Chapter 22. Africa

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Executive Summary

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22.1. Introduction

22.1.1. Scope of the Chapter

[forthcoming]

22.1.2. Structure of the Region

The African continent (including Madagascar) is the world's second largest and most populous (1 billion in 2009 representing 14.7% of the world population) continent behind Asia. It is composed of 55 countries (of which 5 are small island states) of which 33 are belonging to the Least Developed Countries (LDCs). The continent is organized at the regional level under the African Union and at the sub regional level in economic entities, grouping most of the countries, the most important being the CEN-SAD (Community of Sahel- Sahara States grouping 25 countries), COMESA grouping 19 states of Eastern and Southern Africa, ECOWAS (Economic Community of West Africa States with 15 countries), the SADC (Southern Africa Development Community with 15 countries) followed by ECCAS (Economic Community of Central African States with 10 countries). The UMA (Union du Maghreb Arabe) groups the 5 countries of Northern Africa while the Eastern Africa is represented through EAC (Eastern Africa

Community with 5 states). This economic structure is the one used by the African Union and the NEPAD (New Partnership for Africa).

22.1.3. Small Islands Situation

The African continent is surrounded by small islands, 5 being independent states and belonging either to the Atlantic (Cape Verde, Sao Tome and Principe) or the Indian (Mauritius, Seychelles and Comoros) Oceans . Those are going to be considered in the small islands region (chapter 29). Other islands are dependent territories belonging either to France (French Southern and Antarctic islands; Mayotte and Reunion), Great Britain (Ste Helene, Ascencion and Tristan da Cunha), Spain (Canary islands and part of the Plazas de soberania) or Portugal (Madeira). Those should be considered in the European chapter (chapter 23).

22.1.4. Major Conclusions from Previous Assessments

The first evaluation of potential impacts of climate change in Africa was done during the IPCC special report on Regional Climate Change (Zinyowera et al., 1998): Due to the few number of studies on the impacts of climate change on the sectors considered (mainly water resources and coastal zones), this report presented mainly the results of sensitivity of the different sectors considered to some climatic parameters. Since this report, it is considered that climate change will constitute an additional burden on a situation already alarming. The lack of data on energy sources, the uncertainties linked to the climate change scenarios (mainly for precipitation), the need for a better integration of studies as well as the necessary links between science and decision makers are underlined as major challenges for Africa. It is during the 3rd assessment report that specific chapters are dedicated to regions, Africa being one of it (Desanker et al., 2001). In this report the main concern is relative to potential impacts of climate change and vulnerability for the 6 sectors considered (water resources, food security, natural resources and biodiversity management, health, human settlements and infrastructure, desertification), adaptation strategies being considered for each of these sectors. The fact that desertification is considered as a sector express the threats of desertification and droughts on the economy of the continent. Globally, most of the adaptation options suggested are linked with a better management of the different resources. The main gaps and needs are identified like the capacity building, the needs for data, the development of integrated analysis as well as the consideration of the other languages for the assessment. The 4th assessment report just confirmed the vulnerability of the continent to the impacts of climate change mainly due to its low adaptive capacity (Boko et al., 2007). It first considered the different sources of the actual vulnerability of the continent, encompassing socio economic causes (demographic growth, governance, conflicts, etc.) Then a big part of the report examines the impacts of climate change on 8 sectors (energy, tourism and coastal zones are considered separately). The potential impacts of extreme weather events (not only droughts but also floods) are also considered here. The question of the costs of adaptation is raised as well as the need for mainstreaming climate change into national development policies. Two case studies are analyzed on food security and traditional knowledge, the first emphasizing the fact that climate change could affect the three main components of food security while the second case studies allowed to show that African tried to face the climate variability, although it is considered that these knowledges could be insufficient to face climate change impacts. A list of needs is also identified regarding future studies: better knowledge of the climate variability, more studies needed on the impacts of climate change on water resources, energy, biodiversity, tourism, health, examine the links between different sectors (for example between agriculture, land availability and biofuels, the need to develop links with the disaster reduction community, increase the interdisciplinarity for the analysis of climate change, strengthen the institutional capacities. It will be an appropriate time to check whether or not the needs identified have been considered in the past recent years.

22.2. Observed and Future Trends

22.2.1. Climate

22.2.1.1. Observed Trends

22.2.1.1.1. Temperature

The Intergovernmental Panel on Climate Change (IPCC), in its third assessment (IPCC, 2001), states with confidence that global average surface temperatures have already increased. They also note that global mean sea level is rising as a consequence of the thermal expansion of the oceans, that the concentration of ozone in the stratosphere has decreased, particularly over Antarctica, and that world climates have become more variable and the intensity and frequency of extreme weather events appear to have increased.

The change in temperature over Africa during the last 100 years has mirrored that shown by global datasets with a warming of 0.5 °C century−1. As with the global record, warming occurred rapidly in the 1910s–1930s and post 1970s. Spatially, the warming trend has dominated most of the continent with some areas of cooling around Nigeria/Cameroon in West Africa and along the coastal areas of Senegal/Mauritania and South Africa.

Monitoring of temperature in various regions of Africa confirms that changes in the local environment mirrors global patterns described by the IPCC (2001) (Ben Mohamed, 2011; Clark, 2006; Conway and Schipper, 2011; Grab and Craparo, 2011; Hoffman et al. 2011; Kniveton et al, 2009). However, it is noted that only few studies have documented more recent update of temperature trends over the continent.

Over Southern Africa, as provided by Grab and Craparo (2011), although general trends suggest smallest long-term temperature increases along coastal regions and greater temperature changes over interior regions, recent temperature changes (1961–2008) over the southwestern Cape and adjacent interior have been highly variable. These changes are generally higher than the increases reported for other parts of the world (IPCC 2007; Wand et al. 2008). Increases in maximum temperatures were greater and more common than increases in minimum temperatures (Hoffman et al. 2011).

22.2.1.1.2. Rainfall

Trends in rainfall over Africa show a less coherent pattern of change than temperature. Previous assessment from Hulme et al. (2001) relates modest increases (up to 10% century−1) in rainfall over most of equatorial Africa and the Red Sea coast. Drying trends have been most pronounced (>25% century−1) over some eastern and western parts of Sahel, with more modest drying trends along the Mediterranean coast and over large parts of Botswana, Zimbabwe and the Transvaal in South Africa (Hulme *et al*., 2001).

For Africa as a whole, the start of the wet season is getting progressively later each year (Kniveton *et al*. 2009).

For eastern Africa, the most prominent trend has been a tendency towards lower rainfall during the main growing season (March–May) (Funk et al., 2008). This result is at odds with the most recent IPCC assessment (IPCC, 2007), which anticipates precipitation increases.

Some studies have also identified downward trends in many parts of Ethiopia and wider Horn, however, reviews of recent literature show that the situation is non-uniform and is highly sensitive to which region/period of time is used for analysis. There is little evidence for consistent changes in the frequency or intensity of extreme events in Ethiopia (Conway and Schipper, 2011).

For southern Africa, number of studies has documented long-term changes in observed rainfall. However these analyses return contradictory results. Some studies which state a decline of rainfall on both annual and monthly bases agreed with previous IPCC analyses, which anticipate rainfall declines. (Funk, *et al*,2008; Batisani and Yarnal, 2010). In contrast, few studies noted no overall wetting or drying (Mazvimavi, 2010), but did report an increase in inter-annual rainfall variability during the 20th century. Moreover, the number of rainy days has decreased across the sub region, especially in the drier areas.

Recent updates of rainfall trends across the West African Sahel confirm a decrease in rainfall associated with a decrease in number of rainy days (Ben Mohamed, 2011).

The observations made in West Africa reveal a clear depreciation or outright disappearance of the length of the August break which defines the bimodal nature of the rainy season in the southern part of Nigeria. The 2 to 3 weeks traditional break (in rainfall) is gradually fading away and is now replaced by 2 to 3 days break which is not significant enough (Chineke et al., 2010).

22.2.1.2. Projected Trends

22.2.1.2.1. Temperature

According to the IPCC AR4, further warming is expected with certainty. The warming over Africa is very likely to be larger than the global. As simulated in the AIB climate change scenario, the surface warming is largest in desert regions, and relatively more modest in equatorial regions, where the increased radiative forcing is partly used to evaporate soil moisture (Gianini *et al.*,2008).

Recent temperature projections concluded that by 2020–2049, an increase in mean annual maximum temperature would reach 2.3°C under scenario B2 and 2.6°C under A2 in Sahel (Republique of Niger, 2009).

Warming will be associated for the whole of Ethiopia with greater frequency of heat wave events and is likely to lead to higher rates of evaporation (Conway and Schipper, 2011).

22.2.1.2.2. Rainfall

The precipitation signal is less clear. Over Africa, in the A1B climate change scenario multi-model mean in precipitation suggests more intense rainfall in equatorial regions and drier conditions elsewhere, but this prediction is not unanimous across models: it is more robust in eastern equatorial Africa, where a majority of models agree on a trend towards wetter conditions, but less certain in southern Africa, where there is much scatter in the model solutions. A drying towards the west of southern Africa during summer is expected while eastern southern Africa will experience an increase in rainfall during late summer. The projected rainfall decreases are associated with decreases in the number of rainy days and in the average intensity of rainfall. These results broadly agree with the scenario, displaying trends towards decreasing rainfall (including significant decreases during winter months of southern Africa) and decreasing numbers of rainy days (Gianini *et al.*,2008; Hewitson, 2006; Batisani and Yarnal, 2010).

Empirically downscaled climate change SRES A2 scenarios for southeast Africa for the 2046–2065 period confirms a reduction in rainfall during early summer and an increase in late summer. The increase in late summer rainfall which is seen in total, number of rain days and median rainfall events, can be expected over widespread areas than decrease in early summer (Tadross et al. 2009).

There is no agreement on whether the Sahel, Ethiopia and the wider Horn region will be drier or wetter in the future (Gianini *et al.*,2008; Conway and Schipper, 2011).

It is argued that none of the models was able to simulate current climate variability over these regions. The current challenge is to understand the complex interplay between oceanic and continental, local and remote influences of variability and change over Africa (Gianini *et al.*,2008; Conway and Schipper, 2011)**.**

It should be noted that these generalised projections are highly time- and space-dependent. Some of the projected changes are also more clearly apparent in the statistics of daily rainfall as opposed to changes in total rainfall e.g. changes in rainfall intensity and number of rain days may influence total rainfall in opposition to each other (Hewitson, 2006).

22.2.2. Socio-Economic and Environmental Context for Uncertain Futures under Alternative Development Pathways

Although it is not really responsible for the process of climate change observed at a planetary scale, the African continent should face this huge challenge. Less equipped than the other regions of the world, Africa must quickly find relevant solutions to current evolutions in order to remain within the scope of sustainability. In fact, whether it in agricultural and industrial production or deterioration of environmental conditions, rash policies must be implemented to fulfill the Millennium Development Goals. The challenges to take up are both related to demographic issues (rapid population growth, malaria, expansion of HIV-SIDA), good governance (democratic management of power, fight against corruption).

Increasing the standard and quality of living of population through a doubling of the economic growth rate has become absolutely essential in the view of escaping from crisis. This choice must be, within other strategies, founded on basic education for the largest number.

22.3. Impacts, Vulnerability, and Adaptation

Sectors to be considered:

- Freshwater resources
- Terrestrial and inland water systems
- Coastal systems and low-lying areas
- Ocean systems
- (Ecosystems)
- Food production systems and food security
- Urban areas
- Rural areas
- Key economic sectors and services
- Human health
- Human security
- Livelihoods and poverty

22.3.1. Human Security

The protection of the vital core of all human lives in ways that enhance human freedoms and human fulfilment is at the core of the concept of the concept of human security (CHS, 2003). Providing human security means protecting individuals and the community from violent conflicts and from denial of civil liberties and to ensure freedom of expression and belief. It also encompasses the idea of satisfying the basic needs of individuals for food, shelter and clothing (UNDP, 1994). Climate change and variability have the potential to impose additional pressures on the various aspects of human security. Interrelating issues between climate change and human security include water stress, land use and food security, health security, and environmentally induced migration amongst others. Violence, poverty and inequality are inseparable in explaining and addressing the root problem of insecurity, whether social or economic (Kumssa and Jones, 2010). Human security of people in Africa is particularly threatened by the impacts of climate variability. Climate volatility not only deepens poverty vulnerability in developing countries (Ahmed et al., 2009), it impacts on all aspects of human security, either directly, or indirectly.

22.3.1.1. Agriculture, Food Security, and Economic Growth

The impacts of climate change on the agricultural sector in Africa are probably of most direct and profound nature. Impacts of climate change will particularly affect agricultural and food systems (Brown and Funk, 2008). It remains critical that increasing temperatures and declining precipitation in Africa resulting from climate change are likely to reduce yields for primary crops, changes, which will have a substantial impact on food security in Africa, although the extent and nature is uncertain (Boko et al., 2007). Periods of droughts and floods will have an impact on food availability, food access, and on nutrient access (Ziervorgel et al., 2006). Agriculture in Africa is to a large extent rain-fed and water scarcity has a direct impact on crop and livestock farming systems; warmer and drier climates adversely affect net farm revenues translating into worsening food security situation in the region (Nhemachena et al., 2010). The ultimate damages of climate change may significantly affect economic growth (Lecocq and Shalizi, 2007). Climate extremes exert substantial stress on low income populations in particular, the poor are most vulnerable to multiple dimensions of climate change such as heat waves, sea level rise, the destruction of coastal zones and water shortages due to drought (Hope 2009). In Tanzania for example, where food production and prices are sensitive to climate due to the fact that 98 per cent of arable is rain-fed, changes in climate volatility could have severe implications for poverty as agriculture accounts for about half of gross production, and employs about 80 percent of the labour force (Ahmed et al., 2011). For Namibia, computable general equilibrium model simulations indicate that over 20 years, annual losses to the Namibian economy could be up to 5% of GDP, due to the impact that climate change will have on its natural resources alone, affecting the poorest people in first place with resulting constraints on employment opportunities and declining wages, especially for unskilled labour in rural areas (Reid et al., 2008). Agriculture is also the main source of livelihood of the majority of the people living in the West African Sahel, a region stressed by a fast-growing population and increasing pressure on the scarce natural resources. Increases in temperature and/or changing precipitation patterns will impact on the agricultural sector. Thus, the vulnerability of livelihoods based on agriculture is increased and most likely exacerbate and accelerate underdevelopment, poverty and environmental degradation (Sissoko et al., 2011). In Ghana, change and variability in rainfall, temperature, and the way crops and weeds respond to the carbon dioxide fertilisation effect have the potential to influence the productivity of the commercial agricultural sector in central and southern Ghana, and associated employment opportunities (Black et al., 2011). The high sensitivity of cocoa can be cited as one example for agricultural products in Ghana being particularly prone to the effects of a changing climate as the geo-graphical distribution of cocoa pests and pathogens, decrease crop yields, and impact farm income; whilst the magnitude of the carbon dioxide fertilisation effect varies with different crop types (and weed types) and the supply of water and nutrients (Black et al., 2011). This makes Ghana's agricultural and economic sector particularly vulnerable, bearing in mind, that cocoa is the dominant cash crop and – along with gold and timber – Ghana's single most important export product (WTO, 2008) and has been central to its debates on development and poverty alleviation strategies. Furthermore, a decline of the lake levels caused by reduced rainfall over the last forty years has been observed in Ghana, which is critical with regard to economic development considering that the demand for power is increasing due to economic growth and in view of the fact that hydroelectric power stations generate 80% of Ghana's total national power production (Black et al., 2011; Kuuzegh, 2007).

22.3.1.2. Health

Health security is another important aspect of human security endangered by the impacts of climate change and the effects on health will exacerbate inequities between rich and poor (Costello et al., 2009). Africa is particularly vulnerable with regard to health security as threats to health security are usually greater for poor people in rural areas, particularly children, due to malnutrition and insufficient access to health services, clean water and other basic necessities. Major killer diseases such as malaria expand their coverage as a result of global warming. Global and regional climatic variability enhances the risk of a further spread of other infectious diseases such cholera (de Magny et al., 2007), the dengue fever (Jansen and Beebe, 2010), and meningitis (Cuevas et al., 2007), among others.

22.3.1.3. Violent Conflicts

The impacts of climate change on violent conflicts, changing migration patterns and human settlements are further aspects related to the concept of human security with particular relevance on the African continent.

Environmental conflict research and the linkage between climate-related environmental variability and conflict have attracted much attention and debate. While there seems to be consensus in that the environment is only one of several inter-connected causes of conflict and is rarely considered to be the most decisive factor (Kolmanskog, 2010), it remains disputed, whether the changing climate increases the risk of civil war in Africa. With regard to sub-Saharan Africa relevant in this context due to the region's high dependence on rain-fed agriculture, high environmental vulnerability, and weak institutional coping capacity, it is on the one hand concluded that climate variability is a poor predictor of armed conflict. Instead, African civil wars can rather be explained by generic structural and contextual conditions: prevalent ethno-political exclusion, poor national economy, and the collapse of the Cold War system (Buhaug 2010). Another research also focusing on sub-Saharan Africa comes to the diametrically opposite result concluding that warming does increase the risk of civil war in Africa. It has been found that there exist strong historical linkages between civil war and temperature in Africa, with warmer years leading to significant increases in the likelihood of war. A roughly 54% increase in armed conflict incidence is predicted by 2030, or an additional 393,000 battle deaths if future wars are as deadly as recent wars (Burke et al., 2009). It has been argued that conflicts are more likely in regions with more vegetation (possibly resulting from vegetation recovery after population are displaced out of conflict zones), and that increased levels of malnutrition are related to armed conflicts (Rowhani et al., 2011). However, with an emphasis on the role of renewable resources such as freshwater and arable land it is argued, that as a long term trend, population growth and resource scarcities result in violent competition (Homer-Dixon 1994); short term causes may trigger the outbreak of conflict (Hendrix and Glaser, 2007). Distributional conflicts will arise as due to the degradation of natural resources as a result from overexploitation and global warming (Kumssa and Jones 2010). Such distributional conflicts are for example occurring in Somalia, with the converse observation that armed conflict may exacerbate the drought due to the fact that war and military activities, and the lack of State control or any other effective form of governance have led to widespread misuse and overuse of natural resources and environmental degradation. An important part of the war economy in Somalia, namely the commercial production and export of charcoal resulting in deforestation is one example for environmental degradation contributing to drought (Kolmannskog, 2010).

22.3.1.4. Displacement and Migration

Environmental migration due to the effects of climate change is closely related to the concept of human security. The causes for disasters, displacement, and migration, are manifold, however, climate change is one of the interlinking issues. Besides low-lying islands and coastal and deltaic regions, sub-Saharan Africa is one of the regions that would particularly be affected by such population movements (Gemenne, 2011), referred to as environmentally induced migration. While the terminology in this respect is varying and inconsistent and creates conflicts of legal nature, when it comes to the question as to whether or not a person can be classified as a refugee with the legal consequences of international refugee law, it can generally be stated that there are people who migrate either temporarily or permanently, within their country or across borders, and who have an environmental signal in their reason for migration (Warner et al., 2010). Rising human populations will be forced to migrate internally or to cross borders (Gleditsch et al., 2007). Potential drivers of migration are push and pull factors related to the region or country of origin or destination respectively, and intervening factors that facilitate or restrict migration, all of which may interact in different ways (Black et al., 2011). Three types of impacts of climate change on migration have been identified that seem most likely to have an effect on migration patterns: Extreme weather events, sea-level rise and water stress (Gemenne, 2011).

A global study conducted in 2009 reveals that in 2008, at least 36 million people were newly displaced by sudden-onset natural disasters such as floods and storms, of those 697,066 in Africa. The number of displaced people in Africa has increased from 697,066 in 2008 to 1,1 million in 2009 and 1,7 million in 2010 (IDMC 2011; see Figure 22-1). Of the 36 million people displaced, over 20 million were displaced by sudden-onset climate-related disasters, i.e. disasters which climate change can influence both in terms of frequency and severity. It is likely that many more are displaced due to other climate change-related drivers, including slow-onset disasters, such as drought and sea level rise (OCAH, 2009).

[INSERT FIGURE 22-1 HERE
Figure 22-1: Percentage of people displaced; global summary 2008-2010 and by continent 2009 and 2010 (IDMC, 2011).]

It should be noted, however, that estimates on migration flows resulting from climate change remain speculative, as migration drivers are usually not mono-causal but influenced by multiple factors (Smith et al., 2011). With regard to forced migration in sub-Saharan Africa a study observed that conflict and the quest for job opportunities are the most significant determinants of international migration, but that environmental factors are also important. It was found that one additional natural disaster per year could lead to an increase in net migration of 0.6 per 1,000 (Naude 2010).

The available evidence suggests that, globally, the large majority of people displaced by disasters caused by sudden-onset hazards (hurricanes, floods, earthquakes, etc.) remain temporarily and internally displaced with people returning home to rebuild their homes and lives (Tschakert et al., 2010; IDMC, 2011). However, this may apply in the case of slow onset disasters such as droughts and sea level rise with increasing cross-border movement of permanent nature (US National Intelligence Council 2010).

Case studies from Somalia and Burundi (Kolmannskog, 2010), two African countries considered to be among the most vulnerable countries in the world, emphasise the interaction of climate change, disaster (in particular drought), conflict, displacement, and migration. Not only armed conflicts, but also the changing climate and droughts in particular are the main drivers for displacement in Somalia and some of the displaced crossed the border to Kenya, a country which itself has experienced one of the worst droughts in 2009, with millions in urgent need of food aid. Many different protection challenges arise from climate-related disasters and conflict, such as food, water, shelter, healthcare, and sexual and gender-based violence (Kolmannskog, 2010). Although there was no survey or systematic monitoring of people moving away (or subsequent returns) in Burundi, a country that has recently come out of a civil war, the drought in 2008 in the northern province of Kirundo resulted in many people displaced, some of them moving across the border to neighbouring Rwanda (Kolmannskog, 2010). In Ghana for example, an African country with few conflicts caused by political, ethnic, or religious tensions, and thus with migration drivers more likely related to economic and environmental motivators (Tschakert and Tutu 2010), some different types of migration flows are considered to have different sensitivity to climate change. Seasonal migration of pastoralists and agricultural labour to the North of Ghana for example have a high sensitivity to climate change, long-term rural-rural and rural-urban migration have a medium sensitivity to climate change while long-term urban-rural (return), intraregional and international migration are considered to have a low sensitivity to climate change (Black et al., 2011). One analysis shows that at Ghana's national level, districts with more out-migration than in-migration tend to be more sparsely vegetated than districts with a migration surplus. It has been found that migration flows in Ghana can be explained partly by vegetation dynamics but are also strongly related to rural population densities, because access to natural resources is often more important than the scarcity or abundance of natural resources per se (Van der Gesest et al., 2010). In Mozambique, floods, cyclones and droughts are natural hazards particularly affecting the people, just as coastal soil erosion with a particularly high risk of inundation and erosion for the river delta regions. The floods in 2000, the tropical Cyclones in 2000 and 2007 and following flooding made thousands of people temporarily homeless. In 2008 the Zambezi River flooded once again, displacing more than 90,000 people and it has been observed that along the Zambezi River Valley, with approximately 1 million people living in the flood affected areas, temporary mass displacement is taking on permanent characteristics (Warner et al., 2010; EACH-FOR, 2009).

Further empiric research is required on displacement related to climate related shocks and slow-onset disasters in Africa, to provide more evidence on the links between climate change, conflict, and displacement, and climate change impacts on those who already are displaced. Further topics will need to be considered, such as displacement linked to measures to mitigate or adapt to climate change. Biofuel projects and forest conservation could for instance lead to displacement if not carried out with full respect for the rights of indigenous and local people (Kolmannskog, 2010).

22.3.1.5. Human Settlements

Climate change impacts on size and characteristics of rural and urban human settlements in Africa. The problems associated with voluntary or involuntary environmentally induced migration to Africa's large and intermediate cities will exacerbate as a result from climate change. Migration flows can be observed away from flood-prone localities, as well as potentially large-scale internal and cross-border mobility away from agricultural zones undermined by changing climatic conditions or declining water availability (UN-Habitat and UNEP, 2010). Environmental and climatic stress not only raises existing inequalities between rich and poor, it also contributes to rural-urban migration on the African continent (Scheffran and Battaglini 2011; Hope, 2011). In sub-Saharan Africa, climatic change is considered to be an important determinant of urbanization growth and climatic conditions push people out of rural/agricultural areas to urban areas (Barrios et al. 2006). African agriculture relies heavily on rainfall for watering crops. The declining rainfall, droughts and floods have the potential of rendering agricultural lands unproductive or making rural settlements inhabitable, which in turn affects the livelihoods of rural residents, forcing them to migrate to the urban areas (Hope 2011). As a result, African large and medium-sized cities experience extreme population growth. In 2009, almost 40 per cent of Africa's total population of one billion lived in urban areas and it is estimated that by 2030, Africa's collective population will become 50 per cent urban and 60 per cent by 2050 respectively (UN-Habitat and UNEP, 2010). Africa counts 37 cities with populations above one million, half of which are within low elevation coastal zones (Mosha 2011). Low-lying cities located on lagoons, estuaries, deltas or large river mouths, such as Alexandria, Cotonou, Dar es Salaam, Lagos, Maputo and Mombasa as well as the Cape Flats area of Cape Town are particularly vulnerable to extreme weather events caused by climate change. They are likely to experience storm surges, sea-level rises, increased flooding, (semi-) permanent inundation, coastal erosion, land slides, and the increase of water-borne diseases, which may all have devastating effects on human settlements, especially, if no measures have been taken to ensure risk reduction in terms of urban planning, land-use management and the quality of housing and infrastructure (Mosha, 2011). In this regard, the high risk for low-lying urban slums has to be pointed out. Although the proportion of urban slum dwellers is decreasing, informal settlements remain one of the major threats to African urban stability and, by extension, to overall political stability (UN-Habitat and UNEP, 2010). African inland cities are rather exposed to experience higher ambient temperatures and more frequent heat waves, with potential risk of water shortages, damage to infrastructure, and desiccating vegetation, due to the impacts of climate change.

Climate change not only affects populations; increased flooding, more frequent severe storms and rising sea levels increasingly influence the integrity of the built environment including the supporting infrastructure consisting, amongst others of roads, transport, water supply, sewers, energy, electrical grids, and telecommunications. Depending on their location and nature of construction, buildings and supporting infrastructure are vulnerable to flooding and other extreme weather events, which increase the likelihood of landslides and building subsidence, especially on clay soils, requiring enhanced construction and infrastructural standards for resistance for initial protection, such as, raising foundations of buildings, strengthening roads and increasing storm water drainage capacity (UN-Habitat and UNEP, 2010; Mosha 2011).

22.3.1.6. Livelihood and Poverty

The deterioration of the economic and environmental conditions has a real impact on the living means available. As a result, in whatever the country, there is a pauperization of all social classes, in particular, the middle ones.

The rural area, predominantly agricultural, remains dependent on climatic variations which have a negative impact on production and the peasant's incomes.

In the urban areas, the incapacity of the labor market to absorb the increasing number of job seekers and / or unemployment is made evident by the explosion of the informal sector, which reveals the ingenuity of the poorest.

One of the original responses to the economic and environmental crisis of African populations is with no doubt, migration. Whether it is voluntary or forced, local or international, even transcontinental, mobility follows the dynamic of seeking access to resources and /or adaptation to environmental changes (PNUD 2010).

In spite of a more and more extended migratory protectionism, the flux and stocks observed at the national, international, intercontinental migrations levels make the passion of vulnerable groups to mobility more and more striking.

General issues of underlying importance:

- Gender
- Children
- Indigenous / traditional knowledge
- Equity
- Ethics

22.3.2. Impacts

22.3.2.1. Observed Impacts, with Detection and Attribution

[forthcoming]

22.3.2.2. Projected Integrated Climate Change Impacts, with Regional Variation by Scenario and Time Slice

[forthcoming]

22.3.2.3. Valuation of Impacts

[forthcoming]

22.3.3. Vulnerabilities and Risks

22.3.3.1. Vulnerabilities to Key Drivers (including Extremes)

Africa, with a population that has recently passed the one billion mark and is expected to double by 2050 (UN Population Division, 2009), is considered to be one of the most vulnerable regions to climate change in the world (Pat and Winkler, 2007). Such high vulnerability could be attributed not only to the risks involved but also to the low resilience and limited adaptive capacity possessed by African societies due to socioeconomic, institutional, political as well as environmental constraints. Various areas of concerns will be discussed in the following subsections.

Human development status represents one of the most obvious socioeconomic constraints that reflect, among other things; population pressures, extensive poverty, underdevelopment, political instability, widespread disease and the HIV/AIDS crisis (Williams et al. 2008). It is argued, in this respect, that Africa remains the world's poorest and most underdeveloped region, with many of the low HDI countries in the UN Human Development Report 2010 are in Africa (UNDP, 2011). For instance, most African countries, except for North African countries and South Africa which seem to have enhanced human development, have low to very low values of HDI. This reflects low achievements in terms of life expectancy, health, knowledge and a decent living standard (Figure 22-2).

[INSERT FIGURE 22-2 HERE
Figure 22-2: African countries' Human Development Index 2010 (UNDP, 2011).]

In terms of economic activities, the majority of the African population derive their livelihoods from primary activities particularly agriculture, which is mostly rain fed, and represents the single largest economic activity in the continent. Such an economic structure means low level of resilience and high vulnerability to climate changes. In sub-Saharan Africa for instance, it contributes at least 40% of exports, 34% of GDP (more than 50% in some countries), up to 30% of foreign exchange earnings, and 64–80% of employment (Hope, 2008). Similarly, agriculture in North Africa represents both the main land use in terms of area and the principal water-consuming sector, with over 70% of total water consumption (Abou-Hadid, 2006).[1] This means that agriculture plays a dominant role in supporting rural livelihoods and economic growth over most of Africa.

[INSERT FOOTNOTE 1 HERE: Semi-arid and arid regions in Africa, meanwhile, contain some of the largest freshwater reserves in the world, which due to their remote locations and depth do not allow their economic exploitation. The arid and semi-arid regions overlaying these basins, such as the Sahara, Sahel and the Kalahari, still sustain significant population dependent on rain-fed agriculture and the accessible resources of shallow groundwater (Edmunds, 2009).]

Despite such a relatively large share of agriculture activities, African countries continue to face deepening food crises, amplified in recent years by the global food, energy, and financial crises (Adesian, 2010). It is worth mentioning that this situation is part of a long-term structural problem associated with decades of under-investment in the sector and poor policies of support for smallholder farmers. This suggests that there are multiple sets of binding constraints that continue, despite yield gains that have been made in recent time (Adesian, 2010). There is also the soil quality issue, as soils are mostly fragile and infertile, with very low levels of organic matter, particularly in the semi-arid zones (Slingo et al. 2005). There are also the poor land utilization practices, especially in subsistence farming and nomadic pastoral economies in the majority of the African countries, which have accelerated the loss of natural vegetation. This has led to desertification transforming extensive land areas in and across countries into arid- and semi-arid conditions (Yuen and Kumssa, 2011).

Climate change is expected to drastically change the face of agriculture and increase the vulnerability of hundreds of millions of poor farmers, rural, and urban populations in Africa (Adesian, 2010). Dominant climatic factors of concern for agriculture in Africa include rainfall, temperature and extreme weather events (Pat and Winkler, 2007). In terms of erratic rainfall, African agriculture is predominantly rain-fed, meaning that if sufficient rainfall does not fall with the growing season, there will be a loss of harvest, and the potential for not only loss of income but basic livelihood disruption, including food insecurity (Pat and Winkler, 2007). This consequently implicitly means low levels of resilience.

Increases in temperature and enhanced moisture deficits would increase stresses on crop production and food security. Lobell *et al*. show that increasing temperatures and declining precipitation over semi-arid regions are likely to reduce yields for corn, wheat, rice, and other primary crops in the next two decades (Lobell et al, 2008). Today, millions of hungry people subsist on what they produce. If climate change reduced production while populations increase, there is likely to be more hunger (Brown and Funk, 2008).

Among the socio-economic effects of predicted sharp fall in agricultural productivity are falling incomes from agriculture, higher risks and greater vulnerability for the rural population due to changes in their cultural and economic livelihoods, and the risk of rural areas sliding ever deeper into poverty. The prevailing smallholder systems respond particularly sensitively to changes and shocks, such as crop failures due to drought or heavy rains (Christine and Hoeffler, 2011).

It is suggested, using data from over 9000 African livestock farmers in ten countries[2] that farmers in Africa will, in general, adapt to warming by slowly moving towards livestock management. Managing livestock in Africa is likely to be relatively more profitable than crops in future climate conditions. However, the species chosen will be slightly different than today, with less emphasis on cattle and chickens and more on goats and sheep. These changes may be especially hard on larger farms that currently specialize in cattle (Seoa and Mendelsohn, 2008). The analysis also finds that farmers are more likely to choose to have livestock as temperature increase and as precipitation decreases. Under cooler temperatures and wetter conditions, in contrast, they favor crops (Seoa and Mendelsohn, 2008).

[INSERT FOOTNOTE 2 HERE: Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa and Zambia.]

Studies have found, in this respect, that elasticity of farm revenues to climate change is high in African and especially so in the dry areas. In one study it was reported that elasticity of revenue to climate change was as high as – 1.3, suggesting that a 10% increase in temperature will lead to a 13% reduction in revenues. This elasticity was as high as – 1.6 for dryland areas compared to 0.5 for irrigated areas (Kurukulasriya and Mendelsohn, 2008).

Moreover, extreme weather events, including extreme heat, droughts and floods, can seriously damage agricultural systems and food security (White et al 2006, Funk et al 2008, Lobell et al 2008, Battisti and Naylor 2009). As the frequency and intensity of climate extremes increase, crop production damages from such events will change (Schmidhuber and Tubiello 2007). For instance, it is expected that severe drought will occur more frequently, especially in the dry semi-arid regions of the Sahel, which already suffer from low rainfall and high inter- and intra-seasonal variability in rainfall and lengths of growing season (Adesian, 2010). In the coastal areas, it is expected that rising sea temperature levels will lead to greater levels of flooding. It is estimated that 75- 250 million people in the Sahel will be at risk of droughts as the region is expected to be drier; flooding in southern Africa is expected to increase (Adesian, 2010). Nevertheless, impacts of climate volatility on national-scale poverty have not yet been quantified, nor has the impact on the poor in different socio-economic strata (Ahmed et al, 2009).

Extreme events including persistent negative precipitation anomalies (drought) are found to be the most significant climate influence on GDP per capita growth. In some studies the historical effect of climate on GDP growth, agricultural value added and poverty levels in Sub-Saharan Africa were examined using cross-country and panel regression analysis. The most striking result from all analyses is the consistent negative effect of persistent dry conditions, i.e., drought, on economic growth (Brown et al, 2010).

Furthermore, it is argued that all over in Africa, both arid and semi-arid areas are expected to expand by between 5% and 8% by 2080. For instance, during the last decades ecological conditions in West Africa have dramatically changed. Very evident is the climate zones, e.g. a spread of the desert (Sahara) into the Sahelian zone. Especially in climate sensitive regions, where rainfed and irrigated agriculture is the main source of food security and income, concerns about the variability in rainfall, its temporal and spatial distribution, must be taken very seriously. This seems to be particularly true of West Africa where significant alterations in precipitation led to increase in livestock density resulting in an intensification of grazing pressure. This anthropogenous phenomenon leads to similar landscape changes as those caused by the climate (Wittig et al, 2007).

It is suggested that, by the 2080s, climate change is estimated to place an additional 80–120 million people at risk from hunger, and 70–80% of these will be in Africa. This will, in turn, worsen the state of food insecurity and malnutrition while demonstrating agriculture’s position as the most vulnerable sector to climate change (Parry et al. 2004).

It is now a well-known fact that internal migration has been a major factor fueling the growth of Africa's cities. For example, it has been estimated that rural-urban migration has accounted for roughly half of urban growth in Africa between the 1960s and 1990s, with large variations across countries. These evolutions and further predicted increases in urbanization have consequently raised concerns about the capacity of Africa's urban system to absorb such massive movements of population and its impact on sustainable development (Barrios et al, 2006).

It is argued in this respect that climate change, with its associated erratic rainfall and extreme weather events could have significant impacts on urbanization in Africa. In particular, extreme climate variations and, more specifically, water shortages, are likely to cause abrupt changes in human settlements and urbanization patterns in sub-Saharan Africa more than anywhere else in the world (Barrios et al, 2006). Part of the reason of why shortages in rainfall have been important for Africa is certainly due to the importance of the agricultural sector in its economies, which was found to be an important factor explaining urbanization in sub-Saharan African countries it does not affect urbanization elsewhere (Annez et al, 2010). The results strongly confirm those of Barrios, with supply factors, particularly rainfall, having a significant effect on urbanization in Africa but not in other countries (Annez et al, 2010). Their analysis indicates that, unlike the rest of the world, African urbanization has been driven by geographical "first nature" conditions, climate change, in particular, that have made the countryside unviable. Urbanization in Africa is "flight," reflecting choices made under duress, rather than migration to unduly attractive cities (Annez et al, 2010).

Since most of those migrating from rural areas are simple farmers with limited skills and education, they often end up in the informal sector of the urban economy and settle in slums and shanty towns in the peripheries of cities where poverty, overcrowding, unemployment, crime and environmental degradation are common (Yuen and Kumssa, 2011). For instance, despite African cities generating about 55–60% of the continent's total GDP, a massive 43% of its urban populations live below the poverty line (Eriksen et al. 2008). In some African countries, the populations living below the poverty line exceeds 50%, with Sub-Saharan African countries have the highest levels of urban poverty in the world (Eriksen et al. 2008). Similarly, a study on food security in urban settlements in Southern Africa, found that 77% of the people were food insecure (DCETO 2009).

Rapid rates of urbanization are also representing a burden on African economies due to large investments required to provide basic services and infrastructure for expanding urban areas. However, most African economies have not been expanding basic infrastructure services fast enough to keep up with urban growth, which resulted in decline in the coverage of many services, compared to 1990s levels (Banerjee et al., 2007). It was argued, accordingly, that Africa is unlikely to meet the MDGs for water and sanitation. Moreover, on current trends, universal access to these and other household services is more than 50 years away in most African countries (Banerjee, et al, 2007).

Moreover, a recent study on six African cities documents the lack of provision for reducing flood risks or for managing floods when they happen (Douglas et al. 2008). Floods are already exerting considerable impacts on cities and smaller urban centers in many African nations – for instance the floods in Mozambique in 2000, which included heavy floods in Maputo; and the floods in Algiers in 2001 (where about 900 people died, and 45,000 others were affected). So too, were the heavy rains in East Africa in 2002 that brought floods and mudslides, forcing tens of thousands to leave their homes in Rwanda, Kenya, Burundi, Tanzania and Uganda; and the very serious floods in Port Harcourt and in Addis Ababa in 2006 (Douglas et al. 2008).

Another impact of climate change on coastal settlements in Africa is the induced sea-level rise along coastal zones, which is likely to disrupt economic activities such as tourism, fisheries, and mining. It is noted in this respect that more than a quarter of Africa's population live within 100 km of the coast and that about 12% of urban population live within the low elevation coastal zones.

Coastal zones will experience significant impacts arising from storms, floods and sea level rise. In Africa, coastal cities such as Cape Town, Maputo and Dar es Salaam with large and growing populations will be affected (Bunce, 2010). Coastal communities in Africa face pressure from inward migration, urbanization, resource extraction, pollution and industrialization (Bunce, 2010). In a study two poorer coastal communities with reported or evident dependence on marine as well as terrestrial ecosystem goods and services and sites in low-lying coastal areas susceptible to river floods, droughts and storm surges were selected (Bunce, 2010).

It is typically argued that Africa is already vulnerable to several climate sensitive diseases and altered temperatures and rainfall patterns, factors which are expected to increase incidences of vector-borne diseases such as malaria, for example. Human migration in the context of malaria transmission has been widely studied (Longstreth and Kondrachine 2002), and, in the case of the African highlands, it is well-known that the invasion of these regions by malarial parasites has been associated with the migration of people from the lowlands to the highlands. The phenomenon of human migration is tightly linked to socioeconomic inequity and poverty (Martens and Hall 2000), the development of market-based agriculture, and land tenure inequity. Although malaria is becoming a major problem in urban areas today (Sattler et al. 2005), it is, as it has traditionally been, mostly a rural disease affecting people living and working in agricultural areas.

Global warming is expected also to play a major role in the collapse of ecosystems as functioning wholes (Collier and Webb, 2002). However, areas where non-climatic factors have eliminated or controlled malaria are likely, *ceteris paribus* (i.e., everything else being equal), to be insensitive to the effects of global warming on disease transmission by vectors, while other areas where malaria is not present because of climatic conditions (e.g., cities in the highlands of the developing world, especially in Africa) are at potential risk of having an increased burden of the disease (Chaves and Koenraadt, 2010).

For instance, The late 2006-early 2007 outbreaks of Rift Valley Fever (RVF) in humans and animals in the Horn of Africa adds to the historical evidence that inter-annual climate variability associated with ENSO has a large influence on RVF outbreaks in the Horn of Africa through episodes of abnormally high rainfall there (Anyamba et al, 2009). Accordingly, a number of studies have demonstrated a correlation between climatic change and malaria incidence, as well the incidence of dengue fever, for instance; and projections of the regional health effects signal a massive impact on poor countries in Africa. Such impacts may negatively affect the health of millions of Africans, and hinder wider development efforts, and increase vulnerability especially in association with high levels of poverty. In addition to Africa's rural poor, who live in substandard settlements suffer from lack of basic infrastructure and services, which tend to be opportunistic breeding grounds for disease carriers such as mosquitoes. These slums are also characterized by high population densities, supplying a large pool of susceptible individuals. Currently, it is estimated that the majority of the almost one million people who die of malaria each year are poor African children. This poverty indicates that many people are at the edge of survival, and will suffer not just loss of income but also loss of health, or even life, as a result of climate disruptions. It also means that fewer resources are available to adapt to climatic factors (Patt and Winkler, 2007).

22.3.3.2. Multiple Interacting Stresses

Changes in climatic conditions will not be experienced in isolation, but together with changes in political[3], economic and social conditions (Westernhoff and Smit, 2009). It is argued that there are links between human vulnerability in the world's poorest countries, exposure to multiple stressors, which is in turn aggravated by the impacts of climate change (Leichenko and O'Brien, 2008).

[INSERT FOOTNOTE 3 HERE: Sub-Saharan Africa, for instance, has experienced 11 civil wars in 48 countries, in addition to chronic upheaval in the Central African Republic and Somalia (Moyo 2009).]

A vulnerable individual, group, or community is likely to suffer from hunger and increasing poverty when exposed to an external shock such a drought, flood, pest invasion, or disease (Maddison 2006; Smit and Wandel 2006). Income also drops due to job loss or the loss of migration opportunities. The most vulnerable people lack the means to build sufficient food stocks to assure a minimum food intake or to generate income to buy basic food and medication (Barbier et al, 2009).

Climate change is expected to intensify existing problems and create new combinations of risks in Africa, where poverty is widespread and livelihood is dependent on the natural environment (Zievogel and Zermoglio, 2009). This means that it is expected to place considerable additional stress on the biophysical, economic, political and social systems that determine livelihood security (Leary et al. 2008). It can, moreover, have the potential to undermine, and even undo, economic development efforts and progress made in improving the socio-economic well-being that Africa has been experiencing in the past several years (Hope, 2008).

For instance, Southern Africa countries face a mix of potential external stressors including climate, HIV/AIDS, civil insecurity and conflict, macroeconomic stressors (e.g. through domestic and regional food markets). The extent to which these types of stressors amplify each other's effects, and operate interactively to increase vulnerability to other external stressors is the subject of substantial investigation and analysis (Archer et al, 2007). Similarly, Sahel region is particular vulnerability because of two sets of factors. The first is climate. The Sahelian climate is one of the most variable on earth. The droughts of the 1970s and 1980s are reminders that climate has an impact on poverty and people's persistent vulnerability. The second most commonly cited causes of vulnerability are increasing population density with simultaneous scarcity of resources (Barbier et al, 2009).

Changes in rainfall patterns, temperatures and/or in the frequency or severity of extreme events will for instance have direct impacts on productivity of crops, and could result in complete crop failure and possibly severe consequences for the food security situation (Sissoko, et al, 2011).[4] For example, climate change is expected to considerably reduce cereal production in countries such as Nigeria, Ethiopia, Zimbabwe, Sudan, and Chad. In Cameroon, it is estimated that farm losses could be as high as US$20.3 billion by 2100 (Molua and Lambi 2007).

[INSERT FOOTNOTE 4 HERE: Sahel countries covered by this study include Mauritania, Senegal, The Gambia, Guinea-Bissau, Mali, Burkina Faso, Niger, Chad and Cape Verde (Sissoko, et al, 2011).]

The vulnerability of livelihoods based on agriculture is increased and most likely exacerbate and accelerate the current 'downward spiral' of underdevelopment, poverty and environmental degradation, particularly in rural areas (Sissoko et al, 2011). This, in turn, can further increase the rural–urban migrant flows, repeating past trends as nearly half of Africa's urbanization in the last decades has been due to rural-urban migration, yet with large variations across countries. Such rapid urbanization would force large numbers of people, especially the poor, to settle in flood-prone areas such as floodplains usually found in and around urban areas (Douglas et al. 2008). This pattern of settlement, which has resulted in the emergence and concentration of slum communities, has rendered urban areas more susceptible to other climate change impacts such as potential sea level rise and increased incidence of disease. Changes in exposure-sensitivities with future climate are likely to have detrimental impacts on residents' financial situation and overall well-being as household income sources are reduced (Westernhoff and Smit, 2009).

Recent studies highlight links between human vulnerability in the world's poorest countries and exposure to multiple stressors acting across scales in synergy with climate change (Leichenko and O'Brien, 2008). The 'double exposure' analysis by Leichenko and O'Brien, and the later Southern Africa Vulnerability Initiative (SAVI) framework (O'Brien et al., 2009) show how multiple stressors interact through three pathways related to context, outcome and feedback. However, many scientific studies continue to examine the impacts of climate change in isolation from other changes (Felton et al., 2009). This means that failure to consider how different types of stressors are interacting would undermine the ability of poor people to cope with multiple stressors and may lead to policy interventions which in themselves act as stressors (Bunce, 2010). Furthermore, Brooks et al. (2009) argue that undermining local resilience and short termism characterizes current development approaches favoring growth and modernization over resilience and human security (Brooks et al, 2009).

It was suggested, in this respect, that current regional and international development policies in eastern Africa can add to the vulnerability of poor communities and those dependent on natural resource-based livelihoods to cope with multiple stressors and impacts of climate change. This is because, firstly, regional and national development priorities may not take local impacts and local vulnerabilities into account. Secondly, these developments may not take other stressors and particularly the impacts of climate change into account. These two factors, combined, mean that externally driven interventions may actually undermine resilience or the ability of poor people to cope with or adapt to climate change in the context of other stressors they experience (Bunce et al, 2010b). For example, local communities in local communities, in Mtwara, Tanzania, perceived that Marine Protected Area (MPA) in the area has created restrictions on land and sea use in an area, despite a historically rising population (Bunce, 2010).

It is worth mentioning that interactions between stressors can have unexpected outcomes for well-being and livelihoods, with implications for efforts to reduce vulnerability in development planning (O'Brien et al. 2009). Stressors and their interactions may be hidden, and spread across scales, leaving communities subject to risks of double or even multiple exposures to stressors (Bunce et al, 2010b).

22.3.3.3. Uncertainty

Generally, it should be noted that shortage of quantitative data, in addition to uncertainty about changes in the magnitude and frequency of extreme climatic events, means high levels of uncertainty. This consequently necessitates careful handling of any data on implications of climate changes in Africa (Seoa and Mendelsohn, 2008).

It is widely accepted that Global Circulation Models (GCMs) are the best physically based means for devising climate scenarios. They reproduce the global and continental scale climate fairly well but often fail to simulate regional climate features required by hydrological (catchment scale) and national (country scale) impact studies. The main reason for this gap, between the spatial scale of GCM output and that needed for impact studies, is the coarse spatial resolution of GCMs which restricts their usefulness at the grid-size scale and smaller. Other reasons include inadequate parameterization of several processes regarding cloud formation and land surface interactions with the atmosphere (Elshamy et al, 2009).

A study attempting to analyze the output of 17 general circulation models (GCMs) included in the 4th IPCC assessment report, downscaled precipitation and potential (reference crop) evapotranspiration (PET) scenarios for the 2081–2098 period were constructed for the upper Blue Nile basin (Elshamy et al, 2009). These were used to drive a fine-scale hydrological model of the Nile Basin to assess their impacts on the flows of the upper Blue Nile at Diem, which accounts for about 60% of the mean annual discharge of the Nile at Dongola. There is no consensus among the GCMs on the direction of precipitation change. Changes in total annual precipitation range between −15% to +14% but more models report reductions (10) than those reporting increases (7). Several models (6) report small changes within 5%. The ensemble mean of all models shows almost no change in the annual total rainfall (Elshamy et al, 2009).

Modeling has emerged as the key technology for visualizing and anticipating the processes and impacts of climate change and climate variability on agricultural production systems. Combinations of General Circulation Models, Regional Circulation Models, crop models, soil models, agro-ecological system models, and economic models have been used to illustrate potential impacts of climate change in the coming decades based on various climate scenarios [2–5]. In these contexts, modeling is useful in that it enables visualization of potential future scenarios so that potential adaptation strategies can be evaluated for future planning. However, as important as they are in climate change adaptation research, modeling and planning have their limits. Unfortunately, many of these potential adaptation strategies are based on the 'business as usual approach' (Cranea et al, 2011) and thus miss to understanding change in agricultural systems under climate change and climate variability in the social, technical or ecological realms (Cranea et al, 2011).

The magnitude of projected impacts of climate change on food crops in Africa varies widely among different studies. These differences arise from the variety of climate and crop models used, and the different techniques used to match the scale of climate model output to that needed by crop models. Most studies show a negative impact of climate change on crop productivity in Africa. Nevertheless, it was suggested that there will be increases in crop yield across all ecological zones in Nigeria as the climate change during the 21st century (Adejuwon, 2006). Bates et al. (2008) suggests, meanwhile, that agricultural and rural livelihoods in Ghana could suffer a crop net revenue loss of up to 90% by 2100 with small farm households being the most affected (Bates et al, 2008).

Various projections of areas of arable land provided contradictory trends, for instance Zhang et al 2006 suggests that if past pattern continues, arable land area in Africa would increase by 2030 by about 13.9%-17.6% of its present value. However, it is suggested that climate change and population growth will cause reductions in arable land in Africa between 1 and 18%, by 2100 (Zhang and Cai, 2011).

Such wide projections concerning agriculture could provide wide diversity in the sort of impacts on urbanization trends and consequently on urban systems and infrastructure availability. This, accompanied with large range of potential sea level rise, would mean that any demographic and/or economic projections of sea level rise impacts would need to be handled with care.

In terms of health, uncertainty is also notable. For example, the role of changing climates, relative to human development and changes in disease control interventions, in altering the nature and the extent of vector-borne disease prevalence is widely debated (see for example Lafferty 2009 and Pascual & Bouma 2009).

22.3.3.4. Key Vulnerabilities

[forthcoming]

22.3.4. Adaptation and Managing Risks

22.3.4.1. Adaptation Needs and Gaps (based on Assessed Impacts and Vulnerabilities)
22.3.4.2. Practical Experiences of Adaptation, including Lessons Learned
22.3.4.3. Observed and Expected Barriers to Adaptation
22.3.4.4. Observed and Expected Limits to Adaptation
22.3.4.5. Facilitating Adaptation and Avoiding Maladaptation
22.3.4.6. Planned and Autonomous Adaptation
22.3.4.7. Potential and Residual Impacts
22.3.4.8. Thresholds and Irreversible Changes
22.3.4.9. Valuation of Adaptation Cost and Benefits

[entire Section 22.3.4 forthcoming]

22.4. New Emerging Issues

22.4.1. Adaptation and Mitigation Interactions (including Mitigation Efforts and Potential Emissions)

22.4.1.1. Agriculture, Food Security, Energy, and Biofuels
22.4.1.2. Forests and REDD+: the Challenge of Forest Conservation, Importance of Livelihoods

[entire Section 22.4.1 forthcoming]

22.4.2. Inter- and Intra-Regional Impacts

Climate change has a negative impact on the climatic parameters (pluviometer, temperature, biodiversity, etc.) but also on human activities (agriculture, cattle breeding, fishing etc.)

FAO has focused, for many years how much global warming constitutes a threat for food safety in the South which is strongly dependent on agriculture. It is the case of Sub-Saharan Africa where the pernicious effects of drought and inundations, have, for example, contributed to the multiplication of migrations called environmental (REMI 2002).

In fact, the recurrent events as the irregularity of pluviometer and the variation of the rate of flow of rivers have important repercussion.on everyday life. They need therefore more attention on the protection of populations as well as on their activities.

One of the responses from the african population is the change in consumer habits and way of life.

22.4.2.1. Africa in the General Economic Context

A redundant observation in the analysis is that the African economy remains marginalized with regards to world economy. Its wrong integration in the world economy is a weakness in the way leading to development.

Reforms proposed until now by international monetary institutions have provided few effects on the evolution.

Meanwhile, the fact of non taking into account the social dimension of structural adjustment has given birth to clash in many countries.

It will be observed in a macro economical level that if growth has been constant in the last ten years, the rate has been weak to reduce poverty. In fact, only a quarter of the countries with low income have reached a rate beyond 7% while 75 % of these countries have experienced an inflation rate of 10 %.

Beyond development aid, what Africa really need is is to elaborate its own way to development. This one should be based on the own values of the continent.

22.4.2.2. How Sub-Regional Organizations can Deal with Climate Change Issues

One of the major recommendations the African organizations must take care of in the perspective of sustainability is the integration of climate change in all policies of pacification and economic management.

Transferred to the migration mobility issue - which constitutes an original response to crisis - it must be considered as a prior factor to regional complementarity. In this way, it is an emergency to engage a true-hearted dialogue at a sub-regional, even continental level.

22.4.2.3. Links between the Different Parts of the Continent

The multiplication of grouping units at a sub-regional, regional or continental level appears, in many respects, as an indicator of the necessary joining of African forces in the fighting for the development of the continent.

Yet, an attentive observation of the current practices make obvious that the solidarity between states which must guide the will to escape from crisis is almost inexistent. In fact, the nationalism and cultural isolationism they induce have become some attributes for many almost all countries, in particular those called lands of plenty.

22.4.3. Multi-Sector Synthesis

22.4.3.1. Agriculture, Water, and Health
22.4.3.2. Ecosystems, Tourism, and Livelihoods
22.4.3.3. Coastal Zones and Urbanization

[entire Section 22.4.3 forthcoming]

22.5. Case Studies

[forthcoming]

22.6. Research and Data Gaps

[forthcoming]

22.7. Conclusion

[forthcoming]

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Summary of global estimates 2008 - 2010

Number of people displaced (millions)			
Cause of displacement	**2008**	**2009**	**2010**
Climate-related disasters	20.3	15.2	38.3
Geophysical disasters	15.8	1.5	4.0
Total	**36.1**	**16.7**	**42.3**

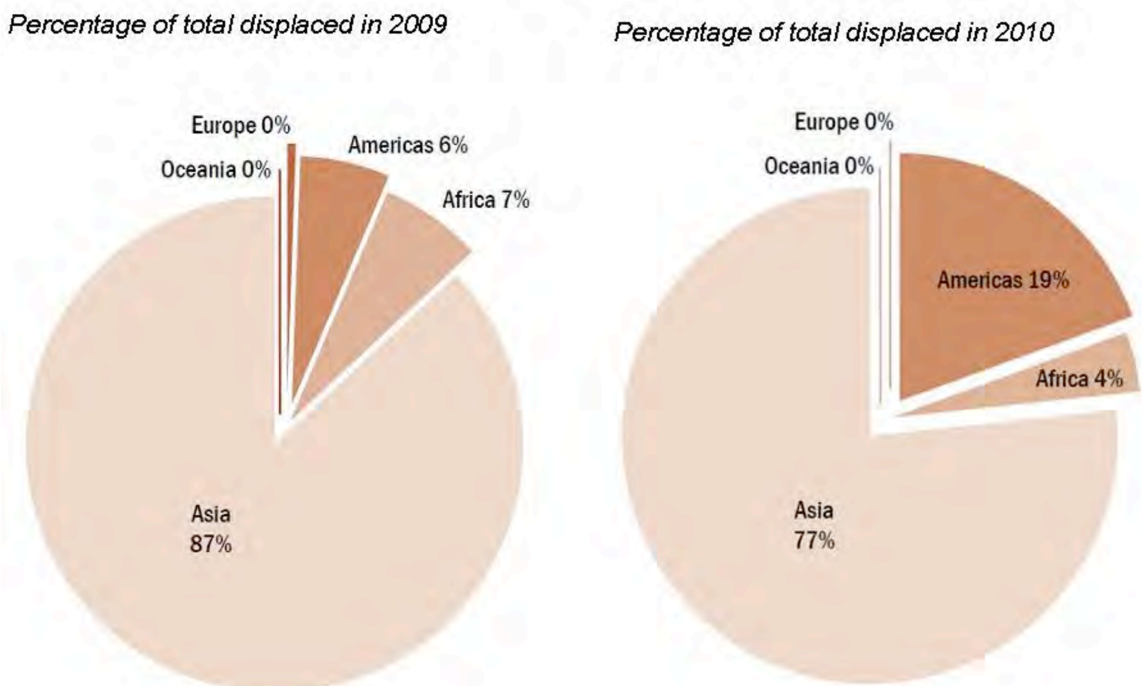

Figure 22-1: Percentage of people displaced; global summary 2008-2010 and by continent 2009 and 2010 (IDMC, 2011).

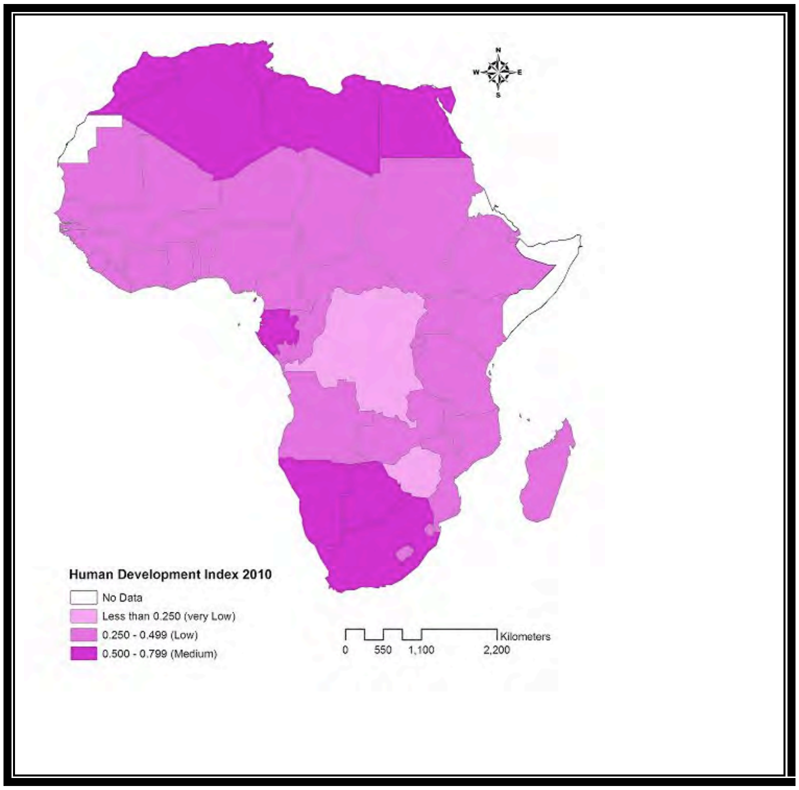

Figure 22-2: African countries' Human Development Index 2010 (UNDP, 2011).