CeSPI
Centro Studi di Politica Internazionale

Working Papers
59/2009

Environmental change and human mobility
A thematic literature and organisational review

by Battistina Cugusi and Marta Piccarozzi

Prepared for the
International Conference
TOWARDS THE G8 SUMMIT

Climate Change and Human Mobility in Africa
Dialogue for a strategic cooperation between Italy and Africa

Rome, 21st of April 2009

Via d'Aracoeli, 11 – 00186 Roma (Italia) – Tel. +3906 6990630 – Fax +3906 6784104 – e-mail: cespi@cespi.it - web: www.cespi.it

CONTENTS

INTRODUCTION

Today, climate change represents one of the greatest threats for mankind. The Earth has warmed by 0.7°C since around 1900. It is an extremely complex issue, and the scientific community agrees – on the basis of the overwhelming empirical evidence – on the seriousness of the phenomenon.
In the 1990s, rising the awareness about the threats stemming from climate change led to new international efforts; two major treaties were agreed, the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and the Kyoto Protocol in 1997. The legal basis for international cooperation is only a starting point and concrete global actions not limited to emergency and assistance, must be adopted within the next few years to effectively revise the ongoing processes. Currently, climate change and its consequences are crucial issues in the international agenda and meetings come one after the other with verbal commitments not sufficiently followed by tangible actions. Recently, the 2008 G-8 meeting in Hokkaido committed to accelerating actions on technology development, transfer, financing and capacity building to support adaptation to climate change, which is unaffordable for many developing countries. In turn, the Fifth World Water Forum organised by the World Water Council which was recently held in Istanbul, acknowledged the need to achieve water security, which is a major threat linked to climate change. In Africa alone, 75 to 250 million people might be exposed to increased water stress due to climate change by 2020 (World Water Assessment Programme, 2009). At the same time, the issue receives increasing attention from the mass media and the public opinion at global level and this is demonstrated, among others, by the award of the Nobel Peace Prize to the Intergovernmental Panel on Climate Change, in 2007.
Climate change is a global challenge and also an opportunity to reshape the current development model. Political willingness and commitments are needed for effective climate policies. The economic and financial crisis affecting the globe can be a major risk and a further obstacle to concrete actions. The G-20 meeting held in London on the 2nd of April 2009, specifically devoted to the global crisis, reaffirmed the commitment to addressing the threat of irreversible climate change, but much more is expected from the next meetings, in particular the reunion on climate change of the world's 16 major economies called for by the US President at the end of April, the G8 summit in Italy on July and the Climate Conference in Copenhagen on December 2009.
Migration phenomena, like climate change, are deeply studied and highly considered at international level but the nexus between climate change and human migration is nonetheless undervalued by the international agenda, despite the increasing number and intensity of claims deriving from the scientific community. In the past twenty years, there has been an increasing debate on whether climate change is a major driver of human mobility or a threat to human security. Already in the 1970s, Lester Brown of the Worldwatch Institute emphasised the link between environmental degradation and forced migration, although a first comprehensive definition of "environmental refugees" is generally attributed to Essam El-Hinnawi, and in particular to his renowned UNEP paper of 1985.
In the following years, literature provided new contributions to the identification of different types of environmental refugees: those temporarily displaced due to local disruption, those who migrate because environmental degradation has undermined their livelihood or poses unacceptable risks to health, and those who resettle because of permanent and untenable changes in their habitat (Jacobson, 1988). In 1990, the Intergovernmental Panel on Climate Change (IPCC) warned that climate change could have dramatic implications for human mobility and soon after, a catastrophic estimation of climate-induced mobility was predicted by Norman Myers and Jennifer Kent, who prefigured 50 million environmental refugees by 2010 and up to 200 million when global warming takes hold, due to sea-level rise and coastal flooding, disruptions of monsoon systems and other rainfall regimes, and by droughts of unprecedented severity and duration (Myers and Kent, 1995).
The poorest areas of the world will be hit hardest, as they are the most vulnerable and the least prepared to react. Millions of people will be threatened by drought and consequently by hunger,

lack of water, and pandemics. The case of Africa is particularly worrisome, since the continent is vulnerable to violent impacts, has very low adaptation capacities and already hosts the highest number of refugees in the world. At the same time, Africa is the region about which we have the lowest number of statistical information and a reliable monitoring system, as well as studies and research and, in general, a certain capacity of managing human mobility. And yet, Europe fears that precisely Africa will be the source, over the coming years, of an unchecked flow of human mobility, both inside and outside the continent.

The international debate on this issue is still open and is trying, in particular, to reach an agreed definition of environmental migrants, to measure the current and future phenomena, and to investigate the routes of mobility.

This thematic literature and organisational review intend to provide the debate with a systematisation of the state-of-the-art knowledge on environmental mobility in Africa by also indicating some of the pathways to be explored as a starting point for the development of a common agenda of concrete commitments by international partners.

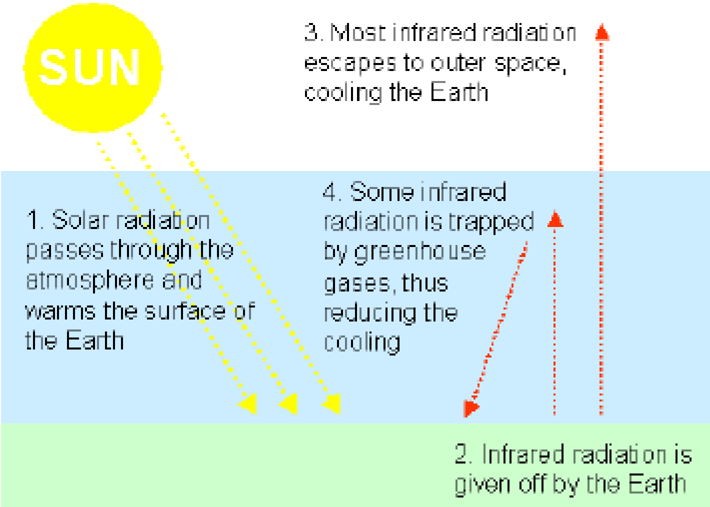
The first chapter introduces the issue of climate change from a scientific perspective, with a particular focus on Africa and its vulnerabilities. The second chapter considers the link between climate change and human mobility, with specific reference to climate and non-climate drivers of mobility and African patterns of displacement. The third chapter focuses on the consequences of forced environmental movements on peace and stability at national, regional and international levels, and its threats to biodiversity. The conclusions highlight the major issues identified by the literature as possible paths to be taken into consideration by the international agenda.

1. THE IMPACT OF CLIMATE CHANGE IN AFRICA

1.1 Understanding the scientific basis of climate change

The international debate on climate change has broadly concentrated on understating the root causes – whether anthropic or cyclical, namely within the range expected from natural variations – or the future scenarios in terms of phenomenon's magnitude.

Figure 1 – The Greenhouse Effect



Source: Stern , 2006.

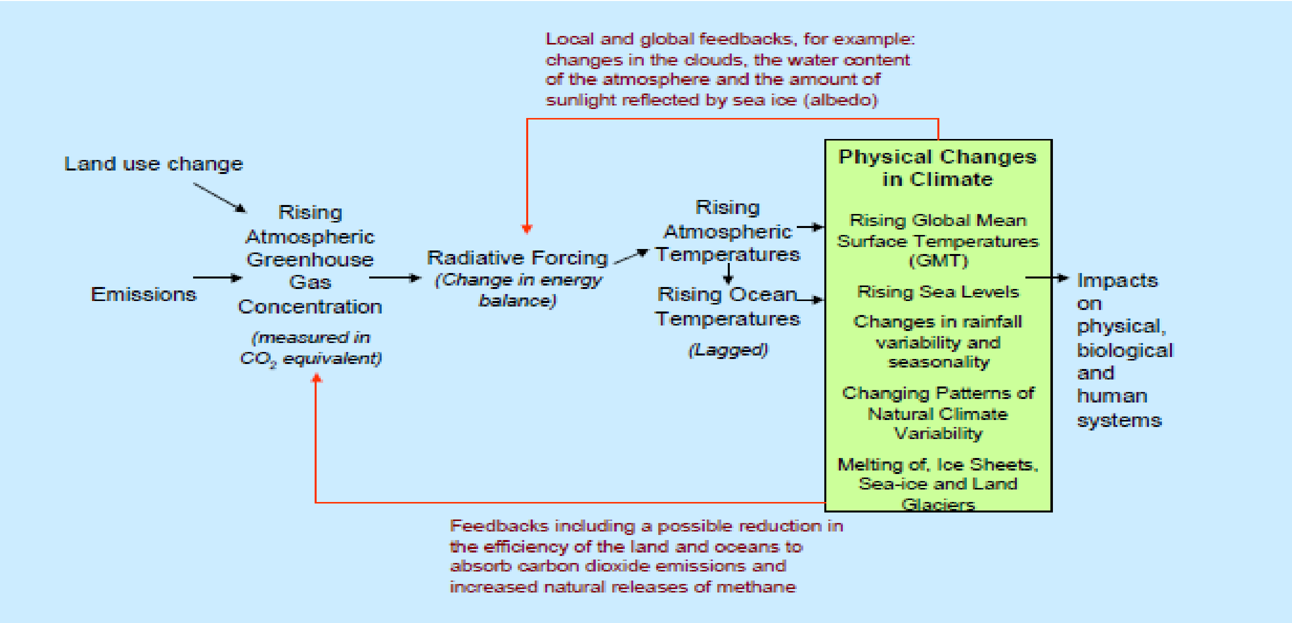
With regard to the first issue, IPCC reports (IPCC, 2001; IPCC, 2007b) and the Stern review (Stern, 2006) – the most comprehensive assessments of the state of science – have given a great contribution to understanding the scientific evidence of human influence on climate. In particular, in 2001, IPCC concluded that there is new and stronger evidence that most warming effects which have been observed over the least 50 years, can be attributed to human activities.

A few years later, the Stern review agreed on these conclusions: the rising levels of greenhouse gases provide the only plausible explanation for the observed trend for at least the past 50 years. If natural factors, such as changes in solar intensity and volcanic eruptions, could be at the origin of the warming in the early nineteenth century, the warming trend observed over the last 50 yeas is mainly due to the "greenhouse effect", that is the warming effect on climate caused by the rising level of greenhouse gases and by the subsequent increase of the amount of infrared radiation trapped by the atmosphere.

Since pre-industrial times (around 1750), human activities (predominantly burning of fossil fuels, deforestation and other changes in land uses) have induced an increase in the accumulation of carbon dioxide (by just over one third, from 280 parts per million (ppm) to 380 ppm today) and other greenhouse gases, such as methane and nitrous oxide. "In total, the warming effect due to all (Kyoto) greenhouse gases emitted by human activities is now equivalent to around 430 ppm of carbon dioxide and rising at around 2.3 ppm per years. Current level of greenhouse gases are higher now than at any time in at least the past 650,000 years" (Stern, 2006 p. 3). It is estimated that the "direct warming effect of a doubling of carbon dioxide concentrations would lead to an average surface warming of around 1°C" (Stern, 2006, p.7). Moreover, the Stern review stated that it is quite probable that the climate sensitivity to greenhouse gases could be even greater than previously thought, for different reasons.

First, direct warming can be amplified by the interaction between feedbacks in the atmosphere, especially those coming from water vapour, a very powerful greenhouse gas. "Evidence shows that, as expected from basic physics, a warmer atmosphere holds more water vapour and traps more heat, amplifying the initial warming" (Stern, 2006, p.7).

Figure 2 – The link between greenhouse gases and climate change



Source: Stern, 2006.

These sensitivities imply that there is up to one out of five chances that the world would experience warming in excess by 3°C above pre-industrial, even if greenhouse gas concentrations were stabilised at today's level of 430 ppm CO2 equivalent (CO2e).

Besides, how much the world will warm in the future remains an open question as well as an area of active research. Nevertheless, predictions have been made by scientists by developing climate models which allowed to make estimate on how changing greenhouse gas levels will affect the climate. So, if "greenhouse gas levels could be stabilised at today's levels (430 ppm) global mean temperatures would eventually rise to around 1°-3°C above pre-industrial (up to 2°C more than today)" (Stern, 2006, p.8).

Table. 1 – Temperature projections at stabilisation

Meinshausen (2006) used climate sensitivity estimates from eleven recent studies to estimate the range of equilibrium temperature changes expected at stabilisation. The table below gives the equilibrium temperature projections using the 5 – 95% climate sensitivity ranges based on the IPCC TAR (Wigley and Raper, 2001), Hadley Centre (Murphy et al. 2004) and the range over all eleven studies. Note that the temperature changes expected prior to equilibrium, for example in 2100, would be lower.

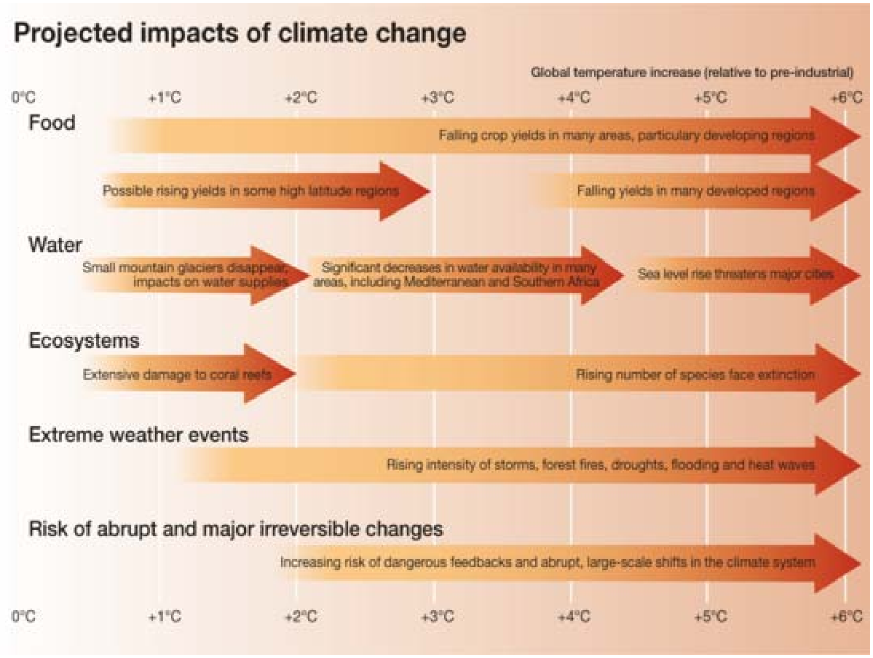
Stabilisation level (ppm Co2 equivalent)	**Temperature increase at equilibrium relative to pre-industrial (°C)**		
	IPCC TAR 2001 (Wingley and Raper)	**Handley Centre**	**Eleven Studies**
400	0.8 – 2.4	1.3 – 2.8	0.6 – 4.9
450	1.0 – 3.1	1.7 – 3.7	0.8 – 6.4
500	1.3 – 3.8	2.0 – 4.5	1.0 – 7.9
550	1.5 – 4.4	2.4 – 5.3	1.2 – 9.1
650	1.8 – 5.5	2.9 – 6.6	1.5 – 11.4
750	2.2 – 6.4	3.4 – 7.7	1.7 – 13.3
1000	2.8 – 8.3	4.4 – 9.9	2.2 – 17.1

Source: Stern, 2006.

However, table 1 outlines that higher climate sensitivities cannot be excluded. It is worth emphasizing that these are conservative estimates. In the absence of an effective climate policy, greenhouses gas emissions could even be higher.

Finally, climate change itself may accelerate future warming by reducing natural absorption and releasing stores of carbon dioxide and methane. “Rising temperatures and changes in rainfall patterns are expected to weaken the ability of the Earth’s natural sinks to absorb carbon dioxide, causing a larger fraction of human emissions to accumulate in the atmosphere” (Stern, 2006, p.9). Preliminary estimates suggest that these “positive feedbacks” could lead to an additional rise in temperatures of 1 - 2°C by 2100.

Figure 3 – Projected impacts of climate change

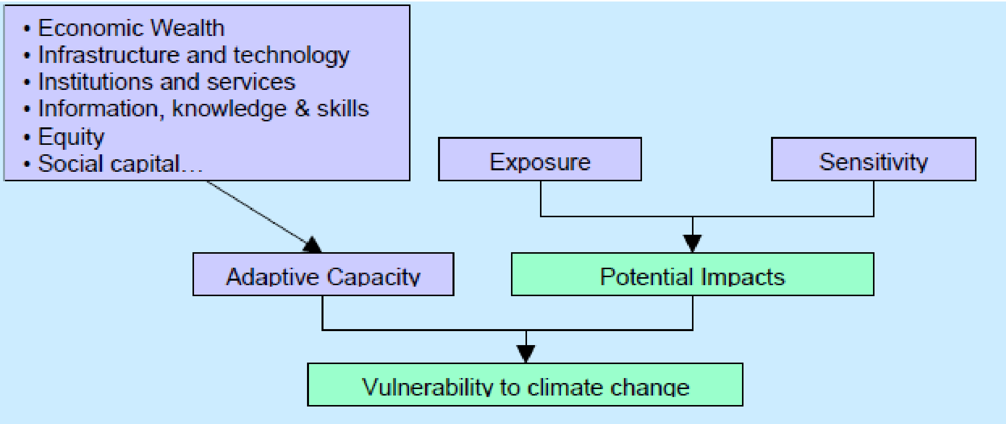


Source: Stern, 2006.

1.2 African vulnerabilities to climate change

Developing countries are the most *vulnerable* to the impacts of climate changes (IPCC, 2007b; Stern, 2006; UN, 2008), given their *sensitivity* – the degree by which their systems are affected or responsive to climate – and their exposure to environmental stresses (see figure below). At the same time, their high degree of vulnerability is also due to their low *mitigation and adaptive capacity,* that is the ability to reduce the negative impacts, to capture any benefits of climate change and to ensure *resilience* to future shocks.

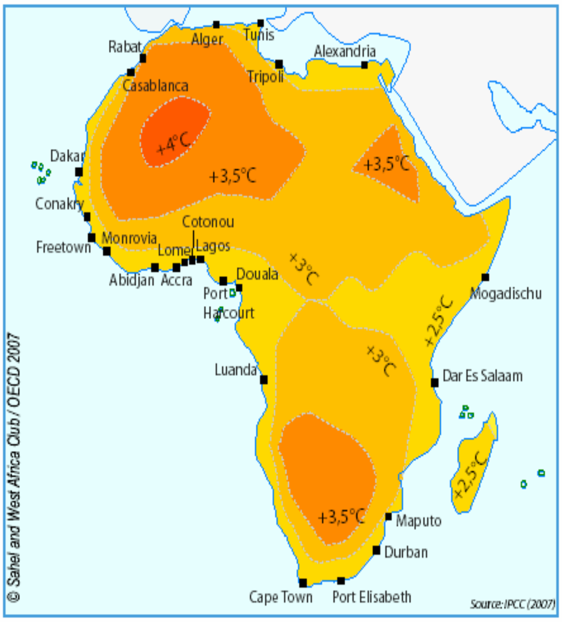
Figure 4 – Vulnerability to climate change: the IPCC Third Assessment Report



Source: Stern, 2006.

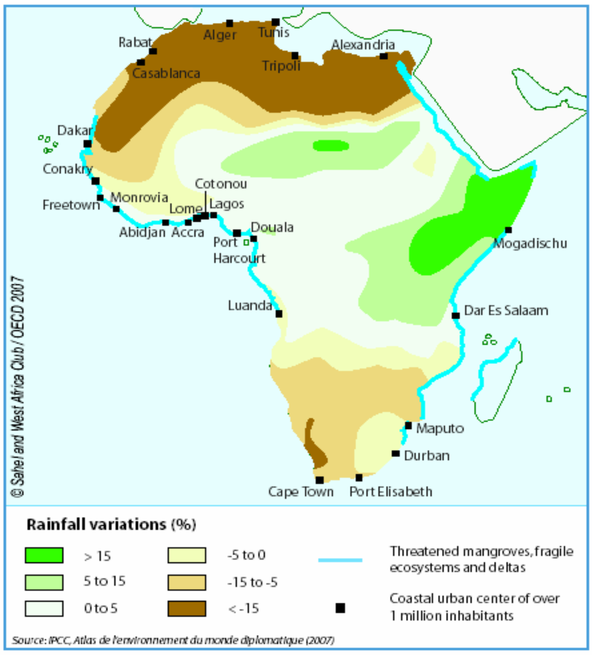
To assess the extent and nature of climate change represents a very difficult task due to the difficulties in forecasting temperature changes. According to the estimate made by the IPCC in its fourth report (IPCC, 2007b), global warming is expected to be more intense in Africa than in the rest of the world. On average, the rise in temperatures between 1980/99 and 2080/99 would be between 3 and 4 °C for the continent as a whole, 1.5 times higher than at global level. The expected warming would not be uniform throughout the continent, the increase would be less marked in coastal and equatorial areas (+3 °C) and the highest increase would take place in the Western Sahara region (+4%) (IPCC, 2007b).

Figure 5: The effects of Global Warming in Africa



Source: IPCC, 2007b.

Figure 6: Rainfall variations (%) in Africa



Source: IPCC, 2007b.

With regard to rainfall, projections are more uncertain. This is due to the difficulty to understand the link between the different factors which influence rainfall variability, like climate change in general, but also vegetation density, change in the atmosphere, dust loading or other human-induced factors (e.g. migration, deforestation and land cover change).

Northern Africa, Southern Africa and Eastern Africa are some of the regions where there is less uncertainty. Africa's Mediterranean coast, like the Mediterranean coastline in general, is likely to experience a decrease in precipitation (-15 to -20%) between 1980/99 and 2080/99. Less rainfall is expected during Winter and especially in Spring in Southern Africa. Along the tropical belt, the results achieved by the models show an increase in rainfall in East Africa which will extend to the Horn of Africa. However, no conclusions can be drawn regarding rainfall in West Africa (IPCC, 2007b).

Furthermore, Africa is particularly vulnerable to extreme changes in climate (e.g. droughts, floods) which are expected to impact on the development of the continent as a whole and in particular, on Sahel and Horn of Africa (see table 2).

As table 2 outlines, with reference to the case of Sahelian and Horn of Africa countries, extreme changes in climate are not the only ones responsible for environmental vulnerabilities affecting the continent. These countries show great sensitivity to the degradation and destruction of the ecosystems due to slow onset physical changes such as desertification, land degradation and water stresses (e.g. water availability and access to safe water). Notwithstanding, vulnerability is not only the result of physical changes in climate, but largely depends on the environmental consequences of human activities (e.g. mining in Burkina Faso, Niger, Mauritania; poaching in Sudan) and other human-induced factors, such as deforestation.

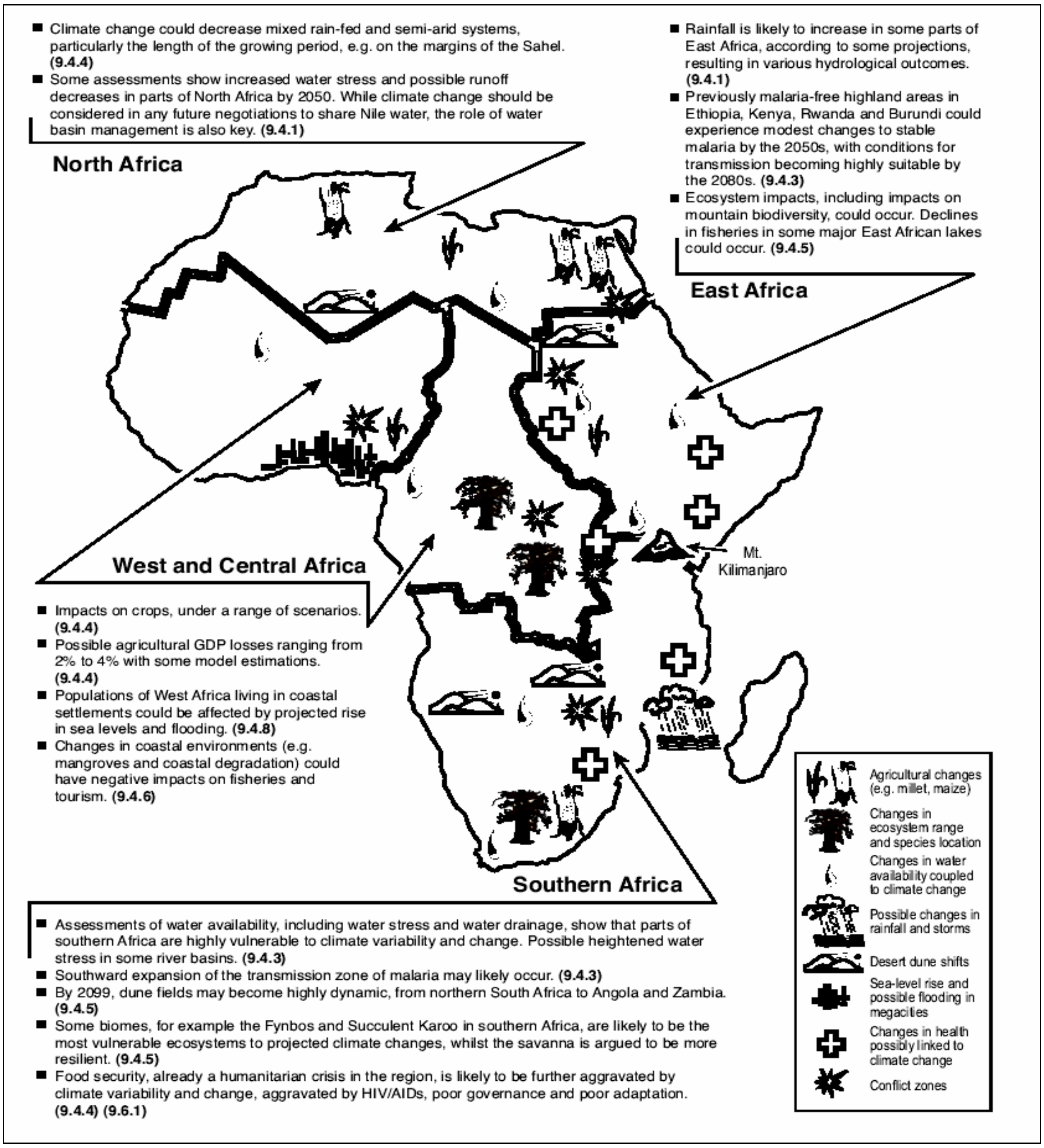
The next paragraphs will give further evidence of this nexus. At first, they will examine more in detail how physical changes in climate affect the essential components of lives and livelihoods of African people, with particular reference to the following sectors: ecosystems, water, human health, agriculture. Secondly, they will analyse African vulnerabilities to climate change as the result of the combination of natural and human factors.

Table 2 – Main environmental vulnerabilities in Sahelian and Horn of Africa countries

Sahelian countries		**Horn of Africa countries**	
Burkina Faso	Water Scarcity Land Degradation and Desertification Deforestation	*Central African Republic*	Subsistence and Commercial Poaching Deforestation and Land Degradation Pollution from diamond mining
Chad	Drought Desertification and Land Degradation Access to Water and Sanitation	*Eritrea*	Water Stress Land Availability and Degradation Deforestation and Threats to Biodiversity
Mali	Desertification and Drought Water Availability and Pollution Threats to Biodiversity	*Ethiopia*	Water Availability and Access to a Safe Source Livestock Soil Erosion and Land Degradation Threats to Biodiversity and Endemism
Mauritania	Desertification and Deforestation Pollution from iron mining Fisheries and Coastal Ecosystems	*Somalia*	Threats to Biodiversity Desertification, Overgrazing and Deforestation Water Scarcity and Drought
Niger	Desertification and Deforestation Threats to Wildlife Environmental Consequences of Mining	*Sudan*	Soil Erosion and Land Degradation Poaching and the Ivory Trade Forests and Fisheries
Senegal	Urban Pollution Deforestation Coastal Wetlands and Fisheries over-exploitation		

Source: UNEP, 2008.

Figure 7: Examples of current and possible future impacts and vulnerabilities associated with climate variability and climate change in Africa



Source: IPCC, 2007b.

1.2.1. Physical factors

SENSITIVITY/ VULNERABILITY OF ECOSYSTEMS

Developing countries and Africa in particular, are highly dependent on vulnerable ecosystems. For this reason, great sensitivity to the degradation and destruction of these natural assets and systems by climate change, exists.

Among the climate change related impact on ecosystems in Africa, desertification represents one of the most pressing challenge. "Approximately half of the sub-humid and semi-arid parts of the southern African regions are at moderate to high risk of desertification. In West Africa the long term decline in rainfall from the 1970s to the 1990s caused a 25-35 km southward shift of the

Sahelian" (IPCC, 2007b, p. 439). Also in the Horn of Africa countries, the risk of desertification is considerably high (see table 4).

Table 3 - Sahelian countries most affected by desertification and land degradation

Burkina Faso	***Chad***	***Mali***	***Mauritania***	***Niger***
Almost 90 per cent of lands are at risk (FAO AGL 2003).	Chad is more susceptible to desertification than any other Sahelian country—an estimated 58 per cent of its land is already classified as desert and another 30 per cent is highly vulnerable (UNEP 2006).	In all, approximately 98 per cent of Mali's territory is at risk of desertification (FAO AGL 2003).	Mauritania is one of the driest countries in Africa, receiving an average of only 92 mm of rain per year (FAO 2007).	It is estimated that the desert in the Republic of Niger is expanding by approximately 200,000 hectares per year (Mongabay 2006).

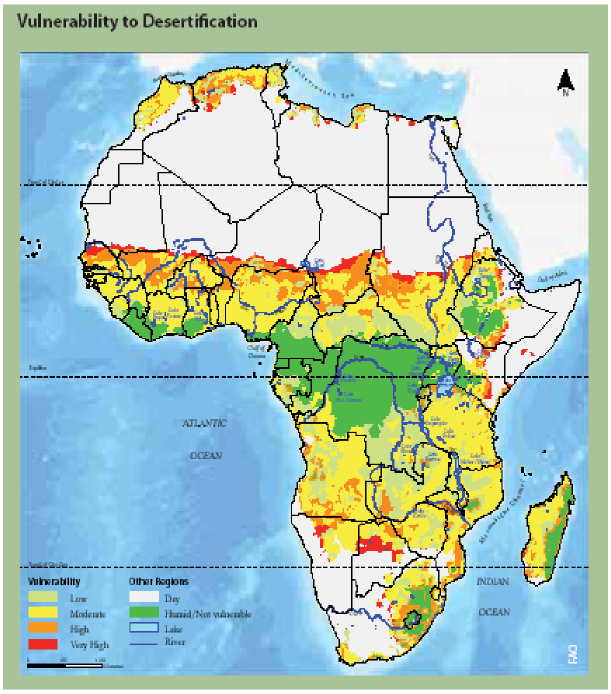
Source: Own elaboration based on UNEP, 2008.

Table 4 — Horn of Africa countries most affected by desertification and land degradation

Eritrea	***Ethiopia***	***Somalia***
Eritrea is at extremely high risk of desertification due to its arid climate and heavy reliance upon agriculture despite limited availability of arable land. In all, 63 per cent of land is considered to be severely degraded (FAO AGL 2003).	In all, 85 per cent of the land is classified as moderately to very severely degraded (FAO AGL 2003) and 70 per cent is affected by desertification (UNCCD 2002).	100 per cent of land is at high risk of desertification (FAO AGL 2003).

Source: Own elaboration based on UNEP, 2008.

Figure 8: Vulnerability to Desertification



Source: UNEP, 2008.

Moreover, "sea level rise will increase coastal flooding, raise costs of coastal protection, lead to loss of wetlands and coastal erosion, and increase saltwater intrusion into surface and groundwater [...]. Some estimates suggest that 150 – 200 million people may become permanently displaced by the middle of the century due to rising sea levels, more frequent floods, and more intense droughts" (Stern, 2006, p. 77). In particular, people living on the coast of Africa and in small islands are expected to be the most affected (Stern, 2006, UNDP, 2004; UNESCO-WWAP, 2006). In Senegal, for example, 1-m rise in sea level could inundate and erode more than 6,000 km^2 of land, most of which is wetlands, thus putting at risk at least 110,000-180,000 people or 1.4-2.3% of the 1990 population of Senegal (Dennis et al., 1995).

Negative impacts of climate change could create a new category of refugees, who may migrate into new settlements, seek new livelihoods and place additional demands on infrastructure (IPCC, 2007b). A variety of migration patterns could thus emerge, e.g. "repetitive migrants (as part of the ongoing adaptation to climate change) and short-term shock migrants (responding to a particular climate event)" (IPCC, 2007b, p. 450) (see the second chapter of this review for more details).

"Climate change is likely to occur too rapidly for many species to adapt. One study estimates that around 15 – 40% of species face extinction with 2°C of warming. Around 15 – 40% of land species could be facing extinction, with most major species groups affected, including 25 – 60% of mammals in South Africa" (Stern, 2006, p. 79). Furthermore, as a consequence of climate change for 81% to 97% of Africa's plant species could face a decrease in the areas of suitable climate.

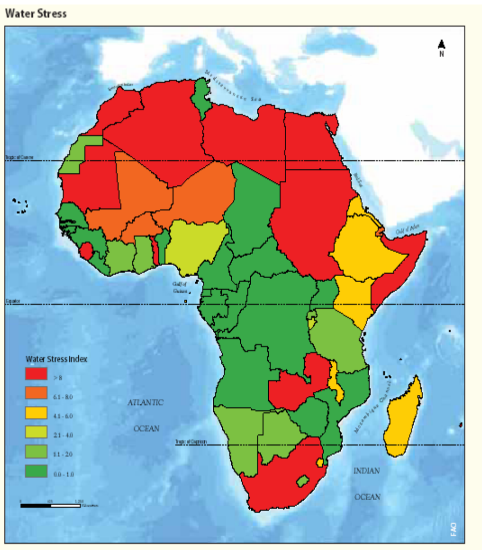
Then, the rising of carbon dioxide levels can provoke ocean acidification which will damage marine ecosystems, with severe consequences on fish stocks. "Fisheries could be affected by different biophysical impacts of climate change, depending on the resources which they are based on (Niang-Diop, 2005; Clark, 2006). With a rise in the annual global temperature (e.g. of the order of 1.5 to 2.0°C) fisheries in North West Africa and the East increase in income […]. In coastal regions that have major lagoons or lake systems, changes in freshwater flows and a greater intrusion of salt water into lagoons will affect the species that are the basis of inland fisheries or aquaculture" (Cury and Shannon, 2004 quoted by IPCC, 2007b, p. 448).

Finally, coral reefs – already at the level of 30% on the Indian Ocean Coasts (IPCC, 2007b) – are expected to bleach in many areas on an annual basis, of which most will never recover and will seriously affect tourism.

Sensitivity/Vulnerability in the water sector

"The impacts on people will be felt mainly through water, driven by shifts in regional weather patterns, particularly rainfall and extreme events" (Stern, 2006, p. 12).

Figure 9 – Water Stress



Source: UNEP, 2008.

Temperature rises of 2°C will result in 1 – 4 billion people experiencing growing water shortages, predominantly in Africa. In Africa, people facing water scarcity conditions are already over 300 million (UNEP, 1999), while 25% of African population experience water stresses (IPCC, 2007b). "The volume of water estimated to have been lost from the African land mass during a three year period ending in approximately 2006 was about 334 km3, which is as much water as Africans consumed over the same period (Amos, 2006)" (UNEP, 2008, p. 21).

By 2025, it is expected that 18 African countries will experience water stress while "by 2050, areas experiencing water shortages in sub-Saharan Africa will have increased by 29 per cent" (UNEP, 1999).

Water availability is not the only water stress to be considered. Change in climate may exacerbate the already existing constraint to access to safe water and adequate sanitation. Actually, only 62% of African population had access to improved water supplies in 2000.

Table 5 – Sahelian countries most affected by water stresses

	Burkina Faso	*Chad*	*Mali*
Water availability	Burkina Faso is a water scarce country with only 906 m3 of freshwater available per person per year (FAO 2007).	Lake Chad is the fourth-largest lake in Africa (in terms of surface area) and the largest wetland in the Sahel region. In recent decades, the lake has shrunk dramatically, now measuring only one-twentieth of its size in 1963.	
Access to water and sanitation		Lack of access to adequate water and sanitation has had pronounced impacts on human health: approximately one out of five children dies before reaching the age of five (UNICEF 2006), primarily due to water-related diseases	Total water resources are relatively large. Only 50 per cent of the total population and 36 per cent of the rural population have access to an improved water source (UN 2007).

Source: Own elaboration based on UNEP, 2008.

Table 6 – Horn of Africa countries most affected by water stresses

	Eritrea	*Ethiopia*	*Somalia*
Water availability/ Access to water and sanitation	With only one perennial river and no natural fresh surface water bodies, Eritrea depends on groundwater resources that are regionally limited at level of quantity as well as quality. The country is below the international threshold for water stress with only 1 338 m3 available per person per year (Earth Trends 2007 and UNESA 2005). It is estimated that demand for water is ten times greater than the national supply, indicating a 3 500 million cubic metre water gap (UNDP 2006).	Although surface water resources are relatively abundant, they are largely undeveloped and unevenly distributed. As a consequence of both natural and economic circumstances, only 22 per cent of the population have access to an improved water source, the lowest proportion in Africa (UN 2007).	In north and east Somalia's arid areas, sub-surface water resources are generally saline; deep boreholes are the only permanent source of freshwater. In the south, two perennial rivers, Juba and Shabelle, play a major role in water access.

Source: Own elaboration based on UNEP, 2008.

In particular, the possible range of Africa-wide climate change impacts on stream flows may increase in all countries significantly between 2050 and 2100, respectively by 15 and 19%. (IPCC, 2007b) "A critical 'unstable' area is identified for some parts, for example, the east-west band from Senegal to Sudan, separating the dry Sahara from wet Central Africa. Parts of southern Africa are projected to experience significant losses of runoff, with some areas being particularly impacted (e.g. parts of South Africa)" (New, 2002; de Wit and Stankiewicz, 2006 cited by IPCC 2007b, p. 446).

Warming may induce sudden shifts in regional weather patterns that have severe consequences for water availability in tropical regions. In West Africa, for example, "temperature changes in northern and southern Atlantic Ocean and Indian water surfaces as well as temperature anomalies in the Pacific, linked to El Nino phenomenon, are important driving force for West Africa's monsoon activity. Temperature variations in the oceans, which are sensitive to global climate changes, will undoubtedly have repercussions on the West African monsoon" (ECOWAS-SWAC/OECD, 2008, p. 11-12). As a consequence of heat waves and of the increasing temperature in the oceans, the number of extreme climate events (e.g. storms, floods and droughts) may augment.

Finally, it is worth stressing that 93% of the African total surface water resources comes from the 59 international transboundary rivers, which "are also home to some 77 per cent of the African population" (UNEP, 2008). This represents a very important issue when dealing with the impact of climate change in Africa, given their potential in triggering conflicts over resources .

SENSITIVITY/ VULNERABILITY IN THE HEALTH SECTOR

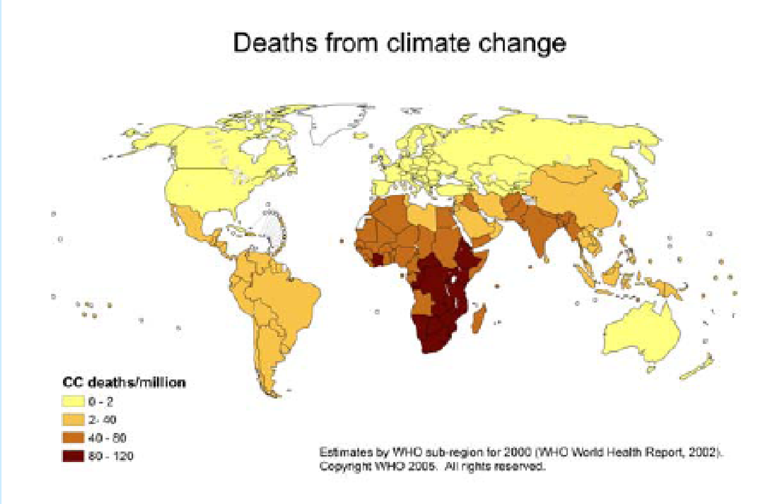
Climate change will affect health from vector-borne diseases and malnutrition. At first, changes in temperatures and rainfall patterns would affect the distribution and abundance of disease vectors. So, for example, the changes regarding the mosquito distribution will have profound impact on the distribution of malaria. "This will be particularly significant in Africa, where 450 million people are exposed to malaria today, of whom around 1 million die each year. Climate change will potentially exacerbate this vulnerability as a greater number of malaria carrying mosquitoes move into previously uninfected areas. According to a study, a 2°C rise in temperature may lead to 40 – 60 million more people exposed to malaria in Africa (9 – 14% increase on present-day), increasing to 70 – 80 million (16 – 19%) at higher temperatures, assuming no change to malaria control efforts. Much of the increase will occur in Sub-Saharan Africa, including East Africa" (Stern, 2006, p. 76).

"Previously malaria-free highland areas in Ethiopia, Kenya, Rwanda and Burundi could also experience modest incursions of malaria by the 2050s, with conditions for transmission becoming highly suitable by the 2080s" (IPCC, 2007b, p. 446). In South Africa, the area suitable for malaria may double with 7.8 million people at risk by 2100.

On the contrary, malaria should decrease in parts of West Africa, taking 25 – 50 million people out of an exposed region, because of reductions in rainfall (Stern, 2006).

The increasing number deaths worldwide will be directly related to the increase in temperatures. "The World Health Organisation (WHO) estimates that climate change since the 1970s is already responsible for over 150,000 deaths each year through increasing incidence of diarrhoea, malaria and malnutrition, predominantly in Africa and other developing regions . Just a 1°C increase in global temperature above pre-industrial level could double annual deaths from climate change to at least 300,000 according to the WHO. These figures do not account for any reductions in cold-related deaths, which could be substantial. At higher temperatures, death rates will increase sharply, for example millions more people dying from malnutrition each year. Climate change will also affect health via other diseases not included in the WHO modelling" (Stern 2006, p. 75). For example, "slum populations in urban areas are particularly exposed to diseases, suffering from poor air quality and heat stress, and with limited access to clean water" (Stern, 2006, p.74). Moreover, "the probability that sea-level rise could increase flooding, particularly on the coasts of eastern Africa may also have implications for health" (McMichael et al., 2006, quoted by IPCC, 2007b, p. 447).

Figure 10– WHO estimates of extra deaths (per million people) from climate change in 2000



Disease/Illness	Annual Deaths	Climate change component (death / % total)
Diarrhoeal diseases	2.0 million	47,000 / 2%
Malaria	1.1 million	27,000 / 2%
Malnutrition	3.7 million	77,000 / 2%
Cardiovascular disease	17.5 million	Total heat/cold data not provided
HIV/AIDS	2.8 million	No climate change element
Cancer	7.6 million	No climate change element

Source: WHO (2006) based on data from McMichael et al. (2004). The numbers are expected to at least double to 300,000 deaths each year by 2030.

SENSITIVITY/ VULNERABILITY OF THE AGRICULTURAL SECTOR

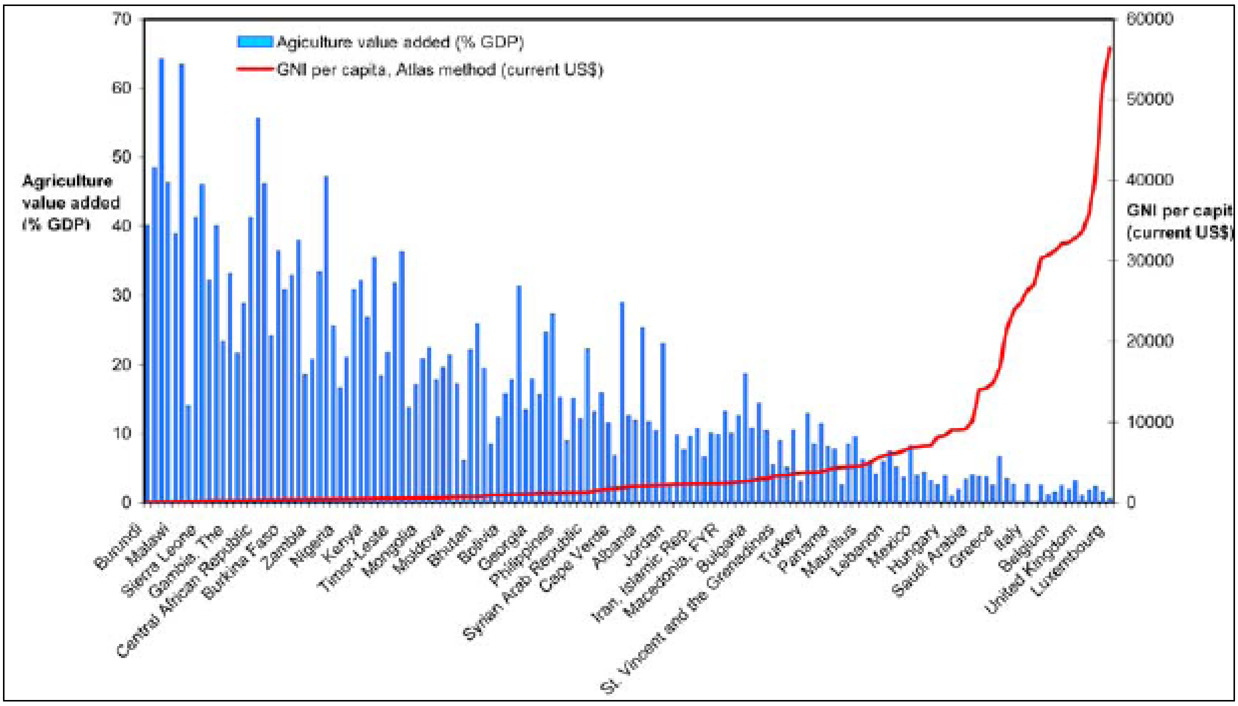
The dependence of African countries on agriculture and related activities is a major cause of vulnerability to climate change (IPCC, 2007b; Stern, 2006). The incidence of agriculture on GDP varies across the continent, but on average it is around 21% (ranging from 10 to 70%) (IPCC, 2007b) and employs around 64% (2004) of people in Sub-Saharan Africa (Stern, 2006). The economies of Sahelian countries, for example, are heavily based on agriculture, which employs more than half of the active population and contributes to about 40% of the GDP (CILSS, 2004).

The agricultural sector is one of the most at risk of the damaging impacts of climate change – and indeed current extreme climate variability - in developing countries. The concentration of activities in one sector also limits flexibility to switch to less climate-sensitive activities, such as manufacturing and services.

Climate change will provoke the declining of crop yields, leaving people without the ability to produce or purchase sufficient food, directly increasing poverty of households in poor countries. Between 250–550 million additional people may be at risk of hunger with a temperature increase of 3°C, of whom more than half will be concentrated in Africa and Western Asia (Stern, 2006). "It is estimated that, by 2100, parts of the Sahara are likely to emerge as the most vulnerable, showing likely agricultural losses of between 2 and 7% of GDP. Western and central Africa are also vulnerable, with impacts ranging from 2 to 4%. Northern and southern Africa, however, are expected to have losses of 0.4 to 1.3%" (Mendelsohn et al., 2000, cited by IPCC, 2007b, p.447). By the 2080s, a significant decrease in suitable rain-fed land extent and production potential for cereals is estimated under climate change. Furthermore, according to the same projections and for the same time horizon, the area of arid and semi-arid land in Africa could increase by 5-8% (60-90 million hectares). The study shows that wheat production is likely to disappear from Africa by the 2080s

(Stige et al., 2006). In other countries, additional risks that could be exacerbated by climate change include greater erosion, deficiencies in yields from rain-fed agriculture of up to 50% during the 2000-2020 period, and reductions in crop growth periods (Agoumi, 2003)" (IPCC, 2007b, p. 448).

Figure 11 – The share of agriculture in GDP and per capita income in 2004



Source: Stern, 2006.

At the same time, many existing estimates do not include the impacts of short-term weather events, such as floods, droughts and heat waves, whose immediate impacts are often compounded by the rising cost of food.

The current experience of extreme weather events underlines how devastating droughts and floods can be for household incomes. In North-Eastern Ethiopia, for example, drought-induced losses in crop and livestock between 1998 –2000 were estimated at $266 per household – higher than the annual average cash income for more than 75% of households in the study region (Stern, 2006). Moreover, during a severe drought in 2003, over ten million people required food aid and the gross domestic product declined by 3.3 per cent (UNEP, 2008).

Another example is represented by the drought periods experienced by the Sahel region during the first (1910-1916, 1941-1945) and the second half of the 20th century, the so-called 'desiccation period', which was characterised by a sustained decline in rainfall begun in the 1970s and continued into the 1980s and - with some interruption - the 1990s. It is estimated that drought-related deaths amounted to 100,000 and about 900,000 people were severely affected by the drought, increased starvation, mass migration and overwhelming economic implications. In Mali and Niger, the drought in 1984 caused a fall of the GDP by 9 and 18%, respectively (Tacko Kandji et al., 2006).

Nevertheless, not all changes in climate and climate variability will be negative, as agriculture and the growing seasons in certain areas (for example, parts of the Ethiopian highlands and parts of southern Africa such as Mozambique), may lengthen under climate change, due to a combination of increased temperature and rainfall changes (Thornton et al., 2006). Mild climate scenarios project further benefits across African croplands for irrigated and, especially, dryland farms. However, it is worth noting that, even under these favourable scenarios, populated regions of the Mediterranean coastline, central, western and southern Africa are expected to be adversely affected (Kurukulasuriya et al., 2006).

1.2.2. Non physical factors

Over the past 50 years, human beings have changed ecosystems more rapidly and extensively than in any other comparable period of time in the history of mankind (World Resources Institute, 2005).

So, the desertification and land degradation processes affecting, among others, the Sahelian and Horn of Africa countries are the result of the combination of natural – e.g. mostly, prolonged droughts and reduction of rainfall – and human factors. The growing population and the consequent increase of human pressure on land resources coupled by unsustainable land use practices (e.g. deforestation, overstocking, overgrazing, deep ploughing and monocropping), thus contributing toward the reduction of vegetation which leads to soil erosion, and toward the reduction of productivity (World Resources Institute, 2005) which amplifies the risks of famine. In Mali - the fastest growing countries in Africa with an annual rate of population growth of nearly 3% (UNESA, 2005) – it is estimated that each year, 100,000 hectares of land are converted in agriculture to cope with rising food needs.

As for land degradation, many other pressures of climate change are driven by the interaction between environment and population. High population growth rates have been identified as factors which have further exacerbated the low level of human well-being and high poverty of dryland population, because of drought-related stresses such as water scarcity, food and health crises (World Resources Institute, 2005).

Africa will have the fastest growth rate in the world between 2000 and 2050, twice the rate of any other region during the same length of time (UN, 2007).

Table 7 - Land degradation and desertification in Sahelian countries: Human-induced factors

Burkina Faso	***Mali***	***Mauritania***	***Niger***
- Intensive cultivation to face the needs of the growing population: the cultivated area has more than doubled since 1961 at the expense of fallow, marginal, and previously unutilized areas, putting pressure on already fragile soils and limited water resources. - Desertification caused by bush fires, which ravage thousands of hectares of land each year and recurrent drought.	- Increasing human pressure on land resources. - Mali is among the fastest growing countries in Africa with an annual population growth rate of nearly 3 per cent (UNESA 2005). - Conversion of an estimated 100,000 hectares of land each year to cope with rising food needs. - Use of fire to manage agricultural land is one of the leading causes of land degradation; an estimated 14.5 million hectares of pasture are burned each year, equivalent to 17 per cent of the country.	- Overgrazing and deforestation are causing the desert to expand southward. - Unsustainable exploitation of groundwater resources.	- Overtaking degraded agricultural land and encroaching on human settlements. - Recurrent drought. - Poor cultivation practices. - Rising demand for agricultural land and fuelwood. - High population growth rate in Africa (UNESA 2005) (the fourth-highest in Africa)

Source: Own elaboration based on UNEP, 2008.

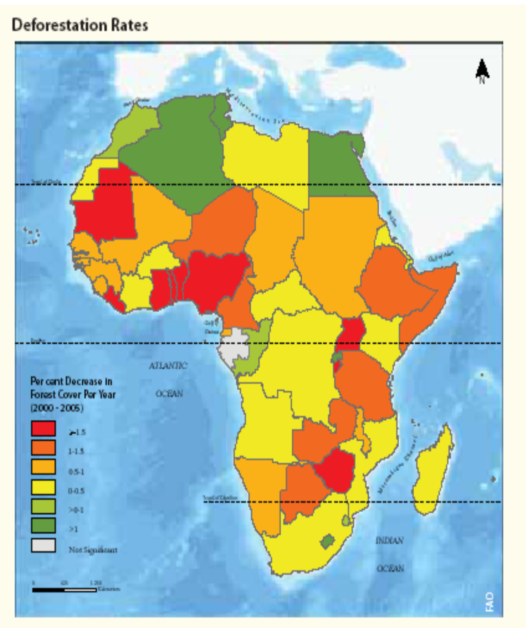
Table 8 – Land degradation and desertification in the Horn of Africa: Human-induced factors

Eritrea	*Ethiopia*	*Djibouti*	*Somalia*
- Continued population growth has forced expansion onto marginal lands and steep slopes. - Livestock grazing, which is predominantly concentrated in the semi-arid western lowlands, has also exposed soils to water and wind erosion.	- Overgrazing (Ethiopia has the seventh-largest cattle stock in the world) (FAO 2007); - Heavy dependence on dung for fuel. - Deforestation and poor farming practices.		- Overstocking and overgrazing have resulted in declining fertility of pastureland, which accounts for nearly 70 per cent of the total Somali Republic's land area (World Resources Institute 2007). - Deforestation.

Source: Own elaboration based on UNEP, 2008.

As tables 7 and 8 outline, deforestation practices have a major role in exacerbating land degradation and desertification processes. Actually, the rate of deforestation is higher in Africa than in any other continent. "Of the ten countries in the world with the largest annual net loss of forested area, six are in Africa (FAO, 2005)" (UNEP, 2008, p. 18). "Africa loses an average of 40,000 km2, or 0.6 per cent, of its forests annually, with the greatest losses occurring in heavily forested countries (FAO, 2005)" (UNEP, 2008, p. 18). For example, Niger has lost one-third of its forest cover since 1990, and now only one per cent of the land is forested (UN, 2007); in Eritrea forests account for only 15% of the land, although original forest cover is estimated to have been twice that amount (FAO, 2001); in Ethiopia, it is estimated that forest cover now constitutes less than 4% of the original forest extent.

Figure 12 – Deforestation rates



Source: UNEP, 2008.

The growing demand for fuelwood and agriculture land are among the main causes of deforestation. "People use controlled fire to manage grasslands and savannahs for livestock production and wildlife, control pests, clear dying vegetation, and convert wild lands to cropland (Trollope and Trollope 2004)" (UNEP 2008, p. 19). In Mali, for example, in 1997, deforestation caused economic damage amounting to an estimated 5.35% of GDP. Moreover, the use of fire to manage agricultural land is one of the leading causes of land degradation; an estimated 14.5 million hectares of pasture are burned each year, equivalent to 17 per cent of the country.

Also in Senegal, deforestation has been blamed for recent increases in soil erosion, desertification, and flooding. Actually, agriculture claims more than 80,000 hectares of forest each year and wild fires, which are used for land clearing and hunting, degrade an additional 350,000 hectares annually. On the contrary, approximately 50 per cent of mangroves along the coast have been degraded as a result of over-exploitation and drought (UNEP, 2008).

As said in the first paragraphs, “deforestation also impacts the global carbon cycle; carbon released when trees are cut, burned, or as they decompose enters the atmosphere as CO2 and contributes to global warming (Willcocks, 2002)” (UNEP, 2008, p.18) In addition to this, a role of deforestation in increasing the risk of malaria in Africa has also been recognised (World Resources Institute, 2005).

Furthermore, as a result of the growth (four per cent a year since 1980; 2.7 of the African population) of coastal urban areas (ODINAFRICA Project, 2007) “Human-induced activities such as construction, dredging and mining for sand, and harvesting corals have led to severe problems of coastal erosion. The Niger River Delta is losing 400 hectares of land a year to erosion (Hinrichsen, 2007)” (UNEP, 2008, p.14). Consequently, “the 500km coast between Accra and the Niger delta will likely become a continuous urban megalopolis with more than 50 million people by 2020” (Stern, 2006, pp. 96).

Africa has also the fastest urban growth rate in the world. This trend is mainly due to people migrating from rural communities to cities — especially young adults looking for work — as well as high urban birth rates (IUSSP, 2007). Population in Addis Ababa (see Box 4 in the Appendix), for example, has doubled in the last 20 years and projections predict a population over 5 million by 2015. In Senegal one out of four Senegalese people (approximately 55 per cent of the urban population) lives in the coastal capital city Dakar (FAO, 2005). The urban growth rate is 3.6% per year, compared to 2.3% of the country as a whole (UNESA, 2006).

Table 9 – Africa’s 20 largest cities in 2015

City	Country	Population 2000 (millions)	Estimated population 2015	Percentage growth 2000-2015
Lagos	Nigeria	8,422	16,141	92%
Kinshasa	DR Congo	5,042	9,304	85%
Khartoum	Sudan	3,949	6,022	52%
Abidjan	Côte d'Ivoire	3,055	4,525	48%
Addis Ababa	Ethiopia	2,494	4,078	64%
Nairobi	Kenya	2,233	4,001	79%
Kano	Nigeria	2,658	3,920	47%
Luanda	Angola	2,322	3,904	68%
Johannesburg	South Africa	2,732	3,674	34%
Cape Town	South Africa	2,715	3,401	25%
Ekurhuleni (East Rand)	South Africa	2,326	3,212	38%
Ibadan	Nigeria	2,195	3,152	44%
Durban	South Africa	2,370	2,876	21%
Accra	Ghana	1,674	2,666	59%
Douala	Cameroon	1,432	2,350	64%
Antananarivo	Madagascar	1,361	2,182	60%
Bamako	Mali	1,110	2,117	91%
Kumasi	Ghana	1,187	2,095	76%
Kampala	Uganda	1,097	2,054	87%
Conakry	Guinea	1,222	2,001	64%

Source: Black et al., 2008, from UN Department of Economic and Social Affairs, 2006.

The number of people living in cities in the developing countries is predicted to rise from 43% in 2005 to 56% by 2030. “It does not follow from this that policies to slow urbanisation are desirable. Urbanisation is closely linked to economic growth and it can provide opportunities for reducing poverty and decreasing vulnerability to climate change. Nonetheless, many of those migrating to cities live in poor conditions – often on marginal land – and are particularly vulnerable because of their limited access to clean water, sanitation, and location in flood-prone areas” (Stern, 2006, p. 96)

"Population movement and growth will often exacerbate the impacts by increasing society's exposure to environmental stresses (for example, more people living by the coast) and reducing the amount of resources available per person (for example, less food per person causing greater food shortages)"(Stern, 2006, p. 59).

1.2.3. Adaptation capacities and practices

Much stress can be faced with investments in adaptation (see table 10 and 11 for examples of adaptation practices).

Table 10 – Examples of adaptation already observed in Africa

Themes	Examples of adaptation
Social resilience	
Social networks and social practices	▪ Perceptions of risks by rural communities are important in configuring the problem (e.g. climate risk). Perceptions can shape the variety of adaptive actions taken. ▪ Networks of community groups are also important. ▪ Local savings schemes, many of them based on regular membership fees, are useful financial 'stores' drawn down during times of stress.
Institutions	▪ Role and architecture of institutional design and function are critical for understanding and better informing policies/measures about enhanced resilience to climate change. ▪ Interventions linked to governance at various levels (state, region and local levels) either enhance or constrain adaptive capacity.
Economic resilience	
Equity	▪ Issues of equity need to be viewed on several scales. ▪ Local scale (within and between communities). ▪ Interventions to enhance community resilience can be hampered by inaccessibility of centres for obtaining assistance (aid/finance).
Diversification of livelihoods	Diversification has been shown to be a very strong and necessary economic strategy to increase resilience to stresses. Agricultural intensification, for example, based on increased livestock densities, the use of natural fertilisers, soil and water conservation, can be useful adaptation mechanisms.
Technology	▪ Seasonal forecasts, their production, dissemination, uptake and integration in model-based decision-making support systems have been examined in several African contexts. ▪ Enhanced resilience to future periods of drought stress may also be supported by improvements in present rain-fed farming systems through: - water-harvesting systems; - dam building; - water conservation and agricultural practices; - drip irrigation; - development of drought-resistant and early-maturing crop varieties and alternative crop and hybrid varieties.
Infrastructure	▪ Improvements in the physical infrastructure may improve adaptive capacity. ▪ Improved communication and road networks for better exchange of knowledge and information. ▪ General deterioration in infrastructure threatens the supply of water during droughts and floods.

Source: IPCC, 2007b.

The relevant literature on climate change in Africa agrees on the limits of implementing adaptation investments and practices in the continent. Africa presents a low adaptive capacity, due to a lack of "infrastructure (see table 10) most notably in the area of water supply and management, financial means, and access to public services that would otherwise help them to adapt" (Stern, 2006, p. 97).

Furthermore, *weak governance and institution capacity* to face the risks linked to environmental degradations and natural disasters are to be considered among the factors which heighten the most vulnerability to climate stresses and limit adaptation capacity. These factors represent major "constraints in technological options [such as early warning systems], limited infrastructure, skills, information and links to markets" (IPCC, 2007b, p. 441). In order to build adaptive capacity, investments in institution and human capital, as well as the promotion of social capital, networks and practices, are required (see tables 10 and 11).

Moreover, improving disaster preparedness and management – such as investments in technology and infrastructure/physical capital (see tables 10 and 11) – are considered among the most important adaptation practices, which contribute to saving lives and to the promotion of early and cost effective adaptation to climate-change risks (IPCC, 2007b). Concerning health management, for example, the fourth IPCC report emphasizes the need for "long-term linked data sets on climate and disease that are necessary for the development of early warning systems (WHO, 2005)".(IPCC, 2007b, p. 442)

Table 11 – Investing in adaptation

Encouraging technology transfer and supporting flows of knowledge	Governments can deliver better climate forecasts, and spread information about climate-resilient crop varieties and irrigation schemes.
Human capital	Investing in health and education raises the effectiveness of explaining to communities and individuals how climate is changing and why and how they should adapt in ways which effectively integrate climate risks into the development process.
Physical capital	Governments can make long-term infrastructure more climate-resilient – through building codes and regulations, land-use zoning, river management and warning systems. Some adaptation may require higher maintenance costs for basic infrastructure such as flood barriers, and sea walls will also be required.
Social capital	Supporting social networks, institutions and governance arrangements to strengthen safety nets for poor people in response to natural disasters. Many traditional risk-sharing mechanisms based on social capital, such as asset pooling and kinship networks, are less likely to be effective when climate change simultaneously damages families and households in an entire region. The same is true for traditional coping systems like selling assets.
Natural capital	Governments can help protect the resilience of natural systems to support the livelihoods of poor people, for example, by planting mangrove belts to buffer the coastal erosion of sea level rise.

Source: Stern, 2006.

Vulnerability to the impacts of climate change can also increase as a result of *maladaptation* (Stern, 2006) practices, such as all those contributing to destroy the fragile ecosystems in Africa, such as the building of dams or the destruction of coastal mangroves (see Box 2 in the Appendix).

The best way for governments to accelerate adaptation is to successfully promote development, empower communities, render them less vulnerable and better able to adapt to changes in their environment. Economic growth, for example, "often reduces vulnerability to climate change (for example, better nutrition or health care) and increases society's ability to adapt to the impacts (for example, availability of technology to make crops more drought-tolerant)" (Stern, 2006, p.61).

Climate change and development are directly linked. "It is clear that climate change and variability, and associated increased disaster risks, will seriously hamper future development" (IPCC,2007b, p. 457). On one hand, climate change and variability may represent an additional impediment in the achievement of the Millennium Development Goals (MDGs). On the other, "a challenge, therefore, is to shape and manage development that also builds resilience to shocks, including those related to climate change and variability (Davidson et al., 2003; Adger et al., 2004)" (IPCC, 2007b, p.447).

Table 12 – Potential Impact of climate change on the Millennium Development Goals

Potential Impacts	**Millennium Development Goals***
Climate Change (CC) may reduce poor people's livelihood assets, for example health, access to water, homes and infrastructure. It may also alter the path and rate of economic growth due to changes in natural systems and resources, infrastructure and labour productivity. A reduction in economic growth directly affects poverty through reduced income opportunities. In addition to CC, expected impacts on regional food security are likely, particularly in Africa, where food security is expected to worsen	Eradicate extreme poverty and hunger (**Goal 1**)
Climate change is likely to directly impact children and pregnant women because they are particularly susceptible to vector- and water-borne diseases, e.g. malaria is currently responsible for a quarter of maternal mortality. Other expected impacts include: • increased heat-related mortality and illness associated with heat-waves (which may be balanced by less winter-cold-related deaths in some countries); • increased prevalence of some vector-borne diseases (e.g., malaria, dengue fever), and vulnerability to water, food or person-to-person diseases (e.g. cholera, dysentery); • declining quantity and quality of drinking water, which worsens malnutrition, since it is a prerequisite for good health; • reduced natural resource productivity and threatened food security, particularly in sub-Saharan Africa.	Health-related goals: • reduce infant mortality (**Goal 4**); • improve maternal health (**Goal 5**); • combat major diseases (**Goal 6**).
Direct impacts: • Climate change may alter the quality and productivity of natural resources and ecosystems, some of which may be irreversibly damaged, and these changes may also decrease biological diversity and existing compound environmental degradation; • Climate change would alter the ecosystem-human interfaces and interactions that may lead to a loss of biodiversity and hence, erode the basic support systems for the livelihood of many people in Africa.	Ensure environmental sustainability (**Goal 7**)
Indirect impacts: links to climate change include: • Loss of livelihood assets (natural, health, financial and physical capital) may reduce opportunities for full time education in numerous ways. • Natural disasters and drought reduce children's available time (which may be diverted to household tasks), while displacement and migration can reduce access to education opportunities.	Achieve universal primary education (**Goal 2**)
One of the expected impacts of climate change is that it could exacerbate current gender inequalities, by impacting on the natural resource base, thus leading to decreasing agricultural productivity. This may place additional burdens on women's health, and reduce time available to participate in decision-making and for practicing income-generation activities. Climate-related disasters have been found to impact female-headed households, particularly where they have fewer assets .	Promote gender equality and empower women (**Goal 3**)
Global climate change is a global issue, and responses require global co-operation, especially to help developing countries adapt to the adverse impacts of climate change .	Global partnerships (**Goal 8**)

* The order in which the Millennium Development Goals are listed here places the goals that could be directly impacted first, followed by those that are indirectly impacted.

Source: IPCC, 2007b.

2. IMPLICATIONS FOR HUMAN MOBILITY IN AFRICA

2.1 The nexus between climate change and human mobility

Notwithstanding the lively debate on the implications of environmental change on human mobility, there is still a lack of a shared and agreed definition of the people forced to displace due to environmental causes. As a consequence, neither an agreement has been achieved upon the number of persons falling into this category nor reliable predictions.

The term "climate refugees" or "environmental refugees" is not commonly accepted and has been used to refer to a broad range of situations. Two of the best-known definitions of environmental refugees are El-Hinnawi's and Myers and Kent's.

El-Hinnawi defined environmental refugees as:

> "those people who have been forced to leave their traditional habitat, temporarily or permanently, because of a marked environmental disruption (natural and/or triggered by people) that jeopardized their existence and/ or seriously affected the quality of their life. By 'environmental disruption' is meant any physical, chemical and/or biological changes in the ecosystem (or the resource base) that render it temporarily or permanently, unsuitable to support human life." (El-Hinnawi, 1985, p. 4)

Myers and Kent proposed the following definition:

> "Environmental refugees are persons who can no longer gain a secure livelihood in their traditional homelands because of environmental factors of unusual scope, notably drought, desertification, deforestation, soil erosion, water shortages and climate change, also natural disasters such as cyclones, storm surges and floods. In face of these environmental threats, people feel they have no alternative but to seek sustenance elsewhere, whether within their own countries or beyond and whether on a semi-permanent or permanent basis." (Myers and Kent, 1995, pp. 18-19)

From a legal point of view, the term "climate refugees" could be misleading. In fact, the Convention relating to the Status of Refugees, applies to any person who:

> "…owing to well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, is outside the country of his nationality and is unable, or owing to such fear, is unwilling to avail himself of the protection of that country; or who, not having a nationality and being outside the country of his former habitual residence as a result of such events, is unable or, owing to such fear, is unwilling to return to it." (Convention relating to the Status of Refugees, 1951, art. 1, A. 2)

Hence, the international law on refugees limits the causes of forced international migration to reasons of race, religion, nationality or membership of a particular social group or political opinion, excluding environmental causes. It is worth noting that the 1951 political discourse based on nation-state is not adequate to the new cross-border issues such as climate change, which require different approaches.

Natural or human-made disasters are recognised as a cause of internal displacement by the UN Guiding Principles on Internal Displacement, which define internally displaced persons as:

> "…persons or groups of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalized violence, violations of human rights or natural or human-made disasters, and who have not crossed an internationally recognized State border." (Guiding Principles on Internal Displacement, 1998, Introduction, art. 2)

This definition does not apply to refugees and only refers to people who have not crossed an international border. Actually, as we will see in paragraph 2.2, most forced migrants are internally-displaced and not refugees. This definition is more complete than the previous one, but it is not sufficient to include all those who have displaced for environmental causes, as gradual environmental degradation is excluded.

It is essential to report that the UN High Commissioner for Refugees (UNHCR), the UN agency responsible for forced displacement, "*has serious reservations with respect to the terminology and notion of environmental refugees or climate refugees. These terms have no basis in international refugee law*." (UNHCR, 2008, p. 7) UNHCR's reservations can be explained by the fear that the use of the term "environmental refugee" may create confusion and undermine the international legal regime for the protection of refugees. The Agency argues that certain cross-border movement scenarios may be dealt with within the existing international refugee framework, but others may require new approaches, premised upon international solidarity and responsibility-sharing (UNHCR, 2008). In fact, in addition to the persons falling under the 1951 Refugee Convention definition, the UNHCR mandate includes persons who fear serious and indiscriminate threats to life, physical integrity or freedom resulting from generalised violence or events seriously disturbing public order. In this sense, population movements provoked by armed conflict rooted in environmental factors fall within UNHCR's mandate.

These conflicts and displacements occur in a number of settings. For instance, the conflict over energy sources, fertile land and fresh water are recognised as crucial factors fuelling the crisis in the Darfur region (UNEP, 2007; Holmes, 2008; Boano et al., 2008). The sinking of low-lying areas such as small islands, resulting from sea level rising, may also fall within the UNHCR's mandate, as inhabitants could be forced to seek safety abroad. In other scenarios where climate change and natural disaster may lead to cross-border movements, the UNHCR's mandate only covers the cases where people are unable or unwilling to be protected by their countries of origin, because "*governments are primarily responsible for protecting and assisting those affected by natural disasters.*" (UNHCR, 2008, p. 6) In practice, many countries lack the resources to assist the victims of disasters, while states and international organisations have traditionally acted in accordance with the principle of international solidarity and burden-sharing, thus giving support and supplementing national response capacities, on case-by-case based determinations.

An alternative to the use of the term "environmental refugees" was offered in 1996 by the International Organization for Migration (IOM), UNHCR and the Refugee Policy Group, which proposed a definition of "environmentally displaced persons", including both people who crossed and people who did not cross an international border. They are defined as:

> "…persons who are displaced within their own country of habitual residence or who have crossed an international border and for whom environmental degradation, deterioration or destruction is a major cause of their displacement, although not necessarily the sole one." (IOM, UNHCR and Refugee Policy Group, 1996).

Recently, IOM proposed a new and broader working definition of "environmental migrants" which does not raise legal problems and is likely to receive the largest consensus:

> "Environmental migrants are persons or groups of persons who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad." (IOM, 2007, pp.1-2)

In addition to international organisations, different opinions about the use of the term "environmental refugees" were expressed also by literature. Some authors have suggested that the Refugee Convention is amended to include environmental causes of displacement, while others have proposed the creation of a specific legal framework. Some others more, have criticised the use of the term "environmental refugees" instead. Kibreab, for instance, similarly to UNHCR, notes that the use of the term can have side-effects and argues that it may lead to further restrict asylum laws and policies in developed countries, because environmental refugees could be made equal to economic migrants (Kibreab, 1997).

Furthermore, some authors argue that the term "environmental refugees" implies that migrants have moved as a direct consequence of environmental factors, a mono causality or primary causality rarely recognisable in reality (Black et al., 2001; Kolmannskog, 2008). Actually, it is very difficult to completely isolate climate change as a cause of forced migration, and this may be a further obstacle to one common definition and prediction on the dimension of the phenomenon. Anyhow, it is important to stress that in the majority of cases, it is almost unproblematic to recognise climate change among the causes of displacement, and the problem of identification of climate change as a mono or primary causality risks of justifying political paralysis.

More in general, the terminological questions reflect political unwillingness, and without an agreed definition of who the environmentally-displaced persons are, it shall be impossible to develop policy responses and protection mechanisms for this category of migrants.

2.2 Migration processes

2.2.1. Climate and non-climate drivers of human mobility

Environmentally-induced mobility can be considered as a type of forced migration because the action is involuntary, and a certain amount of coercion is implicit in the fact that push factors in the origin area could be more important than pull factors in destination areas.

Traditionally, the pastoral way of life has always been one of the most important mechanisms to adjust to ecological changes in Africa, which is a continent characterised by poor soils, unfavourable climate changes and other natural adverseness (Bascom, 1995; Suliman, 2005). In Africa, faced with natural or social problems, people move to ecologically or socially more friendly areas. In particular, mobility across Africa has been facilitated by the following conditions (Suliman, 2005):

1) Low population numbers, even in rich eco-zones, and as a consequence
2) Little competition over natural resources, e.g. availability of large areas of virgin lands, forests, and grasslands;
3) The absence in Africa, except for the Sahara, of insurmountable natural barriers to mobility, e.g. mountain massifs, large waters, and zones with extreme climate and weather conditions;
4) The practical absence of well-defined and well-secured political borders, manifestly reflected in the prevailing sense of people to belong to an ethnic group rather than to a nation or a nation state.

Environmental changes in Africa, including climate change, are expected to create new conditions for migration. As we have seen in the first chapter, all countries will be affected by climate change, but some are more immediately and particularly exposed and vulnerable. As stressed by the IPCC report (IPCC, 2007), Small Island Developing States[1], Africa, Mega-deltas (particularly in Asia) and the polar regions represent the hotspots of the world with respect to vulnerability to climate change and variability.

Climate-induced migration depends not only on exposure to the physical effects of climate change (climate drivers), but also on crucial vulnerability and resilience to changes in climate and on adaptive capacity of areas and people (non-climate drivers). The nexus between climate change and

[1] In Africa, there are six small island states: Cape Verde, Comoros, Guinea-Bissau, Mauritius, Sao Tome and Principe, and Seychelles, with a total population of nearly 4 million people (*source*: UN Department of Economic and Social Affairs, 2003). They are all members of the Alliance of Small Island States (AOSIS), a coalition of small island and low-lying coastal countries sharing similar challenges and concerns about the environment, especially their vulnerability to the adverse effects of global climate change. AOSIS has 39 member states and 4 observers from Africa, the Caribbean, the Indian Ocean, the Mediterranean, the Pacific and the South China Sea.

human mobility, thus, requires to be investigated by taking into account the complex interaction between climate and non-climate drivers.

Global warming is among the highest-impact climate drivers causing displacements. Already in 1995, Myers and Kent stressed the dangerous impact of global warming on forced displacements:

> "Due largely to sea-level rise and flooding of coastal-zone communities, but also as a result of increased droughts and disruptions of rainfall regimes such as monsoonal systems, global warming could put large numbers of people at risk of displacement by the middle of next century if not before." (Myers and Kent, 1995, p.8)

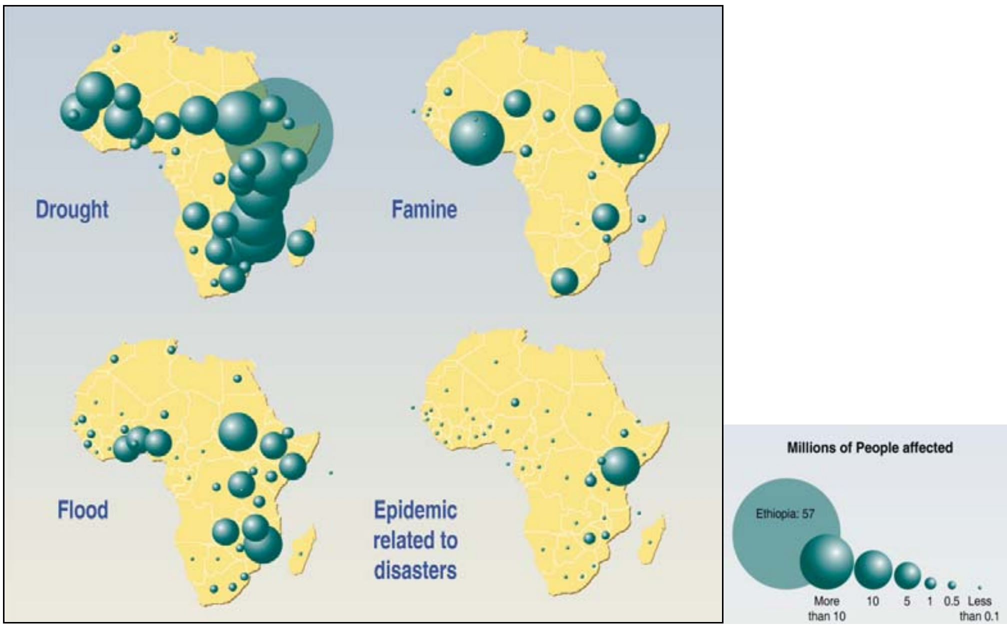
Preliminary estimates indicate that the total of people at risk of sea-level rise in Egypt could be 12 million, out of the 162 million at global level. At the same time, at least 50 million people could be at risk through increased droughts and other climate dislocations (Myers and Kent, 1995).

Many authors (see for example El Hinnawi, 1985; Lonergan, 1998; McLeman, 2006; Stern, 2006; Brown, 2007; IPCC, 2007b; Renaud et al., 2007; Kälin, 2008) agree upon differentiating the meteorological impact of climate change under two distinct drivers of migration: climate events, mainly sudden natural disasters such as floods, droughts, storms and cyclones, and climate processes, i.e. slow onset climate deterioration such as sea-level rise, salinisation of agricultural land, desertification and growing water scarcity (Brown, 2007).

Climate events can serve as an immediate push for migration, creating environmental or disaster refugees (Renaud et al., 2007), who are forced to flee the worst. In these cases, the displacement can be either temporary or permanent. Increased drought risk, heat waves and water stress in tropical and sub-tropical dryland areas and their expansion, are one of the results of higher temperatures and lower overall rainfall; on the contrary, increased flood risk, especially in low-lying coastal deltas in the Tropics, is a result of the combination of sea-level rise, increased rainfall in the Summer monsoon season in South and South East Asia and East Africa, increased intensity (though not frequency) of tropical cyclones, and increased snow and ice melt in major river basins in Asia (Black et al., 2008).

As we can see from the picture below, during the period 1971-2001, millions of people in Africa suffered from droughts, famines, floods and epidemic diseases related to natural disasters.

Figure 13 – People affected by natural disasters during the period 1971-2001



Source: Office of US Foreign Disaster Assistance (OFDA) and Centre for Research on the Epidemiology of Disasters (CRED) of the Université Catholique de Louvain, 2002.

A study realised by Grote and Warner within the framework of the EACH-FOR Project, has emphasised the correlation between natural disasters and migration phenomena in Sub-Saharan Africa. Through the analysis of four case studies - Ghana, Mozambique, Niger and Senegal - the authors highlight the migration flows subsequent to natural disasters, such as the droughts of the 1970s and early 1980s in the Northern part of Ghana, the droughts in the Southern regions of Mozambique over the 1980s and the floods of a number of river basins in 2000, severe droughts in Niger in the mid-1970s, the Sahelian drought lasting from 1972 to 1984 in Senegal (Grote and Warner, 2008).

According to the environmental science, including IPCC reports and the Stern review, African vulnerability to climate change is mainly due to the dependence of people on the environment for their livelihoods, hindered by the presence of multiple stresses (pre-existing conflicts, poverty and unequal access to resources, weak institutions, food insecurity and incidence of diseases). Long-term climate processes are those which mostly affect the livelihoods of African people.

> "At some point that land becomes no longer capable of sustaining livelihoods and people will be forced to migrate to areas that present better opportunities" (Brown, 2008, p. 19).

In these cases, cumulative and slow onset changes in the environment could create environmentally forced migrants (Renaud et al., 2007), pushing people to migrate in order to avoid the worst, often on a permanent basis. Examples include movement due to sea-level rise, a major livelihood threat, especially in vulnerable societies that do not possess the economic and technical means to cope. Global average sea level, after accounting for coastal land uplift and subsidence, is expected to rise between 8cms and 13cms by 2030, between 17cms and 29cms by 2050, and between 35cms and 82cm by 2100, according to the model and scenario used. Thermal expansion of sea water accounts for nearly two-thirds of this rise with glacial melt providing the rest. Large delta systems are at particular risk of flooding (Hemming et al., 2007). The localisation of the consequences of rising sea levels is a relatively easy task because the configuration of coastlines, their altitude and population are well known. The possible melting of Greenland ice cover and the consequent 7-metre rise in sea level, cited by the 2007 IPCC Report, would occur over several thousand years but the thermic expansion of the oceans is a major concern even today. According to the A1B scenario of the IPCC on future CO2 emissions, based on continuing economic growth but with a moderation of the fossil fuel use, the oceans will grow from 0.3 to 0.8 metres by 2300 (IPCC, 2007b). We can therefore consider populations living at an altitude of less than 1 metre to be directly vulnerable by the next century.

Sea-level rise may lead to the flooding of coastal areas, which may be evacuated as water encroaches upon human habitats (Stern, 2006; UNDP, 2004; UNESCO-WWAP, 2006). Sea level rise, caused by a reduction of the glacial coverage, is a major concern in Africa, where UN projections suggest that 123 million people or over 10% of the continent's population, may be living in about 45 cities of a million people or more by 2015. Of these, 53 million will live in 18 coastal cities vulnerable to flooding, including big coastal cities such as Abidjan, Accra, Alexandria, Algiers, Cape Town, Casablanca, Dakar, Dar es Salaam, Djibouti, Durban, Freetown, Lagos, Libreville, Lome, Luanda, Maputo, Mombasa, Port Louis, and Tunis (UN-HABITAT, 2008).

> "Some estimates suggest that 150 - 200 million people may become permanently displaced by the middle of the century due to rising sea levels, more frequent floods, and more intense droughts" (Stern, 2006, p. 77).

In Senegal, for example, a 1-metre rise in sea level could inundate and erode more than 6,000 km^2 of land, most of which is wetland, thus putting at risk at least 110,000-180,000 people-or 1.4-2.3% of the 1990 population of Senegal (Dennis et al., 1995).

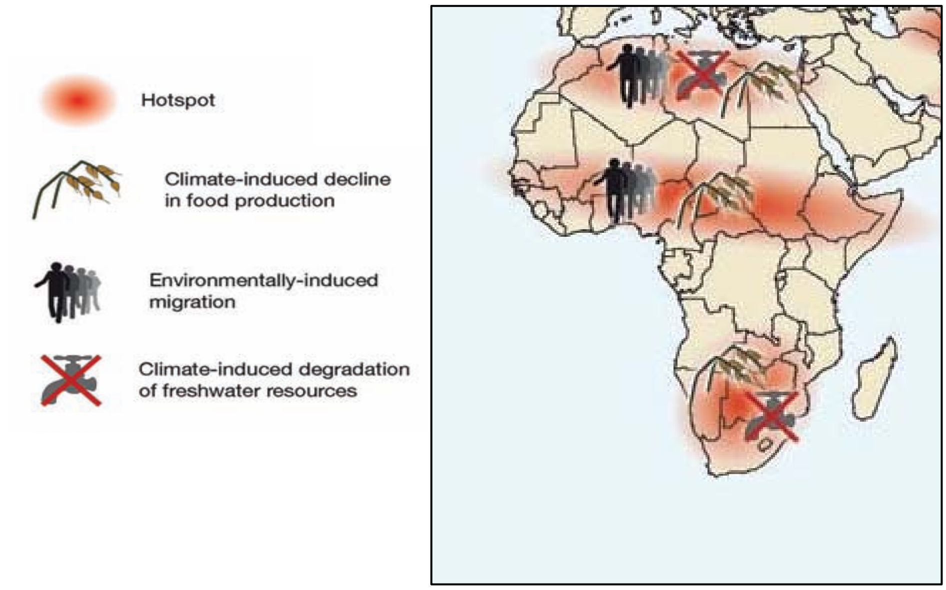
It is worth noting that, as temperatures rise and the land becomes less productive, the process of urbanisation is likely to accelerate, subsequently generating additional competition for scarce resources and public services in cities across the globe. The incidence of vector-borne diseases is also likely to increase as a result of climate change, as well as the cost of food and energy. Increased social tension and political conflict is thus likely, both within and between states. In some situations, people will be displaced in large numbers and in short periods of time as a result of sudden onset disasters such as cyclones, floods and tsunamis (UNHCR, 2008).

Countries across the Sahel zone of Africa have amongst the world's highest fertility rates, and so a rising number of potentially affected people by environmental changes. Furthermore, given that a large proportion of urban growth in Africa is accounted for by the ever-increasing expansion of slums, which are invariably sited in highly vulnerable locations, rural-urban migration may simply mean the translocation (or even escalation) of climate vulnerability from one place to another, especially for the poor (Black et al., 2008).

At the same time, climate processes may also create to leave a steadily deteriorating environment, in order to pre-empt the worst (Renaud et al., 2007). Migrants, in this case, will leave from areas that cannot support their basic needs and desire an improved quality of life. So deterioration of land, water stresses (including water shortages, unsafe water and inadequate sanitation), and altered distribution of disease vectors can lead to a decline in living standards that increase the costs of staying against the costs of leaving.

The picture below suggests that environmentally-induced migration could be felt more dramatically in arid and semi-arid areas.

Figure 14 – Africa: Security risks associated with climate change



Source: German Advisory Council on Global Change, 2007.

As we have seen in the first chapter, the Sahel and the Horn regions are among the most vulnerable areas in Africa to general environmental changes. Additional knowledge is required with respect to the environmental hotspots where displacement is most likely, and coping mechanisms, even if some hypotheses have already been developed. Of the 25 million environmental refugees recorded by Myers in 1995, roughly five million were in the African Sahel, where ten million people fled from droughts, half of whom only returned home. Other four million out of eleven million refugees of all types, were in the Horn of Africa including Sudan (Myers, 2005). In Nigeria, 3,500 square kilometres of land are turning into desert every year. As the desert advances, farmers and shepherds are forced to move into the shrinking habitable areas or overcrowded cities (Brown, 2004).

	McLeman, 2006	*El Hinnawi, 1985*	*Lonergan, 1998*	*Renaud et al., 2007*	*Brown, 2007*	*Kälin, 2008*
Climate drivers	**Climate events** (such as flooding, storms and glacial lake outburst floods)	Migration due to natural disasters	Environmental stresses as natural disasters	**Environmental refugees** (including disaster refugees) flee the worst; displacement can be either temporary or permanent		Hydro-meteorological disasters
	Climate processes (such as sea-level rise, salinization of agricultural land, desertification and growing water scarcity)	Migration due to permanent habitat changes	Cumulative or slow-onset changes of the environment	**Environmentally-forced migrants** "have to leave" in order to avoid the worst, often on a permanent basis. Examples include movement due to sea-level rise or migration from the Sahel zone of Africa due to desertification		Environmental degradation and slow onset disaster; The case of sinking small island states
		Migrants from areas that cannot support their basic needs and desire an improved quality of life		**An environmentally-motivated migrant** "may leave" a steadily deteriorating environment in order to pre-empt the worst.		
Non-climate drivers			Accidental disruptions or industrial accidents;		Non-climate drivers, such as government policy, population growth and community-level resilience to natural disaster, are also important.	Zones designated by governments as being a too high risk as well as dangerous for human habitation
			Development projects that involve changes in the environment (such as dams)			
			Conflict and warfare			Armed conflict

In Africa, the impact of climate change on human mobility is strictly related to African vulnerability to climate change, *"aggravated by the interaction of 'multiple stresses', occurring at various levels, and low adaptive capacity"* (IPCC, 2007b, p. 435). Environmental change rarely causes human mobility in isolation from a broader range of social factors. So, poverty serves as an additional push factor associated with the environmental problems which lead to people displacement. Likewise, population pressures, malnutrition, landlessness, unemployment, over-rapid urbanisation, pandemic diseases and faulty government policies, together with ethnic strife and conventional conflicts represent other push factors (Myers, 2005).

They are all non-climate drivers which can be found in real situations, in close association with climate drivers and with the implication that to draw a causative, linear line between climate change and forced migration is very difficult.

Furthermore, societies themselves are responsible for some of the environmental changes that in turn affect environmentally-induced migration. As we have seen in the first chapter, African vulnerability to climate change and degradation broadly depends on the impacts of human activities on ecosystems. So, the most relevant long-term climate drivers of migration, namely desertification and land degradation, largely depend on human-induced factors such as persistent population growth, increasing pressure on land resources, overgrazing and deforestation, whose effects are mostly amplified by current development models. Climate-driven conflicts are also a major cause of livelihoods contraction and drivers of human mobility (see paragraph 2.2 for further details).

Moreover, among non-climate drivers of human displacement, we can consider the vulnerability and resilience of areas and people, including their capacities to adapt. A natural hazard (e.g. an approaching storm) becomes a 'natural disaster' only if a community is particularly vulnerable to its impacts (Brown, 2008). A tropical typhoon, for example, becomes a disaster if there is no early-warning system, the houses are poorly built and people are unaware of what to do in the event of a storm. Then, a community's vulnerability factor is a function of its exposure to climatic conditions (e.g. a coastal location) and the community's adaptive capacity (the capacity of a particular community to weather the worst of the storms and recover after it) (Brown, 2007).

Different regions, countries and communities have very different adaptive capacities: pastoralist groups in the Sahel region, for instance, are socially, culturally and technically capable of dealing with a different range of natural hazards (Hesse and Cotula, 2006). National and individual wealth is a clear determinant of vulnerability – enabling better disaster risk reduction, disaster education and speedier responses (Brown, 2007).

Migration can also be a result of maladaptation practices. In this regard, Steve Lonergan has emphasised how development projects involve changes in the environment. People involuntarily displaced by public works projects, notably large dams, are increasing by 10 million every year (with a cumulative total of 50 million in just China and India) (Lonergan, 1998). Most of them resettle elsewhere, but the number remaining in a refugee-like situation totals at least 1 million (Myers, 2005).

Table 13 – Migration drivers and their potential sensitivity to climate change

Migration drivers	Sensitivity to future climate change	Intervening factors in migration outcome from climate forcing	Policy implication for reducing sensitivity of migration to climate
Political instability and conflict	Possible conflict and/or displacement resulting from large-scale water management projects that respond to water stress	Humanitarian aid distribution	Conflict early warning and prepositioning of humanitarian aid
	Potential for farmer-herder conflict in drylands	Humanitarian aid distribution	Conflict early warning and prepositioning of humanitarian aid
Lack of economic opportunities	Subsistence agriculture and fisheries most directly affected by environmental shocks and stresses of all kinds. Agriculture particularly affected in drylands and coastal wetlands	Level of technology and capitalisation of sector, extent of diversification of livelihoods; asset base, including human capital; existence of family or social networks; knowledge of opportunities elsewhere. Acute problems may be mitigated by humanitarian aid	Investment in agriculture and fisheries to support adaptive capacity; pro-poor policies to support resilience and adaptive capacity; famine early warning and prepositioning of humanitarian aid
	Undermining of urban livelihoods a possible consequence of floods in low-lying cities, potentially lowering rural-urban migration, and encouraging return, but also potentially encouraging onward international migration	Overall economic climate will affect impact on range of livelihoods	Develop and maintain flood defences in low-lying cities
Lack of access to natural resources	Loss of biodiversity affecting access to forest products	Extent of reliance on ecosystem for biodiversity, food, fibre, medicinal products and 'free' services such as, protection from natural hazards, water and air purification, and disease and pest regulation. Cultural, economic, social, natural and physical asset base to enable migration	Ecosystem protection legislation and programmes.
	Increased length of growing season in some areas could lead to land expropriation and loss of access to land for poor	Possibility of forcible land expropriation dependent on political system	Support rule of law and equitable policies for land distribution
Availability of employment and demand for workers	Increased drought and water stress may undermine employment opportunities in existing areas of commercial agriculture	Effect of agricultural decline may be mitigated by diversification away from agriculture	Migrant worker rights legislation
Higher wages in destination regions	Increased drought and water stress may place pressure on wages in existing areas of commercial agriculture	International and national labour market	Trans-boundary migrant worker agreements
Political stability	Unclear		
Access to resources	Unclear		
Ease of transportation	Flooding may make travel difficult in affected areas	Likely effect temporary	Complementary rural development polices
Family and social networks	Unclear		
Government immigration and emigration policies	Public concern about 'climate change refugees' could lead to either hardening or softening of immigration policy in potential receiving nations		
Trade and investment ties	Unclear		
Social and cultural exchanges	Unclear		

Source: Black et al., 2008, pp. 70-71.

2.2.2. Migration patterns

Migration patterns are difficult to be predicted, particularly where this involves moves across international borders. In general, south-south migration is increasingly significant and is estimated to account for 69 percent from Sub-Saharan Africa, the highest percentage in the world. Furthermore, south-south migration is largely intra-regional, which is estimated to be over three times more diffused than migration to countries in other developing regions (Ratha and Shaw, 2007).

Most forced migration related to climate change, is likely to be internal and regional, as well as particularly concentrated in Asia and Africa. Short-distance migration and mobility are more sensitive to climate change impacts whilst long-distance moves are more likely to be mediated or outweighed by economic or social considerations (Black et al., 2008).

Often, the distance across which people migrate depends on their family's resources (see Box 5 in the Appendix). Temporary migration can help a family's income through remittances and reduce the draw on local resources (Brown, 2007). In Western Sudan, for instance, studies have demonstrated that an adaptive response to drought is to send an older male family member to Khartoum to try to find paid labour, so as to tide the family over until after the drought (McLeman and Smit, 2004). So, although a rise in the numbers of trans-continental migrants from the Sahel region of Africa is possible, it is much more likely that rising numbers of affected populations will seek to earn money by working in the cities of the region, in particular in bigger cities such as Lagos, Abidjan and Accra (Black et al., 2008). Past experience confirms this hypothesis, for istance the studies conducted in Burkina Faso (Henry et al., 2004) and Mali (Findley, 1994) demonstrated that the drought in the 1970s and 1980s was associated with decreases in international, long-distance migration, while short-distance migration to larger agglomerations and circular migration increased.

The case of Ghana is also particularly emblematic, since internal, regional and international migration flows can be found. Internal migration in Ghana is predominantly North-South, from poor rural areas in the North to the most industrialised and urbanised coastal zones in the South. The analysis of regional migration outlines that the majority of migrants from Ghana to the neighbouring states migrated from an urban centre, and also that Ghana is a receiving country, especially from Liberia, Sierra Leone and the Ivory Coast. International migration mostly originated from Southern Ghana, the richest part of the country. The United Kingdom, due to colonial ties, houses the largest and longest-standing Ghanaian community in Europe but sizeable populations are also to be found in Germany, the Netherlands and Italy (Grote and Warner, 2008). These dynamics confirm that long-distance moves (regional or international) are only possible for people with adequate economic resources and cannot be an opportunity for survival for the poorest populations.

Since vulnerable people have little chance to move, adaptation capacities e.g. different land-use techniques, become crucial.

> In addition, "climate change impacts can impoverish them and reduce their mobility even further. As is the case with drought, sudden disaster impact depends on several political and socio-economic factors, including adaptation measures (for example flood defence infrastructure)". (Kolmannskog, 2008, p.4)

An example of this can be found in the case of Mali during the drought of the mid 1980s, where a reduction in international emigration was observed due to the lack of available means to migrate (Findley, 1994). Other examples can be found in a study recently carried out under the frames of the Environmental Change and Forced Migration Scenarios (EACH-FOR) Project with the support of the Sixth Framework Programme of the European Commission, where Ulrike Grote and Koko Warner give evidence - on the basis of a number of case studies - of the different migration patterns related to climate change (Grote and Warner, 2008). Between 1960 and 2000, deteriorating situations due to rainfall decreases, land degradation, and violence in the arid and semi-arid areas of Senegal, Mali, Burkina Faso and Niger resulted in a rapid intra-country migration southward and in a swelling of the big cities like Dakar, Bamako, Ouagadougou, Niamey and Kamo (Dietz and Veldhuizen, 2004).

As already examined, climate change has an impact both on sudden natural disasters, namely floods and hurricanes, and slow-onset disasters, namely droughts: The most vulnerable developing countries are where large sections of the population live directly on agriculture and many of these on subsistence farming. As Brown noted, natural disasters might lead to the displacement of large numbers of people for relatively short periods of time, but the slow-onset drivers are likely to permanently displace a higher number of people in a less headline grabbing way (Brown, 2007). These conclusions are shared and further explored by the analysis carried out by Etienne Piguet on hurricanes, torrential rains and floods which tends to relativise their effects in terms of migration in general, and long-term migration in particular. The victims are poor and consequently have little mobility. The majority of displaced people return as soon as possible to reconstruct their homes in the disaster zones. As a conclusion, the potential of hurricanes and torrential rains which provokes long-term and long-distance migrations, remains limited (Piguet, 2008).

Drought and desertification tend to generate progressive departures, because the effect of a lack of drinking and irrigation water on migration is less sudden compared to meteorological events, like hurricanes and floods. The impact of slow onset disasters can be huge and there are many well-known cases of mass population departures, in particular in Africa (Sahel, Ethiopia) as well as in other regions (Piguet, 2008). For instance, according to Thomas Hammer, droughts and floods in the Sahel between 1973 and 1999 forced an impressive number of people to move, with a maximum figure of one million displaced persons during the drought in Niger in 1985 (Hammer, 2004).

Nevertheless, there are also cases of low migration rates, for example the 1994 drought in Bangladesh, and many researchers highlight the fact that migration is just the last option, when all other survival strategies have been exhausted (Piguet, 2008). In addition to environmental degradation, many other variables need to be considered, on a case-by-case basis. From a study conducted by Sabine Henry, Paul Boyleb and Eric F. Lambin on interprovincial migrations in Burkina Faso, it emerged that environmental variables explain only 5 per cent of migrations, while drought only 0.8 per cent (Henry et al., 2003). As a result, a positive causal link between drought and migration is not always observed, and forecasts of the magnitude of the populations at risk or eventual migrations arising from global warming-induced droughts remain hazardous (Piguet, 2008). On the contrary, in the case of sea-level rise, potential migration is always sizeable. This is a virtually irreversible phenomenon and migration might be the only possible option for the population affected (Piguet, 2008).

Another study about Burkina Faso demonstrated that people from drier regions are more likely to migrate temporarily and permanently to other rural areas (rural-rural migration), compared to people from wetter areas. Furthermore, the same study affirms that long-term migration seems to be less related to environmental conditions than short-term moves (Henry et al., 2004).

Finally, concerning migration patterns, Black also notes that not only push factors may be affected by climate change, but also the conditions in the destination areas, with the effect of both encouraging and limiting migration. He provides two examples. On one hand, large areas in Southern US and Southern Europe currently attract migrant workers from Central America and North and Sub-Saharan Africa, respectively, to work in irrigated agriculture. In these areas, declining rainfall and increased temperatures are likely to augment the costs and could potentially undermine the viability of a number of enterprises. This would, in turn, undermine the patterns of migration that are now well-established, either cutting them off, or diverting them to other places or other sectors. A counter-example is provided by improving conditions for agriculture in Northern Europe, and especially throughout certain areas in Central Russia, which stands to be a major gainer from climate change in terms of length of the growing season under most current forecasts. Here, the effect may be the opposite, i.e. to accelerate existing migration flows from Southern and Eastern Europe to Northern Europe, and from Central Asia to Russia (Black et al., 2008).

Table 14 – Climate changes and their potential impacts in Africa

Slow-onset change					
Climate Changes	**Climate Impacts**	**Societal Related Impacts**	**Confidence/ likelihood of climate change**	**Regional distribution of climate impacts over Africa**	**Main types of migration likely to be impacted**
Increased atmospheric C02	Acidification of the oceans	Detrimental impact on corals and dependent species	Very likely	Global	Coastal to urban and rural
	Carbon fertilization effect	Potential increases in vegetative growth. Possible declines in food quality	Likely	Global impact with maize benefiting less than rice and wheat	International, rural to urban and urban-rural
Temperature increases	Changes in potential evapo-transpiration	Increasing water stress and drought risk and reduced crop productivity over northern, southern and western Africa, central America, Mediterranean Europe and the Amazon	Likely	In all four season throughout Africa the median temperature increase is likely to be roughly 1.5 times the global mean change. The largest values of changed are predicted in western Sahara with the largest responses in North Africa for June, July and August and the largest in southern Africa occurring in September, October and November	Rural to rural, rural to urban and seasonal
	Changes in sea and lake surface temperatures	Changes in distribution and productivity of particular fish species with local extinctions in freshwater and diadromous species			
	Increased plant metabolism	Decreases in yields in seasonally dry and tropical regions. Further warming has increasing negative impacts in all regions			
	Increases in arid and semi-arid land	Declining agricultural yields in marginal areas in Africa and Asia	High confidence		
	Snow and ice melt	Reduced summer and autumn river flows and increased water stress in glacier and snowmelt fed river basins	Medium confidence	Not applicable	Rural to rural, rural to urban and seasonal
	Ecosystem changes change	Loss of biodiversity, food, fibre, medicinal products and 'free' services such as, protection from natural hazards, water and air purification, and disease and pest regulation	Very high confidence	Mangrove, coral reefs, mountain and Mediterranean-type ecosystems most vulnerable to climate change	Rural to rural and rural to urban

	Changes in disease vectors and other influences on human health	Increased burden of diarrhoeal disease; mixed effects on the range and transmission potential of malaria in Africa; increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change; altered spatial distribution of some infectious disease vectors	Likely	Previously malaria-free parts of southern Africa including Zimbabwe and South Africa and highland areas in Ethiopia, Kenya, Rwanda and Burundi could see modest incursions of malaria. Large part of the western Sahel and much of southern central Africa likely to become unsuitable for malaria transmission	Unclear
Sea level rise	Inundation, increases in storm surge frequencies, and salinisation of groundwater and estuaries	Loss of life and negative impacts on economic and transportation systems, buildings and infrastructure. Mega deltas, low lying coastal urban areas and small islands most affected	Likely	Cities such as Lagos and Alexandria vulnerable. East African coasts vulnerable to changes in storm surges related to ENSO events	Coastal to rural and urban, forced migration, internally displaced and distress
Changes in precipitation	Decreased subtropical precipitation for southern Europe, Mediterranean Africa, Central America, southern Africa, southern Andes in and southern Australia	Increased water stress and drought risk and crop yield reductions	Likely	Hydrologically critical ‘unstable’ in east-west band from Senegal to Sudan, separating the Sahara from Central Africa. Significant reductions in runoff in parts of southern and northern Africa (particularly Mediterranean Africa) by 2055	Rural to rural, rural to urban and seasonal
	Increases in rainfall in summer monsoon season of south and southeast Asia and east Africa	Increased flooding risks and some potential increases in crop production	Likely	Reduction in water stress in eastern Africa. Less robust signal in west Africa	Internally displaced and distress
	Increase in heavy rainfall events in many regions	Increased flooding and soil erosion risk. Impacts on water pollution	Likely	Increase in number of extremely wet seasons in East Africa increase from 1 in 20 to 1 in 5. In southern Africa frequency of extremely dry austral winters and springs increases to roughly 20% and frequency of extremely wet austral summers doubles	Rural to rural and rural to urban
Increased in frequency and length of heat waves	Reductions in soil moisture	Increased drought risk and stress on humans and livestock. Impacts on water pollution	Very likely	Increased temperatures over continental interiors	Rural to urban

Decline in frost days	Increase in growing season length	Potential increase in crop production in some mountainous regions	Likely	Highland areas	Rural to rural, urban to rural and seasonal
Changes in number and intensity of tropical cyclones	Increased peak wind intensities, mean precipitation and peak precipitation intensities in tropical cyclones	Increased flooding and soil erosion risks. Loss of life and negative impacts on economic and transportation systems, buildings and infrastructure. Impacts on water pollution	Not given	East African coasts most vulnerable	Internally displaced and distress
Fewer mid-latitude storms	Increased extreme wave heights at higher latitudes.	Decreased storms at some mid-latitudes	Not given	Will affect extreme north and south of Africa	Unclear

Abrupt/catastrophic change			
Climate Change	**Climate Processes Impacted**	**Societal Impacts**	**Main types of migration likely to be impacted**
Collapse of thermohaline circulation	Lower temperatures across Europe and parts of North America and precipitation changes globally	Increase in drought risk and reductions in crop productivity in southern Asia and over much of South America, however with reduced drought risk in eastern Brazil	International, rural to rural, rural to urban and seasonal
Rapid melting of the Greenland and West Antarctic ice sheets	Glacial acceleration and large increases (2m/century) in sea level	Loss of life and negative impacts on economic and transportation systems, buildings and infrastructure. Mega deltas, low lying coastal urban areas and small islands most affected	Rural to rural, rural to urban, urban to rural, forced migration, internally displaced and distress
Accelerated change caused by increased emissions of methane from Thawing permafrost or warmer sea, and release of carbon from soil and dieback of Amazon	Enhanced greenhouse gas effect	Increase in flood risk for east Africa and in south and east Asia; major increase in drought risk and reduction in crop productivity across rest of Africa and South America. Elimination of spring peak runoff across much of Asia reduces water availability for irrigation and power generation. Increased hot season mortality and potential for disease transmission for Africa, South America and Asia	Rural to rural, rural to urban, internally displaced and distress
Permanent El Nino	Drier than normal conditions over south eastern Africa and northern Brazil, during the northern winter season and less than normal Indian monsoon rainfall, especially in northwest India	Increased water stress, drought and drought related ill health and mortality. Crop productivity and potential for power generation reduced	Rural to rural, rural to urban
	Increased sea surface temperature in eastern Pacific	Reduction in fisheries production in eastern Pacific	Coastal to rural and urban
	Wetter than normal conditions along the west coast of tropical South America, and across sub-tropical South America (southern Brazil to central Argentina)	Increased flood risk and flood related ill health and mortality. Potential increases in crop production	Internally displaced and distress

	Storms also tend to be more vigorous in the Gulf of Mexico and along the southeast coast of the United States	Loss of life and negative impacts on economic and transportation systems, buildings and infrastructure. Impacts on water pollution Increased flood risk	Internally displaced and distress
	The eastward shift of thunderstorm activity from Indonesia into the central Pacific during warm episodes results in abnormally dry conditions over northern Australia, Indonesia and the Philippines in both seasons	Increased drought risk and drought related ill health and mortality. Crop productivity and potential for power generation reduced. Fire damage risk increases.	Rural to rural and rural to urban, internally displaced and distress

Source: Black et al., 2008, pp. 64-69.

3. CONCERNS FOR PEACE, STABILITY AND BIODIVERSITY

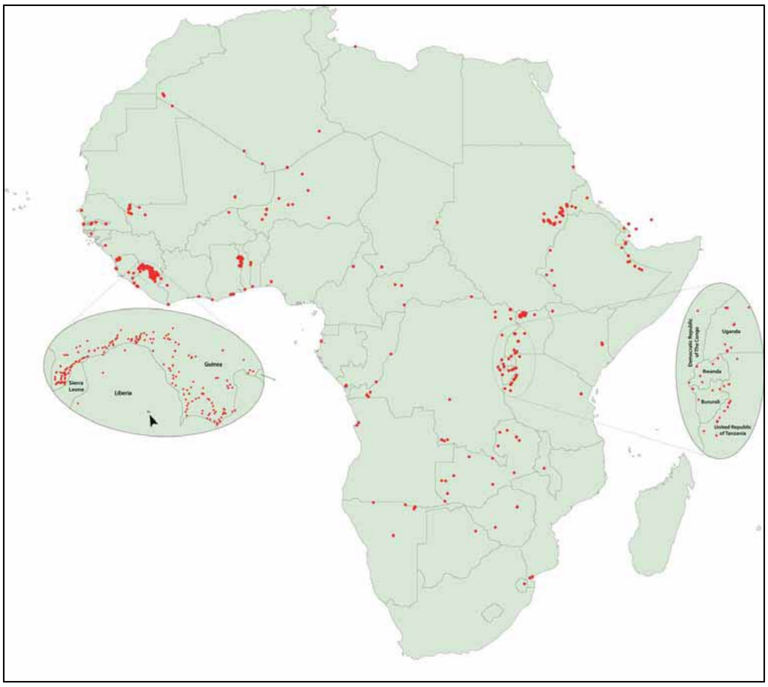
According to several authors, climate-related issues and environmental refugees are foreseen to become an even more direct and common driver of conflicts and, in a vicious circle, conflicts are likely to spawn further forced displacements.

In the context of the north-south discourse, the term "environmental security" can suggest that the underdeveloped South poses a physical threat to the prosperous North by population explosions, resource scarcity, violent conflict and mass migration (Dalby, 2002). Nonetheless, the majority of environmental refugees – and so refugees in general - are located in developing countries, which have very limited hosting capacities. What is more, most forced migration and conflict related to climate change is likely to remain internal and regional (Kolmannskog, 2008).

Climate change will have several impacts on the environment which in turn can impact on forced migration and conflict. Forced migration can be triggered by environmental change or conflicts and trigger conflicts, contributing to competition for land and water resources in transit or destination areas. Obviously, conflict potential also depends on socio-economic and political variables: Environmental degradation or sudden disasters are more likely to have a strong impact on conflicts where socio-economic conditions are particularly adverse and governments are fragile. Governance and the role of the State are often crucial factors for preventing environmentally-induced migrations and conflicts (Kolmannskog, 2008). At the same time, massive migrations, particularly in the arid or semi-arid areas in which more than a third of the world's people live, can weaken governance capacities, thus turning fragile states into failed states and increasing the pressure on regional neighbours (Ashton and Burke, 2005).

Starting from the considerations above, it is easy to understand that Africa is particularly vulnerable also with respect to human security and stability. Weak or absent governments, along with widespread poverty, exacerbate the likelihood of conflicts related to climate change. UNHCR estimates that there were 2.4 million refugees in Africa at the end of 2006 (UNHCR, 2006b).

Figure 15 – Major Refugee Camps in Africa



Source: UNEP, 2008.

Environmental stress may produce direct and indirect effects on conflict, as shown in the diagram below:

Table 15 – Environmental stress, Migration, and Conflict: Direct and Indirect Pathways

Direct Effect

Environmental stress → Migration from region A → Conflict in region B

Indirect Effect

Environmental stress → Conflict in region A → Migration from region A → Conflict in region B

Source: Gleditsch et al., 2007.

It is to be noted that there are important differences between conflict patterns stemming from "environmental migrants" versus "classic" refugees. While classic migrants have the potential to provoke a violent reaction, migrants fleeing directly from natural disasters such as flooding, hurricanes, and desertification are not likely to contribute to organised violence, although sporadic violence may arise. The International Peace Academy argues that purely environmental migrants often do not have political agendas in their home region and they do not necessarily regard themselves as victims of persecution who deserve justice. In addition, many environmental stresses relating to climate change are gradual and will lead to small, though sustained migration streams (Gleditsch et al., 2007).

Environmental degradation can exacerbate conflict, which causes further environmental degradation, creating a vicious cycle of environmental decline, tense competition for diminishing resources, increased hostility, inter-communal fighting, and ultimately social and political breakdown (UNEP, 2008). Circularly, conflicts and the presence of refugees have adverse impacts on the surrounding environments and significant social, political and economic implications.

One of the most significant examples of the circular nexus between climate change and conflicts can be found in the Darfur region in Western Sudan. The Darfur conflict is a complex crisis with multiple drivers, among which decades of drought, desertification and overpopulation which moved pastoralist societies searching for water into regions mainly occupied by farming communities. Apart from the millions internally displaced, more than 200,000 refugees are currently hosted in 12 UNHCR-run camps across the border in Chad, where the need for fuelwood has led refugees to destroy forests around the camps and dig new holes for water, which are depleting aquifers.

In contrast to the gradual and predictable changes in the population caused by high human fertility, migration flows can cause rapid and unexpected increases in population size and density, can be difficult to control and can have sudden impacts on biodiversity. For example, during the 1994 genocide in Rwanda, around 1 million refugees settled in the Goma area of the Democratic Republic of Congo (DRC), with devastating impacts on local forests (UNHCR, 2000).

The main direct negative impacts of migration on biodiversity are the following (Oglethorpe et al., 2007):

1) Species and genetic diversity loss from an area
2) Habitat loss and fragmentation
3) Loss of ecological connectivity and disruption of ecological and evolutionary processes

These impacts occur through unsustainable use of natural resources, habitat destruction, pollution, spread of invasive species and disease and climate change. Moreover, the impact of human displacement on the environment can be particularly dramatic with respect to natural resource management systems of local populations.

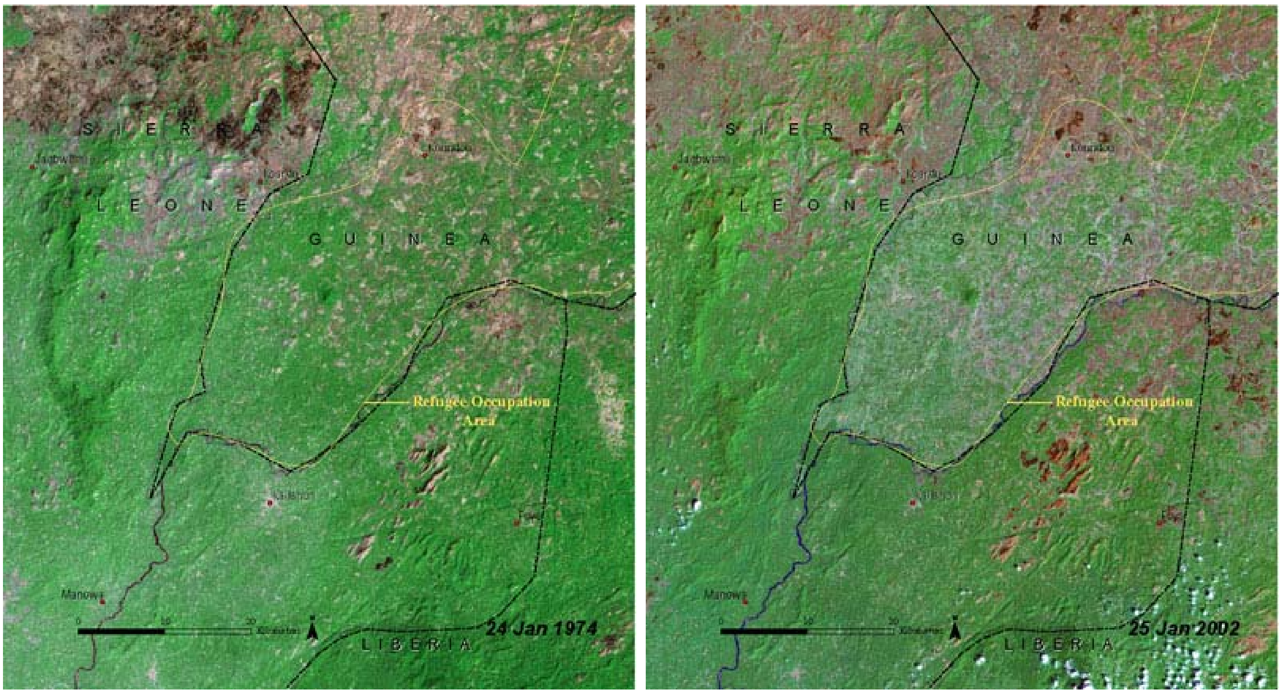
Migration that adversely affects biodiversity is usually rural-to-rural. Rural-to-rural migrations have the greatest impact, as areas of high biodiversity are usually rural, isolated areas (Oglethorpe et al., 2007). Rural-urban migration typically results in conversion of new land for settlement, increased demand for water, and increased fuelwood consumption if alternative energy sources are not available. Many urban centres in developing countries are surrounded by degraded vegetation, which has been cut for firewood and charcoal. This degradation also occurs along major transport routes. Urban-to-rural migration can also damage biodiversity. It often occurs in developing countries during economic downturns, when employment falls in towns and people return to seek a living in rural areas where they may have originated (Oglethorpe et al., 2007).

Much of the damage to biodiversity occurs in destination areas where migrants relocate. However, areas of origin can also be adversely affected. For example, when the traditional managers of land and natural resources leave an area, indigenous knowledge of sound management practices may be lost. There may also be serious impacts along the migration route (Oglethorpe et al., 2007).

Host countries often site refugees in remote, underdeveloped and marginal areas that have valuable but vulnerable biodiversity, where potential environmental impacts are great. If refugees and IDPs do not have adequate food, water and fuelwood, they may cultivate crops, hunt and collect from the surrounding areas. This can result in habitat destruction and species loss from the area (Oglethorpe et al., 2007).

The impact of refugees on the environment can be easily observed from some of the satellite images reported by UNEP (UNEP, 2008). The example below reports the case of Parrot's Beak in Guinea, where hundreds of thousands of people moved from civil wars in Sierra Leone and Liberia during the 1990s. The first image is prior to the flux of refugees, while the second one clearly shows the deforestation of the entire area.

Figure 16 – Changes in the Parrot's Beak region (Guinea) between 1974 and 2002



Source: UNEP, 2008.

Land and resource conflicts are widespread in Africa. For example, in February 1994, a land rights dispute between the Nanumbas and the Dagombas in the Northern region of Ghana erupted into an ethnic conflict, leading to 2,000 deaths and the internal displacement of 150,000 persons. Lake Chad is another major example. After the lake started to shrink in the 1960s, several crises occurred. Many migrants crossed national borders, and in 1983 territorial disputes over emerging islands in the lake led to the institution of the Lake Chad Basin Commission and the introduction of a joint patrol system. Until today, disputes and conflict about water, agricultural land and fishing remain aggravated by conflicts between ethnic groups (Grote and Warner, 2008).

Also development projects involving changes in the environment can lead to conflict. An example can be found in the severe changes in the Senegal river basin caused by the construction of the Manantali Dam, which caused disputes over irrigable land between Mauritania and Senegal and a flow of thousands of Senegalese and Mauritanians who crossed their common border in both directions (UNEP, 2006).

Internal and international conflicts may arise not only over the distribution of resources, especially water and land, but also over the management of migration, or over compensation payments between the countries mainly responsible for climate change and those countries most affected by its destructive effects (German Advisory Council on Global Change, 2007).

The German Advisory Council on Global Change identified four conflict constellations in which critical developments can be anticipated as a result of climate change and which may occur with similar characteristics in different regions of the world. “Conflict constellations” are defined as typical causal linkages at the interface of environment and society, whose dynamic can lead to social destabilization and, in the end, to violence (German Advisory Council on Global Change, 2007):

1) Climate-induced degradation of freshwater resources;
2) Climate-induced decline in food production (with global warming of 2–4 °C, a drop in agricultural productivity is anticipated worldwide; this trend will be substantially reinforced by desertification, soil salinisation or water scarcity);
3) Climate-induced increase in storm and flood disasters (sea-level rise and more intensive storms and heavy precipitation; this risks will be further amplified by deforestation along the upper reaches of rivers, land subsidence in large urban areas and the ever greater spatial concentration of populations and assets);
4) Environmentally-induced migration (migration can greatly increase the likelihood of conflict in transit and target regions).

As we have explained, conflict potential is most likely to remain internal or regional. Anyhow, concerns for international stability and security, mainly stemming from displacements into neighbouring countries, are founded.

The German Advisory Council on Global Change tried to identify the main threats to international stability and security arising if climate change mitigation will fail:

1) Possible increase in the number of weak and fragile states as a result of climate change;
2) Risks of global economic development;
3) Risks of growing international distributional conflicts between the main drivers of climate change and those mostly affected;
4) The risk for human rights and industrialised countries’ legitimacy as global governance actors;
5) Triggering and intensification of migration;
6) Overstretching of classic security policy.

CONCLUSIONS

The determination of the scale of environmentally-induced displacements is probably the most contentious issue among environment-migration matters. Measurement problems may arise because of different constraints, among which the lack of a clear definition of environmentally displaced people, the hitch of recognising environmental factors as a primary cause of migration, the scarcity of data and the use of different information sources.

These limits also reduce the reliability of estimations for the future. In addition, forecasts of environmental or climate change-related migration, and arguments on public policy action in response, can be challenged for further reasons. According to Oli Brown, predictions are complicated by three factors (Brown, 2007):

1) Unprecedented changes in the number and distribution of the world's population;
2) Current migratory movements are not sufficiently monitored and measured, except for cross-border migration;
3) Environmental scenarios, especially those after 2050, largely depend on present mitigation policies and practices.

Future uncertainty about the world's population greatly limits the credibility of future scenarios, as predictions on climate migration are mainly based on population projections. Demographic projections are important not only to understand the size of future displacements, but also because population pressures can boost the inclination to move. The global population is currently growing at a rate of 1.1 percent and in the meanwhile, there is an accelerating move to urban areas. The growth rate of the urban population is nearly double (2 percent) compared to the total population growth (UNFPA, 2006). These trends are even more pronounced in low and middle-income countries. The Sahelian region of Northern Nigeria, for instance, is characterised by high population growth (about 3.1 percent) and rapid urbanisation (about 7 percent) (Nyong et al., 2005).

In addition to this uncertainty, it is to be noted that figures depict the populations at risk, while to attribute both the entire urbanisation and the displacement of the whole population of an affected area to climate change, seems absurd (Brown, 2007; Black et al., 2001).

Forecasts of climate migration are also based on climate change scenarios, and in this case we can count upon more reliable predictions, since meteorological science and climate modelling techniques have progressed dramatically over the past decade. Among the most reliable scenarios, the Intergovernmental Panel on Climate Change (see Box 6 in the Appendix) is able to devise different future emission patterns according to demographic, technological and economic development.

The IPCC outlook for Sub-Saharan Africa is not promising (see the first chapter), since agricultural production and food security (including access to food) in many African countries and regions are likely to be severely compromised by climate change and climate variability. Climate change will also aggravate the water stress currently faced by certain countries, while other countries that currently do not experience this kind of issue, will become at risk of water stress. Changes in a variety of ecosystems are already being detected, particularly in Southern African ecosystems, and climate variability and change could result in low-lying lands being inundated. Also human health could be further negatively affected by climate change and climate variability. According to the IPCC projections, between 75 and 250 million people in Sub-Saharan Africa will be exposed to an increase of water stress (IPCC, 2007b).

In general, we can affirm that forced migration induced by climate change depends on several factors, among which (Brown, 2007):

1) The quantity of future greenhouse gas emissions;
2) The rate of future population growth and distribution;

3) The meteorological evolution of climate change;
4) The effectiveness of local and national adaptation strategies.

With regard to migration in general, at present it is estimated that worldwide migrants are 191 million, IDPs 23.7 million and refugees 8.4 million. Europe (including the Russian Federation) is the largest recipient of migrants, followed by Asia and North America (UNHCR, 2006a). According to Richard Black, in 2050 in the world there will be a total stock of international migrants between 235 and 415 million, with a median estimate of 275 million, 40% higher than the present (Black et al., 2008). As already noted, movement within national borders is at least as numerically significant as international migration, and is certainly the most significant form of migration for poor people. (DfID, 2007).

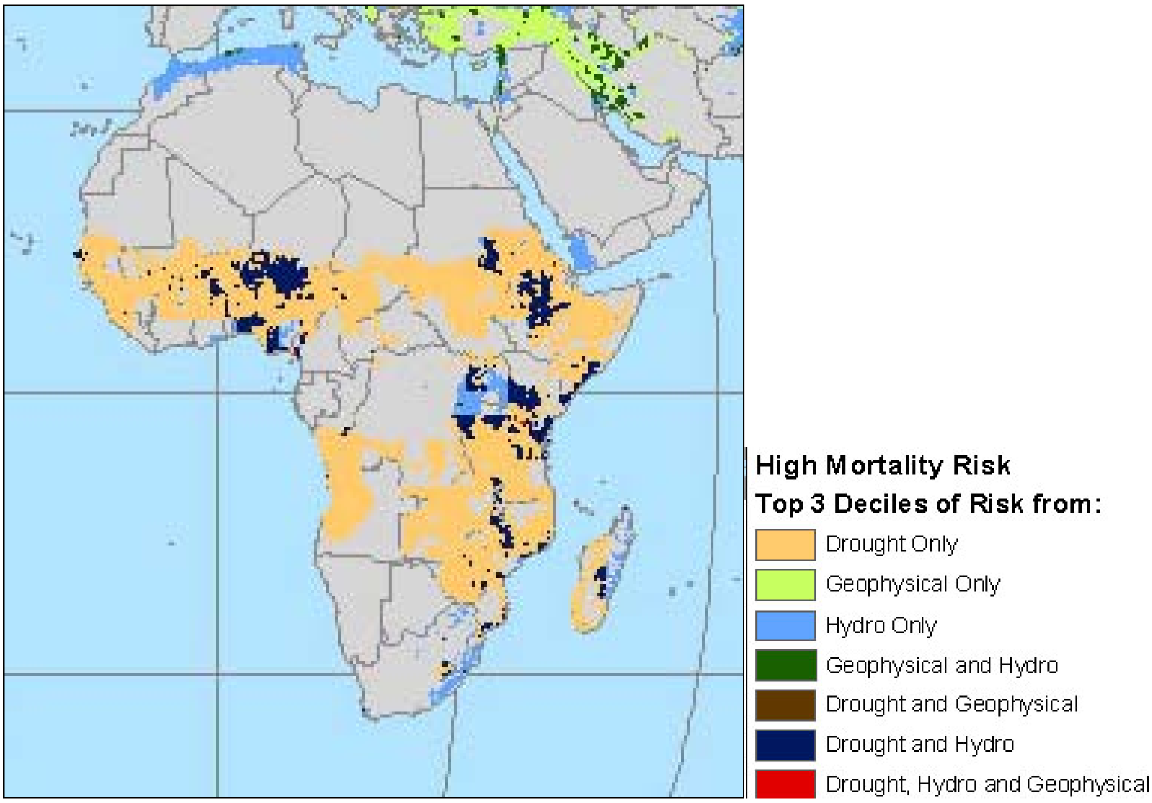
With particular reference to environmental migration, in 2002 the Office of the United Nations High Commissioner for Refugees estimated approximately 24 million people around the world who have fled because of floods, famine and other environmental factors (UNHCR, 2002). As we have already considered, Myers predicted 50 million environmental refugees by 2010 and up to 200 million when global warming will occur, on the basis of those populations at risk of sea-level rise, droughts and other climate dislocations (Myers and Kent, 1995). Myers is a very important reference in literature, but he has also been criticised and his theories alleged to be inconsistent and impossible to be verified (Kibreab, 1997; Black et al., 2001). Nonetheless, he is not the only one who tried to give estimates of the impact of climate change, as a driver of future forced migration; other authors envisaged even worst scenarios. Among others, the Stern Review Report on the Economics of Climate Change predicted from 150 to 200 million environmental refugees (Stern, 2006), while the Christian Aid up to 1 billion (Christian Aid, 2007). Besides, the UN University's Institute for Environment and Human Security confirmed Myers' estimation of 50 million environmental refugees by 2010 (UNU-EHS, 2005) and the Declaration of Almeria of 1994 mentioned that 135 million people could be at risk of displacement as a consequence of severe desertification.

With particular reference to Africa, Norman Myers reported that the region's population is expected to increase up to over 800 million people, 42% more than in 1995, while growth is predicted to stagnate. As a consequence, Africa will not be able to feed itself. About twenty countries with a total projected population of 440 million are expected to suffer up to 25% shortfall in food supplies, and further eight countries with a projected population of 75 million to face more severe deficits. Thus, the total number of malnourished people will continue to grow, and the food deficit will rise even further. In addition to demographic and economic problems, Africa will confront with global warming, increased droughts and other climate dislocations. According to Myers, severe desertification might affect more than 100 million people, while ten countries, collecting more than 400 million people, might experience chronic water shortages or acute water scarcity (Myers, 2001).

The key issues emerged by the literature analysis can be summarised as follows, representing possible paths to be taken into consideration by the international agenda.

Climate change implies a number of different risks for both rich and poor countries. Within the next 10–15 years, resolute climate policy actions are needed all over the world, in order to invert the current trend of unsustainable development, otherwise destructive consequences will intensify over the next decades. The urgency to act can be fully understood if we consider that because of the inertia in climate systems, even if all emissions ceased today, global warming would continue for another 30-50 years. Therefore, mitigation policies are a global challenge. The nation-state approach needs to be revised in favour of a global public goods approach.

Figure 17 – Global distribution of highest-risk disaster hotspots by hazard type: Mortality Risk



Source: Natural Disaster Hotspots - A Global Risk Analysis, The World Bank and Columbia University, 2005.

Besides the efforts to limit climate change and environmental degradation worldwide, investments in adaptation to environmental stresses are specially required in developing countries and in Africa in particular, in order to build local resilience and reduce pushes for migration or displacement as well as the risk of conflicts. Adaptation measures include disaster management, humanitarian response and – even more important – development. In fact, since vulnerability and resilience are also a function of social and economic conditions, local communities in the poorest countries are in need of specific support and adequate livelihoods.

Furthermore, climate change concerns should be more integrated into local, national and international development policies. Local and national governments are essential to implement adaptation policies and to prevent climate displacement because local development may act, at the same time, on multiple drivers such as poverty and social inequalities, unemployment and environmental unsustainability. The regional and sub-regional levels are also essential. African countries already participate in regional and sub-regional initiatives and programmes[2] but it is very important to strengthen this form of cooperation and dialogue, especially as far as the management of cross-border water and migration flows are concerned. The international community is also required to boost its commitments. International efforts should be more specifically targeted to poorest countries and to priority human needs such as basic nutrition, employment generation, health, water and sanitation, primary education and family planning. In Africa, the Sahelian and the Horn of Africa countries should be particularly targeted.

In recent years, climate change gained increasing importance in the international agenda but its implications on human mobility are still marginal. This is mostly due to a scarce worldwide awareness on environmentally-induced migrations and to a lack of official recognition of the

---

[2] Among these, the 1968 African Convention on the Conservation of Nature and Natural Resources and the 1991 Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Waste within Africa.

problem as a global concern. It is thus crucial to adopt an agreed definition for climate change-induced human mobility at international level, in order to avoid climate-induced migrants being considered as economic or voluntary migrants, especially in the case of gradual environmental degradation.

Once a definition will be agreed, it will be possible to set a new legal framework or the unambiguous enclosure of environmental migrants in an existing one, to ensure them access to financial grants, food, shelter, education and health services, and to allocate responsibilities among different actors.

Finally, more research is needed to understand the root causes and consequences of climate migration and to monitor numbers. This effort requires taking into account environmental causes associated with other factors, in particular, socio-economic and human factors, mitigation and adaptation practices, since it is not possible to isolate climate change as a cause of forced migration. A specific need is to develop local case studies, highlighting specific causes, patterns and routes of migration. Given the absence of local and regional data, especially for Africa, research on the causes and consequences has to be complemented by improvements in statistics, which in turn will allow for better estimates in the future.

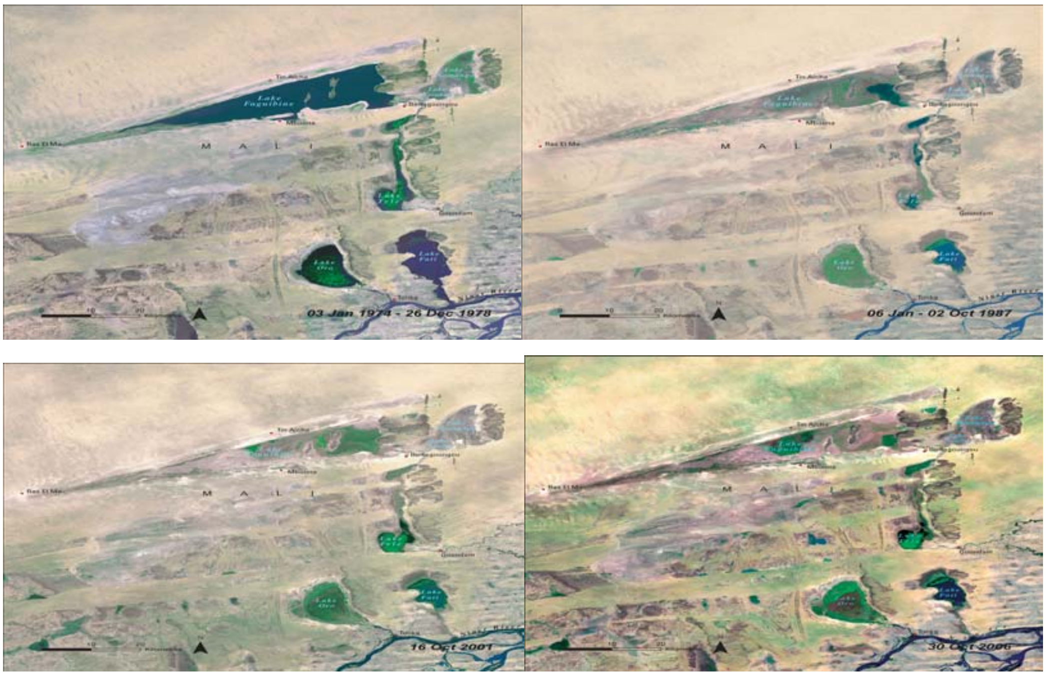
APPENDIX

Box 1. Lake Faguibine in Mali: Changes occured between 1978 and 2006

Lake Faguibine is located in the Sahelian−sub desert zone to the west of Timbuktu in northern Mali. Annual precipitation in the Faguibine area is in the range of 250 mm/yr, with the rainy season beginning in mid-June and lasting 3 to 4 months. When full, the lake is among the largest in West Africa − 590 square kilometers estimated in 1974 − and is an important source of water for the surrounding area. In the late 1980s, Lake Faguibine essentially dried up, making the traditional economic practices of fishing, agriculture and pastoralism difficult or impossible. It remains nearly dry, although normal rainfall in recent years.

Lake Faguibine is located at the end of a series of basins that receive water from the Niger River when it floods, thus creating a close connection between the mean flow of the Niger River and the water levels in Lake Fagubine. Because of this, a lack of rainfall in either the Lake Fagubine catchment or the Niger River catchment upstream of the Niger Inland Delta can affect the water levels in the lake.

West Africa has a history of rainfall fluctuations of varying lengths and intensities. Sub−Saharan West Africa has experienced severe droughts in 1972, 1984 and 1992 and experienced a general trend of reduced rainfall from the early 1970s until the mid 1990s. The Lake Fagubine area, in particular, has seen a trend of decreasing rainfall since at least the 1920s. While water levels have also fluctuated widely in Lake Fagubine since the beginning of the 20th century, the period between the late 1980s and 2000 was extensively characterized by low water with a complete drying up of the Lake in the 1990s. A 2003 Columbia University study links changes in the ocean temperature to the drought in the Sahel in the 1970s and 1980s. There is a speculation that global warming may be responsible for the recent increase in precipitation − since 2000 − and may continue to increase precipitation. In any case, these findings "add another dimension to the variability of the global climate" and to the lives of the peoples who rely on natural systems for their livelihood.



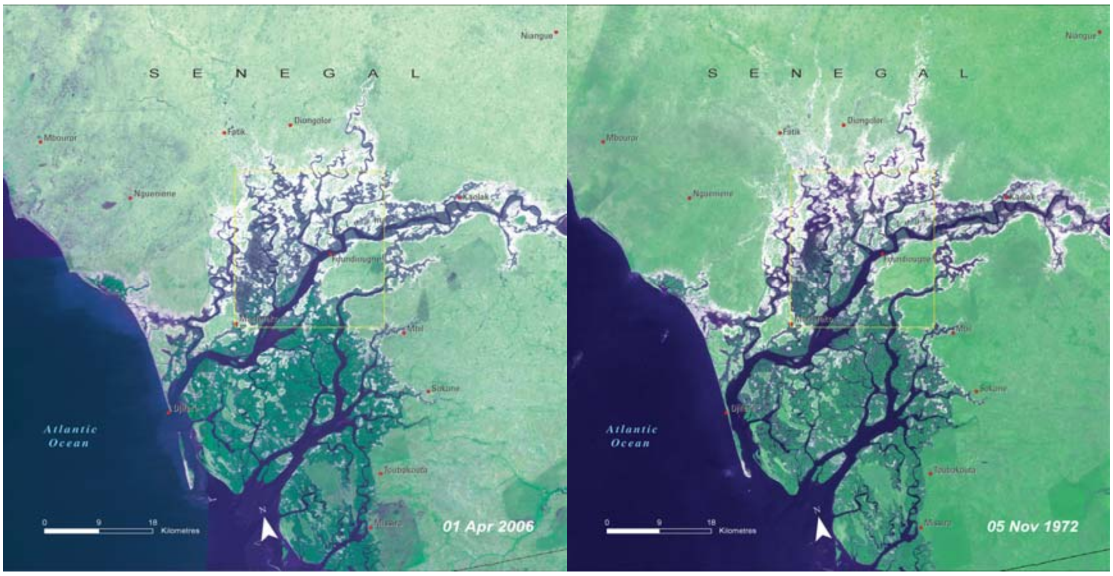
Source: UNEP, Atlas of our Changing Environment, 2007 (http://na.unep.net/atlas/webatlas.php?id=273).

Box 2. The mangrove forests of the Saloum-Sine Delta (Senegal)

The mangrove forests of the Saloum-Sine Delta sprawl across roughly 65,000 hectares of the coast of south-eastern Senegal. They are made up of a variety of salt-tolerant species, ranging from shorter trees forming low canopies to some of the tallest mangrove trees in the world which grow up to 40 meters. These forests play an important role in the natural environment and on the lives of local residents, providing important habitat for deer, antelopes, hyenas, monkeys and other species. They are especially crucial for migrating birds. In addition, they also serve as nursery areas for important fish species and shelter for oyster colonies utilized by local communities.

Parc National du Delta du Saloum provides protection to 76,000 hectares of forests and the surrounding areas, while 180,000 hectares of the delta have been designated as a UNESCO Biosphere Reserve. Nevertheless, since the late 1960s it has been recognized that these forests have been dying. They have declined in both area and density by roughly 25 percent since the early 1970s. This is generally attributed to a decline in rainfall over past decades and over-exploitation of water reserves which have changed the mix of salt and fresh water in the estuary, making it too saline for many trees. In addition, the exploitation of the forests for firewood and lumber and the facilitation of oyster harvesting are occurring at an unsustainable rate.

Areas in the satellite images which have changed from dark green to grey between 1972 and 2006, particularly in the northern portions of the delta, show where the mangroves have died off. While there are large areas under protection and reforestation projects, the fate of these mangroves will mainly depend on adequate freshwater flow to reduce the salinity to levels that favour mangroves. A continued long-term trend of decreasing rainfall would present an enormous challenge to restoration efforts.

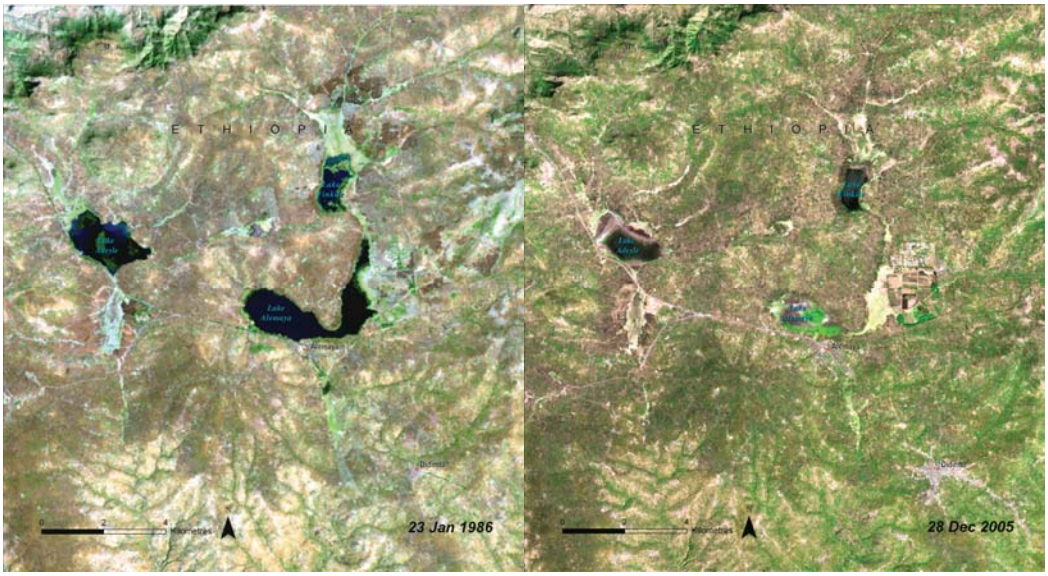


Source: UNEP (http://na.unep.net/atlas/webatlas.php?id=291).

Box 3. Lake Alemaya in Ethiopia: Changes occured between 1986 and 2005

Lake Alemaya in the Ethiopian Highlands has historically provided the surrounding area with water for domestic use, irrigation, and livestock and has served as a local fishery. As in the mid-1980s, recently its maximum depth has been around eight metres and has covered 4.72 km2. Since then, Alemaya's water level and surface area have declined considerably, as it is evident in the images below. In recent years, low water levels have interrupted the water supply in Harar, a nearby town of over 100,000.

Increasing irrigation and domestic water use, change in the local climate, and changes in the surrounding land cover are believed to be the causes of Alemaya's demise. Since the mid-1970s, agriculture has expanded dramatically, due to improved infrastructure, increased population, and changes in government policies toward production and marketing. Among the crops grown is khat, a psychoactive leaf consumed heavily in north-eastern Africa. Khat has become an exported cash crop in recent decades, thus resulting in the increase of irrigation. In addition, siltation caused by the deforestation of the Alemaya watershed has reduced the capacity of the shallow lake. A trend of warmer temperatures since the mid-1980s may also have increased the rate of evaporation from the lake.



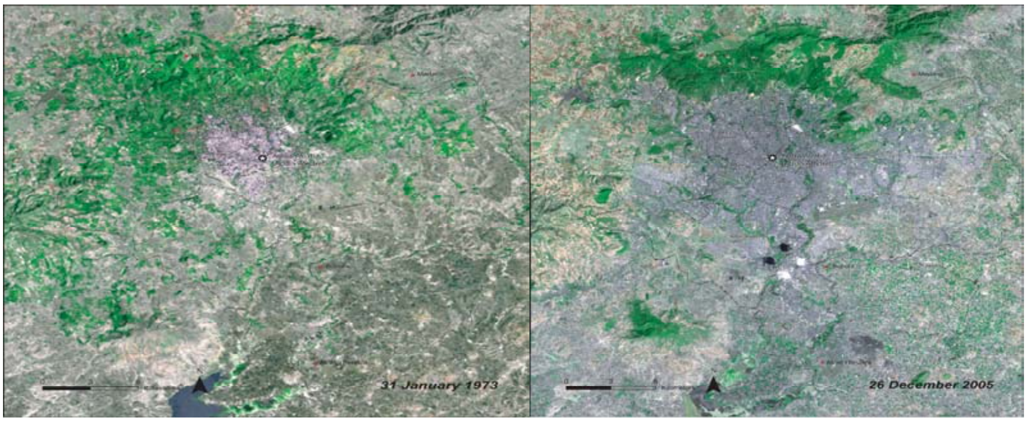
Source: UNEP, Atlas of our Changing Environment, 2007 (http://na.unep.net/atlas/webatlas.php?id=342).

Box 4. Urbanisation process in Addis Ababa (Ethiopia)

Addis Ababa, the capital of Ethiopia, was established in 1889. Major urban migration into the city began in the mid-1970s, driven mainly by unemployment, poverty, and declining agricultural productivity in rural areas. The population of Addis Ababa is currently 2.9 million, and is projected to grow to 5.1 million by 2015.

Ethiopia as a whole has an annual population growth of 2.8 per cent. Twenty-seven per cent of Ethiopia's urban population lives in Addis Ababa and this has created substantial pressure on the city's infrastructure, housing, and urban services. These satellite images taken in 1973 and 2005 show the development of Addis Ababa's massive urban sprawl.

In 1996, the city had only 238,000 residential housing units. In the same year, the total number of households was estimated to be 460,000, leaving 220,000 households or nearly 1,000,000 residents without suitable housing. This situation led to illegal housing construction and uncontrolled settlements, some of which have been encroaching on protected forest and reserve lands at the edges of the city.



Source: UNEP, Atlas of our Changing Environment, 2007.

Box 5. "Eating the dry season" - temporary labour migration in West Africa (Brown, 2007)

In the West African Sahel recent studies have cast light on the use of temporary migration as an adaptive mechanism to climate change. The region has suffered a prolonged drought for much of the past three decades and one way that households have adapted is by sending their young men and women in search of wage labour after each harvest (Science Daily, 1999). But how far they travel depends, in part, on the success of the harvest.

A good harvest might give the family sufficient resources to send a member to Europe in search of work. While the potential rewards in terms of remittances are high, it is a highly speculative gamble – in addition to dangerous journey, the rewards are uncertain. In addition the chances are the migrant will not be back in time for the next year's planting.

But in a drought year, when harvests are poor, the young men and women tend to stay much closer to home, instead travelling to nearby cities for paid work so as to reduce the drain on the household's food reserves and top-up household income. In such years the risk of losing the 'migration gamble' is simply too great (McLeman, 2006).

Migration, especially when it is a response to slower acting climate processes (rather than a sudden climatic event like a hurricane), typically requires access to money, family networks and contacts in the destination country. Even in the most extreme, unanticipated natural disasters – migrants, if they have any choice, tend to travel along pre-existing paths – to places where they have family, support networks, historical ties and so on. Most people displaced by environmental causes will find new homes within the boundaries of their own countries.

Box 6. The emission scenarios of the IPCC special report on emission scenarios (IPCC, 2007a)

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T) or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

BIBLIOGRAPHY

Adger N., Brooks N., Kelly M., Bentham G., Agnew M., Eriksen S. (2004), *New Indicators of Vulnerability and Adaptive Capacity*, Norwich, Technical Report 7, Tyndall Centre for Climate Change Research, University of East Anglia.

Africa Partnership Forum (2007), *Peace and Security in Africa*, 8th Meeting of the Africa Partnership Forum Berlin, Germany 22-23 May, [http://www.africapartnershipforum.org/dataoecd/57/52/38666711.pdf].

Africa Partnership Forum Support Unit (2007), *Climate Change and Africa*, Briefing paper n.1, September, [http://www.oecd.org/dataoecd/17/20/39921733.pdf].

Agoumi A. (2003), *Vulnerability of North African Countries to Climatic Changes: Adaptation and Implementation Strategies for Climatic Change. Developing Perspectives on Climate Change: Issues and Analysis from Developing Countries and Countries with Economies in Transition*, IISD/Climate Change Knowledge Network, [http://www.cckn.net//pdf/north_africa.pdf].

Amos J. (2006), *Satellites Weigh Africa's Water*, BBC News, 13 December, [http://news.bbc.co.uk/2/hi/science/nature/6174689.stm].

Ashton J., Burke T. (2005), *Climate Change and Global Security*, 21st April, [http://www.opendemocracy.net/node/2509/pdf].

Barnett J., Adger N. (2005), *Security and Climate Change: Towards an Improved Understanding,* Tyndall Centre for Climate Change Research, University of East Anglia, paper presented during the Human Security and Climate Change. An International Workshop Holmen Fjord Hotel, Asker, near Oslo, 20–21 June, [http://www.auswaertiges-amt.de/diplo/de/Aussenpolitik/ForumGF/17-GF/17-GF-Barnett.pdf].

Bascom J. (1995), "The New Nomads. An Overview of Involuntary Migration in Africa", in Baker J., Aina T.A. (eds.), *The Migration Experience in Africa*, Uppsala, Nordic African Institute: 197-219.

Black R. (2001), *Environmental Refugees: Myth or Reality?*, UNHCR Working Paper n. 34.

Black R., Kniveton D., Skeldon R., Coppard D., Murata A., Schmidt-Verkerk K. (2008), *Demographics and Climate Change: Future Trends and their Policy Implications for Migration*, Working Paper T-27, Development Research Centre on Migration, Globalisation and Poverty.

Boano C., Zetter R., Morris T. (2008), *Environmentally Displaced People. Understanding the Linkages Between Environmental Change, Livelihoods and Forced Migration*, Oxford, Refugee Studies Centre, Oxford Department of International Development, University of Oxford, Forced Migration Policy Briefing 1.

Brown L.R. (2004), *Troubling New Flows of Environmental Refugees*, Earth Policy Institute, January 28th.

Brown O. (2007), *Climate Change and Forced Migration: Observations, Projections and Implications*, Background Paper for the Human Development Report 2007/2008, Occasional Paper n. 2007/17.

Brown O. (2008), *Migration and Climate Change*, IOM Migration Research Series, n. 31.

Brown O., Crawford A. (2008), "Climate Change: A New Threat to Stability in West Africa? Evidence from Ghana and Burkina Faso", in *African Security Review*, vol. 17, n. 3, Institute for Security Studies, September.

Christian Aid (2007), *Human Tide: the Real Migration Crisis*, London, Christian Aid Report.

Clark B.M. (2005), *Climate Change: a Looming Challenge for Fisheries Management in Southern Africa*, Marine Policy, volume 30, issue 1.

Climate Change and International Security (2008), Paper from the High Representative and the European Commission to the European Council, 14 March, S113/08, [http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/reports/99387.pdf].

Convention Relating to the Status of Refugee (1951), [http://www.unhchr.ch/html/menu3/b/o_c_ref.htm].

Cury P., Shannon L. (2004), "Regime Shifts in up Welling Ecosystems: Observed Changes and Possible Mechanisms in the Northern and Southern Benguela", in *Progress in Oceanography*, vol. 60, n. 2-4: 223-243.

Dalby S. (2002), "Environmental Change and Human Security, in Isuma*",* in *Canadian Journal of Policy Research* 3(2): 71–79.

Davidson O., Halsnaes K., Huq S., Kok M., Metz B., Sokona Y., Verhagen J. (2003), "The Development and Climate Nexus: the Case of sub-Saharan Africa", in *Climate Policy*, n. 3S1: 97-113.

De Wit M., Stankiewicz J. (2006), "Changes in Surface Water Supply Across Africa with Predicted Climate Change", in *Science*, vol. 311, 31st March.

Declaration of Almeria, 11 Feb 1994, International Symposium on desertification and migrations, 9 - 11 Feb 1994, [http://repository.forcedmigration.org/pdf/?pid=fmo:1192].

Department for International Development (2007), *Moving out of Poverty: Making Migration Work for Poor People*, London, DfID Policy Paper.

Dietz T., Veldhuizen E. (2004), "The World's Drylands: a Classification", in Dietz A.J., Ruben R., Verhagen A. (eds.), *The Impact of Climate Change on Drylands, with a Focus on West Africa*, Dordrecht, Boston, London, Kluwer Academic Publishers, Environment and Policy Series, vol. 39: 19-26.

Dupont A., Pearman G. (2006), *Heating up the Planet: Climate Change and Security*, Sydney, Lowry Institute for International Policy, Paper 12.

Earth Trends (2007), *Calculation Using Water Data from FAO Land and Water Development Division,* AQUASTAT Information System on Water and agriculture: Online database, Rome: FAO, [http://www.fao.org/nr/water/aquastat/data/query/index.html].

ECOWAS-SWAC/OECD (2008), *Climate and Climate Change. Atlas on Regional Integration in West Africa*, Environment series, [http://www.oecd.org/dataoecd/44/5/40121025.pdf].

El-Hinnawi E. (1985), *Environmental Refugees*, Nairobi, United Nations Environment Programme.

FAO (2005), *Irrigation in Africa Figures*, Aquastat Survey, [http://www.fao.org/nr/water/aquastat/countries/algeria/algeria_cp.pdf].

FAO AGL (2003), *Land Degradation Severity*, Terrastat online database, [http://www.fao.org/ag/agl/agll/terrastat/#terrastatdb].

Findley S.E. (1994), "Does Drought Increase Migration? A Study of Migration from Rural Mali during the 1983-1985 Drought", in *International Migration Review*, 28(3): 539-553.

German Advisory Council on Global Change (2007), *World in Transition: Climate Change as a Security Risk. Summary for Policy Makers*, Berlin, German Advisory Council on Global Change.

Gleditsch N.P., Nordås R., Salehyan I. (2007), "Climate Change and Conflict: The Migration Link", in *Coping with Crisis Working Paper Series*, International Peace Academy, [http://www.ipacademy.org/asset/file/169/CWC_Working_Paper_Climate_Change.pdf].

Grote U., Warner K. (2008), *Environmental Change and Forced Migration: Evidence from Sub-Saharan Africa*, Environmental Change and Forced Migration Scenarios (EACH-FOR) Project.

Hammer T. (2004), "Desertification and Migration: A Political Ecology of Environmental Migration in West Africa", in Unruh J.D., Krol M. S., Kliot N. (eds.), *Environmental Change and its Implications for Population Migration*, Dordrecht, Kluwer Academic Publishers: 231-46.

Hemming D., Iowe J., Biginton M., Betts R., Ryall D. (2007), *Impacts of Mean Sea Level Rise Based on Current State-Of-The-Art Modelling,* Exeter, Hadley Centre for Climate Prediction and Research.

Henry S., Boyle P.J., Lambin E.F. (2003), "Modelling Inter-Provincial Migration in Burkina Faso, West Africa: the Role of Socio-Demographic and Environmental Factors", in *Applied Geography,* vol. 23, issues 2-3, April-July: 115-136.

Henry S., Schoumaker B., Beauchemin C. (2004), "The Impact of Rainfall on the First Out-Migration: A Multi-level Event-History Analysis in Burkina Faso", in *Population and Environment*, vol. 25, n. 5: 423-460.

Hesse C., Cotula L. (2006), *Climate Change and Pastoralists: Investing in People to Respond to Adversity*, London, Sustainable Development Opinion, IIED.

Hinrichsen D. (2007), *Ocean Planet in Decline*, Peopleandplanet.net, 25 January, [http://www.peopleandplanet.net/doc.php?id=429andsection=6].

Holmes J. (2008), *Opening Remarks at the Dubai International Humanitarian Aid and Development Conference and Exhibition "DIHAD 2008 Conference"*, [http://www.reliefweb.int/rw/rwb.nsf/db900sid/YSAR-7DHL88?OpenDocument].

IOM (2007), *Discussion Note: Migration and the Environment*, IOM, [http://www.iom.int/jahia/webdav/site/myjahiasite/shared/shared/mainsite/microsites/IDM/workshops/evolving_global_economy_2728112007/MC_INF_288_EN.pdf].

IOM, UNHCR, Refugee Policy Group (1996), *Environmentally-Induced Population Displacements and Environmental Impacts Resulting from Mass Migration*, International Symposium, Geneva, 21–24 April.

IPCC (2001), *Third assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge, Cambridge University Press.

IPCC (2007a), *Climate Change 2007 – The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC*, Cambridge, Cambridge University Press.

IPCC (2007b), *Climate Change 2007 – Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC*, Cambridge, Cambridge University Press.

IUSSP (2007), *Urbanization and Poverty in Africa: Evidence on Linkages Between Urbanization, Poverty and Human Well-Being in Sub-Saharan Africa: Panel on Population Growth and Human Welfare in Africa. International Union for the Scientific Study of Population (IUSSP)*, Scientific Panel on Population Growth and Human Welfare in Africa, [http://www.iussp.org/Activities/popgrowth/call07.php].

Jacobson J.L. (1988), *Environmental Refugees: a Yardstick of Habitability*, Washington, D.C., World watch Institute, World Watch Paper n. 86.

Kälin W. (2008), *Panel on Disaster Risk Reduction and Preparedness: Addressing the Humanitarian Consequences of Natural Disasters*, ECOSOC Humanitarian Affairs Segment, 16 July, [http://www.reliefweb.int/rw/rwb.nsf/db900SID/SKAI-7GNQV9].

Kandji S.T., Verchot L., Mackensen J. (2006), *Climate Change and Variability in the Sahel Region: Impacts and Adaptation Strategies in the Agricultural Sector*, ICRAF, UNEP.

Kibreab G. (1997), "Environmental Causes and Impact of Refugee Movements: A Critique of the Current Debate", in *Disasters*, vol. 21, no. 1: 20-38.

King T. (2006), "Environmental Displacement: Coordinating Efforts to Find Solutions", in *Georgetown International Environmental Law Review,* vol. 18, April.

Kolmannskog V.O. (2008), *Future Floods of Refugees. A Comment on Climate Change, Conflict and Forced Migration*, Oslo, Norwegian Refugee Council.

Kurukulasuriya P., Mendelsohn R. (2006), *A Ricardian Analysis of the Impact of Climate Change on African Cropland,* Pretoria, Centre for Environmental Economics and Policy in Africa (CEEPA), University of Pretoria, Discussion Paper n. 8.

Kuwali D. (2008), "From the West to the Rest: Climate Change as a Challenge to Human Security in Africa", in *African Security Review*, vol. 17. n. 3, Institute for Security Studies, September.

Lonergan S. (1998), "The Role of Environmental Degradation in Population Displacement", in *Environmental Change and Security Project Report*, Issue 4, Spring: 5-15.

McLeman R. (2006), *Global Warming's Huddled Masses*, The Ottawa Citizen, 23rd November.

McLeman R., Smit B. (2004), *Climate Change, Migration and Security,* Ottawa, Canadian Security Intelligence Service, Commentary n. 86.

McMichael A.J., Woodruff R.E., Hales S. (2006), "Climate Change and Human Health: Present and Future Risks", in *Lancet*, n. 367: 859-869.

McMichael, A., Campbell-Lendrum D., Kovats S. et al. (2004), "Global Climate Change", in Ezzati M.J. et al. (eds.), *Comparative Quantification Of Health Risks: Global And Regional burden of Disease Due to Selected Major Risk Factors*, Geneva: World Health Organisation, pp. 1543 – 1649.

Meinshausen M. (2006), "What does a 2°C target mean for greenhouse gas concentrations? A brief analysis based on multi-gas emission pathways and several climate sensitivity uncertainty estimates" in Schellnhuber H.J. et al. (eds.), *Avoiding dangerous climate change*, Cambridge: Cambridge University Press, pp.265 – 280.

Mendelsohn R., Dinar A., Dalfelt A. (2000), *Climate Change Impacts on African Agriculture. Preliminary Analysis Prepared for the World Bank*, Washington, District of Columbia.

Ministère de l'Equipement de l'Aménagement du Territoire, de l'Environnement et de l'Urbanisme (2001), *Situation générale de la diversité biologique au Mali*, [http://www.cbd.int/doc/world/ml/ml-nbsap-01-p1-fr.doc].

Mongabay.com (2006), *Guinea-Bissau. Tropical Rainforest Country Profile*, [http://rainforests.mongabay.com/20guinea-bissau.htm].

Murphy J.M., Sexton D.M.H., Barnett D.N. et al. (2004), "Quantification of Modelling Uncertainties in a Large Ensemble of Climate Change Simulations", in *Nature* 430: 768 – 772.

Myers N. (2001), "Environmental Refugees: a Growing Phenomenon of the 21st Century", in *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences*, London, The Royal Society, 2002 April 29, 357(1420): 609–613.

Myers N. (2005), *Environmental Refugees: an Emergent Security Issue*, 13th OSCE Economic Forum, Session III – Environment and Migration, Prague, 23-27 May

Myers N., Kent J. (1995), *Environmental Exodus. An Emergent Crisis in the Global Arena*, Washington, D.C., Climate Institute.

Nellemann C., Mac Devette M., Manders T., Eickhout B., Svihus B., Prins A.G., Kaltenborn B.P. (eds.) (2009), *The Environmental Food Crisis – The Environment's Role in Averting Future Food Crises. A UNEP Rapid Response Assessment*, United Nations Environment

Programme, GRID-Arendal, February, [http://www.grida.no/_res/site/file/publications/FoodCrisis_lores.pdf].

New M. (2002), “Climate Change and Water Resources in the South Western Cape, South Africa”, in *South African Journal of Science,* n. 98: 369-373.

Niang-Diop I., Dansokho M., Diaw A.T., Faye S., Guisse A., Ly I., Matty F., Sene A. et al. (2005), “Senegal”, in. Van Drunen M.A, Lasage R., Dorland C. (eds.), *Climate Change in Developing Countries: An Overview of Study Results from the Netherlands Climate Change Studies Assistance Programme*, Amsterdam, IVM: 101-109.

Nyong A. (2005), *Impacts of Climate Change in the Tropics – the African Experience,* Avoiding Dangerous Climate Change Symposium (Met Office, UK, February), keynote presentation.

Nyong A., Fiki C., McLeman R. (2005), “Drought-Related Conflicts, Management and Resolution in the West African Sahel: Considerations for Climate Change Research”, in *Die Erde*, vol. 137, issue 3.

ODINAFRICA Project (2007), *African Marine Atlas,* Intergovernmental Oceanographic Commission’s (IOC), International Oceanographic Data and Information Exchange (IODE) Programme, [http://www.africanmarineatlas.net/index.htm].

OECD/SWAC (2008), *Climate, Climate Change and Agropastoral Practices in the Sahel Region*, May, [http://www.fao.org/nr/clim/docs/clim_080901_en.pdf].

Oglethorpe J., Ericson J., Bilsborrow R.E., Edmond J. (2007), *People on the Move: Reducing the Impacts of Human Migration on Biodiversity*, Washington, D.C., World Wildlife Fund and Conservation International Foundation.

Piguet E. (2008), *Climate Change and Forced Migration*, Research Paper n. 153, Geneva, UNHCR.

Raleigh C., Jordan L. and Salehyan I., *Assessing the Impact of Climate Change on Migration and Conflict*, Social Development Department, The World Bank, [http://siteresources.worldbank.org/EXTSOCIALDEVELOPMENT/Resources/SDCCWorkingPaper_MigrationandConflict.pdf].

Ratha D., Shaw W. (2007), *South-South Migration and Remittances*, Washington D.C., The World Bank Working Paper n. 102.

Renaud F., Bogardi J.J., Dun O., Warner K. (2007), *Control, Adapt or Flee: How to Face Environmental Migration?*, Publication Series of the United Nations University Institute for Environment and Human Security (UNU-EHS) n. 5.

Science Daily (1999), *Jet Stream Studied in West African Drought*, Penn State, 7th June, [http://www.sciencedaily.com/releases/1999/06/990607072120.htm].

Stern N. (ed.) (2006), *Stern Review on the Economics of Climate Change*, Cambridge, Cambridge University Press.

Stige L.C., Stave J., Chan K.S., Ciannelli L., Pretorelli N., Glantz M., Herren H.R., Stenseth N.C. (2006), *The Effect of Climate Variation on Agro-Pastoral Production in Africa*, National Academy of Science of the USA, vol. 103, February 28: 3049-3053.

Suliman M. (2005), “Ecology, Politics and Violent Conflict”, in *Respect, Sudanese Journal for Human Rights’ Culture and Issues of Cultural Diversity*, Issue n.1, November.

Tacko Kandji S., Verchot L., Mackensen J. (2006), *Climate Change and Variability in the Sahel Region: Impacts and Adaptation Strategies in the Agricultural Sector*, ICRAF, UNEP, [http://www.unep.org/Themes/Freshwater/Documents/pdf/ClimateChangeSahelCombine.pdf].

Thornton P.K., Jones P.G., Owiyo T.M., Kruska R.L., Herero M., Kristjanson P., Notenbaert A., Bekele N. et al. (2006), *Mapping Climate Vulnerability and Poverty in Africa*, Nairobi, Report to the Department for International Development, ILRI.

Togola I. (2006), *Désertification et les migrations: la promotion du Pourghère comme outil de lutte contre la désertification et facteur de création d'emplois pour la lutte contre la pauvreté, Paper presented at the 2nd International Symposium on Desertification and Migrations*, Almeria, 25-27 October, [http://www.sidym2006.com/imagenes/pdf/ponencias/19_se.pdf].

Tol R.S.J., Downing T.E., Kuik O.J., Smith J.B. (2004), "Distributional Aspects of Climate Change Impacts", in *Global Environmental Change*, 14 (3), 259-272.

Traynor I. (2008), "EU Told to Prepare for Flood of Climate Change Migrants", in *The Guardian*, 10 March, [http://www.guardian.co.uk/environment/2008/mar/10/climatechange.eu].

Trollope W.S.W., Trollope L.A. (2004), *Prescribed Burning in African Grasslands and Savannas for Wildlife Management,* Arid Lands Newsletter, 55, May/June, [http://www.ag.arizona.edu/OALS/ALN/aln55/trollope.html].

UN (2007), *Millennium Development Goals Indicators*, [http://mdgs.un.org/unsd/mdg/Default.aspx].

UN Department of Economic and Social Affairs (2003), *World Statistics Pocketbook. Small Island Developing States,* New York, United Nations.

UN Department of Economic and Social Affairs (2006), *World Urbanization Prospects: The 2005 Revision*, New York, United Nations.

UNCCD (2002), *Ghana Environmental Protection Agency. National Action Programme to Combat Drought and Desertification*, Accra, Ghana: Republic of Ghana [http://www.unccd.int/actionprogrammes/africa/national/2002/ghana-eng.pdf].

UNDP (2004), *Reducing Disaster Risk: a Challenge for Development*, New York, UNDP Bureau for Crisis Prevention and Recovery, [http://www.undp.org/bcpr/disred/documents/publications/rdr/english/rdr_english.pdf].

UNDP (2006), *The 2006 Human Development Report Launched in Eritrea,* [http://www.er.undp.org/news/221106-hdr.html].

UNEP (1999), *Global Environment Outlook-2000*, Nairobi, United Nations Environnent Programme, [http://www.grida.no/geo2000/english/index.htm].

UNEP (2006), *Africa Environment Outlook 2. Our Environment, Our Wealth (AEO-2)*, Nairobi, UNEP.

UNEP (2007), *Sudan. Post-Conflict Environmental Assessment*, Nairobi, UNEP.

UNEP (2008), *Africa: Atlas of Our Changing Environment*, Nairobi, Division of Early Warning and Assessment (DEWA), UNEP.

UNESA (2005), *Population Division of the Department of Economic and Social Affairs,* World Population Prospects: The 2004 Revision. Dataset on CD-ROM, New York, United Nations, [http://www.un.org/esa/population/ordering.htm].

UNESCO-WWAP (2006), *Water: A Shared Responsibility. United Nations World Water Development Report 2*, United Nations Educational, Scientific and Cultural Organisation and the United Nations World Water Assessment Programme.

UNFPA (2006), *State of the World Population*, New York, UNFPA.

UN-HABITAT (2008), *State of the World's Cities 2008/2009 - Harmonious Cities*, Nairobi, UN-HABITAT.

UNHCR (2000), *The State of the World's Refugees 2000: Fifty Years of Humanitarian Action*, Oxford, Oxford University Press.

UNHCR (2002), "A Critical Time for the Environment", in *Refugees* n. 127.

UNHCR (2003), *Sexual and Gender-Based Violence against Refugees, Returnees and Internally Displaced Persons: Guidelines for prevention and response*, Geneva, UNHCR.

UNHCR (2006a), *Internally Displaced People: Questions and Answers*, [http://www.unhcr.org/basics/BASICS/405ef8c64.pdf].

UNHCR (2006b), *Global Report 2006*, Geneva, UNHCR.

UNHCR (2008), *Climate Change, Natural Disasters and Human Displacement: a UNHCR Perspective*, 23 October, [http://www.unhcr.org/refworld/pdfid/492bb6b92.pdf].

UNICEF (2006), *United Nations Children's Fund: The State of the World's Children 2007: The Double Dividend of Gender Equality, Tables 1 and 10*, New York, UNICEF, [http://www.unicef.org/sowc07/].

United Nations (1998), *Guiding Principles on Internal Displacement*, Extract from the document E/CN.4/1998/53/Add. 2, 11 February.

United Nations University - Institute for Environment and Human Security (2005), *As Ranks of "Environmental Refugees" Swell Worldwide, Calls Grow for Better Definition, Recognition, Support,* UN Day for Disaster Reduction, 12th October, [http://www.ehs.unu.edu/file.php?id=58].

WHO (2005), *Using Climate to Predict Infectious Disease Epidemics*, Geneva, World Health Organization, [http://www.who.int/entity/globalchange/publications/infectdiseases.pdf].

Wigley T.M.L., Raper S.C.B. (2001), "Interpretation of High Projections for Global-Mean Warming", in *Science* 293: 451-454.

Wijkman A. (2009), "Climate Change is Now Fast Outstripping Climate Policy", in *Europe's World*, issue Spring.

Willcocks A.D. (2002), "Carbon Dioxide", in Goudie A.S. (ed.), *Encyclopedia of Global Change – Environmental Change and Human Society*, New York, Oxford University Press.

World Health Organisation (2006), *WHO/UNEP Health and Environment Linkages Initiative*, Geneva, WHO, [http://www.who.int/heli/risks/climate/climatechange].

World Resources Institute (2005), *Millennium Ecosystem Assessment*, Washington, D.C., Island Press.

World Resources Institute (2007), *Calculation Using Land and Pasture Data from FAOSTAT Statistical Databases*, [http://faostat.fao.org/default.aspx].

World Water Assessment Programme (2009), *The United Nations World Water Development Report 3: Water in a Changing World*, Paris and London, UNESCO and Earthscan.