability (IPCC, 2007).

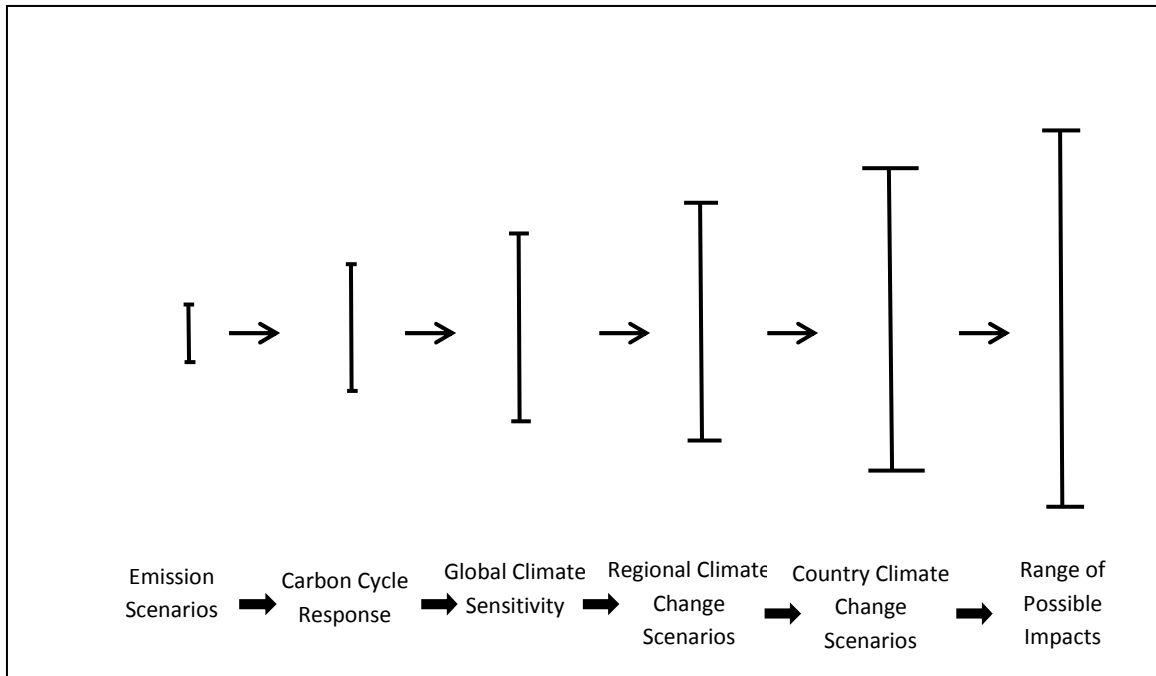
### *Uncertainties with climate change projections*

Four sources of uncertainty associated with climate change projections are:

- i. Natural variability: Climate is influenced by natural factors like seasonal cycles and El Nino Southern Oscillation as well as random external factors like volcanic eruptions.

- ii. Limitations of knowledge, modeling methodologies and computing: Knowledge of how Greenhouse Gases (GHGs) affect the Earth's natural systems like the atmosphere and biosphere is imperfect, thus, thus the representations of these systems in models contain large uncertainties and assumptions.
- iii. Future emissions scenarios: These emission scenarios are not predictions but instead separate storylines on how the world may develop. Although some scenarios appear to be more likely than others bearing in mind recent history and development paths, the IPCC is keen that no probabilities are assigned to any of its Special Report on Emission Scenarios (SRES) scenarios.
- iv. Scaling: Representing local conditions that determine weather into the Global Climate Models (GCMs) and extracting local conditions from some models is very complex and can lead to uncertainties (Environmental Resources Management 2009).

There is a range of uncertainty that comes with climate change projections. Starting from the total effects of emissions on the environment, to how the global climate system will react, and then to how different geographical and climatic regions within the world will be altered and the resulting impacts from all this change, these uncertainties accumulate. This accumulation of uncertainty throughout the process of climate change prediction is known as a cascade of uncertainty (Schneider 1983). The figure below shows range of major uncertainties that arise during impact assessment.



**Figure 5: Range of major uncertainties typically involved in impact assessments, showing the ‘cascade of uncertainty’ as these ranges are multiplied to encompass a comprehensive range of future possibilities.**

*Source: Modified from Jones 2000 and Schneider et al. 2002*

## ***Dealing with Climate Change***

### *Adaptation and mitigation*

With regard to climate change, there are ultimately three responses: Mitigation, adaptation, or “do-nothing.” Mitigation is the “technological change and substitution that reduce resource inputs and emissions (of GHGs) per unit of output (IPCC, 2007)” and adaptation is “the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.” The do-nothing approach refers to a business as usual approach where no efforts are made to change energy use, reduce emissions, or capture CO<sub>2</sub>, and environments are left as they are, rather than modified to improve resilience to climate change.

Harrington (2001) notes that the “do-nothing” option is only acceptable if the potential for harm from environmental changes falls within tolerable limits. However, climate change is already happening, and the adverse effects are being experienced in some regions. With



increased rainfall variability and temperatures, food productivity is threatened, water availability and quality are compromised, and there are increased risks to public health. According to Stern (2006), it is clear that a business-as-usual approach will only lead to dangerous territory. Therefore, the impracticality of a do-nothing approach means only the other two options are available for dealing with climate change.

Adaptation as a strategic response to climate change has only recently begun to receive greater consideration, so it is much less developed than mitigation as a policy response (Bosello et al., 2009; Burton et al., 2002). Bosello et al. (2009) observe that the difficulty of implementing mitigation policies, along with the increasing awareness of climate inertia, eventually made adaptation a possible response to climate change. Adaptation is viewed as a powerful tool in reducing the adverse effects of climate change and taking advantage of the favorable impacts. Some would even argue that adaptation is a superior response strategy to climate change than GHG emissions reduction, although there is limited evidence to back this claim (Tol et al., 1998). The most significant difference between mitigation and adaptation is that mitigation policies contribute to the global good whereas adaptation is only valuable in societies that adapt (Michaelowa, 2001).

Most industrialized countries have committed, as signatories to the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol, to stabilizing GHG emissions at 1990 levels by the year 2000, and to reducing their GHG emissions by an average of 5.2%, compared to 1990, by the 2008-2012 period. Nevertheless, Klein et al. (2005) argue that, due to the lag times of GHGs in the global climate system, no mitigation effort, regardless of its rigor, is going to prevent climate change from happening in the next few decades. Therefore, adaptation is necessary. However, a reliance on adaptation alone, with no mitigation, will lead to climate change impacts to which effective adaptation measures may be too expensive economically, environmentally, and socially. So, both mitigation and adaptation are required to reduce the risks of climate change. Even though

research on adaptation is relatively less advanced than that on mitigation, the need for adaptation, and not just mitigation, is increasingly being recognized.

### ***Vulnerability of developing countries with regards to climate change***

All human societies are sensitive to climate because of the dependence of elements of human survival (food, water, forests etc.) on the climate. However, not all societies will be impacted by climate change in the same way. Knowledge about climate change impacts and vulnerability is accumulating, although the complexity of the problem (uncertainties), and the lack of empirical material, is hindering its progress (Fankhauser et al., 1999). It is a well-established fact that developing countries are disproportionately affected by climate change (e.g. Mirza, 2003; Rosenzweig et al., 1994; Gleick, 1989; Leary et al., 2007).

Vulnerability to climate change is determined by a variety of factors, including exposure to hazards, availability of resources, and entitlement of individuals and groups to call on these resources, in other words, by the ability to adapt (Adger, 2003). In addition, vulnerability is spatially variable, as it reflects local economic, social, and cultural characteristics, as well as physical settings (Sullivan et al., 2009).

The impacts of climate change are expected to be more severe in developing countries for several reasons, including, but not limited to, the following:

- The physical impacts of climate change are expected to be relatively large in developing countries, since precipitation is not likely to increase as is expected in many high-latitude regions, and increases in temperatures will lead to large evaporation losses (Christensen et al., 2007).
- Economic and technical capacity to adapt to climate change is limited in these countries (Mertz et al., 2009).
- Several developing countries rely on agriculture for national income and employment, and this sector is directly influenced by climate (Mertz et al., 2009).

- Lack of adequate/educated human resources. Developing countries contain 80% of the world's population but 25% of the world's scientists, and only 4% of total world research is conducted in developing countries (Leary et al., 2003).
- Climate change is only one of the numerous environmental problems faced by developing countries, many of which are also facing overpopulation, rapid urbanization, and resource depletion (McGuigan et al., 2002).

Vulnerabilities and adaptation strategies are linked to the development of poverty reduction strategies in developing countries (Halsnaes et al., 2009). According to Mertz (2009), this process has been primarily donor-driven because many developing countries do not consider climate change as one of their greatest concerns. More immediate needs for economic growth and poverty reduction take priority. However, some developing countries, particularly small island nations and least developed countries, have insisted on the need for adaptation from the onset of climate change negotiations (Burton et al., 2002). This is a significant step because climate change will have adverse effects not just on the environment but on the economy of developing countries, and it promises to widen the inequity gap between the rich and poor within and across countries (UNDP, 2007; McMichael et al., 2008). For example, in cities in developing countries, the poorest live in unplanned squatter dwellings, often located in flood plains which represent the only available place or a source of fertile agricultural land (McGuigan, 2002). Vulnerability to climate change will, therefore, be further increased in developing countries if appropriate measures are not taken to tackle the impacts of climate change.

### ***Vulnerability of water resources to climate change***

Vorosmarty et al. (2000) note that climate change, apart from population growth and other water stressors, has both favorable and adverse effects on water resources that are highly region specific. The effects of climate change on water resources include changes in

supply and quality for domestic, irrigation, recreational, industrial, and aquatic ecosystem uses.

It is estimated that, by 2025, approximately 5 billion people, of the projected 8 billion in the world at the time, will be living in countries experiencing water stress (Arnell, 1999). This water stress will not be caused by climate change but by other water stressors, particularly economic and population growth (Zimmerman et al. 2008). However, climate change could impose additional pressure on water resources. According to Arnell (2004), with climate change, there will be between 53 and 206 million people moving into the water stressed category and between 374 and 1661 million are projected to experience an increase in water stress under different scenarios.

This change in water stress in different regions occurs as a result of the different effects climate change is having and will have on water resources around the world. Changes in precipitation, runoff patterns, sea level rise, and land use and population shifts that may result from these effects will have both beneficial and adverse effects on water resources. Warmer temperatures will accelerate the hydrologic cycle, altering precipitation, the intensity and frequency of floods and droughts, and the magnitude and timing of runoff (Frederick et al., 1997).

The effects climate change will have on water resources are:

- Saline water profiles in deltas and river mouths pushed further inland and coastal aquifers facing an increased threat of saltwater intrusion as a result of sea level rise and storm surges (Frederick et al., 1997).
- Worsening water quality problems in areas where rising temperatures is the predominant climate change (Gleick, 2000). Rising temperatures would lead to increased evaporation and reduced dissolved oxygen. It could also lead to reduced dilution of algae and other substances as a result of evaporation.

- Worsening water quality as a result of increased transport of sediments and toxic substances into water bodies, for regions that experience precipitation increase (Fisher, 2000).
- Reduced water availability as a result of increased number of extreme drought events. The number of extreme drought is projected to increase by a factor of two by the 2090s (Burke et al., 2006).
- Decrease in groundwater recharge as a result of increased surface runoff from more frequent intense precipitation (BGR, 2008).
- Increased water availability in areas that receive more frequent rainfall.

The table below is adapted from the IPCC Fourth Assessment Report and lists effects of climate change on water sources under different climatic conditions.

**Table 1: Possible impacts of climate change due to changes in weather and climate events.**  
*Source: IPCC Fourth Assessment Report: Climate Change 2007 Synthesis Report.*

Projected Change	Effect on water sources
Warmer/fewer cold days/nights; warmer/more hot days/nights over most land areas.	Impacts water resources relying on snow melt
Warm spells/heat waves: frequency increases over most land areas	Increased water demand, water quality problems like algal blooms.
Heavy precipitation events: frequency increases over most areas	Adverse effects on quality of surface and groundwater; contamination of water supply
Drought increase	More widespread water stress
Rise in sea level	Decreased freshwater availability due to saltwater intrusion

### ***Why Developing Countries need to Adapt to Climate Change***

The argument for the need to adapt to climate change is much stronger when the effects of climate change (current and projected) are presented. It has been confirmed that developing countries are particularly vulnerable to climate change due to the limited access to adequate human, financial, technological, and institutional resources, as well as the vulnerable physical settings of developing countries (particularly coastal areas). The need

for adaptation in developing countries stems from the following current and projected impacts climate change is having and will have on these countries:

- Decreases in crop yields as a result of decreased precipitation. Under similar scenarios, crop yields are expected to increase in developed regions (Parry et al. 2004).
- Increased population at risk of water stress in Africa. By the 2020s, approximately 75-250 million people will be at risk of increased water stress under different scenarios (Arnell 2004).
- In Latin America, approximately 12 to 81 million people will experience increased water stress in the 2020s (Arnell 2004).
- Approximately 1 billion people in South, South-East, and East Asia would face increased risks from reduced water supplies (IPCC, 2007).
- Sea level rise threatens not just water quality but also the lives of millions of people that live in coastal areas. In China, almost 60% of the population reside in coastal provinces, and of the 200 million people in Indonesia, 130 million live on the main island of Java (Hinrichsen, 1999).

The list of impacts presented above is not an exhaustive list of the impacts climate change will have on developing countries. It should be noted that the above impacts are a generalization, as there will be variations within continents.

### ***Possible Adaptation Policies for Water Resources in Developing Countries***

According to Adger (2003), adaptation works to either reduce the susceptibility of vulnerable systems to climate change impacts, like diversifying food production or strengthening existing systems so they are less likely to be damaged by extreme events. There are various adaptation policies and practices currently being implemented in developing countries, however, it is instructive to look at the efficacy of adaptation policies

under current climatic conditions (Scheraga et al. 1998). Also, it should be noted that adaptation measures can have adverse effects if measures are employed without consideration for interdependent systems (Scheraga et al. 1998). For example, building seawalls can be built to protect coastal property from sea level rise but seawalls prevent new wetlands from forming and wetlands are useful for flood control among other things (Scheraga et al. 1998). This will ultimately increase the risks of these other systems to climate change. Based on these categories, the following adaptation policy options have been proposed in different literature:

- Incorporate climate change into long-term planning. The catastrophic impacts of climate change and the long-term effects due to inertia of the climate system makes this a high priority policy option (Smith et al., 1996).
- Disaster relief and hazard reduction. With increasing intensity and frequency of extreme weather events, this policy option should be high priority in disaster prone countries. This policy would likely have net benefits under current climate because risks from disasters would be reduced (Smith et al., 1996).
- Water conservation and contingency planning for drought. Due to the likely increase in the frequency of droughts in many regions, drought early warning and preparedness should be a priority. (Smith et al., 1996; Downing et al., 1997)
- Contingency planning in the event of floods (Madzwamuse, 2010). An increase in rainfall variability is projected to lead to more frequent floods. Although floods can have adverse effects on water resources, with effective water management techniques (reservoirs, increasing storage capacities of storage containers etc.), some benefits can be garnered (Downing et al., 1997).
- Integration of climate change into national water policies. Beneficial effects of climate change can be exploited if water supply options are diversified. One example is the

formulation of the national rainwater harvesting policy in Botswana, as rainwater harvesting was seen as an important aspect of adaptation (Omari, 2010).

- Enhance cooperation among states and countries with shared water bodies (Madzwamuse, 2010). Climate change may cause a direct shortage of water and/or lead to the degradation of water resources shared by communities, states or countries (Gleick, 1989). Hence, cooperation amongst those who share water bodies is vital.
- Cross-sector collaboration. Cross-sector collaboration and coordination is essential in planning and implementing climate change responses because the impacts of climate change span several sectors (AFCC, 2010).

Above are a number of policy/adaptation recommendations for reducing the adverse impacts of climate change and taking advantage of the favorable impacts. The choice of policy options is determined by several factors including confidence in local climate projections, alternative policy choices, and future benefits from adaptation measures (Mertz et al., 2009; Burton et al., 2002; Mendelsohn, 2000).

### ***Status of Preparedness with regards to climate change adaptation in Developing Countries***

There is currently limited information available on assessing the preparedness of countries with regard to climate change. The Heinrich Boll Stiftung Southern Africa (HBS) commissioned three studies in Botswana, South Africa, and Zimbabwe, to evaluate the state of preparedness for climate change adaptation in the region. These status reports look into the current climate situations of the country, climate change projections, national water policies, and how policies have been modified to account for climate change. However, these reports are not just focused on the water sector but also on health, biodiversity and ecosystems, and agriculture sectors. With regard to water resources, the national water policies have been modified to deal with change in demand and specific climate change



impacts on water resources. However, according to the reports, there are still practices that can be undertaken by countries to reduce vulnerability and increase preparedness (Chagutah, 2010; Madzwamuse, 2010; Omari, 2010).

Ikeme (2003) examined the preparedness of sub-Saharan Africa with regard to climate change adaptation and found that the region was not prepared for climate change. He used a framework for assessing the adaptational preparedness of a region developed by Fankhauser et al. (1999) which considered three elements: Timely recognition of the need to adapt, incentive to adapt, and the ability to adapt. According to the research, Ikeme concluded that sub-Saharan Africa was not prepared because there was a lack of recognition of the need to adapt, poor incentive to adapt, and low capacity to adapt.

Although adaptation has only been recently gaining greater recognition as a plausible component of the total strategy for dealing with climate change, it is needed. Adaptation ensures proper preparedness, such that a country that has put in place adequate adaptation policies will be better prepared to eliminate or cope with the adverse impacts of climate change, while taking advantage of the positive effects of such natural processes.

### **Summary**

Climate patterns play a vital role in shaping natural ecosystems, and the human economies and cultures that depend on them. Because many systems are tied or related to climate (agriculture, wildlife, etc.), a changing climate can affect where and how people live by influencing land and water access and use, food production and water resource availability. Climate change is already happening, and the adverse effects are being experienced in some regions. All human societies will be impacted by climate change; however, developing countries will be disproportionately affected due to their limited adaptive capacity. Therefore, adaptation is needed to reduce the adverse impacts and exploit the beneficial impacts of climate change. There is a need for adaptation in developing countries because the adverse impacts of climate change like saline intrusion

into freshwater and decreased water availability as a result of drought, to name a few, that are currently and are projected to affect several regions.

### **c. Methods**

Twenty-one countries (identified below) are used in the analysis of the preparedness of developing countries with regards to adapting water sources (surface and groundwater sources) to climate change effects. These countries are located in three different continents and have varying topographies and climates. Countries used in the assessment were Bangladesh, Cambodia, Cape Verde, Chad, China, Ethiopia, Eritrea, Guatemala, Haiti, Indonesia, Iraq, Madagascar, Nepal, Nicaragua, Nigeria, Pakistan, South Sudan, Sudan, Syria, Vietnam, and Zambia.

#### ***Country Selection***

Country selection was based on water availability and current climate change impacts in the countries. Available evidence indicated that all countries will be adversely affected, to some extent, by the impacts of climate change. Also, many of the countries (10 of 20) are currently either “water vulnerable” or “water stressed.” The countries selected all have the following characteristics and were chosen by our funding agency:

- They are susceptible to the water related hazards associated with climate change;
- They are countries with low drinking water coverage;
- They are countries with high global disease burden; and
- They are countries in which the funding agency’s WaSH staff were actively interested in the project

#### ***Country Assessment***

A literature review was used to carry out country-level assessment. Documents that were used as sources of country-specific information included UN Development Assistance Framework (UNDAF) reports, National Adaptation Programme of Action (NAPA) reports, Initial National Communications (INCs), United Nations Children’s Fund (UNICEF) Situation Analysis (SitAns) and United Nations Development Programme Climate Change (UNDP

CC) reports amongst others. Online databases like the Global Environmental Facility (GEF) were also used in the assessments. These documents were used to assess climate change projections for all countries as well as the presence and efficacy of enabling environment activities that prepare the country to deal with the effects of climate change (Details on these assessments are presented in the *Enabling Environment and Climate, Climate Change Projections, and Hazards* sections in this Chapter).

### ***Enabling Environment activities***

An enabling environment refers to *a set of interrelated conditions—such as legal, bureaucratic, fiscal, informational, political, and cultural—that impact on the capacity of ...development actors to engage in development processes in a sustained and effective manner* (Brinkerhoff 2004). Presence of a number of enabling environment activities (presented below in the *Enabling Environment activities identification* section) was used to determine preparedness. The classes of conditions addressed in this paper are socio-cultural (e.g. supporting vulnerable groups like children and women) and informational (e.g. building institutional capacity). Creating an enabling environment that supports climate change adaptation is vital to achieving long-term, effective and sustainable water supply and quality.

### ***Enabling Environment activities identification***

For successful adaptation practices that ensure continuous supply of clean, safe drinking water, certain individual, community, and national characteristics are essential within that community and/or country. Some of these characteristics include: Increasing knowledge of climate change and its effects for better assessment of needed adaptation measures, human resource capabilities, availability of resources to vulnerable populations (for example, the poor and children), an collaboration among and participation of individuals,

communities, regions, and sectors due to the interconnectedness of climate related issues, and in-built flexibility in the country to adjust to the likely deviations due to the uncertainties present in climate change projections. The enabling environment activities identified have at least one of the characteristics listed.

Nine enabling environment activities that are important in improving informational capacity of the countries, developing human and institutional capacity (capacities generally lacking in developing countries), and reducing equity issues were identified. Identification was achieved through literature search of current policy options and current needs for effective adaptation that achieve the objectives presented in the preceding sentence. These activities are relevant in ensuring effective adaptation of water resources to climate change. The enabling environment activities listed below were gathered from the list presented in the *Possible Adaptation Policies for Water Resources in Developing Countries* sub-section of the *Literature Review* section above. According to Burton et al. (2006), for adaptation policy to be effective, some requirements need to be met. One of these is improved informational capacity. This was not part of the list but is seen as relevant so an activity that achieves this was added. The enabling environment activities are summarized below based on their significance in ensuring continuous availability of safe drinking water in communities in a changing climate. The nine enabling environment activities are:

1. Enhance adaptive capacity of poor and vulnerable (e.g. children) populations to ensure equity amongst all people

The poor and vulnerable populations are least able to fend for themselves and, thus, to adapt to the effects of climate change due to lack of or minimal adequate human resources, limited access to advanced technology and financial resources, and inability to fend for themselves. Adaptive capacity of these populations must be improved to ensure they undergo minimal or no adverse effects of climate change. Some activities include

ensuring these communities have access to alternative water supplies and increasing the capacity of individuals through training workshops and other actions.

2. Raise awareness of climate change on national, regional, and community levels

Climate change preparedness requires the initial awareness of climate change and its effects on water resources. It is vital that individuals in different regions (rural and urban) and decision makers at all levels (community, regional, and national) are informed about climate change risks so that they can take necessary precautions to reduce the vulnerability of water resources to climate change effects.

3. Incorporate Disaster Risk Reduction (DRR) agenda into programmes

An increase in the frequency and intensity of extreme weather events is projected globally due to climate change. This occurrence, which is currently being experienced by numerous countries, whether as an effect of climate change or not, makes the presence of DRR systems essential. An example includes early warning systems which can aid in preparing communities for the onset of a disaster, and thus, protect their water resources.

4. Enhance research on climate change adaptation

Although there exists uncertainties in climate change prediction, credible or probable hazards can be determined from collating a number of climate change scenarios from reliable sources (as was done in Table 3) to help aid in determining effective adaptation policies and practices to carry out. Also, most countries analyzed in this paper are already experiencing increased frequency of extreme events. Conscious research into effective adaptation programs is needed to ensure adequacy of any policies or programs employed.

5. Integrate climate change into planning, design, and management of water resources and supply

The design and management of water resources and supply are largely based on historic climate conditions, estimated population growth to ensure that the needs of future generations are met, and land use patterns. However, with the climate changing so

drastically, an approach that looks at climate change projections, rather than historic data, is required in designing and managing these resources, because climate change can render obsolete design assumptions using historic climate data. This required approach will also benefit present generations, since an increase in extreme weather events is already being experienced.

6. Diversify and adapt water resources used in water supply

Climate change is currently having adverse impacts on water resources, reducing availability (longer droughts and more intense rainfall) and degrading water quality (salinization of groundwater sources). Alternative sources (for example rainwater) may need to be introduced to reduce vulnerability because one source may not be reliable during all seasons.

7. Enhance cross-sector collaboration (e.g. water, health, and agriculture) in climate change adaptation planning

Climate change is expected to exacerbate current stresses on water resources (IPCC 2007). One of these stresses is over-abstraction by the agricultural sector, which will also be affected by climate change. A cross-sectoral collaboration is required among sectors to ensure that policies and programs employed achieve maximum benefit with minimum stress on the environment. If this activity is not employed, goal conflict might arise; that is, an adaptation practice employed by a sector might curb another sector's progress or aggravate a problem.

8. Incorporate climate change adaptation into emergency preparedness and response planning (EPRP)

Incorporating climate change adaptation into EPRP is necessary because of the increasing frequency of climate-related emergencies. It is vital that comprehensive plans for water emergencies are established in advance to reduce adverse effects during and after an emergency. Coordination among national and international organizations, Non-Government Organizations (NGOs), and governments is critical to implementing effective EPRP, as this

will minimize redundancy and ensure that relief programmes are comprehensive, addressing key areas like safe water provision.

#### 9. Capacity building and institutional strengthening

Climate change will introduce burdens on water resources never before considered, and the ability of a country to prepare for these additional burdens is dependent on the financial, technical, and human resources available in different institutions and to different individuals and communities. Critical targets for capacity building and institutional strengthening include water ministries, community organizations, regional and local government, among others.

The literature on country-level programming was assessed for evidence of planning and/or implementation of these nine activities and adequacy of the activities when present. Primary documents used for this analysis include NAPAs, INCs, GEF database, and Adaptation Learning Mechanism website.

- The NAPAs are documents submitted to the UNFCCC that take into account existing coping strategies at the grassroots level, build upon that to identify priority activities, and are focused on urgent and immediate needs (UNFCCC 2011). These documents assess the vulnerability of the country to current climate variability and extreme events, investigate where risks would increase due to climate change, identify key adaptation measures as well as criteria for prioritizing activities, and present a selection of a prioritized short list of activities.
- The INCs are documents required from all Parties to the UNFCCC and include data on country-level anthropogenic emissions, measures to adapt to climate change, and measures to mitigate climate change (UNFCCC, 2004).
- The GEF database contains a list of current and future programmes relating to climate change that can be sorted by country.



- Adaptation Learning Mechanism (ALM) website (a website put together by GEF, UNFCCC, United Nations Development Programme (UNDP), The World Bank, United Nations Environment Programme (UNEP), the Food and Agriculture Organisation of the United Nations (FAO), and Gateway to the UN System’s Work on Climate Change) contains information on country programs.

The documents for each country and the database were studied for evidence of each of the nine enabling environment activities listed above. The chapters in these documents are generally divided into country background, country GHG emissions, country level climate change projections, current and possible adaptation measures, awareness activities, and priority projects. These chapters were specifically reviewed and keyword searches for words like “research”, “awareness”, “adaptation” also aided in the review of the documents. The documents for all countries had similar chapter breakdown so review for all countries were similar. Future projects or planned activities were mainly found in the list of priority projects recorded in the NAPAs. The activities being planned or implemented in each country are included below in the “Results and Discussion” section. Because this study focuses on adaptation and not mitigation, chapters in the NAPAs and INCs on GHG emissions and mitigation procedures were not studied. Country documents that were in languages other than English were given to individuals who could speak those languages and the above protocol was given to them for the document review. Also, *google translate* was used a secondary translation mechanism.

#### *Enabling Environment activities adequacy assessment*

Enabling environment activities present in a country were assessed to determine if these activities were adequate in reducing the vulnerability of the country’s water resources to climate change effects. Adequacy of an activity was determined based on the following criteria:

- The activity addressed all hazards pertinent to this study (floods, drought, and coastal inundation) the country is exposed to, particularly the hazard the country is most frequently exposed to (hazard identification presented below).
- Programs or projects exist or are planned specifically to achieve an activity's objective. For example, are there programs specifically aimed to enhance cross-sector collaboration like the founding of a climate change committee comprised of actors from different sectors.
- The activity was focused on the entire population rather than just a subset of the population.

Programs were found to be adequate when fulfilled at least two of the criteria above, partially adequate if they fulfilled one, and inadequate if they fulfilled none or if activities were absent in the countries. Detailed information on projects and programs could generally be found in the NAPAs and when detailed information was not found in the NAPA, an internet search of the program name was carried out in order to determine adequacy of activity. The name of the program was put in a search engine and information on the program was obtained. Program details were studied to determine if the criteria listed above were satisfied. For some programs, detailed information could not be found so an adequacy assessment could not be made as is noted in the "Results and Discussion" section.

### *Country Comparison*

A comparison of countries to determine if preparedness was determined by certain factors was made. The factors used for this study were Gross Domestic Product (GDP), Human Development Index (HDI), and Disaster Risk Index (DRI). Brief descriptions of these factors are below along with the reasons why they were chosen.

- GDP: The GDP is the value of all final goods and services produced in a country in a year and can be measured by adding all of an economy's incomes, expenditures, and net exports (World Bank, 2004). According to the World Bank, the countries in this study fall into 3 income groups: upper middle income (China), lower middle income (Cape Verde, Guatemala, Indonesia, Iraq, Nicaragua, Nigeria, Pakistan, Sudan, Syria, Viet Nam, and Zambia), and low income group (Bangladesh, Cambodia, Chad, Eritrea, Ethiopia, Haiti, Madagascar, and Nepal). The GDP was chosen to determine if a country's wealth is related to its preparedness to adapt to climate change.
- HDI: The HDI is an index that measures the average achievement in three basic dimensions of human development — a long and healthy life (health), access to knowledge (education), and a decent standard of living (income). The higher the number, the better the achievement in these three dimensions. Fussel (2009) noted in the World Development Report that based on a multi-criteria evaluation, the human development index outperforms several indices as a generic national level index of social vulnerability to climate change. The HDI was chosen for this reason and also because, if there is clear relationship between presence of activities and HDI, it may be attributed to education or income, two of the basic dimensions of HDI.
- DRI: The DRI is an index that shows the statistical link between vulnerability to hazards and levels of development. The indicators used to calculate the DRI are number of people killed per year and number of people killed per million inhabitants per year. The index ranges from a low of 1 to a high of 7 with the higher values representing countries in which both a large number of people are killed (absolute) and a large number of people killed as a percentage of total population (relative). According to global statistics, least developed countries (LDCs) represent 11% of the population exposed to hazards but account for 53% of the casualties while most

developed countries account for 15% of exposure to hazards but only 1.8% of the casualties (Peduzzi et al., 2002; Peduzzi et al., 2009). The DRI was chosen to understand if there was a link between vulnerability to hazards and preparedness.

### ***Hazard Identification***

In determining the preparedness of countries for tackling the effects of climate change, identification of hazards that are relevant to each country is essential in concluding on the adequacy of policies and programs. Hazards were determined based on current climate, climate change projections, and physiographic regions of each country. The hazards addressed in this study include floods (due to increased rainfall intensity and frequency), drought (due to decreased rainfall frequency, particularly during seasons of low rainfall), and coastal inundation (due to sea level rise, storms, cyclones, tidal surges). Coastal inundation does not apply to regions without a coastline. The hazards chosen represent wet climate conditions (flooding), dry climate conditions (drought), and climate conditions that affect a substantial population of the world (coastal inundation).

### ***Climate and Climate Change Projections Analysis***

Information on climate and climate change projections was obtained from several sources including IPCC regional climate change projections, the Met Office Hadley Centre report "Predicted Changes in Precipitation by 2030," NAPAs and INCs, to name a few. Due to the uncertainty in climate change projections (described in the *Literature Review Section* above), one source was insufficient in determining credible climate change scenarios for each country. Information gathered from the aforementioned sources was evaluated and a consensus on a credible climate change scenario was concluded. Four climate change sources were used to determine consensus. These were climate change projections from Hadley report, IPCC regional climate change projections, IPCC country-level climate change

projections, and country-level climate change projections from sources other than the IPCC (for example, NAPAs).

A consensus was achieved only when at least two of the four sources indicated a projected change in a given direction with no sources indicating a projected change in the opposite direction. A source indicating a possible change in either direction was factored in exactly as if that source yielded no data. For example, credible climate change scenario for a country with a projected increase in extreme wet events from two sources and possible change in either direction (that is, either an increase or a decrease in extreme wet events is possible) from the other two sources would be concluded to be an increase in extreme wet events.

## **d. Results**

### ***Regional and Country-level Climate Change Projections***

The preparedness of individual countries in tackling the effects of climate change and, thus, reducing the vulnerability of the water resources of the countries to these effects is based on a practical estimation or interpretation of the climate change effects to which individual countries are susceptible. Climate change projections for individual countries gathered from three major sources: the IPCC Fourth Assessment Report, Met Office Hadley Centre report, and country level documents like NAPAs and INCs are presented below.

The IPCC Fourth Assessment Report presents regional climate change projections for seven major regions, which are then further divided into 30 smaller regions, with at least 15 that include developing countries. The 21 countries assessed in this report fall into 12 of these smaller regions. The countries and the regions into which they fall are listed below in Table 2.

**Table 2: IPCC regions and sub-regions as presented in the Fourth Assessment Report**

Country	IPCC Region	IPCC Sub-Region
Bangladesh	Asia	South Asia
Cambodia	Asia	South East Asia
Cape Verde*		
Chad**	Africa	Saharan Africa and West Africa
China**	Asia	Tibetan Plateau and East Asia
Eritrea	Africa	East Africa
Ethiopia	Africa	East Africa
Guatemala	Central and South America	Central America
Haiti	Small Islands	Caribbean
Indonesia	Asia	South East Asia
Iraq	Asia	Central Asia
Madagascar	Africa	South Africa
Nepal	Asia	South Asia
Nicaragua	Central and South America	Central America
Nigeria	Africa	West Africa
Pakistan	Asia	Central Asia
Sudan**	Africa	Saharan Africa and East Africa
Syria	Europe	Southern Europe and Mediterranean
Viet Nam	Asia	South East Asia
Zambia	Africa	South Africa

\* Cape Verde was not in any IPCC regions

\*\* These countries span more than one IPCC sub-region

The table below illustrates climate change information for each of the countries. An “up” arrow (↑) represents an increase in a particular extreme weather condition, a “down” arrow (↓) represents a decrease in a particular extreme weather condition, and an “up and down” arrow (⇕) represents a possible increase or decrease in a particular weather condition. The extreme weather conditions presented in this report are:

- Wet events – which represent intense precipitation
- Dry events – which represent longer and more intense drought
- Coastal inundation – which represents sea level rise and/or storms and cyclones

Columns with “no data” indicate a lack of specific information in different sources. Information from the Met Office Hadley Centre report “Predicted Changes in Precipitation by 2030” focuses on extreme wet and dry events alone, so no information on sea level rise

and/or storms and cyclones is present. Cape Verde was not represented in the precipitation projection maps in the Hadley report, which explains the absence of information for Cape Verde. The determination of a consensus is explained in the *Methods* section.

**Table 3: Projected changes in the frequency and/or intensity of three categories of extreme weather conditions from four different sources**

Country	Extreme weather condition	Hadley Centre	IPCC Regional*	IPCC Country-level	Non-IPCC sources‡	Consensus
Bangladesh	Wet events	↕	↑	↑	↑	↑
	Dry events	↕	↓	no data	↑	No consensus
	Coastal inundation	no data	↑	↑	↑	↑
Cambodia	Wet events	↕	↑	no data	↑	↑
	Dry events	↕	↓	no data	↑	No consensus
	Coastal inundation	no data	↑	no data	↑	↑
Cape Verde	Wet events	no data	no data	no data	↑	No consensus
	Dry events	no data	no data	no data	↑	No consensus
	Coastal inundation	no data	↑	no data	↑	↑
Chad	Wet events	↕	↕	no data	↑	No consensus
	Dry events	↕	↕	no data	↑	No consensus
	Coastal inundation	N/A**	N/A	N/A	N/A	N/A
China	Wet events	↕	↑	↑	↑	↑
	Dry events	↕	↓	no data	↑	No consensus
	Coastal inundation	no data	↑	↑	↑	↑
Eritrea	Wet events	↕	↑	no data	↕	No consensus
	Dry events	↕	↓	no data	↑	No consensus
	Coastal inundation	no data	↑	no data	↑	↑
Ethiopia	Wet events	↕	↑	no data	↑	↑
	Dry events	↑	↓	no data	↑	No consensus
	Coastal inundation	N/A	N/A	N/A	N/A	N/A



Country	Extreme weather condition	Hadley Centre	IPCC Regional*	IPCC Country-level	Non-IPCC sources‡	Consensus
Guatemala	Wet events	↕	↓	no data	no data	No consensus
	Dry events	↕	↑	no data	no data	No consensus
	Coastal inundation	no data	↑	no data	no data	No consensus
Haiti	Wet events	↕	↓	no data	↑	No consensus
	Dry events	↕	↑	no data	↑	↑
	Coastal inundation	no data	↑	no data	↑	↑
Indonesia	Wet events	↕	↑	↑	↑	↑
	Dry events	↕	↓	↑	↑	No consensus
	Coastal inundation	no data	↑	↑	↑	↑
Iraq	Wet events	↕	↕	no data	no data	No consensus
	Dry events	↕	↑	no data	no data	No consensus
	Coastal inundation	N/A	N/A	N/A	N/A	N/A
Madagascar	Wet events	↕	↓	no data	↑	No consensus
	Dry events	↑	↑	no data	↑	↑
	Coastal inundation	no data	↑	no data	↑	↑
Nepal	Wet events	↕	↑	no data	↑	↑
	Dry events	↕	↓	no data	↑	No consensus
	Coastal inundation	N/A	N/A	N/A	N/A	N/A
Nicaragua	Wet events	↕	↓	no data	↑	No consensus
	Dry events	↕	↑	no data	↑	↑
	Coastal inundation	no data	↑	no data	↑	↑
Nigeria	Wet events	↓	↑	no data	↑	No consensus
	Dry events	↕	↕	no data	↑	No consensus
	Coastal inundation	no data	↑	no data	↑	↑

Country	Extreme weather condition	Hadley Centre	IPCC Regional*	IPCC Country-level	Non-IPCC sources‡	Consensus
Pakistan	Wet events	↕	↕	↑	↑	↑
	Dry events	↕	↑	no data	↑	↑
	Coastal inundation	no data	↑	↑	↑	↑
Sudan (north)***	Wet events	↕	↕	no data	no data	No consensus
	Dry events	↕	↕	no data	↑	No consensus
	Coastal inundation	N/A	N/A	N/A	N/A	N/A
Sudan (south)	Wet events	↕	↑	no data	no data	No consensus
	Dry events	↕	↓	no data	↑	No consensus
	Coastal inundation	N/A	N/A	N/A	N/A	N/A
Syria	Wet events	↕	↓	no data	no data	No consensus
	Dry events	↑	↑	no data	no data	↑
	Coastal inundation	no data	↑	no data	no data	No consensus
Vietnam	Wet events	↕	↑	no data	↑	↑
	Dry events	↕	↓	no data	↑	No consensus
	Coastal inundation	no data	↑	no data	↑	↑
Zambia	Wet events	↕	↓	no data	↑	No consensus
	Dry events	↕	↑	no data	↑	↑
	Coastal inundation	N/A	N/A	N/A	N/A	N/A

‡ Non IPCC Sources are country level projections presented in national documents like NAPAs and INCs and/or the UNDP Climate Change Country Profiles

\* Regional IPCC projections are based on annual changes. Information for sea level rise is based on global sea level rise prediction presented in the IPCC report. Source: IPCC Fourth Assessment Report, The Physical Science Basis, Chapter 11.

\*\* "N/A" indicates that a country does not have a coastal zone so that category is irrelevant.

\*\*\* Sudan is divided into North and South Sudan

### ***Individual Country Hazard Exposure***

Climate change projections for the individual countries presented in the previous section aid in determining the extreme weather events to which each country is increasingly exposed. Hazards occur as a result of these extreme weather events. As was mentioned in

the Methods section, the hazards focused on in this paper include floods, droughts, and coastal inundation. Although there were no consensuses in change in frequency and intensity of extreme wet and dry events found for various countries, according to information found in the NAPAs and INCs, most countries have in the past been, and are currently, vulnerable to most of these hazards.

The current exposure of the countries to these hazards, even when not backed by climate change projections that suggest an increase in these hazards, make preparing for these hazards a practical and reasonable investment. Also, some countries span more than one climatic region so a national consensus for a country may differ from sub-national consensus; that is, a region of a country may be arid while another region is humid so projections for both regions may differ making causing “no consensus” for the national projection. For example, there was no consensus for Nigeria with regards to an increase in the frequency and intensity of extreme wet or dry events, but Northern Nigeria is very prone to drought and desertification while Southern Nigeria is very prone to floods. Countries may, therefore, need to make plans for adaptation based on regional climate projections rather than national climate projections.

The table below shows hazards that each country is susceptible to based on the country-level current climate characteristics and climate change projections. Hazards are distinguished between those that are projected to increase and hazards that countries are currently exposed to.

**Table 4: Credible hazards for individual countries**

Country	Floods	Droughts	Coastal inundation
Bangladesh	◆*	▲*	◆
Cambodia	◆	▲	◆
Cape Verde	▲	▲	◆
Chad	▲	▲	◇
China	◆	▲	◆
Eritrea	▲	▲	◆
Ethiopia	◆	▲	◇
Guatemala	▲	▲	▲
Haiti	▲	◆	◆
Indonesia	◆	▲	◆
Iraq	▲	▲	◇
Madagascar	▲	◆	◆
Nepal	◆	▲	◇
Nicaragua	▲	◆	◆
Nigeria	▲	▲	◆
Pakistan	◆	◆	◆
Sudan (North)	▲	▲	◇
Sudan (South)	▲	▲	◇
Syria	▲	◆	▲
Viet Nam	◆	▲	◆
Zambia	▲	◆	◇

\* ◆ denotes likely hazards due to both consensus in climate change projections due to the country's exposure to the hazards. ▲ denotes likely hazards due to a country's exposure to the hazard alone. ◇ denotes hazards that a country is not exposed to.

### ***Enabling Environment***

A primary search of the nine enabling environment activities listed in the Methods section was carried out in the NAPAs and INCs to determine the existence of these activities as well as the adequacy of the activities either planned or implemented. No NAPAs and INCs have been submitted by Iraq and Syria, so these documents could not be used in the analysis for both countries; however, online searches of databases like GEF produced some information on government-led/supported enabling environment activities. The existence of enabling environment activities and the adequacy of these activities are presented below.

Table 5 below illustrates the presence or absence of each of the nine enabling environment activities in each country and the status or phase (planning or implementation) of the activity when present.

**Table 5: Enabling environment activities currently planned or implemented in each country and the status of each activity.**

(+ denotes an inadequate activity, ++ denotes a partially adequate activity, +++ denotes an adequate activity, and "n" denotes no detailed information available to determine adequacy.)

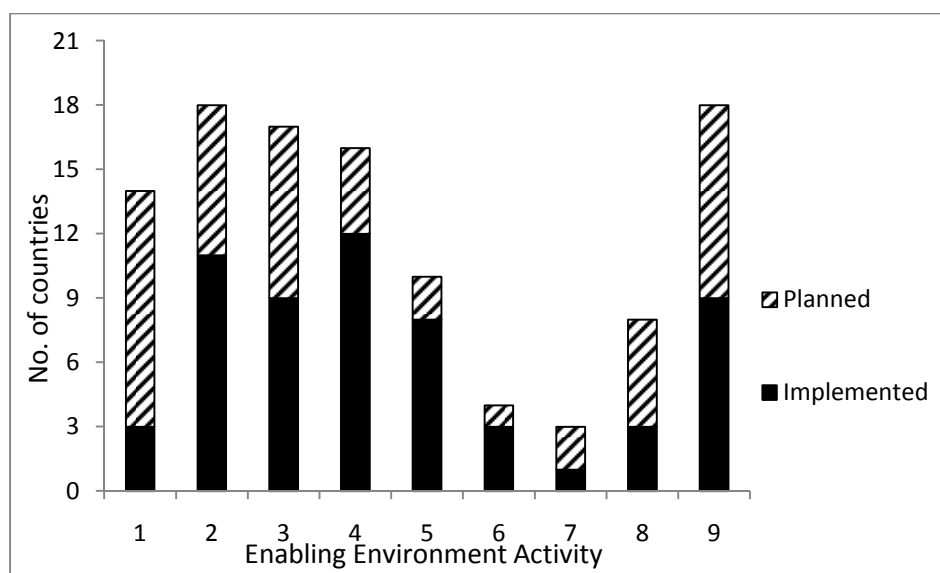
	Enabling Environment Activities*								
	1	2	3	4	5	6	7	8	9
Bangladesh	▲** ++	▲ ++	◆ +++	◆ +++	◆ ++	◆ n	▲ ++	▲ ++	◆ +++
Cambodia	◇	▲ ++	▲ ++	◇	▲ ++	▲ +++	◇	▲ ++	▲ ++
Cape Verde	▲ +	◆ +	▲ +++	▲ +++	◇	◇	◇	◇	▲ ++
Chad	▲ ++	◆ ++	▲ +++	◇	◇	◇	▲ +++	◇	◇
China	▲ +++	◆ +++	◆ +++	◆ +++	◇	◇	◇	◆ +++	◆ +++
Eritrea	▲ ++	◆ +++	◆ ++	▲ +++	◇	◆ n	◇	▲ +++	◇
Ethiopia	▲ ++	◆ +++	▲ +++	◆ +++	◇	◇	◇	▲ +++	◇
Guatemala	◆ +++	◇	◆ +++	◇	◇	◇	◇	◇	◆ ++
Haiti	◇	◇	◆ +++	◆ +++	◆ ++	◆ +++	◇	◆ ++	◆ ++
Indonesia	▲ +	▲ +++	▲ ++	▲ +++	▲ +++	◇	◇	◇	▲ +++
Iraq	◇	◆ n	◇	▲ +++	◇	◇	◇	▲ +++	◆ +++
Madagascar	▲ +	◆ +++	◆ n	◆ +++	◆ +++	◇	◇	◇	◆ +++
Nepal	◇	◆ +++	◆ ++	◆ +++	◇	◇	◇	◇	▲ +++
Nicaragua	◇	◆ +++	◇	◆ +++	◆ +++	◇	◇	◇	◆ +++
Nigeria	◆ +++	◆ +++	◇	◆ +++	◆ ++	◇	◆ +++	◇	◆ +++
Pakistan	◇	▲ +++	◆ +++	◆ +++	◇	◇	◇	◇	▲ ++
Sudan (north)	▲ +	▲ +++	▲ +++	◆ +++	◆ +++	◇	◇	◇	▲ +++
Sudan (south)	▲ +	▲ +++	▲ +++	◆ +++	◆ +++	◇	◇	◇	▲ +++

Syria	◇	◇	◇	◆ n	◇	◇	◇	◇	◆ n
Vietnam	◇	◆ +++	◆ n	◆ +++	◇	◇	◇	◆ n	◆ ++
Zambia	◆ +++	▲ +++	▲ +++	◇	◇	◇	◇	◇	◆ +++

\*Enabling environment activities: (1) Enhance adaptive capacity of poor and vulnerable (e.g. children) populations to ensure equity amongst all people/ (2) Raise awareness of climate change on national, regional, and community levels/ (3) Incorporate adaptation to climate change into Disaster Risk Reduction (DRR) at all levels / (4) Enhance research on climate change adaptation/(5) Integrate climate change into planning, design, and management of water resources and supply/ (6) Diversify water resources used in water supply/ (7) Enhance cross-sector collaboration (e.g. water, health, and agriculture) in climate change adaptation planning/ (8) Incorporate climate change adaptation into emergency preparedness and response planning (EPRP)/ (9) Capacity building and institutional strengthening.

\*\*▲ - Planned activities. ◆ - Implemented activities. ◇ - Activities absent or unidentified

The graph below gives an overview of planned and implemented activities in Table 5.



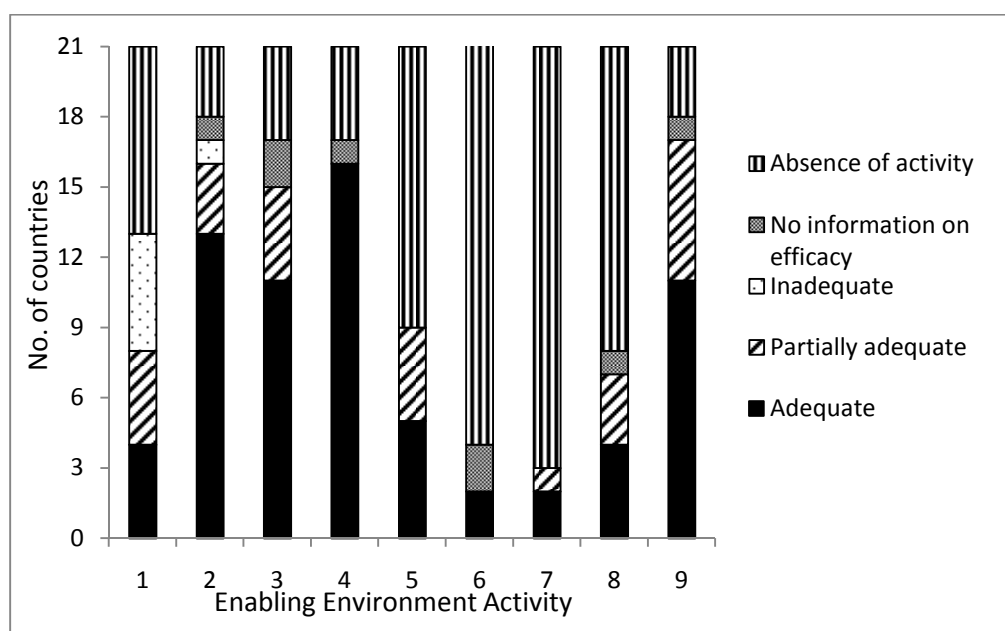
**Figure 6: Number of countries planning and implementing the nine enabling environment activities.**

\*Enabling environment activities: (1) Enhance adaptive capacity of poor and vulnerable (e.g. children) populations to ensure equity amongst all people/ (2) Raise awareness of climate change on national, regional, and community levels/ (3) Incorporate adaptation to climate change into Disaster Risk Reduction (DRR) at all levels / (4) Enhance research on climate change adaptation/(5) Integrate climate change into planning, design, and management of water resources and supply/ (6) Diversify water resources used in water supply/ (7) Enhance cross-sector collaboration (e.g. water, health, and agriculture) in climate change adaptation planning/ (8) Incorporate climate change adaptation into emergency preparedness and response planning (EPRP)/ (9) Capacity building and institutional strengthening.

The graph above shows that raising awareness of climate change on the national, regional, and community levels is the most planned and implemented activity across all countries. Awareness raising activities were found for 18 of the 21 countries and majority of them are already being implemented. Other activities that are widespread across all

countries include incorporating adaptation to climate change into Disaster Risk Reduction (DRR), enhancing research on climate change adaptation and capacity building and institutional strengthening. On the other hand, diversifying water resources used in water supply was found to be supported by only four governments in the documents reviewed. This does not, however, mean that other countries are currently neither planning nor implementing this activity. Information on this particular activity may not be widely available or this activity may not be viewed as critical because countries may already be have been implementing it successfully over a long period of time. Enhancing cross-sector collaboration in climate change planning is another activity not carried out by most countries (only 3 countries are currently either planning or implementing this activity). Again, this might not necessarily mean an absence of this activity in all remaining 18 countries.

The graph below gives an overview of efficacy of activities showed in Table 5.



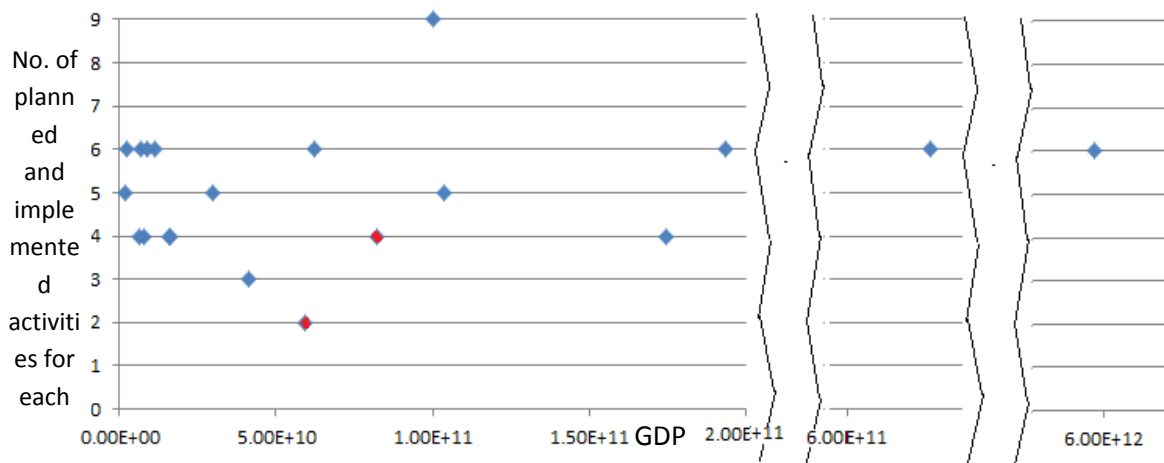
**Figure 7: Number of countries with varying levels of adequacy for the nine enabling environment activities.**

\*Enabling environment activities: (1) Enhance adaptive capacity of poor and vulnerable (e.g. children) populations to ensure equity amongst all people/ (2) Raise awareness of climate change on national, regional, and community levels/ (3) Incorporate adaptation to climate change into Disaster Risk Reduction (DRR) at all levels / (4) Enhance research on climate change adaptation/(5) Integrate climate change into planning, design, and management of water resources and supply/ (6) Diversify water resources used in water supply/ (7) Enhance cross-sector collaboration (e.g. water, health, and agriculture) in climate change adaptation planning/ (8) Incorporate climate change adaptation into emergency preparedness and response planning (EPRP)/ (9) Capacity building and institutional strengthening.

According to Table 5, Bangladesh has the highest number of enabling environment activities currently in the planning or implementation phase with a total of eight. However, presence of numerous activities in a country does not automatically translate to high level of preparedness within that country. The adequacy of the planned or implemented activities also determines the level of preparedness within the country.

*Relationship between presence of activities and GDP, HDI, and DRI*

The graphs below show the relationship between the presence of activity (both planned and implemented) in countries and the Gross Domestic Product (GDP), Human Development Index (HDI), and Disaster Risk Index (DRI).



**Figure 8: Relationship between the presence of activity (both planned and implemented) in countries and the 2010 GDP.**

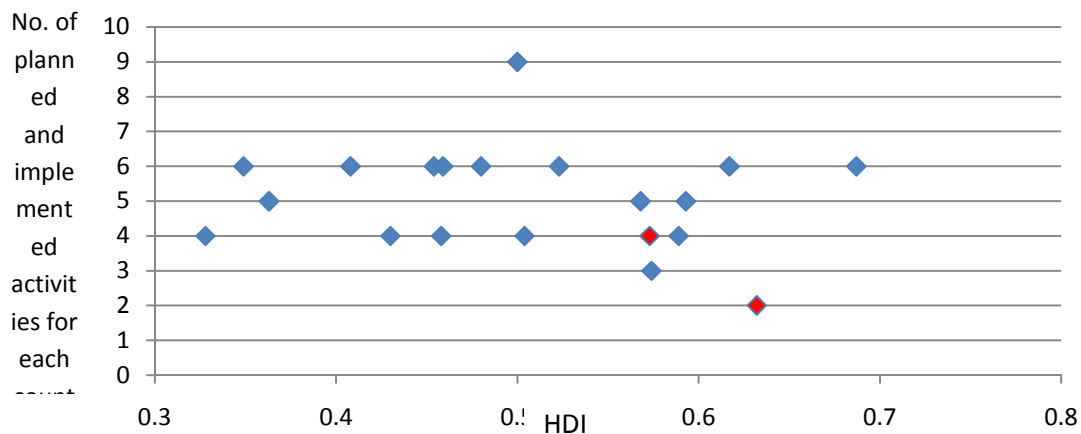
Source: The World Bank 2011. World Development Indicators.

Note: Red diamonds represent Syria and Iraq. The data for these countries is represented solely for observation because there was no NAPA or INC submitted and comparison with other countries should not be made for this reason. There is a single diamond for Sudan and South Sudan because DRI values for the country represent values obtained before both became independent states.

According to the graph above, there is no clear relationship between GDP and the presence of activities in a country. The GDP ranged from a low of \$1.65 trillion in Cape Verde (which has five planned and implemented activities) and a high of 5880 trillion in China (which has six planned and implemented activities). Bangladesh, which has nine



planned and implemented activities, has a GDP that is less than approximately one-quarter of the countries studied.

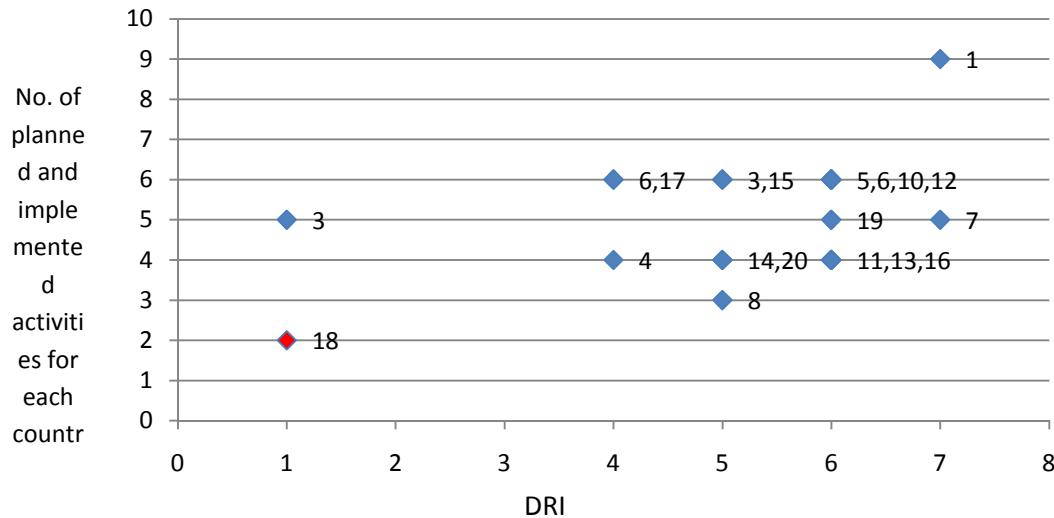


**Figure 9: Relationship between the presence of activity (both planned and implemented) in countries and the 2011 HDI value.**

Source: UNDP 2011 – Human Development Report 2011. Sustainability and Equity: A better Future for All.

Notes: Red diamonds represent Syria and Iraq. The data for these countries is represented solely for observation because there was no NAPA or INC submitted and comparison with other countries should not be made for this reason. There is a single diamond for Sudan and South Sudan because DRI values for the country represent values obtained before both became independent states.

The countries in this study fell into the low and medium HDI groups. The range of values for those countries in the low HDI group was 0.328 (Chad) to 0.504 (Pakistan) and the range of values for those countries in the medium HDI group was 0.523 (Cambodia) to 0.687 (China). From Figure 9 above, Bangladesh, with the highest number of planned and implemented activities (9 of 9) of all countries, is located approximately in the middle of the graph. Similar to the GDP graph, there is no clear relationship between the presence of activities and HDI. There is a fairly even spread of countries with the same number of activities across the graph.



**Figure 10: Relationship between the presence of activity (both planned and implemented) in countries and the DRI value.**

Source: Peduzzi 2009.

Note: Red diamond represents Syria. The data for this country is represented solely for observation because there was no NAPA or INC submitted and comparison with other countries should not be made for this reason. There is a single diamond for Sudan and South Sudan because DRI values for the country represent values obtained before both became independent states.

Note: 1-Bangladesh. 2-Cambodia. 3-Cape Verde. 4-Chad. 5-China. 6-Eritrea. 7-Ethiopia. 8-Guatemala. 9-Haiti. 10-Indonesia. 11-Iraq. 12-Madagascar. 13-Nepal. 14-Nicaragua. 15-Nigeria. 16-Pakistan. 17-Sudan. 18-Syria. 19-Viet Nam. 20-Zambia.

There are 14 points on the graph above because a number of countries are in the same DRI class and the same number of activities present within country. The numbers on the graph correlate to each country and this information can be found below the graph.

There is not a clear correlation between the presence of activities and the DRI class;

however, the country with the highest number of activities (Bangladesh) is in the highest

DRRI class (7). The DRI class with the most number of countries according to the graph is 6

and the number of activities present within the countries in this class range from four to six.

## e. Discussion

### ***Climate Change Projections and Hazards***

#### *Validity of data*

The sources used for determining a consensus for a change in the frequency of extreme weather events have used different models as well as different number of models for their analysis. Below is a brief summary of the models and initial conditions used for the sources.

- The Hadley report uses only one climate model (HadCM3), although it uses a range of initial conditions to aid in quantifying uncertainty in predictions (Met Office Hadley, 2009).
- The IPCC regional projections use 21 models in their analysis and the results presented in this thesis are based on the A1B scenario as presented in the IPCC Fourth Assessment report. This scenario was used in this report because it was the only one for which there was detailed information for each region presented in the IPCC Fourth Assessment report. Regional projections, however, do not represent accurate country-level projections as two countries within a region may have differing climates.
- There was very little information on country level projection data in the IPCC report so many of the counties had a “no data” for this source. This most likely, minimized the possibility of a consensus in the analysis.
- The non-IPCC country level information was obtained primarily from the NAPAs. The number of models used in each document varied as countries (along with their partners like organizations) used different models.

These differences in initial conditions, model choices, and number of models may account for the low number of consensus for the extreme wet and dry events (28 of 42) but

may also be the reason why a consensus may more credible since four instead of only one source was used.

### *Climate Change Projections*

Significant uncertainties plague climate change projections and possible consequences which explain the few consensus found for change in extreme weather events for all countries (Schneider et al., 2002). Future emissions of GHGs, their climatic effects, and the consequences that follow are subject to large uncertainties (Reilly et al., 2001). Starting from the total effects of emissions on the environment, to how the global climate system will react, and then to how different geographical and climatic regions within the world will be altered and the resulting impacts from all this change, these uncertainties accumulate.

Regardless of the uncertainties that come with climate change projections, policy makers still need to make decisions with the sparse and imprecise information. In dealing with uncertainty, policy makers can reduce the uncertainty through data collection, research, etc. or integrating uncertainty into policy making (Schneider et al., 2002). An effort to reduce the uncertainty that comes with climate change projections and its consequences was made by collecting relevant data from different sources that had used different scenarios in their modeling. However, a consensus could not be reached for all countries because of the wide-ranging uncertainties (described in the Literature Review section).

In Table 3, approximately half of the boxes in the “Consensus” column are marked “no consensus” while the other half represent either a consensus change in a particular direction or an “N/A” for countries without coastal regions. All boxes with a consensus project an increase in a particular extreme event. According to the IPCC on global climate change projections, the frequency and intensity of extreme events are projected to increase (IPCC, 2007). A consensus of an increase in extreme wet events is projected for 8 of the 21 countries and a consensus of an increase in extreme dry events is projected for 6 of the 21

countries. There is no consensus for a decrease in the frequency and intensity of any extreme events for any country.

According to Table 3, all countries with coastal regions (except Guatemala and Syria) are projected to have an increase in coastal inundation. The lack of a consensus for Guatemala and Syria arise not from a conflict in projections for sea level rise but instead in a scarcity of available information for both countries. Information for coastal inundation for these countries is assumed based on prediction of a global sea level rise. Apart from coastal inundation as a result of sea level rise and increased storm surges, there were only 14 credible hazards produced by a consensus (out of 42).

The credible climate change scenarios presented here serve as a guide for policy makers. The range of possibilities for future climate evolution from uncertainties needs to be taken into account when planning adaptation strategies (Stainforth et al., 2005). Although there is a lack of consensus for a change in majority (28 out of 42) of the extreme wet and dry events for all countries studied, policy makers need to consider the hazards that could occur as a result of these extreme wet and dry events. Below is a table showing how many disasters that occurred in the past decade (2000-2010) are on the list of top ten disasters (for time period 1900-2011) sorted by the number of people affected.

**Table 6: Number of flood and drought events in the list of top 10 events (1900-2011) sorted by number of people affected.**

*Source: EM-DAT. The International Disaster Database. Centre for Research on the Epidemiology of Disasters.*

Country	# of flood events	# of droughts events
Bangladesh	1	0
Cambodia	4	2
Cape Verde	0	1
Chad	3	2
China	3	0
Eritrea	1	1
Ethiopia	0	4
Guatemala	2	2
Haiti	0	0
Indonesia	2	0
Iraq	4	0
Madagascar	0	2

Nepal	3	1
Nicaragua	0	1
Nigeria	4	0
Pakistan	2	0
Sudan*	2	1
South Sudan*	2	1
Syria	0	1
Viet Nam	1	0
Zambia	5	1

\* Information on disasters was presented for Sudan (a region that became Sudan and South Sudan on 9<sup>th</sup> of July, 2011).

According to the table above, over the past decade (2000 – 2010), 14 of the 20<sup>3</sup> countries have had at least one flood event and 12 of the 20 countries have had at least one drought event in the list of top ten disasters for the period 1900-2011, sorted by number of people affected. The list above shows that even though there were only eight consensus for a change in extreme wet events (an increase) and six consensus for a change in extreme dry events (an increase), many countries are exposed to drought. As a result, there is a need to consider adaptation options even when there is no consensus on change in an extreme event as countries may still be exposed to and vulnerable to the hazards.

### ***Enabling Environment***

#### *Validity of Data*

Information on presence of activities in countries was mainly obtained from NAPAs and INCs. Validation of the information through in-country analysis, interviews with relevant country-level personnel, or other validation mechanisms were not carried out. In other words, information from these documents was taken at face value.

No NAPAs and INCs have been submitted by Iraq and Syria, so these documents could not be used in the analysis for both countries; however, online searches of databases like GEF produced some information on government-led/supported enabling environment activities. It

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<sup>3</sup> Sudan and South Sudan are listed as one country because the information on disasters was presented for Sudan (a region that became Sudan and South Sudan on 9<sup>th</sup> of July, 2011).

is possible that the low preparedness for these countries (four activities either planned or implemented for Iraq and two for Syria) is as a result of limited data obtainable since the NAPAs and INCs were unavailable. Therefore, data for the countries are presented below to illustrate what was found but a good comparison of preparedness between the two countries and the remaining 19 cannot be made.

*Enhance adaptive capacity of poor and vulnerable (e.g. children) populations to ensure equity amongst all people*

Thirteen of the 21 countries are currently planning or implementing this activity (nine planning and four implementing). Of the 13, four were adequate, four were partially adequate, and five were inadequate. Some countries made poverty reduction a criterion for prioritizing adaptation projects but did not have specific programs aimed at enhancing the adaptive capacity of vulnerable populations. This does not necessarily ensure adaptive capacity of vulnerable populations is enhanced because other criteria are in play and because other vulnerable populations (women and children) are not explicitly considered. Vulnerability to climate change is not exclusively related to poverty (O'Brien et al., 2000). Children in developing countries are particularly vulnerable because many of the main killers of children (diarrhea, malaria, under-nutrition etc.) are highly sensitive to climate change (UNICEF, 2009). The proportion of children under the age of five in developing countries (~10%) is higher than that in developed countries (~5%) (UNPD, 2009). Specific programmes geared towards the poor and other vulnerable groups are needed for an adequate activity as is currently being implemented in Zambia. United Nations (UN) organizations in Zambia are implementing early warning systems and services that are fully functional in female-headed households at the national, provincial, and household levels (Republic of Zambia, 2007).

There is a vast literature on what populations are disproportionately (as a result of poverty, dependency, geographic settings etc.) affected by climate change and the need to reduce vulnerabilities of these populations (see Schipper et al., 2006; Bohle et al., 1994; Adger et al., 2003; Woodward et al., 1998; Najam et al., 2003). However, there is limited literature on what should be done to enhance the adaptive capacity of these vulnerable populations. O'Brien et al. (2000) mention neighborhood support schemes that protect the most vulnerable people but do not give examples of what these may entail. Woodward et al. (1998) mention forecasting of climate and climate impacts that have aided farmers in planning harvests and changing crop types when needed. However, this type of forecasting has barely been employed in the health sector and can help in gaining a better understanding of where and under what circumstances disease vectors might arise (Woodward et al., 1998). Literature on practices and policies to aid farmers (like farming technique modifications and crop diversity) is vast but on other vulnerable populations (children, elderly, and women) is scarce.

Many of the priority activities in the NAPAs focus on the agrarian population by planning for irrigation alternatives and crop diversification. The gap in information with regards to other vulnerable populations may play a part in why there are not many programs in place in developing countries that focus explicitly on these vulnerable populations. Although there is limited information, the World Bank along with 10 other development agencies produced a document "Poverty and Climate Change: Reducing the Vulnerability of the Poor through Adaptation" that focuses on these populations.

#### *Raise awareness of climate change at national, regional, and community levels*

Eighteen of these developing countries have either planned or implemented education and awareness programmes. Cape Verde, the only country with an inadequate activity, had this rating because awareness activities only entailed administering a survey to



individuals which is not an effective way of raising awareness of climate change and its impacts but may just help determine level of awareness (MoE Republic of Cape Verde, 2007). China, on the other hand, had an adequate raising awareness activity because it has developed several documents for guidance on climate change education at primary and secondary schools as well as nationwide training for the environment (The People's Republic of China, 2004).

All countries analyzed are parties to the UNFCCC and thus have commitments to fulfill, one of which can be achieved by promoting education, training and awareness programmes at the national and regional levels (Chatterjee, 2002). These awareness programmes are an important component of capacity building in developing countries, although not much has been done by different conference of the parties (COP) since COP1 (in 1994) in Berlin with regards to awareness programmes (Chatterjee, 2002). Regardless, majority of these countries studied are planning or implementing activities. One of the countries that did not have an activity was Syria. However, the reason for this may be the lack of a NAPA or an INC to detail work that is being done in this area.

Awareness is required not just by policy makers or scientists but by the entire population because this will aid in better climate change responses. Climate change will only come on to the public agenda when the domestic population perceives climate change to be of local relevance which can only happen through awareness activities (Gupta, 1997). Between 2007 and 2008, Gallup conducted a comprehensive survey of global opinions about climate change. According to the survey conducted in 128 countries, industrialized countries are more aware of climate change than developing countries even though developing countries are more vulnerable (Pugliese et al., 2009). Awareness in developing countries has also grown and over the past year there has been unprecedented demand from developing countries for support in their efforts to address development and climate change (World Bank, 2010). In fact, interest in climate change adaptation as a policy

response has increased, led by developing country negotiators and this has happened partly due to the growing recognition of climate change (Burton et al., 2002). These activities being planned and carried out in these countries as noted above may be increasing awareness in developing countries.

Talks of a global environmental crisis have become common place and the likelihood of climate change is no longer in doubt (Sokona et al., 2001). Climate change has received large attention of national and global policy makers, researchers, and industry among global environmental issues (Ravindranath 2002). According to Sokono et al. (2001) there is a growing environmental awareness of climate change. Media coverage of stories on climate change was limited a few years ago; however, over the years, major media sources that featured occasional articles on climate change have come to include climate change in the articles on a weekly basis (Carpenter, 2001). Also, awareness raising efforts of environmental NGOs has grown steadily in the past few years (Ravindranath, 2002).

*Incorporate adaptation to climate change into Disaster Risk Reduction (DRR) at all levels*

Over the decade of the 1990s, the number and severity of extreme weather events increased and comparing these figures with figures of the 1960s, the number of natural catastrophes has increased by a factor of three and economic losses by a factor of nine (Munich Re, 1999). Climate change may induce impacts or disasters which are new to a region and, thus, cause infrastructure problems in disaster management due to limited knowledge of how to deal with these new disasters (Kumar et al., 2011). It is imperative that countries incorporate climate change into DRR programs to minimize these losses that are most felt by developing countries. Seventeen of the 21 countries are currently planning or implementing this activity. Two of the countries that did not have an activity were Iraq and Syria. However, the reason for this may be the lack of a NAPA or an INC to detail work that is being done in this area.

Adequate programmes carry out DRR at all levels and address all disasters experienced by a country, not just disasters mostly experienced by that country. Bangladesh adequately carries out its DRR activities at different levels by risk management and mainstreaming (UNDP Newsroom, 2009). The level of vulnerability of Bangladesh to certain disasters, particularly floods (annually one-fifth of the country is inundated, 70% is vulnerable to floods, and it acts as a drainage outlet for river basins of the Ganges, Brahmaputra, and Meghna rivers (Mirza, 2003) likely influences the presence of an adequate program. Bangladesh has a DRI of 7, the highest index there is.

The increasing number of disasters occurring may account for the high number of countries planning and implementing this activity. Table 6 shows that over the past decade at least one disaster (floods or drought) and in many cases more than one is on the list of top ten disasters over the past century (1900-2011) sorted by the number of people affected. And the list presented in this thesis does not include storms which was a disaster that plagued some countries over the past decade. Also, many countries (e.g. Cambodia, Eritrea, Zambia) noted in their NAPAs and INCs that extreme weather events have been experienced more frequently in recent years.

The challenge of reducing vulnerability to climate and weather-related hazards has been taken on by four distinct research and policy communities, two of which are disaster risk reduction and climate change adaptation (Thomalla et al., 2006). The relationship between disaster risk reduction and climate change adaptation is increasingly being recognized, yet both communities still need to develop coordinated efforts towards reducing climate change risks (O'Brien et al., 2008). Table 7 on the next page gives a general characterization of the climate change adaptation and disaster risk reduction communities.

**Table 7: General characterization of the climate change adaptation and disaster risk reduction communities.**

Source: Thomalla et al. 2006

Climate change adaptation	Disaster risk reduction
<b>Approach</b>	
<ul style="list-style-type: none"> <li>• risk management</li> <li>• strong scientific basis</li> <li>• environmental science perspective</li> <li>• highly interdisciplinary</li> <li>• vulnerability perspective</li> <li>• long-term perspective</li> <li>• global scale</li> <li>• top-down</li> </ul>	<ul style="list-style-type: none"> <li>• risk management</li> <li>• engineering and natural science basis</li> <li>• traditional focus on event and exposure and on technological solutions</li> <li>• shift from response and recovery to awareness and preparedness</li> <li>• short term but increasingly longer term</li> <li>• local scale</li> <li>• community-based</li> </ul>
<b>Organisations and institutions</b>	
<ul style="list-style-type: none"> <li>• United Nations Framework Convention on Climate Change (UNFCCC)</li> <li>• Intergovernmental Panel on Climate Change (IPCC)</li> <li>• Academic research</li> <li>• National environment and energy authorities</li> </ul>	<ul style="list-style-type: none"> <li>• United Nations (UN)</li> <li>• ProVention Consortium (World Bank)</li> <li>• International Federation of Red Cross and Red Crescent Societies (IFRC)</li> <li>• International, national and local civil society organisations</li> <li>• National civil defence authorities</li> </ul>
<b>International conferences</b>	
<ul style="list-style-type: none"> <li>• Conference of the Parties (COP)</li> </ul>	<ul style="list-style-type: none"> <li>• World Conference on Disaster Reduction</li> </ul>
<b>Assessment</b>	
<ul style="list-style-type: none"> <li>• IPCC Assessment Reports</li> </ul>	<ul style="list-style-type: none"> <li>• IFRC Vulnerability and Capacity Assessment (VCA)</li> <li>• IFRC World Disasters Report</li> <li>• International disasters databases:                             <ul style="list-style-type: none"> <li>* EM-DAT</li> <li>* NatCatSERVICE (Munich Re)</li> <li>* Sigma (Swiss Re)</li> </ul> </li> </ul>
<b>Strategies</b>	
<ul style="list-style-type: none"> <li>• National communications to the UNFCCC</li> <li>• National Adaptation Plans of Action (NAPA) for Least Developed Countries</li> </ul>	<ul style="list-style-type: none"> <li>• UN International Decade for Natural Disaster Reduction (IDNDR)</li> <li>• Yokohama Strategy and Plan of Action for a Safer World</li> <li>• UN International Strategy for Disaster Reduction (ISDR)</li> <li>• Hyogo Framework for Action 2005–15</li> </ul>

Calls for better cooperation are increasing and there is a perceived need to identify opportunities to develop a joint agenda (Thomalla et al., 2006; O'Brien et al., 2006; Helmer et al., 2006). This may explain why majority of the countries analyzed are either planning or

implementing disaster risk reduction together with adaptation. Also, in the NAPAs, majority of the countries stated that over the past few years there has been an increase in frequency and intensity of extreme weather events. Adverse impacts of climate change increases disaster risk which makes the countries incorporate climate change into disaster risk programs.

#### *Enhance research on climate change adaptation*

Seventeen of the 21 countries studied are either planning or implementing this activity. Sixteen of them had adequate activities. Research on climate change adaptation was not identified for four countries, and although the UNDP is currently planning and carrying out programs in Syria, no detailed information on the programs was unavailable, so an adequacy assessment for Syria was not carried out. The role of adaptation to climate change is increasingly being considered in academic research and its significance in national and international policy debates (Smit et al., 2000). Some developing countries, particularly small island nations and least developed countries have insisted on the need for adaptation from the onset of climate change negotiations (Burton et al., 2002). However, adaptation has only recently been emphasized as a strategic response for climate change so is much less developed than mitigation as a policy response (Bosello et al., 2009; Burton et al., 2002). This coupled with the climate change impacts currently being experienced in many countries makes enhancing adaptation research critical in reducing the vulnerabilities to climate change effects.

Adaptation research is particularly important in developing countries because they have been and will continue to be hit the hardest by climate change due to their limited capacity to adapt. This may explain why most countries analyzed are currently planning or implementing enhanced research into climate change adaptation.

Scientific and technical capacity is required for adequate research into projections, impacts, and vulnerability that will aid effective adaptation measures and developing countries lack this technical capacity. Developing countries contain 80% of the world's population but 25% of the world's scientists and only 4% of total world research is conducted in developing countries (Leary et al., 2003). However, these developing countries have collaborated with international efforts and organizations to ensure adequate research is conducted and thus have succeeded in achieving adequate programs. For Viet Nam, for example, impacts of climate change on water resources and other sectors were evaluated based on the Commonwealth Scientific and Industrial Research Organization (CSIRO) (an Australian research agency) scenarios and this is used to develop adaptation measures for different sectors (Socialist Republic of Viet Nam, 2003).

*Integrate climate change into planning, design, and management of water resources and supply*

Climate change will most likely exacerbate current pressures on water systems. Renewable freshwater covers only a tiny fraction of the global water pool but is the foundation for life in terrestrial and freshwater ecosystems (Jackson et al., 2001). The water cycle will be altered dramatically by land use change, overpopulation, and urbanization. In the next 30 years, accessible runoff is unlikely to increase by more than 10% but the earth's population is projected to increase by one-third (Jackson et al., 2001). Regardless, a presence of this activity was not identified for most countries. Of the nine countries either planning or implementing this activity, five have an adequate activity and four have a partially adequate activity. The lack of integration in most countries most likely arises from the challenges of integrating environmental issues into water management (World Bank, 2007).

Long term management revolves around the dynamic nature of water resources over time and the need for flexible management systems (Adger et al., 2003). However, because adaptation was not addressed early on like mitigation, there are challenges. Most donor and development agencies are in the early stages of understanding ways to address adaptation (IGES, 2007). One challenge with integrating climate change into water management is that analogue year approach is not as effective anymore so new methods need to be employed (Ludwig, 2009). Generally, past weather patterns are used to predict future trends by using analogue years in which weather patterns were similar to the coming season (DAFWA, 2010). Climate outputs from coupled ocean-atmospheric general circulation models (OAGCMs) which take climate change impacts into account in projects can be used. The main challenge for water managers is to develop methods and tools that facilitate the use of these climate outputs in water management, particularly with uncertainties that abound (Ludwig, 2009).

According to the World Bank (2007), Integrated Water Resource Management (IWRM) has, at best, been implemented in a disjointed way in developing countries and when IWRM is implemented, environmental considerations have received little attention. Including environment in national water policies is critical and part of this comprises inclusion of climate change and managing its effects on water resources and supply. Effective water resource management should involve regular analysis of water resource management plans so that when necessary, amendments to planning and designing water supply and allocation of resources based on changes in the environment and other factors that greatly affect water resources can be made. Indonesia had an adequate activity by planning on modifying standard criteria for planning, design, and operation and maintenance of water infrastructure and facilities for climate change adaptation as one of the immediate term strategies (Republic of Indonesia, 2007).

### *Diversify water resources used in water supply*

Four of the 21 countries studied were either planning or implementing this activity. The diversification strategy employed in all countries was rainwater harvesting (RWH), both household level and community level. However, some other diversification activities include desalination, wastewater reuse and reclamation, and storm-water harvesting. In Cambodia, two priority projects, “Community and Household Water Supply in Coastal Provinces” and “Cement Water Tanks Construction”, focus on ensuring safe water during times of droughts and floods by RWH. These projects aim to not only provide cisterns and tanks for populations that cannot afford them but also to educate the population and provide guidance for RWH. One likely reason why the diversification strategy adopted by the four countries is RWH is the affordability of RWH. For example, for household level RWH, rainwater can be collected from roofs and stored in containers for later use. Purification of sea water is expensive and energy intensive (Elliot et al., 2011). Desalination requires substantial economic investment so implementing it can compound inefficiencies in the water sector (Elliot et al., 2001). Although water reuse and reclamation is less expensive, its success is dependent on public acceptance. Educating the public about the safety of recycled water and drawing attention to unintentional reuse which occurs sometimes may reduce public resistance to wastewater reuse (Elliot et al., 2011).

Diversity of water supply increases resilience to climate change impacts and reduces the risks attached to relying on traditional dams and other traditional water supply methods (Maddocks, 2011). Diversification increases water availability by improving access to water that is suitable for human consumption through, for example, the investment in and the development of desalination technologies that will make saline water safe for human consumption by removing salts and minerals (Maddocks, 2011). Desalination is economically intensive, particularly for countries with limited financial capacity; however, other diversification strategies should be considered and employed by governments to



ensure continuous access to safe water. RWH, in particular, can be encouraged by governments because it can be carried out at the household level and it is relatively inexpensive when appropriate roofing is in place. However, there is a need for guidance to help minimize pollution of stored water.

*Enhance cross-sector collaboration (e.g. water, health, and agriculture) in climate change adaptation planning*

Water governance must be expanded to and integrated with non-water sectors (Omari, 2010). When responsibility of drinking water falls to one agency, water for irrigation purposes fall to another, and water for the environment falls to yet another, lack of cross-sectoral coordination can result in conflict, waste and unsustainable systems (Cap-Net, 2005). In developing countries, responsibility for water resource management is usually shared by many different government departments (Cap-Net, 2009). Also, there is very thin literature available on sector collaboration with regards to climate change. This may explain why only three countries (two have adequate and the third partially adequate activities) are either planning or implementing this activity.

Collaboration among different actors (scientists, tourism researchers, private sector, businesses, states, and countries) is greatly encouraged (Scott et al., 2005; Francisco, 2008; Stern, 2008; Harley et al., 2006). However, there is little on sector (water, agriculture, forestry, etc.) collaboration with countries. Tribbia et al. (2008) call for between collaboration among all agencies at the federal, state and local levels in coastal management. Also, several countries (Republic of Palau, Guam, the Commonwealth of Northern Marianas Islands, the Federated States of Micronesia, and the Republic of the Marshall Islands) have called for improved collaboration of climate relevant sectors (Anderson et al., 2010). Beg et al. (2002) notes the need for health ministries, infrastructure, and coastal zone management

to work together to maximize efficiency given limited resources and ensure consistency with other policy goals. This will also reduce the likelihood of conflict goals with different policies.

Water resources are dependent on the climate and are shared by various sectors with a country. This makes collaboration among the different sectors vital. Collaboration among sectors with regards to climate change can be achieved by setting up inter-sectoral committees, holding annual meetings of several sectoral ministries, and/or allowing transparency among ministries to ensure goal conflicts are minimized. Nigeria has an Inter-ministerial Committee on Climate Change (ICCC) which advises the government on issues related to climate change and is made up of representatives from different ministries including the Federal Ministry of Water Resources, the Federal Ministry of Agriculture and the Nigerian Meteorological Agency (Federal Republic of Nigeria 2003).

*Incorporate climate change adaptation into emergency preparedness and response planning (EPRP)*

Although many countries have an emergency preparedness and response plan in place, most of them do not incorporate climate change into the plan. EPRPS cannot be based on historical data anymore. Of the eight that do incorporate climate change, this incorporation was found to be adequate for four, partially adequate for three, and no detailed information on the program currently being implemented in Viet Nam was available to make an adequacy assessment. In Iraq, UNDP together with UN's Office for the Coordination of Humanitarian Affairs (OCHA) is supporting the development of an effective emergency response plan at both the national and local levels, which includes short-term solutions to disasters related to water supplies. This involves UNDP assisting Iraq in improved management and use of water resources addressing various scenarios possible with climate change (UNDP 2009).

Proper emergency preparedness comprises planning for recovery and reconstruction after a disaster and here lies the opportunity to recreate settlements in ways that make them more compatible with changing environmental conditions (Handmer et al. 1999). However, emergency management is generally focused on short term adaptability so that communities can continue as before with minimum delay (Handmer et al. 1999). With increasing intensity and frequency of extreme weather events as a result of climate change which could translate to more emergencies, there is a need for effective emergency management practices. EPRP and DRR work together to eliminate or at least minimize adverse impacts of disasters on human lives and property. EPRP aims to minimize the adverse effects to human livelihoods and rebuild communities after a disaster occurs, whereas, DRR aims to reduce the likelihood of the disaster occurring (like putting plans in place to ensure settlements are not built in areas highly susceptible to floods or landslides) and when it does occur having plans in place (like early warning systems) that will ensure that lives are not affected, or at the very least minimally affected.

Uncertainties inherent in climate change predictions and impacts delay abatement of extreme events which results in a greater reliance on emergency management (Handmer et al. 1999). With climate change occurring, planning assumptions in organizational strategies may need to be adjusted to account for changing risk profile (Baumann et al. 2010). This may mean modifying planning scenarios to address an increase in frequency and/or intensity of a hazard. For natural hazards, the Hazard Identification and Risk Assessment (HIRA) process is principally based on historical occurrence (Baumann et al. 2010). However, given the changing patterns of these hazards, climate change needs to be integrated into the emergency management process.

Effective emergency preparedness and response will help in reducing fatalities that result from natural disasters and this is crucial for those in developing countries because ninety percent of disaster victims live in developing countries (Annan 1999).

### *Capacity building and institutional strengthening*

Majority of the countries (18 of 21) are currently planning or implementing capacity building and institutional strengthening efforts. This is not unexpected since research has shown that developing countries are eager to build their capacities and their vulnerability stems from limited capacities in information, institutions, technology, and adequate human resources (Smith et al., 2003; Adger et al., 2003; Eakin et al., 2006; Beg et al., 2002). The activity planned or implemented was found to be adequate for 12, partially adequate for five, and although programs are currently being planned and implemented by UNDP in Syria, an adequacy assessment was not made because no detailed information on these programs was found.

Specific interests of particular countries may vary but one of the key interests of developing countries is enhancing the capacities of communities to respond to climate change (Najam et al., 2003). The need for capacity building and institutional strengthening efforts in developing countries has been analyzed and recognized globally (Ikweme, 2003; Leary et al., 2003; Smith et al., 2003; Kandlikar et al., 1999; Mirza, 2003; Naess et al., 2005; Beg et al., 2002). Some of these efforts include training, effective infrastructure and technology building and management, to name a few (Engle et al., 2010; Meenawat et al., 2010).

For this paper, effective capacity building exercises aim to improve the skills of institutions and individuals through training and awareness workshops as well as improving material resources and infrastructure. In Madagascar, one of the countries with adequate programs for this activity, a policy of capacity building has already been implemented in priority sectors, in terms of human resources, financial and material resources. For water and coastal sectors, trainings are offered to water users and installations of windbreaks in

coastal regions are among some programs that aim to increase and improve human and material resources (Republic of Madagascar, 2006).

### *Relationship between the presence of activities and GDP, HDI, and DRI*

#### *Validity of Data*

There were 19 countries used in this analysis (Iraq and Syria were excluded due to the absence of their NAPAs and INCs). Also, Sudan and South Sudan were grouped as one country because GDP, HDI, and DRI were provided for Sudan before the country was split into 2 independent states. This relatively small number of countries may be the reason why there was no clear relationship between the presence of activities and GDP, HDI, and DRI of the countries. It is possible that if more countries were added to the analysis, a relationship may arise; however, this is not definite.

From figures 8, 9, and 10, it can be seen that there is no clear relationship between a country's GDP, HDI, or DRI and the presence of activities in the country. Bangladesh, the country with the highest number of activities present, neither has the highest GDI nor the highest HDI value. However, Bangladesh has the highest DRI value along with Ethiopia. Regardless, there was no clear relationship between DRI and activity presence. Sudan<sup>4</sup> and South Sudan have one of the lowest HDI values and have the eighth highest GDP, yet there were six activities present, the second highest number of activities present in country. According to the IPCC (2007), high adaptive capacity does not necessarily relate to actions that reduce vulnerability. This may be one reason why there was no clear link between these factors and the presence of the enabling environment activities identified. For

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<sup>4</sup> Information for Sudan was gotten from literature (NAPA, DRI, GDP, and HDI data sources) that was put together before the country was divided into Sudan and North Sudan. In the analysis Sudan and South Sudan, therefore, have the same number of present activities and the same GDP, HDI, and DRI.

example, despite the high capacity to adapt to heat stress, residents in some parts of the world, including developed regions, continue to experience high levels of mortality (IPCC, 2007).

Although there is literature assessing the vulnerability and adaptive capacity of countries (Fussel, 2009, Fussel, 2007, Diffenbaugh et al., 2007), no literature comparing presence of and/or effectiveness of adaptation measures in countries to social, financial, technological etc. capacity was found. There are significant constraints to adaptation, some of which, like cultural factors and behavioral factors, do not affect adaptive capacity as characterized by the IPCC.

### ***Conclusion***

The conclusion for this section of the thesis is presented later in the final *Conclusion* section of this report on page 103.

## **II. Climate Change Perceptions in Lagos and Akwa Ibom States**

### **a. Introduction**

One factor that can influence a country's preparedness for climate change is the perception of risks posed by climate change. Perceptions are principally formed by observed impacts of climate change effects on lives and property (Whitmarsh, 2008). For example, a community that experiences frequent floods and few droughts is more likely to prepare for floods than for droughts. However, perceptions are also formed by and can be strengthened by knowledge of climate change effects relevant to a country; this is achieved by awareness raising and information dissemination. Perceptions help promote attitudes that inform policy level decisions, influence adaptive response to climate change, and will lead to either the employment or dismissal of practices that will minimize the adverse impacts of climate change and enhance the positive impacts. Although developing countries are especially vulnerable to climate change impacts due to lack of financial, institutional, and technological resources. Knowledge and awareness of climate change play a significant role in helping tackle climate change impacts. An accurate perception of the risks of climate change is only achieved by determining the current level of awareness of climate change and its potential impacts in a country and educating/informing individuals based on their level of awareness.

### ***Preparedness in Nigeria***

From the previous chapter, it can be gathered that, of the nine enabling environment activities, six<sup>5</sup> are currently being implemented in Nigeria. Of the six being implemented in the country, five activities are considered adequate while one is partially adequate based on the criteria presented in the method section of *Climate Change Preparedness in Developing Countries* above. Based on the sources examined, Nigeria is one of the most prepared countries of the twenty analyzed in the previous chapter. However, it should be noted that assessments were based solely on information presented in the documents and no field research was conducted to verify the planning and/or implementation of programs. Although not fully prepared, this level of preparedness is attained in part by perceptions of policy makers in Nigeria regarding climate change. Climate change preparedness is vital in Nigeria because the country is currently experiencing more frequent heavy rainfalls leading to flooding, particularly in Southern Nigeria, and more frequent droughts and desertification, particularly in Northern Nigeria (BNRCC 2008). According to the IPCC fourth assessment report, the projected sea level rise will have significant impacts on coastal megacities, and Lagos, Nigeria's economic hub, most populous city, and a coastal city that is vulnerable to sea level rise, will probably be affected (IPCC 2007).

### ***Climate Change and Nigeria***

With regard to temperature, Nigeria is projected to experience an increase in both the Southern and Northern regions. This increase in temperature is projected for all seasons through the end of the 21<sup>st</sup> century (MoE Federal Republic of Nigeria 2003). According to the Ministry of Environment (2003), an increase in precipitation is projected in the rainy season

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<sup>5</sup> The six enabling environment activities currently being implemented in Nigeria are: Enhance adaptive capacity of poor and vulnerable (e.g. children) populations to ensure equity amongst all people, Raise awareness of climate change on national, regional, and community levels, Enhance research on climate change adaptation, Integrate climate change into planning, design, and management of water resources and supply, Enhance cross-sector collaboration (e.g. water, health, and agriculture) in climate change adaptation planning, Capacity building and institutional strengthening



for Nigeria, particularly for Southern Nigeria. In Southern Nigeria, this increase may be accompanied by an increase in rainfall intensity. However, the decrease in rainfall during the dry seasons could lead to droughts in the Southern regions of the country. In the Northern regions, an increase in rainfall is projected for the short rainy seasons and a decrease during the long dry seasons. This, coupled with the increase in temperature, will increase the likelihood of drought in the already arid region of the country (MoE Federal Republic of Nigeria 2003).

### ***Water Resources***

Water resources in Nigeria are exposed to floods, droughts, and coastal inundation. Some of the effects of these hazards on water resources in Nigeria include:

- Increased rate of evaporation due to increases in temperature will lead to high rates of water loss. High rates of evaporation can adversely impact water quality through reduced dilution.
- Reduced water volumes in natural reservoirs (e.g. Lake Chad) due to increasing temperatures and decreasing rainfall in dry season when water is needed most, particularly in the North, will reduce water availability across the country. Although, population pressures play the major role in diminishing volumes of natural reservoirs.
- Diminished groundwater levels due to poor recharge of aquifers as a result of decrease in rainfall in the dry season and increase in rainfall intensity would lead to less net infiltration. This would reduce water availability, particularly in communities that use groundwater resources.
- Increased coastal flooding and coastal erosion in coastal areas due to sea level rise will lead to salinization and reduced quality of water resources.

The potential reduction in quantity and quality of water resources in Nigeria due to the effects of climate change makes it essential for the country to establish practices that

minimize the effects of climate change on its water resources. It is crucial that current policy makers in Nigeria are knowledgeable about climate change and employ policies and practices to reduce its effects. Due to the long-term effects of climate change, the next generation of policy makers (current university students) needs to be knowledgeable about climate change and its effects on the country to ensure an uninterrupted preparedness for climate change and its effects.

### ***Objectives***

The importance of determining the level of awareness of climate change in a developing country led to research being conducted in Nigeria (one of the 21 countries studied to determine level of preparedness) for this purpose. This constitutes the second portion of this study.

The objective of this section of the research was to

- Assess the knowledge and attitudes of university students in Lagos and Akwa Ibom states in Nigeria with regard to climate change and its effects in Nigeria
- Assess the knowledge, attitudes, and practices of ministry and agency officials in Lagos and Akwa Ibom states in Nigeria with regard to climate change and its effects in Nigeria
- Compare knowledge and attitudes of both study populations

This is a pilot study, so two (Lagos and Akwa Ibom) of the thirty-six states in Nigeria are studied. The results obtained from this study are useful in determining the need for awareness campaigns, or modifying them where present. These states were chosen because they have similar literacy rates so knowledge differences (if present) could not be attributed to difference in literacy rates in both states. The states were also chosen because the presence of representatives in both states made collecting information possible and straightforward.

## **b. Literature Review**

### ***Background on Nigeria***

Nigeria is a country located in West Africa and bordered by the Republic of Benin to the west, Niger to the north, Chad and Lake Chad to the north east, Cameroun to the east, and the Atlantic Ocean to the south. The population of the country is approximately 158 million (most populous country in Africa) and the total area is 923,768 square km (UNPD, 2009). The country has a coastline that is approximately 850 km long.

### ***Climate***

The climate in Nigeria varies from the south to the north of the country. The country experiences a tropical climate in the South and an arid climate in the North. The mean annual temperature in Nigeria is 27°C and over the last few decades, there has been a general increase in temperature in the country (MOE Federal Republic of Nigeria, 2003). Mean annual rainfall also varies greatly from south to north. The South (along the coast) receives greater than 3000mm of rainfall annually, while the North receives less than 250mm of rainfall annually (Maduabuchi, 2004). The country experiences two seasons: the rainy season and the dry season. The length of the rainy season ranges from 9-12 months in the South to 2-3 months in the North. The annual variation of rainfall is large, particularly in the North. This often results in floods and droughts.

### ***Freshwater Resources***

In 1995, the National Water Resources Master Plan was completed and surface water and groundwater resources were estimated to be approximately 267billion and 52 billion cubic meters of renewable yield per year, respectively (Maduabuchi, 2004). Taking into account overlap of groundwater and surface water, the total annual renewable water resources becomes 286 billion cubic meters (FAO, 2005). Combining data on population and freshwater availability, approximately 1810 cubic meters per year is available per capita,

placing Nigeria in the “water vulnerability” category, the category leading to “water stress.” However, due to the vast difference in the climate of northern and southern Nigeria, water availability varies between regions. Northern Nigeria has more water availability issues than southern Nigeria due to the aridity of the region, its susceptibility to drought due to longer dry seasons than rainy seasons, and the encroachment of the Sahara desert into the region.

The main drainage systems in Nigeria are the Rivers Niger and Benue, Lake Chad, and coastal river systems. River Niger is the largest river in Nigeria, followed by River Benue. Both rivers form a confluence at Lokoja. Lake Chad is the largest natural lake and a water source for people in the North as well as for a significant population of Chad, Niger, and Cameroun. However, according to the United Nations, it shrank approximately 90% from about 1963 to 2001 (UN News Centre, 2009).

### ***Background on Lagos and Akwa-Ibom States***

#### ***Lagos State***

Lagos is a coastal state that shares boundaries to the south with the Atlantic Ocean. The climate of the state is tropical and it experiences two distinct seasons: Wet season which lasts approximately seven months and dry season which lasts approximately 5 months. Lagos is the economic hub of the country and contains the nation’s largest urban area. Although, Lagos is the smallest state by size, it boasts a population of approximately 17 million, the largest population of all states in the country. Metropolitan Lagos, which is 37% of the state’s area, is home to 85% of the total state population (Lagos State Government 2011). For Lagos state, stress on water systems is affected not by climate change alone, but by overpopulation and urbanization as well. The main economic center and millions of people in the country are vulnerable to sea level rise.

### *Akwa Ibom State*

Akwa Ibom is a coastal state that shares boundaries to the south with the Atlantic Ocean. It is characterized by humid climate and experiences abundant rainfall. Two seasons exist, the rainy season which lasts 8-9 months and the dry season which lasts 3-4 months. The relief of the country is generally flat making it susceptible to sea level rise. Population of the state according to the 2006 census was 4 million and approximately 60% of the population is agrarian, 25% commercial oriented, and 15 % constitute the civil and public sector (AKSG 2008). Although the majority of the population is engaged in subsistence farming, there are large deposits of oil and gas both on and offshore, making it an economically important state.

### ***Climate Change projections for Nigeria***

#### *Projections for West African (WAF) region*

In the IPCC fourth assessment report, climate change projections are presented on a region by region basis (using continental scale basis) but these are further subdivided into sub-continental regions due to the broad range of climates within continents. Nigeria falls into the West Africa (WAF) region and projections for this region are presented below.

Research on changes in extremes specific to Africa, in either observations or models, is limited. Warming is *very likely* to be larger than the global mean throughout Africa and for all seasons. For the WAF region, an increase in the frequency of extreme wet events is projected for the 9-month period June to February and there is no consensus for March through May. There is variability among models with regards to change in extreme dry events. The only consensus is for a decrease in dry events in the Dec-Jan-Feb season. A “no consensus” finding was reported when less than 14 out of the 21 models used by the IPCC to determine climate change effects agreed on an increase or a decrease in the extremes (Christian et al., 2007).

**Table 8: Seasonal change in frequency of extreme wet and dry events in West Africa.**  
*Source: IPCC 2007. The Fourth Assessment Report.*

<b>Extreme Wet Events</b>				
<b>Seasons</b>				<b>Overall Annual</b>
<b>Dec/Jan/Feb</b>	<b>Mar/Apr/May</b>	<b>Jun/Jul/Aug</b>	<b>Sep/Oct/Nov</b>	
↑	no consensus	↑	↑	↑
<b>Extreme Dry Events</b>				
<b>Seasons</b>				<b>Overall Annual</b>
<b>Dec/Jan/Feb</b>	<b>Mar/Apr/May</b>	<b>Jun/Jul/Aug</b>	<b>Sep/Oct/Nov</b>	
↓	no consensus	no consensus	no consensus	no consensus

### *Country-level projections*

With regards to temperature, Nigeria is projected to experience an increase in both the Southern and Northern regions. An increase in temperature will cause an increase in the rate of evapotranspiration. This increase in temperature is projected for all seasons through the end of the 21<sup>st</sup> century.

An increase in precipitation is projected in the rainy season for Nigeria, particularly for Southern Nigeria. In Southern Nigeria, this increase may be accompanied by an increase in rainfall intensity, particularly during severe storms. However, the decrease in rainfall during the dry seasons coupled with the increase in temperature could lead to droughts in the Southern regions of the country. In the Northern regions, an increase in rainfall is projected for the short rainy seasons and a decrease during the long dry seasons. This coupled with the increase in temperature will increase the likelihood of drought in the already arid region of the country (MoE Federal Republic of Nigeria, 2003).

Greater variability in rainfall and temperature will accompany climate change in Nigeria. Increase rainfall variability would result in more frequent floods and droughts. The coastal region of the country is vulnerable to sea level rise and increased storm surges.

## **Hazards**

Nigeria is highly vulnerable to numerous hazards. In the North, the greatest hazard is desertification and desert encroachment to the south is occurring at a rate of about 0.6km per year (Mogbo 1999; UNCCD 1999). The North is also vulnerable to droughts, a hazard that has characterized this region, particularly since the 1960s (MoE Federal Republic of Nigeria 2003). Even though the South is projected to experience increase in precipitation, the increase in temperature which could increase evaporation and potential evapotranspiration could lead to droughts in parts of the humid areas of the South. The south is also vulnerable to coastal flooding from sea level rise and storm surges (MoE Federal Republic of Nigeria 2003). So the hazards Nigeria is vulnerable to are

- Droughts – from increased temperatures in the entire country and reduced precipitation in the dry seasons. Desertification would be exacerbated (it should be noted that land use practices significantly influence desertification).
- Floods – from increased precipitation and increased rainfall variability
- Coastal flooding – from sea level rise and increased storm surges

## **Why Nigeria is Vulnerable to Climate Change Impacts**

Adaptation depends greatly on the adaptive capacity of the affected community or country and according to Smit et al. (2006), improving adaptive capacity reduces vulnerability (IPCC, 2001). Adaptive capacity is *the potential, capability, or ability of a system to adapt to climate change stimuli or their effects of impacts* (IPCC, 2001). Adaptive capacity is determined by economic wealth, technology, information and skills, infrastructure, and equity.

Nigeria is vulnerable to climate change impacts because it has limited capacity to adapt to climate change effects. Below is information for some of the determinants for adaptive capacity Nigeria.

- Economic wealth - Seventy percent (2007 est.) of the population in Nigeria is below the poverty line (CIA, 2011)
- Information and skills - average adult literacy rate in the country is 71.6% (ranges from a low of 42.6% in one state to a high of 87.7% in another) (NBS, 2010).
- Equity – regionally, literacy rate is lower in the North than in the South and on average, literacy rate among adult females is 15% less than among adult males (NBS, 2010). In terms of inequality of wealth, richest 20% have 49% of the total income while the poorest 20% have 5% (UNDP, 2007).

### ***Water Stressors in Nigeria***

Water resources in Nigeria are not only vulnerable to climate change impacts<sup>6</sup> but are also vulnerable to population growth and rapid urbanization. By 2025, it is projected that Nigeria will be water stressed, although the cause will be predominantly overpopulation (Falkenmark, 1989). Nigeria is currently the most populous country in Africa and the eight most populous in the world (CIA, 2011). By 2025, Nigeria would be the fifth most populous country in the world. This occurs as a result of the high population growth rate in the country (twice that of the world for the five year period 2010-2015). Population in 2025 is projected to be approximately 210 million which will put freshwater availability per capita at approximately 1362 cubic meters – in the “water stress” category (UNPD, 2009). Nigeria is also experiencing rapid urbanization which is having adverse impacts on water quality and quantity. The country is currently 50% urban but is expected to be 60% and 75% urban by 2025 and 2050, respectively (UNPD, 2009). Farmlands and watersheds are being destroyed and used for residential purposes and this is having adverse impacts on water quality and quantity in Nigeria (Eni et al., 2011; Nsiah-Gyabaah, 2004).

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<sup>6</sup> Effects are summarized in the *Water Resources* section in the Introduction to this section of the thesis



## ***Knowledge, Attitudes, and Practices (KAP) Studies***

### *Past KAP studies*

There has been substantial research conducted on assessing knowledge, attitudes, practices and/or behaviors of the public with regards to climate change. These studies have been carried out in Africa, Asia, Australia, Europe, North America, and South America. These studies range from studies on general understanding of climate change and human contributions (Bulkeley, 2000; Macharia et al., 2010; Mings, 2008; Plotnikoff, 2004; Rawlins, 2007), concern about climate change (Bulkeley, 2000; Brechin, 2003; Lorenzoni, 2006), effects of climate change and/or experiences (Macharia, 2010; Rawlins, 2007), and adaptation/mitigation practices carried out (Rawlins, 2007; Macharia, 2010; Bulkeley, 2000). However, there have been few studies that have used KAP surveys. According to Lowe et al. (2006), Lorenzoni et al. (2006), and Lugadiru et al. (2010) experiences shape people's knowledge of the causes and effects of climate change in their countries.

Brechin (2003) collected information from various public opinion polls carried out in different countries and put all the information together.

is adapted from the study and illustrates views about seriousness of global warming in 24 countries. The poll was conducted in 1993 and since then climate change has received extensive media attention and is currently on the international public health agenda (Plotnikoff, 2004). With the extensive attention climate change has received, it is likely concern has increased over the years. For example, Mings (2008) conducted a climate change awareness study in Antigua and Barbuda and found that awareness had increased due to awareness activities carried out over the years.

**Table 9: Cross National Public Perceptions on the Seriousness of Global Warming.**

Source: Brechin 2003, adapted from Dunlap, R., G.H. Gallup and A.M. Gallup. 1993. *Health of the Planet Survey: A George H. Memorial Survey*. Gallup International Institute, Princeton

	Very Serious %	Somewhat Serious %	Not very Serious %	Not At All Serious %	Not Sure/ DK %
Nigeria	26	13	11	11	39
India	36	29	10	3	22
Philippines	40	35	15	2	8
Turkey	45	22	9	3	21
Poland	59	22	5	1	13
Chile	59	23	7	1	10
Mexico	62	14	3	1	20
Uruguay	69	14	2	1	14
Brazil	71	14	6	1	8
Hungary	33	38	8	1	20
Russia	40	26	9	1	24
Portugal	72	16	2	0	10
Korea (Rep)	47	30	8	1	14
Ireland	63	23	4	1	9
Great Britain	62	25	4	1	8
Netherlands	36	39	14	1	10
Canada	58	27	5	1	9
USA	47	31	7	3	12
Denmark	55	25	6	1	13
Germany	73	21	2	1	3
Norway	66	23	3	2	6
Japan	47	33	5	1	14
Finland	34	43	17	2	4
Switzerland	62	27	6	1	4

There was no reason given in the report for the order of countries in the table above. However, Nigeria was the only country of all 24 that did not fall in the category of support (39% in Nigeria consider it at least somewhat serious versus a low of 65% for other countries). From the table above, Nigeria is least concerned about global warming and also the least sure about its seriousness. From this study, it can be deduced that awareness

about global warming and climate change is needed in Nigeria. However, this poll was conducted almost two decades ago and since then there have been numerous awareness campaigns carried out in the country (Agwu, 2009).

### ***Summary***

Nigeria is vulnerable to climate change impacts, not just because of the limited capacity in the country but also because of the geographical setting and climate of the country. KAP studies will aid in determining the level of awareness and based on the results, more effective awareness campaigns can be carried out. Knowledge about climate change will aid in ensuring that effective adaptation policies and practices for water resources are carried out (Mings, 2008). However, it is important that students, not just policy makers are aware and knowledgeable about climate change. This is because climate change effects will occur for decades and current students will be policy makers tomorrow (Macharia et al., 2010).

## **c. Methods**

### ***Knowledge, Attitudes, and Practices (KAP) survey***

A Knowledge, Attitudes, and Practices (KAP) survey was used in this study. A KAP survey is a representative survey of a specific population to collect information on what is known, believed, and done with regards to a particular topic (WHO 2008). Because KAP surveys gather information on what respondents know, think, and do concerning a particular topic, as well as their major information sources, they are useful in determining knowledge gaps, behaviors, and information media which can help in planning effective advocacy, communication, and social mobilization (ACSM) programs.

### ***Study Sites***

This pilot study took place in Lagos and Akwa Ibom states. Descriptions of the states are in the *Literature Review* section.

### ***Study Population***

State ministries and water agencies were the representative population for policy makers while university students were the representative population for future policy makers. Ministries that were surveyed included Lagos and Akwa Ibom state Ministries of Environment, Education, and Rural Development, Lagos Water Corporation, and the Akwa Ibom Water Company. The Lagos Water Corporation and Akwa Ibom Water Company are government agencies responsible for water distribution in urban areas in Lagos and Akwa Ibom respectively. Below is a brief description of why each ministry was picked and is relevant to this study.

*Ministries of Environment:* Climate change is currently one of the most talked about environmental issues which affects all sectors (water, agriculture, fishery, public health etc.) in a country.

*Ministries of Education:* Knowledge and awareness of climate change is vital to minimizing risks posed by the effects of climate change, and educational institutions can provide this type of information at different levels.

*Ministries of Rural Development:* These ministries are responsible for water supply in rural areas and as of 2008, 52% of the population in Nigeria lived in rural areas (WHO/UNICEF 2010) so rural areas make up a significant number of the population.

*Lagos Water Corporation and Akwa Ibom Water Company:* Part of the aim of this study is to determine adaptation practices employed pertaining to water resources and supply, and these corporations are responsible for urban water supply.

Two universities were surveyed during this study: University of Lagos in Lagos state and University of Uyo in Akwa Ibom state. These universities were chosen because they are the largest universities in both states and the main federal government universities in both states so the Ministries of Education play a significant role in assisting both universities. Three faculties were selected and the reasons are below:

*Engineering:* This faculty comprises of several departments including civil and environmental engineering and mechanical engineering. The relevance of this faculty lies in their direct connection with both mitigation and adaptation technologies and students will likely end up being trained to build and operate water supply structures

*Environmental Sciences/Studies:* This faculty is made up of departments like urban planning and land use management which are vital in reducing vulnerabilities of communities to climate change. It is also involved in designing communities that have minimum adverse impacts on the environment.

*Law:* Due to the importance of oil exploration to the country's economy, the environmental consequences of oil and gas exploration have become a very important issue to policy makers. Gas flaring is the second highest emitter of CO<sub>2</sub> in Nigeria. Environmental Law is one of the ways that the government sees as being able to regulate environmental issues and protect the environment.

### *Informed consent*

Before the start of the study, approval to conduct this research was obtained from the University of North Carolina at Chapel Hill's (UNC) Institutional Review Board (IRB) (Study # 11-0523). Written permission to carry out this research was also obtained from commissioners of all ministries, directors of Lagos Water Corporation and Akwa Ibom Water Company, and Vice Chancellors of both universities. Completion of a questionnaire by a participant was considered as consent on the parts of the participants because a consent script attached to each survey was provided to each individual.

### ***Questionnaire Development***

The questionnaires administered (Appendix A) were developed after a study on KAP surveys and climate change KAP surveys was conducted. There is limited information on climate change KAP surveys but literature available assisted in question modeling. The two major sources used were *Advocacy, communication, and social mobilization for TB control: A guide to developing Knowledge, Attitude, and Practices Surveys* by World Health Organization and *Determination of Knowledge, Attitudes and Practices on Climate Change Issues* by Environment Tourism Consulting, Antigua (WHO, 2008; Mings, 2008). The former was used because it provided a comprehensive and detailed explanation of KAP surveys, while the latter was used because it was a study done on schools and other groups like financial sector and media to determine the efficacy of awareness activities carried out in

Antigua and Barbuda. Questions for this study were modeled after some of the questions used in *Determination of Knowledge, Attitudes and Practices on Climate Change Issues*.

Questionnaires administered to students and those who work in ministries differed in structure and content, but not completely. Questions on knowledge and attitudes were posed to both groups, while questions on adaptation practices were posed to ministry officials but not to students. For this study, the KAP survey administered gathered information on basic knowledge of climate change (including causes and effects), attitudes regarding climate change (relative importance compared to other environmental issues), and practices concerning climate change (particularly adaptation programs and communication practices). The data collated can help set program priorities and select the most effective communication channels.

Preliminary survey distribution was carried out in Akwa Ibom alone due to the delay in obtaining consent from ministries in Lagos state. Two surveys were administered in ministries and five surveys in universities. Data collated from the survey responses were useful in finalizing questionnaire make-up. After the pilot survey analysis, 1 question was added to both surveys, "I don't know" options were added to some questions to minimize "forced" answers, and some options were revised to aid more accurate analysis of data.

### ***Questionnaire Distribution***

Each ministry is comprised of different departments, so questionnaires were distributed to departments responsible for projects related to climate change, basic and higher education, and project implementation of water supply. For the Ministries of Environment, questionnaires were administered to the climate change department, particularly divisions concerned with adaptation and school advocacy. For the Ministries of Education, questionnaires were administered to departments responsible

for primary, secondary, and university education as well as the science and technology departments. For Ministries of Rural Development, questionnaires were administered to the departments of rural water supply and community development (whose main goal is sensitizing communities to different issues). Questionnaires were distributed to field engineers and project implementation units at the Lagos Water Corporation and Akwa Ibom Water Company. Similar departmental make-ups of the different ministries in both states allowed for comparable distribution and the number of questionnaires distributed to each ministry were approximately the same. Approximately 10-15 questionnaires were distributed in each department. Because departments generally were assigned separate rooms, individual selection was relatively simple. Individuals were randomly approached, informed about the study, provided the consent on the page, and if there were willing, completed a questionnaire.

For the universities, questionnaires were distributed using a simple random sampling method. Approximate data on number of students was obtained from both registrars. Questionnaires were administered in classes after lectures as well as between classes when students were either waiting for their next class or just lingering. Approximately 50 questionnaires were distributed to each faculty in order to get a representative sample of the faculties and to get similar confidence levels (Appendix B).

#### *Data collection and analysis*

All questionnaires collected were stored in a locked cabinet only accessible to the principal investigator and the country representative who distributed surveys in Akwa-Ibom. Each questionnaire was labeled with an alpha-numeric code to ensure no questionnaire responses are duplicated. Data from the questionnaires were collated, analyzed, and stored



in an excel file located in a password protected online database. Statistical analysis of data was conducted using SAS.

#### **d. Results**

There were 379 participants in this study, and of the 379, 242 (64%) were male, 133 (35%) were female, and 4 (1%) did not disclose gender. 295 of the respondents (64% male, 35% female, 1% unknown gender) were university students and 84 (60% male, 39% female, and 1% unknown gender) were officials from state ministries and agencies. Students were asked questions on knowledge and attitudes about climate change while policy makers were asked questions on knowledge, attitudes, and practices.

##### ***Knowledge of Climate Change***

1. *Causes of climate change*: Most university students and ministry officials “strongly agree” or “somewhat agree” that human activity is responsible for climate change (Table 10). There is a strong agreement across the board that human activity is responsible, as less than 10% of respondents disagree to some extent that human activity is responsible for climate change. With regard to natural climate variability being responsible for climate change, most people (70.9% students and 77.4% policy makers) agree to some extent that it is responsible as well (Table 11); although, agreement is not as strong as it is for human activity. There was significant difference ( $p=0.044$ ) in answers between the two study populations for the question on human activity being responsible for climate change but there was no significant difference ( $p=0.425$ ) for the question on natural variability.

**Table 10: Response to "human activity is responsible for climate change."**

	Universities		Ministries	
	N	%	N	%
Strongly agree	194	65.8	64	76.2
Somewhat agree	69	23.4	14	16.7
Don't know	9	3.1	1	1.2
Somewhat disagree	5	1.7	0	0
Strongly disagree	13	4.4	3	3.6
Don't believe the global climate is changing	2	.7	0	0
No response	3	1	2	2.4

$\chi^2 = 4.1$ ;  $dF=1$ ;  $p\text{-value}=0.044$ .

**Table 11: Response to "natural climate variability is responsible for climate change."**

	Universities		Ministries	
	N	%	N	%
Strongly agree	86	29.2	30	35.7
Somewhat agree	123	41.7	35	41.7
Don't know	31	10.5	3	3.6
Somewhat disagree	20	6.8	7	8.3
Strongly disagree	21	7.1	8	9.5
Don't believe the global climate is changing	0	0	0	0
No response	14	4.7	1	1.2

$\chi^2 = 0.64$ ;  $dF=1$ ;  $p\text{-value}=0.425$ .

Although, a greater percentage of people strongly agreed that human activity is responsible for climate change rather than natural variability, majority of survey participants (34.2% students and 45.2% policy makers) chose that both human and natural variability are equally responsible than any other option (Table 10). Because 25.1% and 16.7% of university students and ministry officials, respectively, did not answer this question, respondents may not have been willing to definitively pick one cause over the other.

**Table 12: Response to "to what extent are human activity and natural climate variability responsible for climate change."**

	Universities		Ministries	
	N	%	N	%
Solely human activity	10	3.4	8	9.5
Mainly human activity	83	28.1	20	23.8
Both equally	101	34.2	38	45.2
Mainly natural variability	21	7.1	3	3.6
Solely natural variability	4	1.4	1	1.2
No response	74	25.1	14	16.7

$\chi^2 = 7.7$ ;  $dF=4$ ;  $p\text{-value}=0.103$

2. *Effects of climate change in Nigeria:* The differences in the answers from the students and policy makers were not significantly different ( $p=0.4584$ ). Of the eight options presented for consequences of climate change in Nigeria, the three most commonly picked for both study populations were rising temperatures (77.3% students and 77.4% policy makers), flooding (59.0% students and 73.8% policy makers), and sea level rise (48.5% students and 71.4% policy makers). This is understandable because all respondents were based in southern Nigeria and these are all hazards that southern Nigeria is prone to. Northern Nigeria, on the other hand, does not have a coast so is not vulnerable to sea level rise; the region is also arid so not as prone to flooding as the humid, tropical south.

**Table 13: Response to "which of the following will affect Nigeria as a consequence of climate change"**

	Universities		Ministries	
	N	%	N	%
Sea level rise	143	48.5	60	71.4
Drought	102	34.6	45	53.6
Flooding	174	59.0	62	73.8
Coastal erosion	114	38.6	51	60.7
Rising temperatures	228	77.3	65	77.4
Melting glaciers	26	8.8	10	11.9
Desertification	125	42.4	48	57.1
Increasing frequency and intensity of extreme weather events	146	49.5	48	57.1
I don't know	8	2.7	0	0
None	2	0.7	0	0
No answer	5	1.7	2	2.4

$\chi^2 = 7.7$ ;  $df=8$ ;  $p\text{-value}=0.4584$

3. *Region of Nigeria most vulnerable to climate change:* According to the analysis done for this survey question, approximately the same percentage of students believe that northern Nigeria is more vulnerable and that both regions are equally vulnerable (35.3% responded Northern Nigeria is more vulnerable and 39.3 responded both Northern and Southern Nigeria are equally vulnerable). 65.5% of policy makers believe that both are equally vulnerable and of the remainder, more people believe that northern Nigeria is more vulnerable than southern Nigeria. Overall, the differences in answers from the students and policy makers were statistically significant ( $p=0.0006$ ). Location of respondents did not influence their responses since for both populations more people believe the North is more vulnerable than the South. Most popular reasons given for vulnerability of the north were desertification and extreme temperatures, while for the south they were sea level rise, flooding, and industrial activity.

**Table 14: Response to "What region of Nigeria is more vulnerable to climate change."**

	Universities		Ministries	
	N	%	N	%
Southern Nigeria	52	17.6	7	8.3
Northern Nigeria	104	35.3	19	22.6
Both equally vulnerable	116	39.3	55	65.5
Other	2	0.7	0	0
No response	21	7.1	3	3.6

$\chi^2 = 19.695$ ;  $dF=4$ ;  $p\text{-value}=0.0006$

### ***Attitudes regarding climate change***

4. *Top environmental issues in Nigeria:* Below is a tabular response given by respondents about the top three environmental priorities in the country. Despite the fact that the students may have been biased due to the fact that the survey was on climate change, pollution (56.3%) and overpopulation (37.6%) were thought to be more important than climate change (35.9%). On the other hand, policy makers chose climate change as the top environmental priority of the country. This may be due to bias due to the fact that the survey was on climate change but also may be due to the fact that policy makers do believe climate change is the top priority of the country. There was a significant difference ( $p=0.0033$ ) between the options chosen by students and those chosen by policy makers.

**Table 15: Response to "top three environmental issues in Nigeria."**

	Universities		Ministries	
	N	%	N	%
Overpopulation	111	37.6	30	35.7
Urbanization	67	22.7	20	23.8
Deforestation	74	25.0	32	38.1
Desertification	22	7.5	8	9.5
Climate change	106	35.9	51	60.7
Pollution	166	56.3	37	44.0
Recycling	71	24.1	10	11.9
Environmental education	96	32.5	38	45.2
Renewable energy	90	30.5	19	2.3
Other	1	0.3	0	0
No response	27	9.2	1	1.2

$\chi^2 = 23.1$ ;  $dF=8$ ;  $p\text{-value}=0.0033$

### ***Climate change adaptation practices***

5. *Current adaptation practices*: Officials from ministries and agencies were asked what climate change adaptation practices were carried out in Nigeria with regard to water resources. From the options presented, improved sanitation disposal (74%) and surface water protection (51.8%) were the two adaptation practices most picked by respondents. When analyzed at the individual state level, these were the top two picked by policy makers in both states. The practice least implemented according to policy makers is groundwater recharge (11.1%) even though more people in Nigeria rely on groundwater than on surface water. Comparing responses of those who work at the water agencies and ministries of rural development (department of water) to responses from other agencies, the trend was the same. Groundwater recharge was the least picked option by officials of the water agencies and ministry of rural development (department of water) (Appendix C).

**Table 16: Response to "what climate change adaptation practices are carried out in Nigeria."**

	Ministries	
	N	%
Improved sanitation disposal to prevent contamination of water resources during floods	60	37.6
Groundwater recharge	9	22.7
Domestic water conservation	34	25.0
Surface water protection	42	7.5
Promotion of industrial and agricultural processes that minimize water demand	35	35.9
None	6	56.3
I don't know	4	24.1
No response	3	32.5

6. *Climate change awareness campaigns carried out in schools:* Most policy makers responded that climate change awareness campaigns are carried out in schools and of that number 75% responded that these awareness campaigns are carried out in universities. However, 75% of students who responded to the survey question claim that there are no climate change awareness activities carried out in their universities. Table 18 shows the percentage of university students and policy makers that responded that awareness campaigns are carried out in universities. There is a significant difference ( $p < 0.0001$ ) between the responses given by students and policy makers. Better exposure of the awareness campaigns carried out is crucial because Universities of Lagos and Uyo are the most populous universities in both states.

**Table 17: Percentage of Ministry and agency respondents who answered "Are climate change awareness activities carried out in schools?"**

	Yes	No
<b>Ministries</b>	<b>79.5%</b>	<b>20.5%</b>
Lagos State	82.9%	17.1%
Akwa Ibom State	75%	25%



**Table 18: Percentage of Ministry and agency respondents who answered "In what schools are climate change awareness campaigns carried out?"**

	Primary Schools	Secondary schools	Universities	Polytechnics
<b>Ministries</b>	<b>45%</b>	<b>76.7%</b>	<b>75%</b>	<b>58.3%</b>
Lagos State	59.4%	86.4%	72.9%	56.7%
Akwa Ibom State	21.7%	60.9%	78.2%	60.9%

**Table 19: Percentage of University respondents who answered "Are climate change awareness activities carried out at your university?"**

	Yes	No
<b>Universities</b>	<b>25.5%</b>	<b>74.5%</b>
Lagos State	27.5%	72.5%
Akwa Ibom State	23.5%	76.5%

**Table 20: Percentage of University and Ministry respondents who answered that awareness campaigns are being carried out in universities.**

	Yes	No
Universities	25.5%	74.5%
Ministries	60.2%	39.8%

$\chi^2 = 29.3$ ;  $dF=1$ ;  $p\text{-value} < 0.0001$

## **e. Discussion**

### *Validity of Data*

Surveys are subject to sampling errors. An effort was made to minimize sampling error by using the random sampling method during survey distribution. There were no follow up interviews during the study so no opportunity to determine the reasons why some questions were left unanswered, particularly the question regarding the extent to which human activity and natural variability were responsible for climate change which was left unanswered by approximately 25% of the study population. However, the pilot study that was carried out aided in reviewing questions and clarifying questions when it seemed it could be misinterpreted or when it seems answers could be forced from participants. Also, certain responses like the presence or lack of awareness campaigns in schools could not be verified.

### ***Knowledge of Climate Change***

#### *Causes of Climate Change*

The study population showed considerable knowledge on the causes of climate change. Majority agreed that human activities are responsible for climate change. Study participants were all based in southern Nigeria, and gas flaring, one of the major environmental pollution issues in Nigeria, occurs in the south. In Nigeria, there has been significant literature on the relationship between gas flaring and climate change (Bassey, 2008; Nzeadibe et al., 2011; Aminzadeh, 2007; Uyigue et al., 2007). Also, NGOs have been active in raising awareness about gas flaring and its linkages with climate change (Nzeadibe et al., 2011). Nigeria has the second highest gas flaring level in the world, and this accounts for approximately 30% of CO<sub>2</sub> emissions in the country (Elvidge et al., 2009; MoE Federal Republic of Nigeria, 2003). This may contribute to the high level of knowledge with regard to climate change causes.

Currently, climate science does not provide tools that can sharply distinguish climate variability according to human and natural causes (Fussler et al., 2005). However, according to the IPCC (2007), human activities have become a dominant force and are responsible for most of the warming observed over the past 50 years. A greater percentage of people agreed that human activity rather than natural climate variability is responsible for climate change. More people responded that they did not know whether natural variability was causing climate change than that they did not know whether human activity was causing it. This shows the confidence people have about the causal link between human activities and climate change.

Regardless of the fact that a greater percentage of people agreed that human activity rather than natural variability was responsible for climate change, most people responded that “both were equally responsible” for climate change, when asked to what extent both were responsible. Approximately one-third of people who chose “both equally responsible” picked the same degree of agreement in response to human activity and natural variability being responsible for climate change. The remaining two-thirds picked different degrees of agreement (e.g. a participant “strongly agreed” human activity was responsible and “somewhat agreed” natural variability was responsible but responded that “both were equally responsible”) for human activity and natural variability being responsible. Also, approximately 25% and 16% of students and policy makers, respectively, did not respond to this question. For these reasons, respondents may be unwilling to definitively state that human activities are mostly responsible for climate change or may not know which is more responsible. However, there is no doubt that the composition of the atmosphere is changing because of human activities, and GHGs are the largest human influence on global climate (Karl et al., 2003).

### *Effects of Climate Change in Nigeria*

Eight climate change effects were presented to the survey participants, all of which (excluding melting glaciers) Nigeria is currently exposed to and/or will be increasingly exposed to due to climate change according to *Nigeria's First National Communication under the United Nations Framework Convention on Climate Change (2003)*. Melting glaciers was the least picked option most likely because there are no glaciers in Nigeria or the surrounding countries. Excluding melting glaciers, drought was the least picked options for both study populations most likely due to the fact that both study sites are not only located in the humid and wet south, but are also coastal states that experience annual average rainfall of 2000mm in Lagos and between 2000mm and 3000mm in Akwa Ibom (Metz, 1991; AKSG, 2008).

The consequences of climate change most picked by respondents (rising temperatures, flooding, and sea level rise) are effects southern Nigeria is particularly vulnerable to. According to Lorenzoni et al. (2006), individuals characterize climate change in relation to their everyday experiences. Perceptions of climate change are linked to people's own direct experiences, Lowe et al. (2006) notes as well. Since all respondents either attend school or work in the south, it is understandable that southern Nigeria is particularly prone to the top effects chosen by respondents. These effects will not only negatively affect water quality but also water quantity. However, there are some positive impacts that can be exploited. For example, increased precipitation can lead to increased water availability if household level and/or community level rainwater harvesting techniques or other water collection and storage systems are employed.

There was no statistically significant difference between the frequency of options picked by students and policy makers. Although, all effects were picked by a greater percentage of policy makers than university students, it cannot be definitively stated that policy makers are more knowledgeable about the effects than students. Generally,

respondents were more knowledgeable about the causes of climate change than about the effects. In a study conducted by Sundblad et al. (2009) about climate change knowledge among experts, journalists, politicians, and laypersons, knowledge of climate change causes was also greater than that of future consequences in all groups. There is a need for increased awareness of the effects of climate change in Nigeria.

#### *Region of Nigeria Most Vulnerable to Climate Change*

A greater percentage of total respondents believe that both regions (Northern and Southern Nigeria) are equally vulnerable to climate change effects. However, more respondents (both policy makers and students) selected Northern Nigeria as being more vulnerable than Southern Nigeria.

According to Woodley (2011), with regard to natural capital (water resources, forestry), communities in the Sahel and Savannah regions (northern Nigeria) are more vulnerable than communities in the south due to greater water scarcity and fewer natural resources, and climate change impacts are predicted to be greater in the arid northern regions of Nigeria. Also, literacy rates of northern Nigerian states are generally lower than that of southern Nigerian states (NBS, 2010). Education is significant in reducing vulnerability by increasing adaptive capacity (Smith et al., 2003; Yohe et al., 2002; Brooks et al., 2004). However, southern Nigeria, particularly coastal areas need to prepare for climate change as well because 25% of the country's population live in coastal areas and projected sea level rise will have significant impacts on coastal megacities like Lagos (MoE Nigeria, 2004; IPCC, 2007).

#### ***Attitudes regarding climate change***

##### *Top environmental issues in Nigeria*

Climate change ranked in the top three for environmental issues that should be priorities in Nigeria. For policy makers, it ranked number one and for students, number

three. Students believe that pollution is the most pressing environmental issue by far. 20% more students chose pollution than the second highest ranked environmental issue (overpopulation). The top three environmental issues in order of decreasing priority according to policy makers' responses were climate change, environmental education, and pollution.

For both study populations, desertification was the least picked environmental issue. This was most likely because study sites were in southern Nigeria, an area currently not prone to desertification. Experiences play a role in determining relevant environmental issues or effects as posed by Lowe et al. (2006). This is observed here because according to UNCCD (1999), desertification is affecting 10 northern Nigerian states and accounts for 73% of the total cost the country is losing due to environmental degradation and yet it was the lowest priority of both students and policy makers. It is considered the most pressing environmental issue in Nigeria and desert encroachment to the south is occurring at a rate of about 0.6km per year.

Nigeria currently has to contend with various environmental issues including desertification, deforestation, pollution, and rapid urbanization (Agwu et al. 2009). And each of them is significant in the country. For example, between 1983 and 1993, Nigeria lost approximately 20% of its forest and woodland area (Agwu et al. 2009). Also, it is estimated that annually, Nigeria loses \$5.1 billion due to environmental degradation (Adegoke et al. 1997). The fact that Nigeria has numerous environmental problems can be seen in the responses to this question. Apart from the most picked responses for both populations (pollution for students and climate change for policy makers) and the least picked (desertification), all other responses were picked by roughly the same percentage of people. This shows that climate change is viewed as a relevant environmental issue by respondents. With regard to water resource quality and availability, the other environmental issues need to be addressed as well because they negatively affect water resources. For

improved water quality and increased water availability in the country, climate change has to be addressed alongside some of the other effects (e.g. population, urbanization, pollution etc.)

### ***Climate change adaptation practices***

#### *Current adaptation practices*

The question on climate change adaptation practices was posed to policy makers and not students. According to majority of respondents who answered this question, improved sanitation disposal to prevent contamination of water resources during floods is currently carried out in the country. Only 11.1% of respondents answered that groundwater recharge is currently being implemented in the country while over 50% stated that surface water protection is being implemented. Remarkably, approximately one in every four Nigerians relies on surface water while over 75% of Nigerians rely on groundwater for domestic use (Foster et al., 2011; Goni, 2006). However, with both study sites being in coastal regions of Nigeria, a focus on surface water protection may be well warranted. Saltwater intrusion into freshwater aquifers in coastal Nigeria is currently occurring and poses a great risk as many boreholes are being abandoned (Oteri et al., 2003; Adepelumi, 2008). With coastal Nigeria being vulnerable to sea level rise, saltwater intrusion into freshwater aquifers could accelerate over the years (FME, 2008).

#### *Climate change awareness carried out in schools*

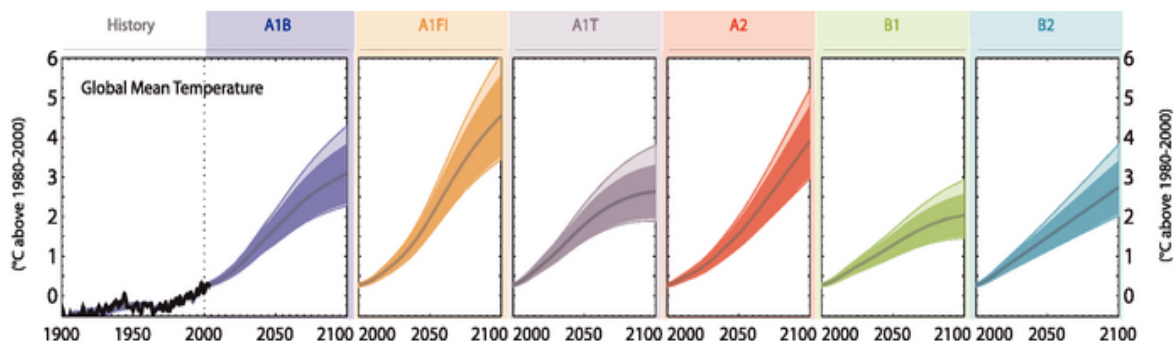
Majority (80%) of policy makers who responded to the question “are climate change awareness campaigns carried out in schools?” stated that climate change awareness activities are currently being carried out in schools. Of that majority, 75% further stated that awareness activities are carried out in universities (other options were primary schools, secondary schools, and polytechnics). Despite the high percentage of respondents that

asserted that awareness campaigns are carried out in universities, only 25.5% of students claim to be aware of campaigns at their universities. Due to the lack of follow-up interviews, it could not be deduced if the climate change awareness campaigns claimed to be carried out by policy makers are being carried out at these universities. However, if they are, the level of reach of the messages to the target audience is very important and the low level of reach may occur as a result of several factors including wrong media channels or rate of message distribution (Maibach, 1993). There is a need for better exposure of the awareness campaigns carried out. If the awareness campaigns are not being carried out at these universities then there is a need because Universities of Lagos and Uyo are the most populous universities in both states.



### III. Conclusion

Climate change is already happening. Global average surface temperatures rose by about 0.6°C during the 20<sup>th</sup> century, and the five warmest years on record since 1861 all occurred between 1995 and 2003 (IFRC, 2003; WMO, 2004). Climate change is disproportionately affecting developing countries due to their vulnerability to increased rainfall variability and extreme weather events. Vulnerability of a country is determined by its exposure, its physical setting and sensitivity, and its ability to adapt to change (Adger et al., 2003). Developing countries are exposed to numerous hazards like floods, droughts, and cyclones, are located in low-lying coastal areas, arid regions and other vulnerable settings, and, most significantly, have little to no technological, financial, human, and institutional capacity to adapt to climate change. Climate change can be lessened by reducing emissions of GHGs; however, under all IPCC scenario models, even the most modest temperatures increase (Figure 11) and impacts of climate change will still be felt, so adaptation is essential.



**Figure 11: Global Mean Temperature from Different Scenarios (A1B, A1F1, A1T, A2, B1, and B2).**

Source: IPCC 2007. The Physical Science Basis.

Developing countries need financial assistance from developed countries, international organizations, and donor agencies, and as of May 2011, 21 developed

countries and the European Commission had publicly pledged \$28.14 billion intended to help developing countries reduce emissions and adapt to climate change (WRI, 2011). However, developing countries can also prepare on their own by integrating climate change into current national policies, as adaptation will work best this way in the context of sustainable development and disaster risk reduction (Smith et al., 1996; World Bank et al., 2003). Policy and programming should prepare for increasing intensity and frequency of extreme events, sea level rise, and other climate change effects that threaten water availability and quality.

In the NAPAs and INCs, most countries report currently experiencing more frequent floods, droughts, and increasing intensity and frequency of weather events, and water quality and availability is currently threatened (salinization of freshwater resources is reported in some countries). With countries currently experiencing the effects of climate change, adaptation is necessary and cannot be delayed any longer.

Support to the creation of an effective enabling environment is inconsistent among countries. On average, the 19 countries (Syria and Iraq excluded) studied are implementing approximately half of the enabling environment activities identified. There is a need for better preparedness in developing countries so that adverse impacts of climate change can be minimized and the benefits can be exploited.

In many developing countries, climate change adaptation has probably suffered from the fact that it has been regarded as a single issue, rather than as part of the background against which development planning has to take place (Chambwera et al., 2010). The enabling environment activities identified here are “no-regrets” interventions. This means that the activities not only minimize adverse impacts and exploit benefits of adaptation but also generate net social benefits (Heltberg et al., 2008). The social sectors may offer valuable options for no-regret interventions but are not yet widely appreciated (Heltberg et al., 2008). Many interventions have focused on direct sectoral impacts of climate change like

climate proofing, crop diversification etc. but have given little attention to indirect impacts like effects on vulnerable populations. According to Heltberg et al. (2008), a robust social policy response that is embedded in an understanding of the risks associated with climate change facing the poor can aid in bringing about this no-regrets interventions. These no regrets interventions can yield benefits regardless of climate change projections. For example, the enabling environment activities identified in this thesis can help in reducing inequity (Enhance adaptive capacity of poor and vulnerable (e.g. children) populations to ensure equity amongst all people), build better relationships across sectors (Enhance cross-sector collaboration (e.g. water, health, and agriculture) in climate change adaptation planning), and improve human capacity (Capacity building and institutional strengthening) while minimizing adverse effects of climate change impacts. A high priority should be given to increasing the capacity of countries, regions, communities and social groups to adapt to climate change in ways that are synergistic with wider societal goals of sustainable development (IPCC, 2007).

The fact that even countries with high adaptive capacity sometimes fail to adopt adaptation measures means that there are factors beyond financial resources and technical capacity that affect preparedness for climate change. This sheds a little light on the fact that there was no clear relationship between presence of activities and GDP, HDI, and DRI. In spite of increasing attention to potential adaptation strategies, there is little understanding of their feasibility, costs, efficacy, and the likely extent of their actual implementation (U.S. National Assessment, 2001). Understanding the economic costs and benefits of adaptation along with the effectiveness of adaptation measures can help countries in making choices between different adaptation measures and in better preparing themselves for impacts of climate change. However, this is very complicated because in many cases, the economic effects of climate change are highly uncertain and the exact benefits of adaptation measures are also uncertain (Chambwera et al., 2010). There is a need for a comprehensive

understanding of the costs, barriers and limits to adaptation, which is not well established at the moment (Chambwera et al., 2010). Research is needed to monitor progress on adaptation, and to assess the effects of different adaptation strategies. A better understanding of these factors can aid in pushing countries towards better adaptation policies and practices. It is

Progress has been made by developing countries with regard to climate change, particularly with the UNFCCC, to which most countries are signatories. The Convention on Climate Change has set a framework for efforts from different governments to tackle the effects of climate change, commitments have been made by national governments, and NAPAs and INCs have been submitted; however, developing countries still need to employ several policies and practices to ensure preparedness. There are a lot of gaps in terms of ensuring adaptation preparedness. Part of the reason for this is most likely that mitigation studies have had more time and financial resources than adaptation (Omari, 2010; Bosello et al., 2009; Burton et al., 2002). In fact, most donor and development agencies are in the early stages of understanding ways to address adaptation (IGES, 2007). This was the same conclusion reached by Omari (2010), Chagutah (2010), Madzwamuse (2010), and Ikeme (2003) in their studies on preparedness of Botswana, Zimbabwe, South Africa, and sub-Saharan Africa, respectively.

Preparedness can be facilitated by improved knowledge and awareness of climate change. Nigeria, one of the 21 countries analyzed, has an adequate awareness raising activity. With inputs from UNICEF and United Nations Industrial Development Organization (UNIDO), UNDP works to raise awareness of the likely impacts of climate change as well as adaptation needs at the national, state, and local levels, in order to build broad and informed partnerships for climate change (ALM, 2010). Also, a Building Nigeria's Response to Climate Change (BNRCC) project which sprung from an earlier initiative called the Canada-Nigeria Climate Change Capacity Development Project raises awareness of climate change issues,

and Nigeria's first national communication recommends incorporating climate change into school curricula where it does not already exist, and strengthening it in institutions that already have these programmes and seminars, workshops, and informal discussions for the general public (BNRCC, 2008; MoE Federal Republic of Nigeria, 2003). Below are the conclusions drawn from the analysis of knowledge, attitudes, and practices of current and future policy makers (university students) in Lagos and Akwa Ibom states in Nigeria with regards to climate change.

Participants were more knowledgeable about the causes of climate change effects than of the effects. This conclusion is similar to the conclusion drawn by Sundblad et al. (2009). Both policy makers and students were very knowledgeable about the causes of climate change. More people responded that human activity was responsible than those that responded that natural variability was responsible. Regardless, people were unwilling to state that human activity was mostly responsible meaning there is a need for awareness about the roles that human activity and natural variability play in the current climate change crisis. According to Bord et al. (2000), knowing what causes climate change, and what does not, is the greatest predictor of both specified intents to take voluntary actions and to vote to enact new government policies regarding climate change.

Lowe et al. (2006) and Lorenzoni et al. (2006) deduced from their studies that knowledge of climate change effects is affected by personal experiences. Although not definitive, a similar theory was drawn in this study. Responses on climate change effects seemed to be influenced by the experiences of study participants. For example, for effects of climate change in Nigeria, drought was the least selected option, excluding melting glaciers. The study population was based in southern Nigeria, which experiences abundant rainfall, but Northern Nigeria is very prone to drought. A more definitive conclusion about the experiences shaping knowledge of the effects can be made if a similar study is carried out in Northern Nigeria and drought is one of the most picked options and flooding, one of the

least picked. There is a need for knowledge to be driven by more than just experiences because rainfall is projected to decrease during the months that southern Nigeria experiences the dry season which will increase the likelihood of droughts in the region (MoE Federal Republic of Nigeria, 2003).

Although awareness activities are carried out in universities according to current policy makers, it was not clear if they are being carried out at the universities that were studied. If they are, university students are mostly unaware of it. There is a need for better promotion of awareness campaigns in schools. Although students were knowledgeable about the causes of climate change, they were not as knowledgeable about the effects of climate change on the country. A basic understanding of cause and probable effects is necessary, and even an understanding of the uncertainties as well (Bord et al., 2000). Knowledge of the effects will aid in ensuring the right adaptation measures are carried out. Awareness campaigns in schools would improve the knowledge of the population and ensure preparedness in the country is never stalled due to the limited knowledge of a future generation.

If awareness campaigns are being carried out at both universities studied, the lack of knowledge of these campaigns carried out by the students shows the need for not just planning and implementing adaptive measures and campaigns but also assessing the efficacy of these measures and ensuring the goals are being met. Preparedness of developing countries with regards to climate change adaptation will depend not only on appropriate measures being carried out but also on effective implementation and ensuring target populations are reached.

# Appendix A

## Questionnaires

Questionnaires administered to university students

### Climate Change and Nigeria

#### Introduction

Climate change has become one of the most talked about environmental issues both nationally and internationally. The purpose of this questionnaire is to obtain information about your perception of climate change and how it relates to Nigeria.

#### Consent

I am a researcher from the University of North Carolina at Chapel Hill and I am conducting a survey to learn about perception of climate change and how it relates to Nigeria. This survey will take approximately 10 minutes. You are being asked to be in the study because you are a university student and, thus, a potential future policy/decision maker. The information that I collect will be used for research purposes and will be confidential. No personal information will

be requested on this form and no information provided will make any of the participants identifiable. There is no penalty for refusing to fill out the survey and there are no consequences to filling it out either. If at any moment during completion of this questionnaire you are uncomfortable or do not wish to respond to a question you have the right not to respond. There are no risks or benefits from taking part in the study. If you choose to take part, you will be asked a series of questions about climate change and how it relates to Nigeria. These questions are below. If you agree to the information gathered below being used, please read the instructions and fill out the questionnaire. By filling out this survey, you are providing consent.

#### Instructions:

Please fill out the form below, to the best of your knowledge by ticking boxes and providing short answers in the spaces provided. All answers are relevant to this research even when the answer is “I don’t know.” If you are unable to answer a question, leave it blank.

a. What faculty are you in?

- Environmental sciences
- Engineering
- Law

b. What level of study are you in?

- Undergraduate
- Graduate

c. In what area do you reside/live?

(Choose where you reside when you’re not in school)

- Rural (Village)
- Urban (City)

d. What gender are you?

- Male
- Female

### **Climate Change information**

1. Human activity is responsible for climate change:

- Strongly Agree
- Somewhat Agree
- Don’t Know
- Somewhat disagree
- Strongly Disagree
- I don’t believe the global climate is changing

2. Natural variability is responsible for climate change:

- Strongly Agree
- Somewhat Agree
- Don’t Know
- Somewhat disagree
- Strongly Disagree
- I don’t believe the global climate is changing

3. Using the scale below, indicate the extent to which human activity and natural variability are responsible for causing climate change: Tick or circle option



Solely human activity responsible	Mainly human activity responsible	Both equally responsible	Mainly natural climate variability responsible	Solely natural climate variability responsible
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4. What do you think the effects of climate change are? Tick all that apply

- Sea level rise
- Drought
- Flooding
- Coastal erosion
- Rising temperatures
- Melting glaciers
- Desertification
- Increasing intensity and frequency of extreme weather events
- None
- Other (explain):  
\_\_\_\_\_
- I don't know

5. Which of the following do you think will affect Nigeria as a

consequence of climate change?

Tick all that apply.

- Sea level rise
- Drought
- Flooding
- Coastal erosion
- Rising temperatures
- Melting glaciers
- Desertification
- Increasing intensity and frequency of extreme weather events
- None
- Other (explain):  
\_\_\_\_\_
- I don't know

6. What region of Nigeria do you think is more vulnerable to the effects of climate change?

- Northern Nigeria. Why?  
\_\_\_\_\_
- Southern Nigeria. Why?  
\_\_\_\_\_

Both equally vulnerable. Why?

---

---

Other (explain):

---

7. Who should be responsible for financing climate change adaptation measures? Tick all that apply.

Nigerian government

Developed countries

Donor agencies

Conservation Non-Governmental Organizations (NGOs)

Industries

No climate change adaptation measures are needed for Nigeria

Other (explain):

---

I don't know

8. To the best of your knowledge are climate change awareness campaigns carried out at your university?

Yes

No

If **Yes**, proceed to Question 9

If **No**, skip to Question 10

9. Do you attend climate change awareness campaigns at your university?

Yes

No. Why?

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—

10. Were you taught about climate change in school?

Yes

No

If **Yes**, What were you taught?

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If **Yes**, please proceed to question 11.

If **No**, please skip to question 14

11. What schools were you taught about climate change? Tick all that apply.

Primary school

- Secondary school
- University
- Polytechnics

12. How knowledgeable are you about climate change?

- Very knowledgeable
- Knowledgeable
- Somewhat knowledgeable
- Not at all knowledgeable

13. Of the ten environmental issues listed below, please choose ONLY three you believe should be the top priorities of the country.

- Overpopulation
- Urbanization
- Deforestation
- Climate Change
- Desertification
- Pollution
- Environmental Education
- Recycling

- Renewable Energy
- Other (name):

---

14. What are your THREE main sources of climate change information?

- Internet
- School
- Television
- Newspapers/magazines
- Radios
- Religious leaders
- Government agencies
- Non-Governmental Organizations (NGOs)
- International Organizations
- No sources of climate change information
- Other (explain):

---

Questionnaire administered to ministry and agency officials

## **Climate Change and Nigeria**

### **Introduction**

Climate change has become one of the most talked about environmental issues both nationally and internationally. The purpose of this questionnaire is to obtain information about your perception of climate change and how it relates to Nigeria.

### **Consent**

I am a researcher from the University of North Carolina at Chapel Hill and I am conducting a survey to learn about perception of climate change and how it relates to Nigeria. This survey will take approximately 10 minutes. You are being asked to be in the study because you a ministry official and thus, a policy/decision maker. The information that I collect will be used for research purposes and will be confidential. No personal information will be requested on this form and no information provided will make any of the

participants identifiable. There is no penalty for refusing to fill out the survey and there are no consequences to filling it out either. If at any moment during completion of this questionnaire you are uncomfortable or do not wish to respond to a question you have the right not to respond. There are no risks or benefits from taking part in the study. If you choose to take part, you will be asked a series of questions about climate change and how it relates to Nigeria. These questions are below. If you agree to the information gathered below being used, please read the instructions and fill out the questionnaire. By filling out this survey, you are providing consent.

### **Instructions:**

Please fill out the form below, to the best of your knowledge by clicking boxes and providing short answers in the spaces provided. All answers are relevant to this

research even when the answer is “I don’t know.” If you are unable to answer a question, leave it blank.

a. To what ministry or agency do you belong?

- Lagos State Ministry of Education
  
- Lagos State Ministry of Environment
- Lagos State Ministry of Rural Development
- Lagos State Water Corporation
- Akwa Ibom State Ministry of Education
- Akwa Ibom State Ministry of Environment
- Akwa Ibom State Ministry of Rural Development
- Akwa Ibom Water Company

b. What area(s) does your ministry serve primarily?

- Rural (Village)
- Urban (City)
- Both

c. What gender are you?

- Male
- Female

d. How long have you worked at the ministry or agency?

- 0 to 5 years
- 6 to 10 years
- 11 to 15 years
- 15 years or more

### **Climate Change information**

1. Human activity is responsible for climate change:

- Strongly Agree
- Somewhat Agree
- Don’t Know
- Somewhat disagree
- Strongly Disagree
- I don’t believe the global climate is changing

2. Natural variability is responsible for climate change:

- Strongly Agree
- Somewhat Agree
- Don’t Know
- Somewhat disagree
- Strongly Disagree

I don't believe the global climate is changing

3. Using the scale below, indicate the extent to which human activity and natural variability are responsible for causing climate change: Tick or circle option

Solely human activity responsible	Mainly human activity responsible	Both equally responsible	Mainly natural climate variability responsible	Solely natural climate variability responsible
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4. What do you think the effects of climate change are? Tick all that apply

- Sea level rise
- Drought
- Flooding
- Coastal erosion
- Rising temperatures
- Melting glaciers
- Desertification

Increasing intensity and frequency of extreme weather events

None

Other (explain):

\_\_\_\_\_

\_\_\_\_\_

I don't know

5. Which of the following do you think will affect Nigeria as a consequence of climate change?

Tick all that apply.

Sea level rise

Drought

Flooding

Coastal erosion

Rising temperatures

Melting glaciers

Desertification

Increasing intensity and frequency of extreme weather events

None

Other (explain):

\_\_\_\_\_

I don't know

6. What region of Nigeria do you think is more vulnerable to the effects of climate change?

Northern Nigeria. Why?

---

---

Southern Nigeria. Why?

---

---

Both equally vulnerable. Why?

---

---

Other

(explain) \_\_\_\_\_

—

7. What adaptation practices are currently in place to reduce the vulnerability of Nigeria's water resources to climate change impacts? Tick all that apply.

Improved sanitation disposal to prevent contamination of water resources during floods

Groundwater recharge

Domestic water conservation promotion

Surface water source protection

Promotion of industrial and agricultural processes that minimize water demand

None

Other (explain):

---

I don't know

8. What policies are currently in place to ensure effective adaptation of Nigeria's water resources to climate change impacts? Tick all that apply.

Integration of climate change into water resource management

Collaboration of different sectors to ensure effective response since water resources are utilized by numerous sectors

Capacity building and institutional strengthening

Awareness campaigns about climate change and its effects (Information dissemination)

Improved research on climate change adaptation

Community mobilization/involvement

None

Other (explain):

\_\_\_\_\_

I don't know

9. Who should be responsible for financing climate change adaptation measures? Tick all that apply.

Nigerian government

Developed countries

Donor agencies

Conservation Non-Governmental Organizations (NGOs)

Industries

No climate change adaptation measures are needed for Nigeria

Other (explain):

\_\_\_\_\_

I don't know

10. To the best of your knowledge, are climate change awareness

campaigns carried out in rural communities?

Yes

No

If Yes, please proceed to the next question.

If No, please skip to Question 14

11. How is climate change information disseminated in rural areas?

Pamphlets

Radios

Television

Newspapers/magazines

Town criers

Other(Name): \_\_\_\_\_

—

12. To the best of your knowledge, are climate change awareness campaigns carried out in urban areas?

Yes

No



If Yes, please proceed to the next question.

If No, please skip to Question 13

13. How is climate change information disseminated in urban areas?

- Pamphlets
- Radios
- Television
- Newspapers/magazines
- Other

(Name): \_\_\_\_\_

14. To the best of your knowledge, do the schools in the state in which your ministry operates teach students about climate change?

- Yes
- No

If Yes, please proceed to the next question.

If No, please skip to Question 16.

15. What schools have climate change in their curriculum? Tick all that apply.

- Primary schools
- Secondary schools
- Universities
- Polytechnics

16. To the best of your knowledge, are climate change awareness campaigns carried out at the schools in the state in which your ministry operates?

- Yes
- No

If Yes, please proceed to the next question.

If No, please skip to Question 18.

17. In what schools are climate change awareness campaigns carried out? Tick all that apply.

- Primary schools
- Secondary schools
- Universities
- Polytechnics

18. Of the ten environmental issues listed below, please choose ONLY

three you believe should be the  
top priorities of the country.

- Overpopulation
- Urbanization
- Deforestation
- Climate Change
- Desertification
- Pollution
- Environmental Education
- Recycling
- Renewable Energy
- Other (name):

---

19. What are your THREE main  
sources of climate change  
information?

- Internet
- Conferences and Workshops
- Television
- Newspapers/magazines
- Radio
- Religious leaders
- Government agencies
- Non-Governmental Organizations  
(NGOs)

- International Organizations
- No sources of climate change  
information
- Other:

---

## Appendix B

### Sample size analysis of university students

For sample size calculations, a confidence level used was 95% and it was assumed that 50% of respondents were knowledgeable (worst case scenario).

#### University of Lagos

Department	Number of students	Sample size	Confidence interval
Law	1156	50	13.56
Environmental Sciences	1884	48	13.97
Engineering	2304	53	13.31
<b>Total</b>	<b>5344* (21933**)</b>	<b>151</b>	<b>7.86 (7.95)</b>

\* - Total number of students in the three departments

\* - Total number of students in the university

#### University of Uyo

Department	Number of students	Sample size	Confidence interval
Law	592	46	13.89
Environmental Studies	766	46	14.02
Engineering	1800	52	13.4
<b>Total</b>	<b>3158 (14765)</b>	<b>144</b>	<b>7.98 (8.13)</b>

## Appendix C

**Comparison between state water agencies, state ministries of rural development, and all ministries and agencies (including state water agencies and state ministries of rural development)**

	All ministries and agencies	State Water Agencies	State Ministries of Rural Development
Improved sanitation disposal to prevent contamination of water resources during floods	71.4	77.8	68.4
Groundwater recharge	10.7	22.2	15.8
Domestic water conservation	40.5	55.6	36.8
Surface water protection	50	83.3	26.3
Promotion of industrial and agricultural processes that minimize water demand	41.7	33.3	52.6
None	7.1	5.6	5.3
I don't know	4.8	5.6	0
No answer	3.6	0	0

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