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Demographics and Climate Change: Future Trends And their Policy Implications for Migration

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1. Introduction

According to United Nations estimates, the world's population will rise to between 7.8 and 11.9 billion people by 2050, with a 'medium variant' estimate of 9.2 billion.[1] (UNESA, 2007) In turn, the number of people living outside their country of birth grew from 75 million in 1960 to 191 million in 2005, which is a rise from around 2.5% to 3.0% of the world's population. Assuming that the percentage of international migrants in the world either stays at 2005 levels, or continues to rise at the same rate as in the last decades of the 20th century, this implies a total stock of between 235 and 415 million international migrants in the world in 2050, with a median estimate of 275 million, 40% higher than at present. At the same time, it is clear that movement within national borders is at least as significant numerically as international migration, and is certainly the most significant form of migration for poor people. (DFID, 2007)

In addition to demographic drivers of migration, a number of recent reports, including the *Stern Review Report on the Economics of Climate Change*, have highlighted the potential for additional mass migration as a result of climate change, with estimates ranging from 150-200 million [2] (Stern, 2007: 77) to as many as 1 billion.[3] (Christian Aid, 2007) However, the lower figure, quoted by Stern, originates from the work of Norman Myers in the mid-1990s, (Myers & Kent, 1995) and has been widely criticised. (Black, 2001) In turn, Christian Aid's much more alarming figure of 1 billion climate change refugees by 2050 appears to be based only on Stern's observation that 'climate change will lead to hundreds of millions more people without sufficient water or food to survive or threatened by dangerous floods and increased disease'. (Stern, 2007: 77) Summarizing, the 4th Assessment report of the Intergovernmental Panel on Climate Change (IPCC) describes the estimates of numbers of environmental migrants as 'at best, guesswork', because of a host of intervening factors that influence both climate change impacts, and migration patterns, (Wilbanks et al, 2007: 365) suggesting the need for extreme caution.

It is in this context that this working paper seeks to explore the potential impact of future demographic and climate change on migration patterns in developing countries, in order to identify policy implications for international development and evidence gaps that could be plugged with appropriate new research.

1 The population projections generated by the Population Division of the United Nations and updated every two years are the 'gold standard'. Different variants are a result of different assumptions about fertility, but for most general work (and in this report) 'medium variant' estimates are usually used.

2 These figures are quoted as 'conservative assumptions' by Stern; see also Jakobeit, C. and Methmann, C., 2007, *Klimaflüchtlinge – Die verleugnete Katastrophe*, Hamburg: Greenpeace.

3 The report acknowledges, however, that there are "no recent, authoritative, global figures on the number of people who could be displaced from their homes by climate change": 22

After a brief review of definitions and terms, it reviews both the pattern of anticipated demographic change to 2050, and likely climate change trends and impacts over the same timescale, before going on to explore ways in which demographic and climate change might combine to influence future migration patterns. Four case study analyses complement this working paper, focusing on national trends in four developing countries – Bangladesh, Ghana, Ethiopia and Sudan. A final section then seeks to draw out the implications of such patterns for international development policy.

2. Background

The focus of this report is on medium-term demographic trends and the potential impact of climate change on developing countries over the period to 2050. It seeks to identify the likely scale and movement of people both within and between developing countries; identify ways in which such estimates might be improved; and explore some of the likely consequences of this migration, and the different types of migrant groups involved, including internal, cross-border, regional and international migration. International migration to the UK – in terms of the stock of foreign born population – was estimated at 5.4 million in 2005, (UN ESA, 2005: 3) or less than 3% of global flows of international migrants, with just 15% of this migration coming from sub-Saharan Africa. However, notwithstanding the relatively small scale of international migration that flows from Africa to the UK, specific mention is made of likely trends to the UK.

A major problem that has beset existing work on migration related to climate change has been definitional, with a significant part of the literature dedicated to defining and estimating the number of 'environmental refugees', or 'environmental migrants' that can be distinguished from other kinds of migrants.[4] Crucially, such migration is often constructed as a major public policy challenge for industrialised nations, as this is where 'environmental refugees' are expected to seek 'asylum'. However, such forecasts of environmental or climate change-related migration, and arguments for public policy action in response, can be challenged for a variety of reasons. First, predictions of the number of people likely to be displaced are often based on quite crude population estimates, as reliable population statistics do not exist in many affected areas. Second, it is unlikely that a whole population would leave an affected area as a result of most forms of climate change, whilst even those who might are relatively unlikely to cross an international border, let alone travel across continents to reach an economically more developed Western country. Moreover, there is broad theoretical consensus that it is

4 Definitions of 'environmental migrants' have been offered by IOM (2007): *Migration and the environment,* Ninety-fourth session, Discussion note, International Organization for Migration: Geneva: 15.

generally not the poorest people who migrate overseas because international migration is an expensive endeavour that demands resources for the journey and to cross national borders. (Castles, 2000; De Hann, 2000; Skeldon, 2002) It is thus difficult to imagine that people whose livelihoods are undermined by climate change will immediately embark on a journey to Europe or to North America as 'refugees' in need of 'protection'.

However, perhaps most important is that the term 'climate change refugee' or 'climate change migrant' implies that it is climate change that is primarily responsible for forcing people to leave their homes. Yet such an approach is problematic, as there is wide agreement in the field of migration studies that different causes of migration cannot be isolated from each other, since migration is a multi-causal phenomenon in which a range of factors are inter-related. (Kritz et al., 1992; Castles & Miller, 1993; Boyle et al., 1998; Wood, 2001) Reflecting this, our aim here is somewhat different – to explore the ways in which climate change may influence the factors that drive migration, affecting both patterns, and the volume of people likely to move. We argue that a shift towards identifying the *sensitivity* of the drivers of migration to climate change and variability would provide a more robust way forward in terms of predicting future migration flows, although there remains an insufficient evidential base to make clear predictions at present.

3. Medium-term demographic trends

3.1 Population growth

Although overall global population growth to 2050 is likely to add around 3 billion people to the world's population, this masks substantial regional variations, reflecting major differences in fertility and mortality rates around the world. Indeed, over 98% of population *growth* between 2000 and 2050 will be accounted for in the less-developed regions of the world (Table 1), where, although falling, fertility rates remain high. In contrast, the population of more developed regions is projected to decline from 2030.

Table 1. Population change 2000-50 (millions)

	Total population 2000	Estimated population 2050	% contribution to global population growth, 2000-50
World population, of which:	6,124	9,191	…
Less-Developed Regions	4,930	7,946	98%
More-Developed Regions	1,194	1,245	2%
Population growth in selected regions:			
South Central Asia	1,516	2,536	33%
East Asia	1,476	1,591	4%
Sub-Saharan Africa	679	1,760	35%
South East Asia	519	766	8%
Latin America & Caribbean	523	769	8%
West Asia	192	372	6%

Source: World Population Prospects: the 2006 Revision Population Database

Even in less-developed regions, projected population growth is highly concentrated, with around 35% of growth occurring in sub-Saharan Africa[5], the fastest-growing world region, and a further 33% in South Central Asia.[6] By far the largest single country contributing to global population growth is India, which accounts for a projected 20% of the world's population growth alone, and is likely to become the world's most populous country around 2025. Other individual countries contributing significantly to global population growth over the first half of the century include China (5% - although here fertility decline has been so sharp that its population is predicted to decline from 2035); Pakistan (5%); Bangladesh (4%); Indonesia (3%) and Brazil (3%).

3.2 Urbanisation

In addition to fertility decline, the second major demographic trend observable since 1950, and expected to continue in coming decades, is that of urbanisation. In 1950, only 29% of the world's population was defined as living in towns and cities; by 2000 this proportion had reached 47%, and it is predicted to

5 In principle, UN projections incorporate mortality estimates that include the effect of HIV/AIDS. However, the 2006 projections do not include adjustments necessary in light of data published in December 2007 by UNAIDS (*2007 Aids Update*) that show a fall from 39.5 million to 32.7 million in estimates of the numbers carrying the virus, and suggest that new infections peaked in the late 1990s. This suggests that future population projections may revise upwards estimates of populations in affected countries – notably in Southern Africa.

6 Afghanistan, Bangladesh, Bhutan, India, Iran, Kazakhstan, Kyrgyzstan, Maldives, Nepal, Pakistan, Sri Lanka, Tajikistan, Turkmenistan, Uzbekistan

reach almost 60% by 2030.[7] The increase in the share of the population living in urban areas is particularly remarkable in East and South-East Asia, where the growth of large mega-cities is already a highly visible phenomenon; however, it is also worth noting that by 2030, almost half of sub-Saharan Africa's population is expected to live in cities, with the highest proportion in Southern Africa (69%) and the lowest proportion in East Africa (34%).[8]

Table 2: Proportion of population living in urban areas in selected world regions, 2000-30

Region	% Population in urban areas 2000	% Population in urban areas 2030	Increase in urban population 2000-30
Latin America & Caribbean	75.4%	84.3%	8.9%
West Asia	63.6%	72.1%	8.5%
East Asia	40.4%	62.5%	22.1%
South East Asia	39.6%	61.2%	21.6%
Sub-Saharan Africa	32.9%	48.3%	15.4%
South Central Asia	29.4%	42.9%	13.5%

Source: World Population Prospects: the 2006 Revision Population Database

It is important to note that (internal) migration is just one component of urban growth, and not necessarily the most important – where fertility is high, the natural increase of urban populations can be the most important factor in urban growth, whilst the reclassification of rural populations to urban without their movement is also a significant factor. In Africa and Latin America, natural increase is estimated to have accounted for a little under 60% of urban growth in the 1970s and 1980s, although in Asia, the proportion accounted for by net migration and reclassification grew from 44% in the 1970s to 55% in the 1980s, reflecting fertility decline in that region.

3.3 Migration patterns

Compared to fertility and mortality decline, the third demographic variable of migration is far more difficult to predict, particularly where this involves movement across international borders. One problem is that over the last half of the 20th century, a number of countries in southern Europe and East Asia have shifted from being net emigration to net immigration countries as a result of dynamic economic growth, and this trend can be expected to continue into the future, with countries such as Malaysia,

7 Projections for urban and rural populations are made by the UN only to 2030.

8 There are however some legitimate concerns about the quality of projections of urban growth, which have often produced significant over-estimates of city size in the past. See Satterthwaite, 2007

Thailand and Turkey likely also to undergo a migration transition in the coming decades. In turn, countries elsewhere, such as Ghana, have moved in the other direction over the second half of the 20th century, becoming net countries of emigration as economic and political events led to expulsions of foreign populations and a new exodus of nationals. Yet such trends are not built into UN projections: for example, Turkey is projected to have net positive migration to 2015, but negative migration thereafter; whilst Thailand is never considered to have had net negative migration.

In practice, UN projections suggest international migration to more developed countries peaked in the period 2000-05, with 3.3 million people added to their populations during that period. Yet there is considerable uncertainty, reflecting the fact that UN migration projections are based on 'past international migration estimates and consideration of the policy stance of each country with regard to future international migration', but, where existent, databases are weak at best. It is also important to point out that these projections tell us nothing about the magnitude of total flows, but merely the balance between immigration and emigration; nor do they tell us the reasons why people move – whether forced or voluntary, for example; nor about internal movements within countries, which we know are significant. A first attempt to generate a global origin-destination international migration database, based partly on censuses, and partly on UN global migrant stock data, has been made by the Development Research Centre on Migration, Globalisation and Poverty.[9] Although it will be some time before this database can be refined to the extent necessary for it to be useable in medium-term projections, and significant problems arise from using countries as the unit of analysis in any database, given their hugely different sizes[10], the *Global Migrant Origin Database* does provide some evidence on key migration systems that are significant in different world regions.[11]

Amongst important points to note from this is the significance of south-south migration, and specifically intra-regional migration. Around half of all migrants from developing countries live in other developing countries, (Ratha and Shaw, 2007: 2) whilst intra-regional moves account for two thirds of all migration within Sub-Saharan Africa, as well as two thirds of moves within Europe and Central Asia.[12] (Parsons et

9 See: www.migrationdrc.org and C. R. Parsons, R. Skeldon, T. L. Walmsley and L. A. Winters, "Quantifying international migration: a database of bilateral stocks", in C. Özden and M. Schiff (eds.), *International Migration, Economic Development and Policy*, Washington, The World Bank, 2007: 17-58.

10 Given that levels of migration are generally greater over shorter distances, it will always be the case that geographically large countries will have lower levels of emigration than small countries. This is reflected in the fact that the top 20 countries of emigration as a proportion of the population are all countries with less than 1 million inhabitants.

11 For example, a revised version of the database is used to underpin estimates in Ratha, D. and Shaw, W., 2007, *South-south migration and remittances*, Washington DC: World Bank Working Paper no. 102

12 It should be noted that since these figures relate primarily to stocks of 'foreign born' populations, the effect of historic border changes (i.e. break-up of the former Soviet Union) is clearly significant.

al., 2007) Beyond intra-regional migration, distinct migration 'corridors' can also be identified: from South Asia, and the Middle East & North Africa to the Gulf; from Europe & Central Asia to the EU and EFTA countries; and from Latin America & the Caribbean, and East Asia & the Pacific, to North America. In addition, analysis of the database also shows that over half of world migration in 2000/01 was between countries with a common language; (Parsons et al., 2007) whilst over 80% of south-south migration occurs between countries with contiguous borders, much of it between countries with relatively small differences in income. (Ratha and Shaw, 2007: 2)

One generalisation that can certainly be made about migration is that the majority of migrants are young adults, and hence the number of migrants in and from a population is likely to be a function of the number of people in these cohorts. Whilst it would be naïve to assume that a direct relationship exists, it is worth noting that in the least developed countries, the absolute number of people aged 15-24 is set to double from 135 million in 2000 to 309 million in 2050, massively increasing the pool of potential migrants.

3.4 Key migration drivers

There is a large literature on the causes of migration, but also a measure of agreement that the key drivers of migration fall into three categories: (a) factors related to the region or country of origin, including political instability and conflict, lack of economic opportunities, and lack of access to resources ('push' factors); (b) factors related to the region or country of destination, including the availability of employment and demand for workers, higher wages, political stability or access to resources ('pull' factors); and (c) intervening factors that facilitate or restrict migration, including ease of transportation, family or social networks, government immigration or emigration policies, economic ties such as trade and investment linkages, or social and cultural exchanges.

However, whilst there is a degree of agreement that each of these factors is a *potential* driver of migration, the devil is in the detail: both of the particular 'push', 'pull' and enabling factors that may apply in any one circumstance, and of the way in which different factors may interact. For example, some of the most relevant factors are *relational* across space – thus classic migration theory posits that people will move from poorer to richer regions or from places where there is population pressure on resources to places where there is not. Yet this does not tell us whether the 'push' of poverty, or the 'pull' of economic opportunity is more important, even though this may be critical in terms of understanding whether and how much climate change will influence economic drivers of migration. Similarly,

'population pressure on resources' is often cited as a reason for people to leave a particular area, yet this may well lead to migration to an urban area where population densities are much higher, but where economic growth has meant a much larger population density can be supported.

4. Medium-term climate change trends

Climate change can occur due to both natural and human causes. Human-induced climate change arises primarily from the burning of fossil fuels and changes in land use. These activities produce greenhouse gases (such as carbon dioxide and methane) that trap outgoing long wave radiation in the climate system, warming the planet. Natural causes of climate change include volcanic eruptions, changes in the sun's activity, and changes in ocean circulation. In the last 100 years a number of changes have been observed in the global climate, including an increase in global surface temperature by 0.74°C ± 0.18°C (from 1906-2005); significantly increased precipitation in the eastern parts of North and South America, northern Europe and northern and central Asia; drying in the Sahel, the Mediterranean, southern Africa and parts of southern Asia; substantial increases in heavy precipitation; an increase in the destructiveness of tropical cyclones; a significant decrease in snow cover especially in spring; a reduction in arctic sea ice coverage (by about 2.7 ± 0.6% per decade since 1978); widespread mass losses of glaciers and ice caps; and a rise in the global mean sea level by about 1.8 ± 0.5 mm yr^{-1} from 1961 to 2003 (as measured by tide gauge data) and 3.1 ± 0.7 mm yr^{-1} from 1993-2003 (as measured by satellite altimetry). (Solomon et al., 2007) Model simulations of the climate system have attributed many of these changes, especially in the latter part of the 20th century, to an increase in human-produced greenhouse gases.

Simulation of future climate change uses different emission scenarios of greenhouse gases and aerosols. The Intergovernmental Panel on Climate Change (IPCC) has defined four narrative storylines describing the relationships between the forces driving greenhouse gas and aerosol emissions and their evolution during the 21st century for large world regions and globally. Brief summaries of these storylines are as follows: (Nakićenović et al., 2000)

- A1 storyline: a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and rapid introduction of new and more efficient technologies. Three commonly used scenarios in the A1 scenario family are: 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).
- A2 storyline: a very heterogeneous world with continuously increasing global population and

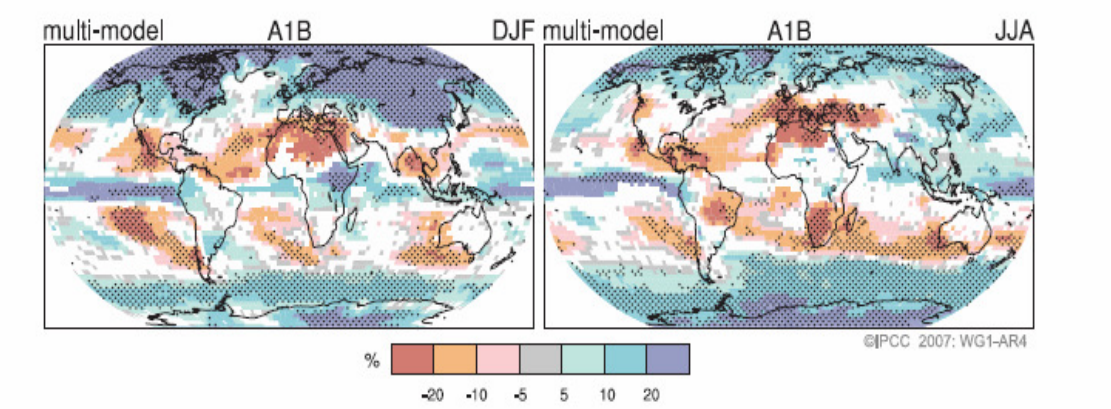
regionally oriented economic growth that is more fragmented and slower than in other storylines.

- B1 storyline: a convergent world with the same global population as in the A1 storyline but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.
- B2 storyline: a world in which the emphasis is on local solutions to economic, social, and environmental sustainability, with continuously increasing population (lower than A2) and intermediate economic development.

Families of projections based on each storyline have been developed from projections of the major driving variables such as population and economic. It should be noted that in simulations of the future the IPCC assumes each of the scenarios are equally valid.

Not surprisingly, given the difference in storylines, the projected changes in global average surface warming for the end of the 21st century are dependent on which emission scenario is chosen. By 2046-2065 likely global changes of +1.3°C, +1.8°C and +1.7°C for B1, A1B and A2 scenarios are predicted. The increase in temperature is predicted to be greatest over land and high latitudes in the northern hemisphere in the winter. On the continents, model simulations suggest the warming will increase from the coasts to the interiors and will typically be larger in arid compared to moist regions. Associated with global warming, global sea level is predicted to increase by the end of the century by 18 to 59 cm depending on the emission scenario. Predictions of changes in rainfall are less robust than those of temperature with the signal of change rising above natural variability more slowly than temperature. This is in part due to the high natural variability of rainfall and in part due to reduced knowledge of factors controlling rainfall variability. Over the globe, rainfall is predicted to very likely increase at high latitudes and likely to decrease in most sub-tropical land regions (Figure 1), although projections of rainfall change over the tropics are more uncertain than those at higher latitudes. However, there is some agreement by different climate models for an increase in the summer monsoon season of south and southeast Asia and east Africa. It is also worth noting the magnitude of the changes with some of the land regions in the subtropics experiencing 20% decreases in rainfall.

Figure 1. Relative changes in precipitation (in percentages) for the period 2090–2099, relative to 1980–1999.



Notes: Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change.
Source: Solomon et al (2007).

In the last century, increases have occurred in the number of heavy rainfall events and this trend is set to continue in many regions including some regions that are predicted to experience decreased rainfall. In these cases the drop in rainfall results from a decrease in the frequency of rainfall rather than intensity. Models also indicate that a warmer future climate will be accompanied by increased peak wind intensities and increased mean and peak rainfall intensities in tropical cyclones. However, total numbers of tropical cyclones globally are predicted to drop. (Solomon et al., 2007) The impact of climate change on climate variability is predicted to include a decrease in temperature variability during the cold season in the extra-tropical northern hemisphere and a slight increase in temperature variability in low latitudes and during the warm season in the northern mid-latitudes; and an increase in monthly mean precipitation in most areas. (Räisänen, 2002) However it should be borne in mind that research on changes in climate extremes, in locations such as Africa, in either models or observations, is limited. (Christensen, 2007)

4.1 Abrupt climate change and tipping points

Information about climate change in the long distant past reveals that the climate system can abruptly change over relatively short time periods. These changes occur when the climate system is forced to cross a threshold and subsequently changes dramatically beyond the level which would be expected from the initial forcing. In other words the climate system can be forced to a point where it suddenly flips into another state. These points are collectively known as tipping points and include the shut down of the Gulf Stream in the Atlantic, the die-back of the Amazon tropical rainforest, stronger and prolonged

ENSO events and the collapse of ice sheets leading to large sea level rises. These climate surprises would have dramatic consequences for society and the potential for massive demographic change. Furthermore these points signify a loss of control of change of the climate system by humans and introduce the concept of irreversible climate change. This has important ramifications for efforts to reduce greenhouse gases as once these points are past, no matter how committed global society is to preventing climate change, large and widespread changes in the atmosphere are inevitable. At present the IPCC consider that currently understood tipping points in the climate system are unlikely to occur in the 21st century, suggesting both that they are irrelevant to projections to 2050, and that the world may have time to adjust to their potential impact. However it is also recognised that many of the climate feedbacks that are responsible for causing abrupt changes in the climate after the initial forcing, are poorly understood at present. (Shindell, 2007)

4.2 Impacts of climate change

Currently more than one-sixth of the world's population lives in glacier or snowmelt–fed river basins which are very likely to experience a decline in water volumes stored in glaciers and snow cover in the future due to warming of the climate. The impact of this will be increased flows and flooding due to melting in the short-term, and permanently reduced summer and autumn flows in the medium-long term. While runoff and water availability are very likely to increase at high latitudes and in some wet tropics, areas that are presently water stressed in the mid-latitudes and dry tropics are predicted to experience drops in these variables. These changes will probably increase the frequency and severity of floods and droughts. The number of people living in severely stressed river basins is projected to increase from 1.4 -1.6 billion in 1995 to 4.3-6.9 billion in 2050 for the A2 scenario (see above). Freshwater availability will also be reduced in coastal areas as sea level rise increases the extent of areas of groundwater and estuaries that are subject to salinisation. Ecosystems, human health and water system reliability and costs are likely to be impacted by exacerbated water pollution resulting from higher water temperatures, increased precipitation intensity and longer periods of low flow. The most severe hydrologic effects this century are likely to be reductions in subtropical precipitation. Water stress may become particularly acute in the southwest US and Mexico, and in the Mediterranean and Middle East, where rainfall decreases of 10-25% (regionally) and up to 40% (locally) are projected. (Shindell, 2007)

Human societies rely on ecosystems not only for food and resources but also for free services such as water purification and defence against natural hazards. The natural ability of many ecosystems to adapt may be exceeded by both the rate of climate change, as well as a combination of changes in climate

variables such as increased flooding, drought conditions, wildfires and ocean acidification. On continents the most vulnerable ecosystems to climate change impacts are those of the tundra, boreal forest, mountain and Mediterranean ecosystems. At the coasts mangroves and salt marshes are particularly vulnerable to climate change impacts, while in the oceans coral reefs are virtually certain to be severely negatively impacted. Ocean acidification brought about by increased atmospheric carbon dioxide concentrations will impair the formation of shells and exoskeletons of ocean dwelling organisms requiring calcium carbonate. Species likely to be affected include corals, crabs, squids, marine snails, clams and oysters. (Parry et al., 2007)

In terms of food, fibre and forest products the increase in carbon dioxide in the atmosphere will initially increase plant production in locations where water and nutrients are not limited. The net impact of this is dependent on crop type, water and nutrient availability, disease, pests and other climate-related hazards. In mid- to high- latitude regions moderate warming will benefit cereal crop and pasture yields however decreases in yields are expected in seasonally dry and tropical regions even for a slight warming. Importantly, it should be noted that for temperature increases above 3°C, global food production is very likely to decrease, with declines in yield throughout the world. Coasts and low-lying areas will be exposed to increasing risks due to more intense coastal storms and sea level rise. At present the coastal communities most vulnerable to climate changes and sea level rise include deltas, especially Asian mega-deltas such as the Ganges-Brahmaputra in Bangladesh and West Bengal; low-lying coastal urban areas which are prone to human-induced subsidence and tropical storm landfall such as New Orleans and Shanghai; small islands, especially low-lying atolls such as the Maldives. (Parry et al., 2007)

5. Linking migration to climate change

Despite wide coverage of recent reports warning about the massive potential flows of 'climate change refugees' in newspapers, magazines and other media, there remains a surprising lack of empirical evidence to support these claims. (Salehyan, 2005: 2) In part this is due to the relatively low magnitude of climate change in the last 100 years. However, there are some empirical studies that identify how past manifestations of climate variability such as droughts, heavy rainfall, storms and other extreme weather events have affected people's migratory behaviour, and these are relevant to how people will react to future climate change and variability. This section seeks to provide an overview of such studies.

Most studies into the nexus between extreme weather events and migration are concerned with the

effects of drought or changing rainfall patterns on migratory behaviour. One recent study of southwest Mexico found a correlation between declining rainfall and rising migration to the US, since many rural communities depend on rain-fed agriculture. (Munshi, 2003) In an earlier time period, it is estimated that as many as 2.5 million people were displaced by drought and associated dust storms in the Mid West of the US in the 1930s, with most moving to neighbouring states, but as many as 300,000 moving to California as some of the world's first 'ecomigrants'. (Reuveny, 2008)

However, an analysis of migration and rainfall data for the Mexican states of Zacatecas and Durango, suggests the reverse relationship – in other words, migration to the US *decreases* as rainfall declines.[13] (Kniveton et al., 2008) This latter result is in agreement with findings from studies in Burkina Faso (Schoumaker and Beauchemin, 2004) and Mali, (Findley, 1994) where drought in the 1970s and 1980s was associated with decreases in international, long-distance migration. These studies suggest that food scarcity during drought leads to increased prices, forcing people to spend more money on their basic needs rather than on long-distance migration. However, they also show short-distance migration to larger agglomerations increased during drought years, as women and children left in search of work to contribute to household incomes.

Perhaps the key point here is that the effects of declining rainfall and drought on migration depend on the socio-economic situation of the people concerned. Such dependence has been demonstrated in relation to the migration decisions of pastoralists in Northern Sudan, (Haug, 2002) and of peasant farmers in Northern Ethiopia, where a survey of more than 100 peasant farmers concluded that 'people in marginal regions have developed a great variety of adaptation mechanisms, which strengthen their ability to cope with both slow climatic changes and extreme climatic events'. (Meze-Hausken, 2004) Meanwhile, in the case of the Dust Bowl, there is evidence that longer-distance migration from eastern Oklahoma to California was dominated by 'young, intact nuclear families with a high level of social capital in the form of pre-existing family connections to California'. (McLeman, 2006: 6) Dust bowl migrants were also more likely to have no land, or to not have repaid the mortgage on their land, and to have agricultural skill sets that were in demand in California at the time. It is also important to note that migration out of the Mid West had already begun before the periods of drought, reflecting over-capitalisation of agriculture in the region, and the overall depression of the US economy from 1929.
There has also been some interest in the phenomenon of migration linked to tropical cyclones and hurricanes, with Hurricane Katrina, which hit parts of the US states of Alabama, Mississippi, and

13 The analysis uses migration data from the Mexican Migration Project and rainfall data from the University of Delaware dataset.

Louisiana, and destroyed the city of New Orleans in 2005, as the most prominent recent example. Several studies of Katrina have highlighted demographic changes as a result of the hurricane, although most have focused on the nature of return migration, and why this has or has not been possible for different groups. (Elliott and Pais, 2006; Falk et al., 2006; Landry et al., 2007) One important feature of the displacement associated with Katrina is that initially at least, as many as 70,000, mainly poorer, black residents of New Orleans were unable to leave; (Landry et al., 2007: 2) yet, over time it appears that it is poorer, black residents who have been least able to return. Similarly, analysis of displacement following Hurricane Andrew, which hit parts of Florida in 1994, has found that people who lived in the wealthier southern part of the state migrated in much larger numbers than people who lived in the poorer northern part. (Smith and McCarty, 1996) However, the question of whether this was caused by the fact that the south was more severely affected or by the distribution of wealth in the population is left unanswered in the study. Meanwhile, in one of the few studies explicitly concerned with the effects of tropical cyclones on migratory behaviour, no relationship was found at all between the arrival of a devastating cyclone and long-term migration patterns from two village communities in north-central Bangladesh. (Paul, 2005)

Overall, it would seem that empirical studies into the relationship between climate-related environmental events and migration are few, and that their results are not conclusive. It is clear, however, that the assumption that climate-related shocks and stresses lead inevitably to migration in a linear way is not supported by empirical investigation. Many other factors play into the nexus between environmental factors and migration. Furthermore, a distinction has to be made between different types of movements, along both geographical and time scales.

6. Climate impacts and migration decisions

In the absence of robust predictions based on the extrapolation of existing studies of climate-migration interactions, this section turns to consider *in principle* the ways in which climate change and climate variability is likely to be associated with migration in the medium-term. As discussed above, there are two ways of thinking about this interaction: (a) to identify the major types of socio-economic impacts that have been identified in climate science, and consider ways in which these might lead to increased (or reduced) migration; and (b) to identify the major patterns and drivers of existing migration, and consider the ways in which these might be sensitive to climate change impacts. The bulk of existing literature on the subject seeks to do the former, often making quite crude assumptions about how socio-economic impacts are likely to be translated into population movements. Here we start with this approach but seek

to move towards an approach that would begin with migration, and explore its climate sensitivity.

6.1 Climate change impacts and their major societal/migration consequences

Drawing on the broad sweep of likely climate change impacts over the period to 2050 highlighted in section 4.5 above, Appendix 1 provides a first attempt to summarise these impacts systematically in terms of their likely effect on different regions of Africa, and to identify the types of migration that might be affected. Two tables are presented in Appendix 1, to reflect the likelihood of slow-onset climate change on the one hand, and abrupt or catastrophic change on the other having different impacts on societies, and as a result, on migration. It is important to note that even slow-onset climate change is likely to manifest itself both as *gradual change* – for example in terms of rising or declining agricultural yields, increased water stress, loss of biodiversity or changing distribution or productivity of fish species; and in the form of *major events* – such as floods, storms, or acute periods of famine. In this sense, our categorisation is slightly different to summaries elsewhere that have suggested a distinction between gradual change and individual climate events, (McLeman, cited in Brown, 2007) but have rarely included the possible consequences of catastrophic climate change in relation to migration consequences.

Looking at the first table in Appendix 1, it is clear that some slow-onset climate change phenomena are relatively unlikely to have impacts on migration – it is thought unlikely, for example, that changing patterns of diarrhoeal disease or malaria will impact significantly on migration patterns. There are possible migration impacts resulting from changes in coral, mangrove and fish productivity, where communities are specifically dependent on these resources. Besides, an extension of the growing season and reduced frost risk in some mid- to high-latitude areas, as well as the possible effects of increased carbon fertilization, may lead to increased demands for migrant agricultural workers in some areas.

However, there are two key areas in which the likelihood of slow-onset climate change having significant impacts on migration patterns appears quite high:

- First, increased drought risk, heat waves and water stress in tropical and sub-tropical dryland areas, and an expansion of these areas, as a result of higher temperatures and lower overall rainfall, is likely to significantly affect underlying 'push' factors for migration in affected regions (see Ghana, Sudan and Ethiopia case studies);
- Second, increased flood risk, especially in low-lying coastal deltas in the tropics, as 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, is likely to be a powerful force for additional 'distress' migration in affected regions (see Bangladesh case study).

In addition, a projected decline in the *predictability* of weather systems will potentially severely undermine rural livelihoods and could play a key role in decision-making on migration and other possible livelihoods – particularly for the poor who can't afford to take risks.

Looking first at drought risk, it is abundantly clear that migration is already a significant response to the risk of drought in many dryland areas, as part of a livelihood diversification strategy that seeks to minimise vulnerability. Experience of drought events is high throughout parts of dryland Africa. In Ethiopia for instance, research documented by the UNDP, found that half of all Ethiopians had experienced at least one major drought during the brief period from 1999-2004 (see Ethiopia case study). In addition, recurrent droughts increase societal vulnerability to future droughts with the destruction of key social insurance mechanisms such as livestock, by generating poor terms of trade and preventing households from replenishing stocks (see Sudan case study). In this general context, increased drought risk might logically be expected to be associated with increased migration, particularly in the context that affected countries across the Sahel zone of Africa have amongst the world's highest fertility rates, and so a rising number of potentially affected people. Yet it is also clear that international migration is, and is likely to remain, an expensive endeavour, with significant resources required both to undertake the journey from Africa to Europe or North America, and especially to cross international borders. Therefore, 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 within the region, or in agricultural areas less affected by drought, both in the form of seasonal or circular migration, and as distress migrants at times of particularly acute conditions. Whilst much of this migration is likely to be within countries, some will be international, particularly to major cities such as Lagos, Abidjan and Accra. Existing empirical evidence reviewed in section 5 confirms this reasoning.

Elsewhere, the IPCC observes that in Latin America already dry regions such as southern Chile, south-west Argentina, southern Peru and western Central America have become drier, whilst in other areas such as south-east Brazil, Paraguay, Uruguay, the Argentinean Pampas and some parts of Bolivia, increases in rainfall have affected land use and crop yields. (Magrin et al., 2007: 583) Yet most current

migration to the US takes place from Central America, with about 164,000 Mexican migrants crossing the border to the US every year, (OECD, 2007: 38) whilst migrants from Guatemala, Honduras and El Salvador also move north, using Mexico as a transit country or staying there. (IOM, 2005: 88) In this context, a decrease in crop yields in combination with a lack of economic alternatives in rural areas may influence labour migration from Central America to the US, but it appears less likely to drive South American migration, except in that Mexico might become less attractive as a destination for migrants from the south. Indeed, changes in the climate of the South West of the US might itself lower agricultural output of the region, and in turn, the demand for migrant workers.

Turning to flood risk, increased flooding of coastal and low-lying areas is also a major livelihood threat, especially in vulnerable societies that do not possess the economic and technical means to cope. Sixteen of the 22 largest cities in the world projected for 2015, representing more than 260 million people, are port cities, many of them in developing countries. (UNESA, 2006) Yet once again we should not assume that the resulting migration will be long-distance. The Asian Tsunami in 2004, for example, killed more than 200,000 people and displaced over 400,000, but most were received locally, and most have returned. (Brown, 2007: 16) The fact that there was a swift and internationally-supported humanitarian response in this case may be relevant, but is surely not the only reason why people did not move to richer countries.

For example, in Bangladesh, millions of people are left homeless each year due to flooding, although most of them travel very short distances, and try to return and rebuild their houses after the disaster (see Bangladesh case study). Meanwhile, whilst internal and international migration from Bangladesh is well-established, some of the regions most affected by migration – such as Sylhet, the region of origin of the majority of Bangladeshi migrants in the UK – have very low levels of flood risk. In practice, factors such as poverty, landlessness and lack of economic opportunities all play into the decision-making process of migrants, and the loss of livelihoods brought about by more frequent flooding is certainly an aspect that might trigger future migration decisions. As with drought-related migration, it is reasonable to expect much greater rural-urban, rural-rural and distress migration as a result of increased flood hazard in Bangladesh, but it is less clear that this will impact significantly on migration flows to developed countries such as the UK.

The coast of the Gulf of Mexico is another example of a region in which frequent flooding occurs. The most recent example is the flooding of the Mexican state of Tabasco in 2007 which forced many to seek refuge in the neighbouring state of Veracruz. However, whether more devastating hurricanes and more

frequent flooding in the region will cause only temporary displacement, or whether people will migrate more permanently is unclear. For example, labour migration from Guatemala and some of the southern districts of Mexico to the US and other destinations in Mexico has existed for decades. In Veracruz, a Mexican state that encompasses a large section of the Gulf of Mexico, large-scale migration started in the 1990s and could therefore be linked to increasing damage due to flooding and hurricanes. However, factors such as a decline in prices for cash crops, especially sugar cane, and the desire to migrate to earn money for a project, for example a house or a business, have also been identified as important drivers of migration.

There is also the possibility that there may be some interaction between the effects of drought risk and flood risk on migration, given that both are likely to promote an increase in internal rural-urban migration, but those increased populations in coastal cities are themselves likely to be more vulnerable to flooding. In Africa, UN projections suggest 123 million people, or over 10% of the continent's population, will already be living in some 45 cities of a million people or more by 2015, even without additional climate-related movements. Of these, 53 million will live in 18 coastal cities vulnerable to flooding, including Lagos, the continent's biggest city, which is predicted to double in size by 2015 (Table 3). The likely consequences for urban growth if projections were to be extended to 2050 are clearly huge.

Table 3: Africa's 20 largest cities in 2015

City	Country	Population 2000	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	Cote 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: UNESA, 2006. Note: projections for large cities are made only to 2015.

More broadly, in 2005, more than 1 billion people, almost one sixth of the world's population, were estimated to be living in slums, with 90% of these in the less developed regions. (DPU-UCL, 2003; UNPF, 2007) It is also estimated that, by 2030, some 60 per cent of all urban dwellers will be under the age of 18. 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.

6.2 Abrupt climate change and migration

Discussion in the previous section focused on both slow-onset climate processes, and extreme events related to those processes, and highlighted key migration outcomes that might be expected to follow. In the case of abrupt or catastrophic change, however, there is clearly an increased risk of the emergence of new migration streams, including the possibility of long-distance flows, rather than the reinforcement of existing patterns of migration.

6.3 Drivers of migration and their sensitivity to climate change

An alternative way of looking at the likely impact of migration on climate change is to consider the major drivers of migration, and then look at how sensitive they are to climate change. An initial attempt to do this is provided in Appendix 2, based on the categorisation of drivers of migration in section 3.4 above. What is immediately clear from this table is that it is predominantly the 'push' factors influencing international migration that are sensitive to climate change, rather than 'pull' factors or intervening factors such as ease of transportation or family or social networks. This is important, since there is a school of thought, which believes that the main factors driving migration are indeed either the 'pull' of economic opportunities in advanced capitalist areas of the world, (Hooghe et al., 2008) or alternatively the social networks that shape and channel migration, allowing it to grow. (Haug, 2008)

In so far as 'push' factors are key drivers of migration, an initial caveat is that these are quite locally specific in terms both of their significance, and their sensitivity to climate change. A response to this local specificity is partly provided by the case studies produced as annexes to this report; this is also an area in which more specific local research in regions likely to be most heavily impacted by climate change would be welcome. However, drawing on the empirical literature cited above, a small number of generalisations are possible, even at a global level.

First, short-distance, circulatory migration often has different drivers to long-distance, more permanent migration. Thus, whilst the former is often a response to shocks – food shortage, or flooding, or a temporary or cyclical shortage of employment or income, the latter is more usually planned, often as part of a household decision to 'invest' in the migration of certain household members in order to bring longer-term benefits to other members of the household through remittances, investment in schooling or the development of a small business. An example of circulatory migration is seen in Bangladesh in the response of rural populations to flooding (see Bangladesh case study), while planned migrations are

exemplified by the movement of rural workers seeking employment in plantation agriculture in central and southern Ghana and to gold mining areas in Ashanti, Ghana (see Ghana case study). In this sense, we might expect short-distance, cyclical migration and mobility to be more sensitive to climate change impacts: both because those engaged in short-term migration tend to be more vulnerable than those able to invest in accessing more distant and remunerative markets; and because those who normally do not migrate at all are more likely to respond to a drought year or a flood by moving over relatively short distances in a reactive manner. There may however also be a shift towards the increased permanence of some of these flows, as it becomes less possible to support a livelihood in areas of origin, even in the season when economic opportunities are greatest. In contrast, although decisions about long-distance moves may be affected by climate change, and its impact on the relative economic and other opportunities in places of origin and destination, these are more likely to be mediated or indeed outweighed by other economic or social considerations.

A second point is that it is in rural areas that the effects of climate change are likely to be least 'mediated' by other socio-economic or political factors, since people are likely to be more directly dependent on natural resources, the productivity of the land or other natural factors of production. In contrast, in urban areas, the extent of vulnerability to climate change will be mediated significantly both by the overall strength of the urban economy, to the extent that a strong economy may provide a diverse range of possible coping mechanisms; and also by the extent to which there is public and private investment in disaster protection and response, to shield people from the worst effects of a climate shock.

However, it is also important to note that with or without increased rural-urban migration, demographic predictions make it clear that the world's urban population will grow over the next 20-30 years, and quite dramatically in the case of many of the world's largest cities. This puts a focus squarely on whether these cities will be able to cope with such population increases, and whether the density of urban populations in many developing countries may itself be a factor that provokes either violent confrontation, or migration, or both.

Third, it is clear in the historical record of significant migrations that have been associated with climate variability – such as the Dust Bowl in the US – that the extent of vulnerability of individuals and families to migration as a consequence of environmental degradation is highly dependent on their own asset base, understood in a wide sense to include not only physical capital (such as land and other infrastructure) but also human and social capital. In other words, droughts, famines and floods – all

likely consequences of climate change – do not have the same consequences for all sectors of the population; rather, there is now a substantial literature that establishes how individuals' vulnerabilities are a function of their endowments and entitlements, rather than simply the availability of jobs, food or housing in a particular area. At the same time, some will find it easier to leave than others – with a likely polarisation of social structures in places of origin as a consequence.

It is also important to note that it is not only 'push' factors that may be affected by climate change – conditions in destination areas may also be affected, with the effect both of encouraging, and limiting migration. Two examples can be tentatively offered. On the one hand, large areas of the 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 increase costs and could potentially undermine the viability of a number of enterprises. This could in turn undermine patterns of migration that are now well-established, either cutting them off, or diverting them to other places or other sectors. However, a counter-example is provided by improving conditions for agriculture in Northern Europe, and especially over parts of 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 – to accelerate existing migration flows, from Southern and Eastern Europe to Northern Europe, and from Central Asia to Russia.

7. Country Studies

7.1 Climate Change and Migration: Bangladesh

Overview: demographics and climate change in Bangladesh

Demographic Trends: With a population of over 144 million, Bangladesh is one of the most densely populated countries in the world at 1,064 inhabitants per sq. km. Annual growth rates are slowly declining, currently at 1.8%, and projected to fall to 0.56% by 2045-2050. Nonetheless, population is set to increase by over 100 million over the same period (to 254 million by 2050), with densities rising dramatically to 1,764 per sq. km. Rates of urban growth are high at 5% per year, and the proportion of the population living in urban areas is projected to increase by 15% to 2030, reaching almost 40%. Nonetheless, the total rural population of Bangladesh is still predicted to rise in absolute terms by an additional 17 million people. (World Bank, 2007; UN ESA, 2006; UN-HABITAT, 2007)

Climate change: Bangladesh is projected to be one of the countries most adversely affected by climate change. Limited economic strength and levels of social development, high dependency on the natural resource base, and inadequate infrastructure and institutional capacity make the country particularly vulnerable to both climate shocks and stresses.

Impacts are characterised by the exacerbation of extreme events that already plague the country and present an ominous forecast, including: prolonged and widespread drought and water scarcity in the north east, intensified and more frequent storm activity, exacerbated in coastal regions by rising sea levels, accelerated river bank erosion and more frequent flooding on account of intensified rainfall and (in the short-term) upstream deglaciation, drainage congestion and deeper penetration of salinity in surface water, ground water and soils.

7.1.1 Current migration systems

Internal migration: Internal migration is important and increasing. Case studies reveal that seasonal migration to both rural and urban areas provides vital income sources for the rural poor during periods of low local employment opportunity: almost two-fifths of rural households in Faridpur and Rajbari send adult members to nearby towns, while in the northwest 19% of households across all wealth groups migrate in the lean agricultural season, rising to 25% for chronically poor households . (Afsar and Baker,

1999, cited in Afsar, 2003; Hossain et al., 2003) In some villages, more than 80% of incomes are derived from outside the village with temporary labour migration becoming increasingly common. (Toufique, 2002, cited in Asfar 2003)

Long-term migration is dominated by rural-urban flows, largely to the centres of Dhaka and Chittagong, and such migration is estimated to account for about two thirds of all urban growth since independence. One study attributes nearly two-thirds of internal migration to rural-urban flows, compared to just 10% for rural-rural migration.[14] (Rahman et al., 1996, cited in Afsar, 2003) Another study has concluded that net migration to urban areas increased dramatically from 1.2 to 16.4 per thousand between 1984 and 1998, compared to an increase from 1.5 to 4 per thousand of rural-rural migration during the same period. (Asfar, 2003)

Economic migrants are typically young, poor and male, although this has changed significantly with the recent increase in demand for female labour in the readymade garment (RMG) factories of Dhaka and other metropolitan areas. Most poor migrants live in slums and squatter settlements, which have been growing at 4% per year and account for 86% of the urban population. (UN-HABITAT, 2007) Such areas lack security and basic amenities and are located in ecologically vulnerable areas such as flood plains. As a result they are among the first and largest urban casualties of climate shocks. (Barkat and Akhter, 2003)

International migration: Bangladesh is a major labour-sending country. International migration plays a considerable role in both livelihoods and the national economy, accounting for some US$5.5bn in 2006. (World Bank, 2007a) Remittance flows have increased by an annual rate of 10% for the past 25 years, (Siddiqui, 2003) and recent growth has outstripped both national economic growth and international assistance: from 2000-2005 aid remained relatively constant while GDP increased at a (high) average annual rate of 6%. By contrast, remittances and compensation of employees grew by 18% per year over the same period, now constituting more than four times what the country receives in aid. (calculated from World Bank, 2007a) Further, unofficial channels, such as *Hundi*, are estimated to account for an additional 40% of total remittances. (Siddiqui, 2003)

Most long-term or permanent emigration is to the UK or US (some 500,000 Bangladeshis in each). (Siddiqui, 2003) Short-term contract migration to the Middle East and South East Asia has grown

[14] Panel data was generated from 62 randomly sampled villages.

considerably since the mid-1970s (aided by the emergence of private recruiting agencies in the 1980s), and is now the dominant form of international migration. More than 3 million Bangladeshis have migrated overseas for employment during this period, with an annual average of around 226,000 leaving from 1991-2002. (Siddiqui, 2003) However, substantial increases in the cost of migration and growing competition from other countries since 2000 have recently led to a small decline. Such migrants largely constitute male, semi and unskilled labour. The number of unofficial female migrants is likely to be substantially higher than official estimates of 1%. While international migrants have financial resources at their families' disposal (or access to social networks for generating further resources to finance migration), case study evidence suggests that poorer migrants may also migrate by acquiring visas and flights through employers and social networks abroad. (Siddiqui, 2003)

Forced migration: Over one million people lose their homesteads or land to river erosion each year. (RMMRU, 2007) Case studies suggest that displaced people initially try to relocate themselves within the village, or in neighbouring villages, reflecting the fact that the annual cycle of flooding both erodes land, and may slowly create new areas for potential settlement as a result of siltation. However, while river bank erosion may occur overnight, sedimentation is a considerably longer process and may not necessarily occur in the same location. Local population pressures therefore rise and some of those displaced gradually move to urban areas when no other income options are available. (Hossain et al., 2003)

Climate shocks can exert a heavy toll on lives and livelihoods. Floods in 1988 and 1998, for example, left 45 million and 30 million homeless respectively, and an estimated combined death toll of 3,000-7,600. (Rahman et al., 2007) Evidence for the impact of rapid-onset disasters on population displacement is mixed. Heavy monsoonal rains in 2007 affected over 10 million people in 39 of the country's 64 districts, driving a reported 3,000 migrants a day to Dhaka due to inadequate relief and lack of incomes. (IRIN, 2007) However, where aid has been effectively distributed and food markets supported, (e.g. 2004 tornado and 1998 floods) out-migration has been minimal. (Del Ninno et al., 2001; Paul, 2005)

7.1.2 Key migration drivers

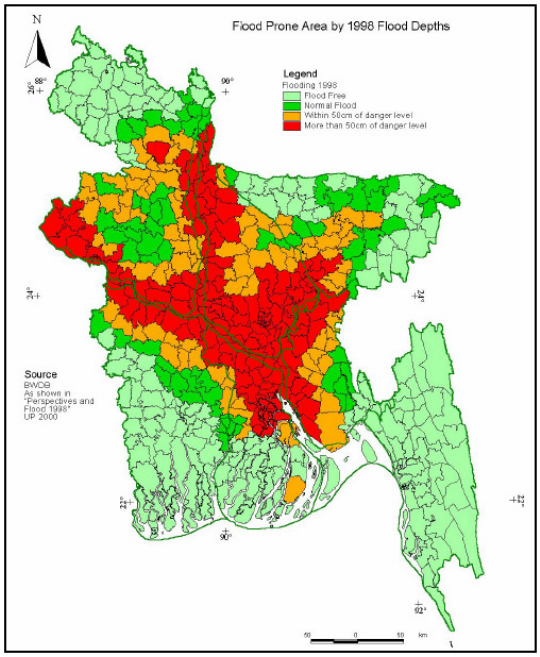
Limited access to natural resources: 70% of rural people are either completely or functionally landless. Poor access to land, exacerbated by high population densities and inheritance laws, is a key factor mediating the flow and nature of migration. Landless labourers are the first to suffer the effects of

reduced production, and with reduced access to traditional social insurance mechanisms such as informal credit and reciprocity, are less able to manage risk. Consequently, the landless migrate in larger numbers, often in family groups. Half of all poor migrants to Dhaka are landless labourers, while three quarters of women and two thirds of men working in textile factories have been found to be functionally landless. (Afsar, 2003; Afsar, 2005)

Differential employment opportunities: It is estimated that one-third of the total working-age population of Bangladesh is either unemployed or underemployed, of whom 80% live in rural areas. International migration has kept the unemployment rate virtually unchanged since the 1980s, although the growth rate of the labour force is almost twice that of the population growth. (Siddiqui, 2003) The economic pull of urban areas, where non-agricultural incomes grew six times that of agricultural incomes from 1988-1995 is a complementary driver. (Afsar and Baker, 1999, cited in Asfar, 2003) Urban incomes are also more secure. Even in slums, case studies suggest that employment is commonly found within days of arrival, and provides key remittances back home. (Afsar, 2003; Barkat and Akhter, 2003) Limited employment is not confined exclusively to rural areas: lack of year-round employment has been one of the major reasons for out-migration by adult members in almost two-fifths of the households in small and medium towns. (Afsar and Baker, 1999)

Ecological vulnerability: Limited productivity and labour opportunities, notably the *monga* season in the drought-prone northwest, and prolonged flooding elsewhere is a key driver of migration, particularly where climate variability is high. Migration triggered by ecological vulnerability – particularly floods and cyclones – is significant in number and frequency, but commonly temporary and local/regional in nature. (Afsar and Baker, 1999)

Figure 2: Current flood-prone regions of Bangladesh



Source: Ministry of Environment and Forest Government of the People's Republic of Bangladesh (2005) National Adaptation Programme of Action (NAPA)

Migration networks: The most substantial flows of migrants abroad are significantly steered by networks. In the case of migration to the UK, colonial era migration flows have been reinforced in particular by the search for marriage partners amongst UK-based Bangladeshis; in the case of the Gulf, movement has depended on employment opportunities generated either through kin networks, or through networks of recruitment agents.

Political instability: Political security is also often cited as a driver of overseas long-term/permanent migrants. In addition to economic push factors, it has also been a primary motivation for cross-border migration into India, where some 15 million are estimated to be living illegally. Between October and December 2002, for example, an estimated 5,000 to 20,000 Bangladeshi Hindu and other minorities fled to India to escape violence following Bangladesh's national election which brought a pro-Muslim party to power. According to an estimate by the West Bengal Border Police Department, about one thousand cross the border each day and enter West Bengal, although it is unknown how many stay or return after temporary employment. (Datta, 2004)

7.1.3 Susceptibility of drivers to climate change

The diverse impacts of climate change on sectors and regions of Bangladesh can be summarised as follows, suggesting that the coastal, north-western, and central zones together with the piedmont plain are most vulnerable:

Table 4: Impacts, vulnerable areas and sectors

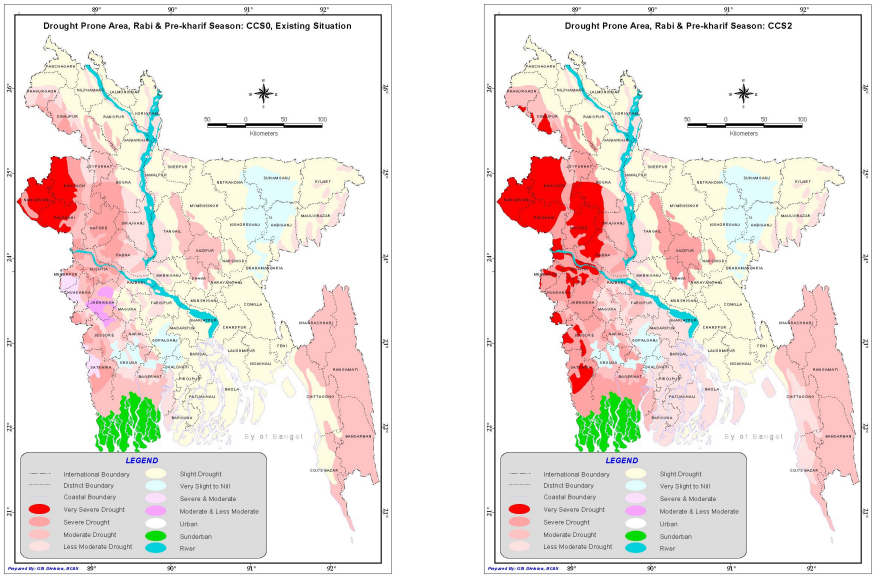
Climate and Related Elements	Critical Vulnerable Areas	Most Impacted Sectors
Temperature rise and drought	▪ North-west	▪ Agriculture (arable, livestock) ▪ Water ▪ Energy ▪ Health
Sea-level rise and salinity intrusion	▪ Coastal ▪ Islands	▪ Agriculture (arable, fisheries, livestock) ▪ Water (water logging, drinking water, urban) ▪ Human settlement ▪ Energy ▪ Health
Floods	▪ Central ▪ North-east ▪ Char lands	▪ Agriculture (arable, fisheries, livestock) ▪ Water (urban, industry) ▪ Infrastructure ▪ Human settlement ▪ Health ▪ Energy
Cyclones and storm surges	▪ Coastal and marine zones	▪ Marine fishing ▪ Infrastructure ▪ Human settlement
Drainage congestion	▪ Coastal ▪ Urban ▪ South-west	▪ Water (navigation) ▪ Agriculture (arable)

Source: adapted from Rahman et al., 2007

Limited access to natural resources: Climate change is likely to impact detrimentally on almost all rural production systems, which, combined with a growing population, may dramatically reduce both productivity of and access to natural resources. Local access to common resources on which the rural poor depend (e.g. fisheries, forest, river bank cultivation) will also decline, driving out-migration of the rural poor. Adaptive responses (e.g. development of shrimp farming in response to increasing salinity) currently benefit outside (e.g. urban) investors, while local populations are increasingly forced to abandon land and migrate to the city.

Differential employment opportunities: Increased risk to agricultural productivity is likely to widen real and perceived rural-urban differences in income opportunities and access to services. In the drought-prone northwest, where rainfall is almost half the national average (1240mm/year), the period 1978-1990 has already witnessed trends of increasing temperature (0.05ºC/year) and a decline in the length of the monsoon. (Rahman and Alam, 2003) Rice, the nation's principal crop, is particularly sensitive to higher temperatures, and in the absence of long-term changes to cropping patterns, may lead to declines in rural incomes. Relatively small deficiencies in 2006 monsoonal rainfall, for example, generated *aman* rice losses of 25-30%. (Rahman et al., 2007) While major investment over the last two decades in some regions (e.g. rainfed Barind) has succeeded in raising agricultural productivity, most of these efforts will be challenged by predicted increasing drought in the northwest. (Rahman et al., 2007) One can thus expect accelerated rural-urban flows and increased international migration (for those able to access such markets) as urban centres become increasingly over-burdened and competition for employment increases.

Figure 3: Current and projected drought prone regions of Bangladesh



Source: Rahman et al. 2007

Ecological vulnerability: Increased ecological vulnerability will reduce rural incomes and heighten risks faced by human settlements, particularly in the absence of effective adaptation and disaster risk reduction investments. Projections of rising sea-level impacts vary around 10-21% of land permanently inundated for a 45cm and 1m rise respectively, (IPCC, 2001) the latter directly threatening settlements which represent 11 percent of the total population, and 70 million affected from the impact on river levels. (UNDP, 2007) Further sea level rise will bring the water line further inwards in such a way that

storm surges, projected to increase in both frequency and intensity, will penetrate deeper inland, incurring ever-increasing losses to communities and ecosystems. (Rahman et al., 2007) While current disasters may not generally produce permanent out-migration in Bangladesh, this may change as shocks become more frequent and damage to infrastructure more intense, threatening the sustainable recovery of affected regions.

Migration networks: Migrant networks that steer people to the UK, US or the Gulf are likely to be unaffected by climate change.

Political instability: Rising populations combined with increased climate risks threaten to undermine efforts to improve political stability, particularly as ever-increasing demands for (timely) disaster relief and urban services over-burden the government's modest financial and institutional resources. Cross-border and international migration flows could increase as a result.

7.1.4 Intervening Factors

Persistent poverty and inequality: While Bangladesh has made considerable progress in economic and social indicators, 50% of the population remains below the poverty line and over half the country is functionally illiterate. Access to services is highly unequal – for example, the proportion of births attended by a doctor or midwife is less than 1.5% for the poorest households, compared to 22% for the richest – one of the highest equity gaps in the world. (World Bank, 2005) Poverty undermines peoples' capacity to cope and manage climate risks, leaving out-migration the only option available for many.

Natural resource dependency: Despite the ongoing transformation of the economy towards non-farm and service industries, agriculture accounts for 20% of GDP and continues to account for the largest proportion of the workforce. (World Bank, 2007a) Declines in rural production will thus directly affect large proportions of the population, presenting a significant migration driver.

Governance: Law and order in Bangladesh is weak and there has been steady erosion in the quality of the civil service and the Government's capacity to deliver essential services, further constrained by highly centralized political and administrative systems. A recent World Bank cross-country study of governance shows the country performs particularly poorly in the control of corruption, political stability, regulatory quality, and rule of law, which has both hampered prospects for long-term foreign capital inflows and increasingly driven international out-migration. (World Bank, 2005)

Infrastructure: Migration and share of remittances to household income in Bangladesh have been found to be lowest among villages with poor infrastructure. Poor transport links also considerably inhibit the delivery of timely aid, generating isolated pockets of extreme deprivation. Extreme poverty rates on char islands, for example, are severe at 80%, compared to the 23% national average. (Dasgupta and Mitra Associates, 2005) Conversely, as markets, communications and transport and access to electricity have improved, so has the significance of economic migration to rural livelihoods.

Environmental degradation: Inland capture fisheries, a valuable resource for the poor, have come under threat due to encroachment and degradation of natural assets and rapid urbanization. Combined with impacts of urban air pollution and increasing quantities of untreated sewerage from Dhaka, costs are estimated at 4% of GDP, most of which are borne by the poor. Increased encroachment into mangroves are reducing key ecosystem services along the coast, while there are increasing concerns over soil quality and productivity on account of increasingly intensive cultivation and rising salination. Such degradation renders local populations more sensitive to climate risks, thus contributing to out-migration drivers.

7.1.5 Policy implications

As donors are just starting to consider the impacts of climate change on their investment, research suggests that aid to Bangladesh is highly vulnerable to climate risk. One OECD assessment of development assistance to the country found that over $500m, almost a third of all annual aid, was susceptible to climate change. (Agrawala (ed), 2005)

Perhaps the most prominent migration-related consequence of climate change in Bangladesh is the likelihood of increased short-term displacement as a result of flooding and storm surges. In this context, an important policy priority is to ensure the efficient functioning of a system for flood preparedness, and to support the timely delivery of aid that will prevent temporary displacement from becoming permanent. This is being partly addressed through the Comprehensive Disaster Management Programme (CDMP), a $14.5m multi-sectoral programme supported by UNDP, the EC and DfID that encompasses a wide range of risk management tools, including early warning, disaster risk reduction and preparation and poverty reduction, and facilitates a move from a single agency relief system to a government-wide strategy to reduce national and community-level vulnerability. (Mallick et al., 2005; UNDP Bangladesh)

While not yet fully operational, the devastating impacts of floods and storms witnessed in 2007 hint at the scale of the challenge, and considerably more investment in this area may be necessary.

Given that climate change is considered likely to accelerate rural-urban migration flows, particularly to slum areas of larger cities such as Dhaka and Chittagong, attention should be paid to the provision of infrastructure and basic security in such settlements. One point to bear in mind here is the susceptibility of these cities themselves to flood and storm hazards (evidenced by the slum landslides of 2007) that could become more extreme as a consequence of climate change. This implies an urgent need to improve disaster preparedness and response in the city, and in the long-term, address the prickly issue of land tenure for millions of highly vulnerable urban squatters.

This does not mean, however, that investment should be systematically withdrawn from rural areas. Rural population is still projected to increase in absolute terms despite rising rates of out-migration, and it is the most vulnerable who will be left behind. The rate and scale of erosion of the sustainability of rural production systems (e.g. drought-prone northwest) and settlements (e.g. char river island dwellers) as a consequence of climate change is far from certain. A number of community-based adaptation programmes, such as the CIDA-funded Reducing Vulnerability to Climate Change (RVCC) project, are successfully enhancing productivity (agriculture and small-scale industry), local livelihood options and local knowledge about climate risks and responses. Investment in such vulnerable areas can be cost-effective: DFID's pilot Orchid programme, for example, has found that investment in basic flood protection for char island dwellers generates favourable cost-benefit ratios in relation to damage to infrastructure and relief costs for those displaced if such investments are not made. (Tanner et al., 2007) More effort is required to address structural constraints (e.g. markets, access to land and productive resources) that are beyond the reach of small-scale projects.

In contrast, international migration will less clearly be impacted by climate change, as the drivers of this migration are more associated with existing migrant networks. There is the potential for increased cross-border migration to India, although neighbouring parts of West Bengal will be similarly affected by flooding (and siltation) in the delta region. Perhaps the major issue here is less the relative allocation of aid resources to Bangladesh or West Bengal, and more the need to address tensions between the two states that could arise from any increase in such flows.

7.2 Climate Change and Migration: Ghana

Overview: demographics and climate change in Ghana

Demographic trends: The population of Ghana is projected to rise to nearly 42 million in 2050, almost a doubling compared to 2005. This reflects the fact that fertility in Ghana is high at 2.2%, although it is projected to reduce to 1.0% by 2045-50. The proportion of the population living in urban areas is projected to rise from 48% at present to 65% in 2030, suggesting that almost all population growth over this period will occur in urban areas. A significant proportion of this growth is projected to be in the cities of Accra and Kumasi, both of which are predicted to have over 2 million inhabitants by 2030.

Climate Change: Generally rainfall in Ghana decreases from south to north, with the wettest area in the extreme south-west recording an annual rainfall of about 2000mm, and supporting areas of tropical rainforest, whilst the driest, in the extreme north, receives less than 1100mm, putting it firmly within the dryland zone of the Sahel. (Environmental Protection Agency of the Government of the Republic of Ghana, 2000) Simulations of future climate change for Ghana indicate that temperatures will increase by up to 3°C by 2100, with the increases highest in the north. At the same time, mean annual rainfall is projected to decrease across much of the country, and especially in the north, although in the High Rainforest Zone of the southwest, it is likely to increase. (Environmental Protection Agency of the Government of the Republic of Ghana, 2000)

These climate changes are likely to considerably impact on water resources, with a reduction in river flows and reduced groundwater availability; they are also projected to negatively affect agricultural yields, particularly in the centre and north of the country. (Environmental Protection Agency of the Government of the Republic of Ghana, 2000) In addition, Ghana is vulnerable to anticipated sea level rises over the next century with extensive flooding and inundation of coastal regions expected especially in the low-lying sandy coastal areas such as the Volta delta.

7.2.1 Current migration systems

Seasonal migration: There is both seasonal labour migration and movement of pastoralists in and from northern Ghana, reflecting differences in the timing of the rainy season, (Primavera, 2005) and fluctuating work opportunities in commercial agriculture. In the coastal south, seasonal fishing migrations have also historically occurred, although there is little evidence that this has been due to the

population pressure or local over-exploitation of fish resources; rather, economic opportunities and the seasonal availability of fish have encouraged migration. (Marquette et al., 2002)

Longer-term internal migration: In addition to seasonal migration, there is also substantial longer-term and longer-distance internal migration, involving both rural-urban and rural-rural moves, and lasting from a few years to a lifetime. Again this migration is primarily orientated from north to south, as well as to urban and mining areas, although evidence on whether it is increasing or decreasing, and the degree of return or circularity, is limited. Movements include substantial rural-rural moves of workers seeking employment in plantation agriculture in the centre and south of the country, movement to the gold mining areas in Ashanti, and significant movement of children and young adults from the north to work in commerce and petty trade in the cities of Accra and Kumasi.

Inter-regional migration: West Africa has a long history of migration across national borders, reflecting freedom of movement within the Economic Community of West African States (ECOWAS). (See http://www.ecowas.int/) However, this has had its limitations: Ghana itself was a major destination for migrants until the 1970s, when economic collapse led to return and expulsions of foreign workers. Meanwhile, between 900,000 and 1.2 million Ghanaians were deported from Nigeria in mass expulsions of 1983, (Black et al., 2004:22) whilst movement from Ghana and other countries to neighbouring Côte d'Ivoire has been limited recently as a consequence of conflict in that country. (Peil, 1995) However, it is true that the ECOWAS Protocol has enhanced inter-regional migration in West Africa. For example, 500,000 West African immigrants are estimated to be working on cocoa farms and in the hotel industry in Ghana. (Hernández-Coss and Bun, 2007)

Overseas migration: Since the 1970s, large numbers of Ghanaians have moved overseas, initially in response to political instability and economic hardship, or to seek educational opportunities, but increasingly to work, to do business abroad, or to follow or join family members. This mass emigration of Ghanaians has increased the Ghanaian diaspora especially within Europe, where there are at least 100,000 Ghanaians[15] (Bump, 2006) and North America, where there are at least 80,000[16], (Bump, 2006) but also in the Middle East and Asia. One troubling aspect of this is the movement of skilled health professionals: it is estimated that over 60 % of all doctors trained within the country in the 1980s had emigrated by 1999, (Ahmad, 2007) with main destinations being the UK and the US. (Black et al.,

[15] A total of 55,537 Ghanaian-born were counted in the UK census in 2001; whilst there were an estimated 32,754 Ghanaians in Italy, and 20,636 in Germany in 2004

[16] A total of 16,985 Ghanaian-born were in Canada in 2001, whilst 65,570 were in US in 2000.

2004) The choice of destinations was mainly based on the educational and professional opportunities available to them, language and cultural issues, the costs of living and the presence of family and kin at destination.

Displacement and forced migration: In addition to some forced resettlement in the past associated with major dam projects, as of early 2006, Ghana hosted 38,684 refugees from the war in Liberia, and 14,138 fleeing civil conflict in Togo, (UNHCR, 2007) whilst recurrent violent conflicts in the north since 1980 have also led to some internal displacement due to insecurity. Many of these conflict-induced displacees have moved to the south of Ghana, especially Accra. (Shepherd and Gyimah-Boadi, 2004)

7.2.2 Key migration drivers

Differential employment opportunities: A major driver of migration in Ghana is the significant (and growing) inequality in employment and income-generating opportunities, broadly between the north and south of the country, but also between West Africa and Europe, which has driven a growing number of people to seek to move internationally. In particular, the relatively strong economic growth in Ghana over the last decade has been very much concentrated in urban and mining areas, and in areas of commercial cultivation of coffee, cocoa and newer export crops such as pineapples. In contrast, significant areas of the north of the country have witnessed little productive investment and a decline in employment opportunities in public services.

Fragile natural resource base and need for diversification: Traditionally, farmers and pastoralists in northern Ghana have sought to mitigate the risks associated with living in the marginal Sahel zone by diversifying their sources of income, and migration has long been one such livelihood strategy. In particular, variability in rainfall encourages patterns of seasonal migration in good years, and distress migration in drought years; the growing variability and uncertainty associated with rainfall patterns has arguably encouraged more anticipatory migration, whilst periods of drought in the north have contributed to undermining other forms of social insurance, leaving migration as a primary strategy to support livelihoods.

Social networks and family ties: The establishment of a Ghanaian diaspora has created an international social network and enables more Ghanaians to travel abroad and so increases migration (and remittances) from abroad. (Higazi, 2005) Marriage and other family reasons are also major factors which contribute to migration within Ghana. According to the 1998 Ghana Living Standards Survey,

around 60 percent of migrants from rural to urban areas moved because of family-related factors, although this includes dependents of those who migrated for economic reasons. (Anarfi et al., 2003)

Conflict: Conflict, notably between farmers and pastoralists, has been a feature of northern Ghana in recent years, and though less visible internationally than in some other countries of the region (e.g. Nigeria), it has been a driver of both temporary and more permanent displacement.

7.2.3 Susceptibility of drivers to climate change

Differential employment opportunities: Rapid economic growth in Ghana's major cities is underpinned by the need for energy; however, within Ghana, hydroelectric power stations generate 80% of total national power production. This could be seriously affected by climate change, especially reduced rainfall, which has already caused a decline in the lake levels, leading to power crises. Projections for future electricity production have pointed to a 60% decrease by 2020, whereas an increase in the demand for electricity due to population growth in urban areas could necessitate the building of new power plants. Thermal power plants are now regarded as the major alternative source of electricity in Ghana. (Environmental Protection Agency, 2000)

In addition, there is the potential for climate change to influence the productivity of the commercial agricultural sector in central and southern Ghana, and associated employment opportunities. For example, cocoa is very sensitive to drought; climate change could alter the geographical distribution of cocoa pests and pathogens, decrease crop yields, and impact on farm income. (Anim-Kwapong and Frimpong, 2005)

Related to this, a rise in sea level can be expected to raise the soil moisture content of sandy and silty soils along the coastline of Ghana. These soils could be at risk of collapse during earthquakes that are prone to occur particularly in the Accra and the West Coastal areas, where active geologic faults lie and where unconsolidated sedimentary formations occur. (Environmental Protection Agency, 2000) Saltwater intrusion is also expected as a consequence of a rise in sea level. Increased flood risk in the city of Accra and other coastal cities resulting from higher sea levels and increased intensity of tropical storms could also impact on economic activity in these areas, and hence on future employment opportunities.

Fragile natural resource base and need for diversification: Increased temperatures and reduced rainfall in central and northern parts of Ghana are likely to lead to increasing water stress, reduced crop productivity, and an increase in drought risk and food insecurity. This could increase the risk of distress migration during times of acute stress, unless there is substantial anticipatory migration to mitigate this risk.

7.2.4 Key intervening factors

Persistent poverty and malnutrition: Many of the poor in Ghana are already malnourished, partly because they live in areas marked by drought and partly because they live in areas of natural low productivity. This makes them more vulnerable to climate change impacts. In the case of Ghana, half of the children living in the drought-prone northern area are malnourished, compared with 13 percent of those in the capital city, Accra. (UNDP, 2007) The result of research on the impact of the 1972-73 drought, in Upper Volta found that 20 percent of the children of the sedentary people in Ghana suffered from malnutrition, while this was approximately 40 percent among migrants. (Afolayan and Adelekan, 1998) People suffering from malnutrition are far more susceptible to the impact of climate change, increasing the pressure to migrate.

Access to markets: the strength of rural-rural flows of people in Ghana is dependent in part on access to international markets for commercial agricultural products; thus the decline of the cocoa sector in the 1970s and 1980s reduced seasonal flows of migrant workers to cocoa areas, and reflected weak international prices and restrictive government agricultural policies. In contrast, recent reorientation of Ghanaian agriculture to international markets has driven rising migration to commercial farming areas.

Deforestation: It has been argued that deforestation of the humid rainforest along the southern belt of West Africa may have significantly decreased the strength of the West African Monsoon and have contributed to the increased drought period. (Bonell, 1998)

Weak environmental management: Ghana is relatively weak in terms of managing its natural resources. For example, water resources which are already threatened by climate change have been made more vulnerable by poor water management. Growing urban migration to the river basins has increased the pressure on water resources, which is already used for irrigation.

7.2.5 Policy implications

Mitigating climate change impacts: Improvements to agricultural practices, such as land management, supporting agricultural ventures with technological assistance, and increasing access to water, should benefit rural livelihoods. Subsidy removal increased the vulnerability of the farmers who already have little or no access to credit for agricultural improvements; (Braimoh and Vlek, 2005) improving access to credit could be of much help in this context, particularly as the potential value of agricultural products on world markets has begun to rise again.

Managing natural resources: In 1993 the National Environmental Action Plan (NEAP) was initiated to ensure the sound management of natural resources and to avoid their over-exploitation. (Environmental Protection Agency, 2000) Enhanced management of soil, water, land, and the coastal zone could mitigate the impact of climate change on productive activity.

Addressing urban growth: It appears likely that the trend of urban growth will continue into the future, and may be accelerated by climate change. This makes it an urgent policy priority to address issues such as the provision of basic services in urban slum settlements, including health, education and basic infrastructure such as roads and transport networks. A 'double impact' of climate change may be felt in some coastal cities, including Accra, where climate change may both increase population levels living in slum areas on the edge of the city, but also make these populations directly vulnerable to damage to life and property as a result of increased intensity of storms and coastal flooding. Development of urban flood management plans in major coastal cities is clearly important, and is ongoing (see Figure). (Twumasi and Asomani-Boateng, 2002)

Migration policies: Emigration from Ghana is probably inevitable in the medium term, but the government could do more to maximise the potential benefits of migration, particularly by encouraging flows and investment of remittance income, and encouraging the engagement and return of Ghanaians abroad in the development of the country. Some steps have been taken in this direction, through the organisation of 'homecoming summits', the offering of dual citizenship to those of Ghanaian origin abroad, and other measures. One area such policy could be developed to specifically respond to the demands of climate change is to promote diaspora investment and return in more marginal areas of the north that are likely to be most affected by climate change.

Figure 4. Mapping urban flood zones in Accra

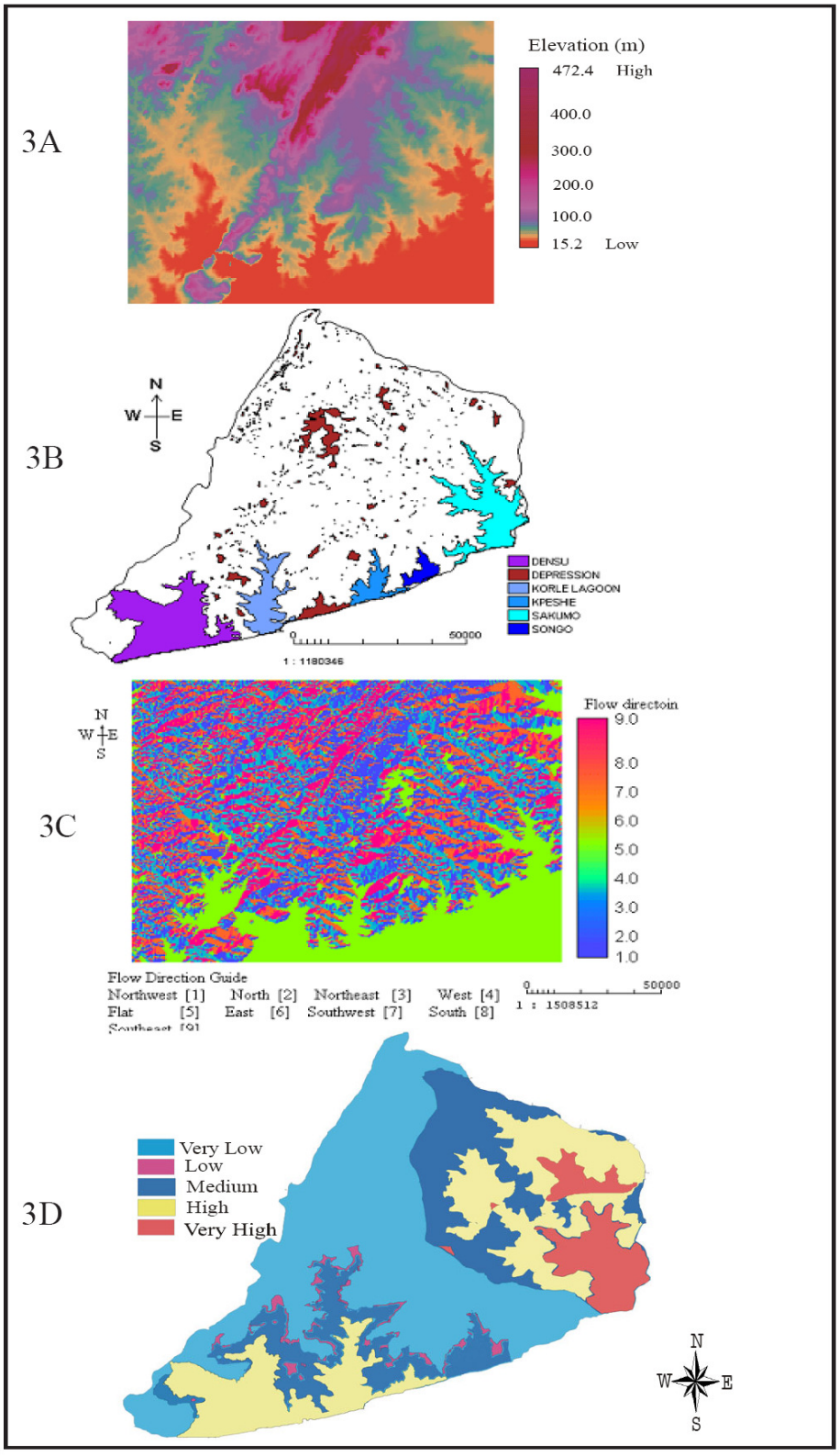


Figure 3A: Elevation map of Greater Accra.
Figure 3B: Watercourse areas in Greater Accra.
FIgure 3C: Flow direction of runoff over the topography.
Figure 3D: Flood risk areas of Accra and Tema Metopolitan areas.

Source: Twumasi, Y.A. and Asomani-Boateng, R., 2002: 2876

7.3 Climate Change and Migration: Ethiopia

Overview: demographics and climate change in Ethiopia

Demographic trends: Ethiopia had a population of around 79 million in 2005, and annual population growth rates of around 2.5%, amongst the highest in Africa. Although fertility is predicted to decline, and population growth to reduce to 1.2% in 2045-50, Ethiopia's population is still expected to more than double to 183 million by 2050. (UN ESA, 2006/7) Most of the population (84%) is currently rural based, (Population Reference Bureau, 2007) but urban growth is predicted to outstrip rural growth in the future. Addis Ababa is officially predicted to grow to over 4 million by 2015, and may unofficially already have this number of inhabitants; whilst the overall urban population is predicted to rise to 37 million by 2030. Nonetheless, the population of rural Ethiopia is still predicted to rise by around 50% over the same period, taking it to nearly 100 million in 2030.

Climate Change: Ethiopia essentially has three climatic zones: (a) a cool highland zone in the north above 2,400 metres; (b) a temperate zone between 1,500 and 2,400 metres, and (c) hot lowlands below 1,500 metres. Rainfall is highest in the southwest, and decreases to the northeast and southeast; in the highlands there are short rains in February-March (*belg*) whilst the main rainy season (*meher* or *keremt*) lasts from July to September. Rainfall records over 40 years show a decrease in annual rainfall over northern and southwest Ethiopia, and increasingly unpredictable short rains, but increasing rainfall over central Ethiopia. These trends are set to continue in the future, whilst temperatures are predicted to rise by between 0.5 and 3.6°C by 2070. (National Meteorological Services Agency, 2001: 74)

Unfortunately, rainfall predictions for Ethiopia vary hugely between climate models and for different seasons. For instance in the north, one climate model predicts a doubling of precipitation during the main rainy season, whilst another predicts a decline. However, all models predict an increase in rainfall during the dry season (October-January). (National Meteorological Services Agency, 2001: 75) Economic growth in Ethiopia appears highly correlated with rainfall (Figure 5), suggesting significant potential for climate change to impact on livelihoods.

7.3.1 Current migration systems

Internal migration: According to the 1999 Labour Force Survey, there were 1.1 million migrants in urban areas in Ethiopia, and 1.2 million in rural areas. (Casacchia et al., 2001: 6) However, it is often difficult to distinguish voluntary and forced moves, whilst highly fluid economic and political circumstances over the last two to three decades have superimposed flows and counter-flows to create a bewildering array of movements. For example, the 1980s was a decade of vast internal migration for the Ethiopian population living in rural areas, but this was a result simultaneously of the consequences of drought and famine, economic collapse, ongoing civil war, and government policies. Much of this movement was to towns and cities, notably the capital Addis Ababa, and has ended up being relatively permanent.

Data from various international agencies suggest there are currently around 200,000 conflict-induced internally displaced persons (IDPs) in Ethiopia. (Internal Displacement Monitoring Centre, 2007) However, it is unclear how many of these are recently displaced and how many relate to earlier conflicts. Meanwhile, a survey of five states in 2000 indicated that intra-regional migration has become more frequent than inter-regional migration, with the exception of movement to Addis Ababa.[17] (Tadele, 2006) This is consistent with findings from DFID's Sustainable Livelihoods Programme, which found that although there was a long history of out-migration, study sites actually had unexpectedly low rates of migration: only a quarter of households were found to have a migrant (i.e. a person who had ever lived or worked elsewhere), and less than 2% of households received remittances. (Carswell et al., 1999)

Of particular interest is the movement of people as part of government resettlement policies since the 1970s and 1980s. At least 600,000 people were forcibly moved in the mid 1980s, mostly from the northern highlands to the western and south western lowlands; after the change of government in 1991, return migration from resettlement sites to areas of origin in the north became considerable. (Ezra, 2001) Yet since 2003, a renewed 'Voluntary Resettlement Programme' is aiming to resettle up to 2.2 million people, with up to half of these already moved.

In this context, and given continued civil conflict and a lack of up-to-date statistics, it is difficult to discern which 'current' internal migration patterns are dominant.

[17] Findings of the Migration, Gender and Health Survey conducted jointly by the Addis Ababa University and Brown University, with a focus on the five most populated regional states, Oromia, Amhara, SNNPR and Tigray.

International migration: Compared to internal movements, the international movement of Ethiopians over longer distances is relatively limited, and is oriented primarily to the US. (Black, 2004) There were an estimated 18,000 Ethiopian-born residents in the US in 18,000 in 1995, increasing to 68,000 in 2000, and 84,000 in 2006.[18] There is also an Ethiopian community in the UK, and most other European countries. (Papadopoulos et al., 2004) Again, these populations contain a mix of 'economic' migrants and refugees.

Displacement to and from neighbouring countries: Despite the relative lack of long-distance refugee movements from Ethiopia, movement within the region is substantial. Internal conflict within Ethiopia began in 1962 and continued until Eritrean independence in 1991, displacing nearly 400,000 Eritrean and Ethiopian refugees to neighbouring Sudan. (Kibreab, 2002) The more recent conflict with Eritrea saw over 300,000 Ethiopians displaced internally, around 63,000 people deported to Eritrea, (Kibreab, 2002) and more than 40,000 Ethiopians deported from Eritrea. (Nordanger, 2007) There have also been major refugee movements, with 15,901 Somali refugees, 73,927 Sudanese refugees and 10,700 Eritrean refugees in Ethiopia as of early 2006, whilst 14,862 Ethiopian refugees were reported to be living in Kenya. (UNHCR, 2007)

Human trafficking: Human trafficking also is reported to be a significant problem in Ethiopia, especially the trafficking of women and young girls to Arab countries. The number of young girls going to Middle Eastern countries to work as maids, servants and so on has grown considerably in recent years, although overall volumes are probably low compared to other forms of migration.

7.3.2 Key migration drivers

Conflict: Over the past three decades, Ethiopia has been wracked by periodic social and economic crises, including recurrent famines and political turmoil, both internally, and with neighbouring states, leading to major episodes of conflict-induced displacement. These crises have been compounded by the collectivisation and de-collectivisation of land, and continued tension between central government and the regions.

Increasing drought and famine risk: Drought and famine are chronic problems in Ethiopia, which has experienced over five major droughts since 1980, and more than 10 localised droughts over the same

[18] According to the US Census Bureau Current Population Survey (CPS)

period. The North Shoa, Wollo and Tigray regions of Ethiopia have been the most severely affected by famine and drought during the last three decades. (Ezra and Kiros, 2001) Survey data suggests that more than half of all Ethiopian households have experienced at least one major drought from 1999 to 2004. (UNDP, 2007) Food insecurity, unemployment and loss of grazing land associated with droughts are major causes of migration and poverty in Ethiopia, although it is important to note that food insecurity is not necessarily or directly related to the failure of rains: indeed, migration can be seen as a strategy of livelihood diversification to avoid vulnerability to drought.

Government resettlement policies: The official objective of government resettlement policies, both in the 1980s and today, is to prevent famine and to achieve food security, by easing pressure on the northern and central highlands that have been heavily affected by famine. (Ezra, 2001) However, there is widespread agreement amongst scholars that resettlement, in the 1980s at least, was forced, and formed part of a counter-insurgency strategy. Resettlement in Ethiopia remains politically contested.

7.3.3 Susceptibility of drivers to climate change

Conflict: The conflict to 1991 was primarily a war of secession for Eritrea, supported by regional and other opposition movements, whilst conflict with Somalia has largely been over territory, although tension over access to limited natural resources is a relevant factor. More recently, competition for limited land resources has contributed to ongoing insecurity within some regions of Ethiopia, notably in the culturally extremely heterogeneous south.

In this context, important climate changes include a change in the length of the growing season, which is related to both rainfall and temperature, and is a major factor determining agricultural productivity and hence the potential for natural resource-related conflict. A number of climate models agree that in much of Ethiopia, the growing season is projected to reduce by between 5% and 20% by 2050, with particularly negative effects in dryland areas in the south and south east. This change is predicted using a number of emission scenarios. (IPCC, 2000) Past research in Tigray has also found evidence of a shorter growing season since the 1970s. (Meze-Hausken, 2000) All are regions of conflict-related displacement, which could be exacerbated by lower agricultural productivity. However, some models predict that there may be an increase in growing season length in some parts of the Ethiopian highlands, due to increases in temperature and precipitation.

Drought and famine risk: In the past, the Ethiopian highlands and dryland areas of the south and south east have been particularly susceptible to drought and famine. As noted above, this risk may decline in the highlands if there is an increase in the length of the growing season; however, dryland agricultural systems are likely to register further damaging impacts from climate change, including reduction in revenue from arable land, (UNDP, 2007) and destruction of assets such as livestock, which provide people with a productive resource, nutrition, collateral for credit, and a source of income to meet health and education costs as well as providing security for crop failure. Research on the 1999/2000 drought in Ethiopia revealed that livestock sellers received less than half the price for animals during drought periods, compared to periods before the drought. The rich were able to compensate and calibrate for lost food consumption and exchange goods in this situation without seriously diminishing their financial assets. However, poor households, especially pastoral ones, relied on livestock for their livelihoods and suffered severe asset losses during the droughts due to decreases in livestock prices and rises in cereal prices. The loss of animals as a result of reduced rainfall therefore increases the future vulnerability of poorer Ethiopians, and may stimulate increased distress migration during drought periods.

7.3.4 Key intervening factors

Weak Infrastructure: Weak infrastructure, especially irrigation systems, increases people's sensitivity to climate change impacts, especially that of drought. In 2005, the Economic Commission for Africa called for a doubling of the arable area under irrigation by 2015. Improved access to irrigation could help simultaneously to raise productivity and reduce climate shocks.

Malnutrition: Decline in the production of rain-fed crops such as maize and beans harms both people's diet and their purchasing power. People tend to get locked into poverty traps when malnutrition levels rise. Furthermore, many people's immune systems are compromised by malnutrition. Deteriorating nutrition and falling incomes cause increased vulnerability to illness and prevent the acquisition of resources for medical treatment. Droughts and floods are often catalysts for wide-ranging health problems, including an increase in diarrhoea among children, cholera, skin problems and acute under-nutrition. In Ethiopia, an epidemic of cholera following the extreme floods in 2006 led to widespread death and illness in flood-affected areas. These health problems are hampered by an increase in poverty. This physical vulnerability of the poor indirectly again increases the probability of distress migration due to increasing drought and famine risk.

Dwindling land holding: Ethiopia has a high level of soil erosion (Meze-Hausken, 2000) and deforestation. (Transitional Government of Ethiopia, 1992) A rise in the occupation of marginal lands has arguably contributed to the depletion of natural resources and environmental degradation. Moreover, population growth in rural areas has also reduced the availability of arable land.

7.3.5 Policy implications

Much existing and recent migration in Ethiopia has been 'distress' migration, related to conflict or lack of resources, or both, and climate change is likely to exacerbate both, except in parts of the highlands. In this context, it is appropriate that policy focuses on how to reduce the risk of such additional distress migration occurring, and on improving responses to it when it does. However, it should be borne in mind that some of this migration is likely to continue to take on a permanent character, with acceleration in the growth of towns, and especially Addis Ababa, as a probable outcome. This suggests a need for attention to the provision of basic services in major towns and cities. In addition, across the country, policy implications focus on:

Information on climate-related risk: Many of the world's poorest countries lack the capacity and the resources to assess climate risks. In sub-Saharan Africa, high levels of rural poverty and dependence on rain-fed agriculture makes meteorological information an imperative. However, the region has one of the world's lowest densities of meteorological stations. In France, the meteorological budget amounts to US$388 million annually. In comparison, Ethiopia has a budget of just US$2 million even though over 90 percent of its people rely on agricultural activities for their livelihoods.

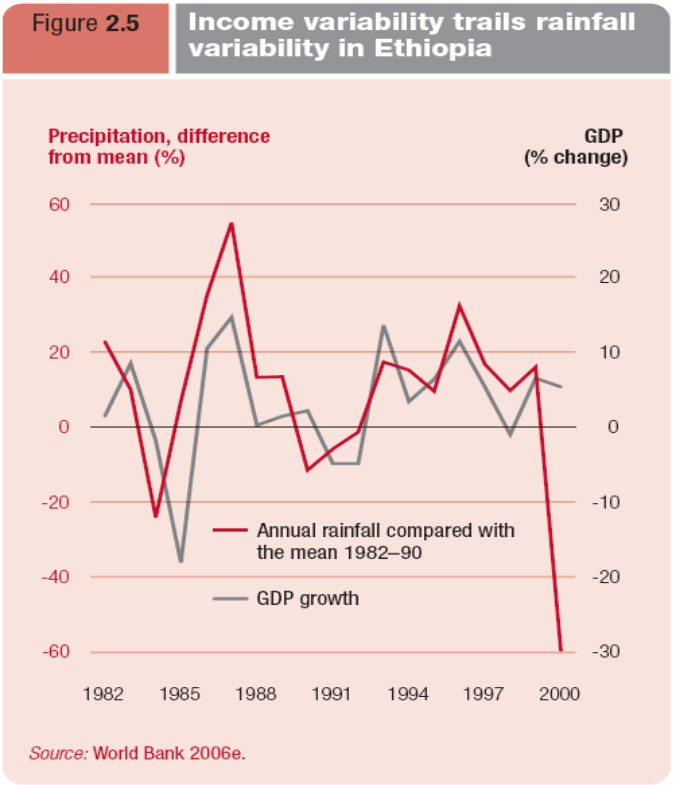
Irrigation and water storage: The development of community-based infrastructures for water harvesting could reduce vulnerability and empower people to cope with the risks associated with climate change. Ethiopia spans 12 major river basins and has relatively abundant water supplies in the highlands, but one of the lowest reservoir storage capacities in the world: 50 cubic metres per person compared with 4,700 in Australia. (UNDP, 2007) There are several plans under way to develop dams in Ethiopia; in the absence of such storage capacity, water availability may not increase even if rainfall increases.

Insurance for social protection: Social protection programmes can help those vulnerable to drought to cope with risk, while expanding opportunities for employment, nutrition, and education. In Ethiopia, the Productive Safety Net Programme is an attempt to strengthen the capacity of the chronically poor to cope with droughts without having to sacrifice opportunities for health and education. The programme

provides people with transfers of up to US$4 a month in cash or food. The programme is designed to overcome the uncertainties associated with annual food aid appeals and provides approximately five million people in food insecure areas in Amhara, Oromiya, SNNPR and Tigray with a predictable source of income and employment. As well as decreasing the vulnerability of people to poor nutrition during drought, the relatively small cash transfers are designed to enable the poor to build up their productive assets and invest in health and education. (Table 5) Altering the targeting of such assistance to reflect migration is probably unnecessary, and would in any case be logistically complex.

Creating a detailed climate disaster database: The Centre for Research on the Epidemiology of Disasters (CRED) maintains the current climate disasters database. The database has played an invaluable role in providing information on disasters in the past, although it has some limitations, including a lack of comprehensive coverage. In the context of the continued likely importance of distress migration in Ethiopia associated with climate change, investment in this database would be timely.

Figure 5. Income variability trails rainfall variability in Ethiopia



Source: UNDP, 2007:91
Source: Peel, Finlayson and McMahon, 2007:467

Table 5

The human impact of safety nets

	Outcome of productive safety net programme (PSNP)	Beneficiary households (%)	Households directly attributing outcome to PSNP (% of beneficiary households)
Food security	Consumed more or better food than last year	74.8	93.5
	Retained food production for consumption	62.4	89.7
Asset protection	Avoided having to sell assets to buy food	62.0	91.3
	Avoided having to use savings to buy food	35.6	89.7
Access to services	Used healthcare facilities more than last year	46.1	75.9
	Kept children in school longer than last year	49.7	86.5
Asset creation	Acquired new household assets	23.4	55.3
	Acquired new skills or knowledge	28.6	85.5

Source: Devereux et al 2006.

Source: UNDP, 2007:180

7.4 Climate Change and Migration: Sudan

Overview: demographics and climate change in Sudan

Demographic trends: 2006 population is estimated at 37 million, accounting for approximately 4.8% of sub-Saharan Africa's population.[19] (World Bank, 2007a) Assessments of annual population growth rates vary from around 2.1%[20] (World Bank, 2007a) to 2.6% – which would put Sudan's population growth among the highest in the world. (Ministry of Environment and Physical Department, 2007) Even though overall annual rates of growth are projected to fall to 0.9% by 2050, population is still projected to double by 2050. Meanwhile, the proportion of urban residents is projected to increase from around 40% in 2005 to 60.7% by 2030, suggesting that almost all (94%) of population growth during this period will be accounted for by urban areas. (UN ESA, 2006)

Climate Change: Over half of Sudan consists of arid and semi-arid ecosystems. Throughout much of the country, water resources are limited, soil fertility is low, and drought is common. These underlying conditions are exacerbated by political instability and population growth, creating a situation in which Sudan is already highly vulnerable to current climatic shocks. The country will become even more vulnerable in the face of future climate change, although it may also be able to draw on considerable oil wealth in the future.

Average temperatures are expected to rise significantly relative to baseline expectations. By 2060, projected warming ranges from 1.5ºC-3.1ºC during August to between 1.1ºC-2.1ºC for January. Projections of rainfall under climate change conditions also show sharp deviations from baseline expectations. Some models show an average rainfall decrease of about 6 mm/month during the rainy season. (Ministry of Environment and Physical Department, 2007) Other climate phenomena, such as dust storms, thunderstorms and heat waves are expected to increase in both frequency and intensity. (Ministry of Environment and Physical Department, 2003) The livelihood impacts of climate change will be felt particularly through impacts on agriculture, water resources and public health (see below).

[19] Many figures are given as estimates since long-term political instability has hampered the collection of accurate, aggregate national statistics.
[20] This figure is for 2000-06, and is slightly below the average for sub-Saharan Africa.

7.4.1 Current migration systems

Historically, the population of the Sudan has been highly mobile. On average, 40% of the population is believed to be on the move every year. (Assal, 2006) The semi-arid regions of western and northern Darfur are particularly affected. Migration can be characterised by four key systems:

Seasonal migration: Seasonal rural migration has long been a livelihood strategy for semi-arid regions of Sudan, with principal destinations being wetter parts of southern Darfur and central Sudan (e.g. Western Kordofan). Regional differences in the rainy season allow both male and female labourers of all age groups to temporarily migrate and return for their own cultivation. However, once the dominant strategy for agro-pastoralists in poor areas, rising transport costs and increased competition of labour markets since the 1990s have rendered seasonal migration less profitable, driving labourers further distances and for longer periods (over three years) away from home. (Bakhit, 1991)

Longer-term migration: Darfur has a long history of migration to east Sudan, such as Gedaref, where (male) migrants commonly stay for 3 or more years to generate cash incomes that can be remitted home. The small number and unequal distribution of cities has also exacerbated migration to urban centres in central Sudan, particularly for the better-qualified. Between 1970 and 1990, for example, the population of Khartoum quadrupled, and it is now sub-Saharan Africa's third largest city. (Grawert, 1998)

Annual urban growth rates between 1990 and 2001 have stood at 5%, more than double the national average. This has put considerable strain on urban infrastructure, resulting in the rapid growth of urban slums (5% per year over the same period) which now account for 86% of the urban population. (UN-HABITAT, 2007) Insecurity caused by recent conflict in Darfur, however, has drastically hindered labour mobility, seasonal livestock migration and the flow of remittances, putting considerable strain on rural livelihoods already under stress.

International migration: International migration from Sudan has followed long-established trade routes. Destinations are dominated by the Gulf states (particularly for male professionals) and Libya for male semi-skilled labourers. Statistics are scarce (the IOM, for example, holds no data for Sudan). Workers' remittances and compensation of employees are estimated to have increased from US$640m to US$1bn between 2000 and 2005 (currently 2.7% GDP), (World Bank, 2007a) although such figures considerably under-represent total flows through informal channels such as *hawala* systems.

Numbers of migrants are problematic to assess. One 1992 UNDP study estimated 3.1% of the total labour force were international migrants in oil rich countries. (Grawert, 1998) Studies in the 1980s estimated that 20% of Darfurian households had a member working in Libya, and numbers are now estimated to be 150,000-200,000. However, the closure of the Libya-Sudan border in 2003, combined with heightened insecurity along migration routes has dramatically curtailed this movement, with estimated annual remittance losses of $15m to Darfur alone. Recorded remittances fell by almost $400m (28%) between 2004 and 2005 as a consequence. (Development Prospects Group, 2007) Case study evidence suggests migrants are increasingly looking towards European labour markets. (Young et al., 2005) Until recently these have been poorly accessed, averaging 1,386 migrants per year between 1995 and 2000. (Black, 2004)

Displacement and forced migration: There are an estimated six million IDPs in Sudan, displaced largely by drought, desertification and famine in the North, and conflict, famine and flood-induced epidemics in the South. From being host to a net influx of refugees from neighbouring states in the 1970s and early 1980s, Sudan has become a generator of forced migration on an unprecedented scale. (Verney, 2006)

Voluntary and forced migration related to *drought* lie on a continuum of household decision-making. Western and northern parts of Sudan within the semi-arid portions of the Nile Basin have been the hardest hit areas over the last three decades. A succession of dry years from 1978 to 1987, for example, resulted in the resettlement of close to three million people along the Nile valley and urban peripheries, particularly Khartoum.

Since 1983 one million people have fled from *conflict* to neighbouring countries and one sixth of the population have been displaced within the country, commonly around major urban centres such as Khartoum. The process has, until relatively recently, been accelerating. It took two decades of war in Southern Sudan to displace four million people, but less than three years to displace two million in Darfur. (Verney, 2006) The more recent migrants to Khartoum are typified by IDPs displaced by conflict in Darfur, and are principally women and children.

7.4.2 Key migration drivers

Regional climate variability and climate shocks: The vulnerability of communities and economic sectors to current climate drivers is associated with both intra-seasonal variability and inter-annual rainfall fluctuations that generate conditions of prolonged drought. Rainfall is erratic and varies significantly

from north (minimal rain, >100% variability) to south (>1000mm/year, 15-20% variability). (Ministry of Environment and Physical Department, 2007) Such variability encourages patterns of seasonal migration in good years, and more extensive distress migration in bad years.

Over the last three decades, prolonged cycles of drought, exacerbated by minimal government investment in traditional rain-fed systems and extension services, have heightened baseline vulnerability to declining soil fertility, low agricultural productivity, and persistent food insecurity in semi-arid areas, while compounding overgrazing and soil erosion in savannah areas. It has reduced crop diversity and forced people into low-risk, low return production systems (encouraging migration). Recurrent drought has destroyed key social insurance mechanisms such as livestock by generating poor terms of trade and preventing households from replenishing stocks. For example, three famine disasters within less than 2 decades since 1972 have completely decimated stocks for over 40% of households in western Sudan, with remaining households seeing stocks reduced 15-fold. Research in eastern Darfur has found that those without livestock are among the first to migrate in times of crisis. (Ibrahim, 1991)

Conflict: The country has suffered warfare of varying intensity for most of the period since independence in 1956. Civil war, and more recently conflict in Darfur, stem largely from a historical struggle between the concentration of political and economic power of the centre (Khartoum and adjoining states) and the marginalized periphery (the South, Darfur, the Three Areas, and the East). Appropriation of productive land, water resources and more recently oil reserves has often been achieved through violent asset-stripping and displacement of local populations. The forced depopulation of oil-rich areas in the Upper Nile region of South Sudan in the 1990s, for example, made it possible for oil exploitation to proceed unhindered, and was accompanied by the influx of ethnic groups, often of Northern origin, seen as loyal to the government. (Verney, 2006)

Sudanese development policies have concentrated investment in modern large-scale agricultural schemes located in the east-central parts of the country, compounding impacts on people's livelihoods in neglected regions. As seen in Darfur, rural stagnation in marginalised regions has led to destructive patterns of land use and to armed conflicts over depleting resources. Thus, the underlying drivers of conflict are essentially the same as those of underdevelopment and associated sensitivity to climate shocks. (Assal, 2006)

The 2005 Comprehensive Peace Agreement (CPA) and the acceptance of the Sudan People's Liberation Movement (SPLM) to join the government in December 2007 bode well for the future. However, the situation in Darfur continues to deteriorate, and tensions in Eastern Sudan are also mounting. This means that forced movements of people are likely to continue.

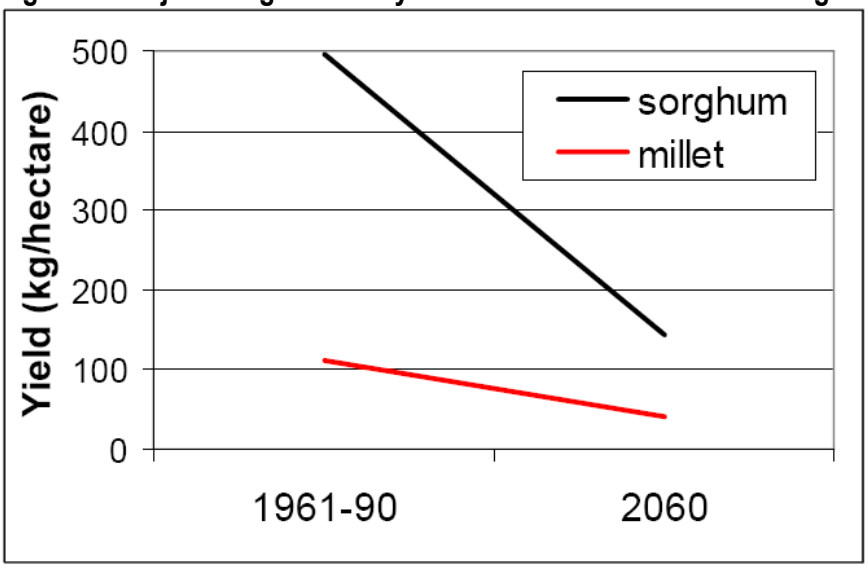
Differential opportunities and incomes: New household survey data (2006) shows that recent growth has not been broad-based, and inequality has risen. Key human development measures such as school enrolment, sanitation facilities etc. in Sudan's disadvantaged regions (Darfur, the South, the Three Areas, and the East) rank among the lowest in the world, while Khartoum and some Northern states along the Nile perform well above the sub-Saharan Africa average. Large urban-rural and regional north-south disparities are closely related to public spending patterns, conflict, isolation and displacement. Access to secure sources of income and government services characterise the motivation of long-term internal migrants from poor areas, while the higher incomes available in oil-rich nations are the principal drivers of international migration.

7.4.3 Susceptibility of drivers to climate change

Increased drought and variability: Migration patterns induced by climate and agro-ecological conditions will be directly affected by climate change projections. A trend of decreasing annual rainfall and increased rainfall variability is already contributing to drought conditions in many parts of Sudan. Annual rainfall patterns in each of the country's four ecological zones (arid, semi-arid, savannah and southern) has fallen by about 0.5% per year over the last 60 years from 425 mm to 360 mm/year. Meanwhile, predictability of rainfall has declined over the same period, making both livestock and arable farming an increasingly risky enterprise.

Increased climate variability and climate change is likely to intensify the ongoing desertification of arable areas, and shift pastoral zones southward. Crop production is predicted to decline substantially for both millet and sorghum, the key staple of poor rain-fed farming systems, impacting on both local incomes and food security (see Figure 6). The important gum arabic belt is also projected to decrease in size. Employment opportunities in key rural sectors will therefore decline whilst rural out-migration from more marginal areas will rise, exacerbating urbanisation and long-term, more distant patterns of migration for those who are able.

Figure 6: Projected agricultural yields in Sudan with climate change



Source: Ministry of Environment and Physical Department, 2003

Conflict: Reduced groundwater recharge through decreased precipitation and increased evaporation has grave repercussions for livelihoods and security. With only 921m³ of renewable water per capita, Sudan is already below the water-stress threshold (1,000m³/capita) and well below the agreed threshold of water scarcity (1,600m³). (Earth Trends, 2007; UNDP, 2006) While the agricultural sector is declining, it still accounts for over 95% of water use. Growth in industrial sectors and more intensive commercial irrigated agriculture will increase demand and competition for this declining resource, and subsequent water transfers may be detrimental to poorer users without political voice.

In the absence of effective conflict mitigation, climate change may heighten already existent tensions over resources, with the potential to further destabilise populations and compound displacement. One current cause of conflict appears to be a shift southwards of livestock, but with the maintenance of the frontier of arable cultivation, partly due to investment of migrant remittances: this appears to be exacerbating conflict in some parts of Darfur. However, it is important to note that climate change is not, and is unlikely to become the *primary* driver of conflict-related displacement.

Differential opportunities and incomes: The existence of declining rural economies alongside an oil-fuelled construction boom in major cities will widen rural-urban inequalities and accelerate patterns of urbanisation. While case study evidence suggests that private urban remittances in Sudan play a key role in funding communal services and infrastructure back home, the frequency and value of remittances may decline over time as costs (and risks) of urban living rise for poorer migrants. (Young et

al., 2005) As settlements and urban labour markets become increasingly crowded, migrants may widen their search for employment into international markets.

7.4.4 Key intervening factors

A series of intervening factors influence people's sensitivity to climate change and their ability to cope, impacting on the migration drivers identified above.

Economic structure - the narrow dependency of labour on agriculture: Since the rapid increase in oil revenues beginning in the late 1990s, agriculture's contribution to GDP has fallen from roughly half to around 30%. However, over 80% of the population remain dependent upon crop production and livestock husbandry to support their livelihoods, the majority of which is typified by poor, subsistence rain-fed systems that are highly vulnerable to climate variability. Increased investment in labour migration may be one of the few options available to millions of rural livelihoods in decline.

Poverty and unequal economic growth: Economic growth has been robust and among the highest in Africa since the advent of the oil sector in the late 1990s, reaching over 10% in 2006. However, a rapid appreciation of the real exchange rate driven by oil exports and foreign direct investment has reduced competitiveness and production of key rural products such as livestock, gum arabic, and sesame. This has hurt rural poor producers of these goods, and in turn, one assumes, rural migrant labourers, potentially driving more towards the city. (World Bank, 2007b) While reliable poverty headcount figures are unavailable, an estimated 40-50% of the population (15-20 million people) live on less than a dollar a day. Rural poverty is thus deep and entrenched. (Ministry of Environment and Physical Department, 2007; DFID, 2007) Capacity to adapt to increased climate risks is therefore extremely low, and case study evidence in Northern Sudan suggests that the poorest are unable to migrate and access other labour opportunities to generate sustained remittance flows. (Haug, 2002) Rising mortality and rates of forced displacement are anticipated outcomes.

Weak markets and infrastructure: Like much of sub-Saharan Africa, Sudan is characterised by poor markets and under-developed infrastructure. The inefficiency of urban, and particularly rural markets is directly associated with their distance from major production areas and poor transport links. One recent study has found that Darfur grain markets are not integrated with those of central Sudan because of high transport costs which represent up to 60% of the market price in Darfur. Inefficiency has been exacerbated by the closure of some of the region's most important markets due to conflict. Of the 154

registered village, primary and secondary markets that used to operate, 49 are totally closed while a further 61 are only partly operating, dramatically eroding the coping capacity of rural households. (Young et al., 2005)

Irrigation remains under-developed and highly concentrated in small productive enclaves. Only 11.2% of cultivated land is equipped for irrigation, of which only 43% is actually irrigated. By 1999, over half of this land was affected by salination. (Aquastat, 2007)

Population density and natural resource degradation: While aggregate density is relatively low at 10 people/km², density of arable and cultivated land is considerably higher and rising (63/km² and 370/km² respectively) with much of the population clustered around central Sudan and along the Nile. (Ministry of Environment and Physical Department, 2007) Land degradation and desertification, brought on both by human land-use pressures (increasingly intensive grazing due to reduced grazing areas, inappropriate agricultural practices and increased cultivation on fragile lands due to population displacement) as well as recurrent drought, are widely reported to be extensive and continue to threaten already vulnerable arable zones, although official figures are largely absent.

Deforestation, primarily for household fuel use, rising urban demand and commercial timber threatens biological diversity and the ecosystem services on which communities depend. Between 2000 and 2005 alone over 4% of forested area was lost, equivalent to 30,000km². (World Bank, 2007a) Rising population densities and depleted resources will intensify migration patterns as climate risks become more acute.

7.4.5 Policy implications

Longer-term aid investments in Sudan are focused on pro-poor growth (agriculture, infrastructure, financial services) through contributions to a Multi-Donor Trust Fund. DFID has been the second largest bilateral donor in Darfur since 2003, and plans to almost double its aid in 2007/08 to $228m. (DFID, 2007a) DFID works in three areas, namely governance and conflict, humanitarian aid and access to basic services. Humanitarian aid and basic services, which include special regional programmes such as the interim Basic Services Fund, constitute the bulk of financial commitments, and accounted for approximately two thirds of all 2006-07 assistance. (DFID, 2007b)

Given the evidence that natural resource pressure has already contributed to violent conflict, climate change is clearly relevant to donor policies on governance and conflict. Policies aimed at conflict resolution and the return of displaced persons and refugees need to pay attention to the likely decline in productivity of the natural resource base in rural areas that will result from climate change. When combined with the declining availability of temporary migration options to Eastern Sudan and Libya in particular, there must be doubts about the ability of these areas to sustain a growing population as a result of return, unless there are substantial long-term investments in agriculture and productive infrastructure – or unless new temporary migration routes are opened up.

Turning to donor investment in basic services and pro-poor growth, both existing projections of urban growth, and the likely acceleration of rural-urban migration as a result of climate change impacts in source and rural destination areas, all suggest the need for special attention to be paid to urban slums. This is not to say that there should not be investment in basic services – health and education, for example – in rural areas, as these areas are likely to maintain at least a relatively constant population. Additionally, the rural chronically poor are in most need of access to basic services and social investment, as they are least able to migrate. However, it seems likely that no matter how strong investment is in rural areas, urban slums will continue to grow, making it urgent that these areas also see investment.

Finally, interactions between climate change, conflict and forced migration are likely to ensure the dominance of immediate humanitarian needs for some time to come. Prompt and efficient humanitarian action to respond to drought in situ can help to prevent temporary, short-term displacement from becoming either long-term, or long-distance, in turn reducing the risk of reinforcing resource-related conflict.

8. Policy implications and conclusions

It should be clear from the discussion above that we are a long way away from predicting with any degree of certainty what the migration consequences of climate change might be over the next 40-50 years. Estimates of the likely numbers of 'environmental' or 'climate change' migrants or refugees are guesses at best, and have their origin in a mapping of likely climate impacts, but such a mapping doesn't allow for any concomitant understanding of how migration might be sensitive to such impacts. It is unclear how far climate change will emerge as a significant or predominant factor in influencing human migration, distinct from other economic, social or political factors, and/or overriding their effect. This is perhaps reflected in the fact that the most widely-cited figure for climate change migrants over the coming years is itself not greatly different from the net increase in migration that might be estimated simply by extrapolating existing figures, holding migration as a constant percentage of population growth into the future.

Having said all of this, it is recognised that the challenges posed by climate change are many, and that these challenges are likely to be particularly acutely felt by the world's poorer populations. A number of policy responses may be appropriate. Country specific policy recommendations are contained in the case studies.

8.1 Climate sensitive development policies

A first important area where policy-makers can respond to climate change is in the form of *climate sensitive development policies* – i.e. pro-poor climate change adaptation policies that build local resilience and adaptive capacity, reducing the *need* for the poor to migrate away from affected areas. These should include new policies to build specific adaptive capacity amongst some of the most affected populations in areas such as the African Sahel, as well as the integration of climate change concerns into existing policies, to ensure that programmes do not further undermine the resilience of the poor when faced with climate change. A case in point is the urgent need for policies in the world's major cities that mitigate the effect of overcrowding, and make it less likely that the growing ranks of the urban poor will be left with no other option than to move on to international destinations.

One point worth making here is that although attention up until now has been focused on poorer (origin) countries of potential 'climate change migrants', how *developed* countries adapt to climate change will also have significant impacts on the nature and extent of international migration flows. This is an area

that calls for more research.

However, beyond this, the underlying argument of this paper – and the implicit conclusion of the latest IPCC report on the societal impacts of climate change – is also that a policy based on trying to *prevent* migration resulting from climate change is doomed to failure. This is partly because of the inertia in climate systems, which means that even if all emissions ceased today, global warming would continue for another 30-50 years (and so some migration impacts are likely anyway); it is also because migration itself can have both positive and negative effects, for the individuals who move, and for the areas they move from and to. Rather, policies need to be developed which support those who will migrate in the future at least in part as a result of climate change.

8.2 Policies to support migrants

Policies aimed at migrants and migrations that are linked to climate change might range across a number of areas, including:

- ***Incorporation of migration into National Adaptation Programmes of Action (NAPA),*** which are designed to help less developed countries identify and rank priorities for adaptation to climate change. (Brown, 2007: 26)
- ***Incorporation of both migration and climate change into national development plans,*** such as PRSPs and Country Strategy Papers.
- Policies aimed at ensuring the ***social protection*** of more vulnerable or poorer migrants. To the extent that there is likely to be some increase in international migration, particularly across borders within Africa and South Asia, this might include measures to improve the portability of social benefits across borders; however, more important (at least numerically) is ensuring the protection of poorer migrants who move from rural to urban, or rural to rural areas within developing countries, but may find themselves vulnerable to exploitation, abuse or physical violence when they do so.
- Policies aimed at those moving to ***slum areas of large cities***. Indeed, the provision of basic housing, safe water, basic health and education, as well as employment, in large cities remain some of the principal challenges for the twenty-first century, challenges which are likely to increase in the context of climate-related migration.
- Policies aimed at ***defusing tensions*** where migration exacerbated by climate change may involve the crossing of a sensitive border. A case in point is the border between Bangladesh and India, where the construction of a 3.6m high fence is the current policy response to ongoing tensions

between the two countries. (Ali, 2006) Past experience however (e.g. between Mozambique and South Africa) suggests such a policy will be ineffective.

- Policies to ***expand the definition of a 'refugee'*** to include environmental or climate change-related factors. Despite some NGO interest, there is currently little consensus on a way forward on this.
- Policies to support the ***relocation*** of affected populations. This is perhaps the most contentious of all possible policy options, since relocation could itself be seen as a 'forced migration', one that pro-poor policies should be seeking to avoid. A case in point here is the experience of Ethiopia, which resettled tens of thousands of people from drought-stricken areas in the northern Highlands to southern Ethiopia in the mid-1980s, although this was a highly contested policy at the time. (Pankhurst, 1992) Ironically, some current climate models predict that the Ethiopian highlands may now benefit in aggregate from climate change in the future, from a lengthened growing season.

8.3 Research into migration and climate change

Given the absence of local and regional data, a final area in which policy makers must take action is to support further research, both to understand the specific causes and consequences of migration associated with climate change, and to seek to improve estimates of the likely numbers involved. It has been tentatively suggested here that a good way forward in doing this is to develop locally-specific, case study research which highlights how the drivers of existing migration streams might be impacted by, or sensitive to climate change, rather than seeking to produce crude global estimates based on delineation of affected areas.

Appendix 1 - 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 $C0_2$ [1]	Acidification of the oceans[2]	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[3]	Likely	Global impact with maize benefiting less than rice and wheat	International, rural to urban and urban-rural
Temperature increases [4]	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 seasons 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[5]			
	Increased plant metabolism	Decreases in yields in seasonally dry and tropical regions. Further warming has increasing negative impacts in all regions[6,7]			

	Increases in arid and semi-arid land[8]	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[9]	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 [13]	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 salinization of groundwater and	Loss of life and negative impacts on economic and transportation systems, buildings and infrastructure. Mega deltas, low lying coastal	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

	estuaries	urban areas and small islands most affected			displaced and distress
Changes in precipitation	Decreased sub-tropical 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[10]	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[11]	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	Likely	Highland areas	Rural to rural, urban to rural

		mountainous regions			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[12]	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

[1] Greenhouse gases of $C0_2$, CH_4 and N_20 are chemically stable and persist in the atmosphere over time scales of a decade to centuries.
[2] Multi-model projections based on emission scenarios give reductions in pH of between 0.14 and 0.5 units in the 21st century (Meehl et al., 2007)
[3] In theory, carbon dioxide has a direct fertilisation effect upon plants, dependent on the adequate supply of water and soil nutrients, with increased yields of crops such as wheat and rice (but not for maize) for small temperature rises. However, the effects in the field have been found to be lower than witnessed from experiments in the laboratory (Royal Society, 2005; Long et al., 2005). Additionally episodes of high tropospheric ozone concentrations (which are predicted to increase with climate change) are predicted to further reduce the CO_2 fertilization effect, as will outbreaks of pests and diseases, reductions in crop pollinators, and by a predicted increasing frequency in extreme weather [such as a day or an hour of extreme heat] (Warren et al., 2006).
[4] SAT increases are likely (> 66% likelihood of occurrence) to fall with -40 to 60% of the means for each scenario. The greater uncertainty at higher values results from uncertainties in carbon cycle feedbacks (Meehl et al., 2007). Almost everywhere daily minimum temperatures are predicted to increase faster than daily maximum temperatures (Meehl et al., 2007). Mountainous regions are predicted to experience heightened warming relative to lower altitudes (Bradley et al., 2004).
[5] At present Lake Tanganyika provides 25-40% of annual protein intake for the population of the surrounding countries with climate change likely to reduce primary production and potential fish yields by roughly 30% (Parry et al., 2007)
[6] In the short and medium term globally, forestry production is estimated to change only modestly (Parry et al., 2007)
[7] Mixed rain-fed semi arid systems in the Sahel heavily affected under A1 and B1 emission scenarios with decreases in yields in some areas by up to 50% by 2020. Increases in crop yields in East and Southeast Asia and decreases up to 30% in Central and South Asia by mid 21st century (Parry et al., 2007).
[8] Including desert dune mobilization in Southern Africa (Thomas et al., 2005).
[9] The Amazon forest in particular is expected to show major changes with global mean temperatures increases exceeding 3°C (Parry et al., 2007).

[10] Including increased inter-annual season–averaged precipitation variability in Asian monsoon (Meehl et al., 2007).
[11] Pollutants include sediments, nutrients, dissolved organic carbon, pathogens, pesticides, salt and thermal pollution (Parry et al., 2007)
[12] Annually 120 million people are exposed to tropical cyclone hazards with 250,000 killed from 1980 to 2000 (Nicholls et al., 2007). Experience of past extreme weather events indicates that costs of major events range from several percent of annual GDP and income in very large regions with very large economies, to more than 25% in smaller areas that are affected by the events (Parry et al., 2007).

Abrupt/catastrophic change

Climate Change	**Climate Processes Impacted**	**Societal Impacts**	**Main types of migration likely to be impacted**
Collapse of thermohaline circulation[1]	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 Brasil.	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	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

Amazon			
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

[1] The impact of the collapse of the thermohaline circulation depends on when it occurs with the impacts of a collapse in 2050 to a certain extent being offset by warming to the enhanced greenhouse effect (Arnell, 2006)

Appendix 2 – 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 implications 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 pre-positioning of humanitarian aid
	Potential for farmer-herder conflict in drylands	Humanitarian aid distribution	Conflict early warning and pre-positioning 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 pre-positioning 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,	Ecosystem protection legislation and programmes.

		water and air purification, and disease and pest regulation. Cultural, economic, social, natural and physical asset base to enable migration	
	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		

Glossary

Aerosol: Airborne liquid droplets or solid particles that arise from human activity and natural processes, such as biomass burning and dust storms.

CFCs: Chemical substances composed of chlorine, fluorine and carbon used in refrigerators, air conditioners and solvents that drift to the upper levels of the **stratosphere** and dissociate, affecting the ozone layer.

Carbon fertilization: the stimulation of faster plant growth by increased levels of carbon dioxide in the atmosphere that, in turn, increases the rate of carbon dioxide removal from the atmosphere.

Circulatory migration: movement of people, not necessarily across international borders, that is periodic in nature and involves multiple departures and returns.

Ecomigrants: a neologism to categorize those people who are forced to move because of environmental factors. The word avoids the implications that arise when using the term "**environmental refugee**", but may erroneously imply a single cause of movement.

Ecosystems: the community of living things and the environment in which they live.

ENSO: El Nino Southern Oscillation, a global event arising from the large-scale interaction between the ocean and the atmosphere. Based initially in the Pacific Ocean it has important consequences for weather around the globe.

Environmental refugees: those people forced to migrate as a result of environmental factors. It is a controversial term as it extends the category of "refugee" from the internationally accepted definition.

Emission scenarios: are alternative images of how greenhouse gas emissions in the future might unfold in terms of different trajectories of demographic development, socio-economic development, and technological change.

Greenhouse gases: gases that absorb outgoing terrestrial radiation such as water vapour, methane, CFCs, and carbon dioxide.

HCFCs: chemical compounds composed of one or more carbon atoms and varying numbers of hydrogen, chlorine and fluorine atoms. They have similar properties to **CFCs** but lower ozone-destroying potential.

IPCC: Intergovernmental Panel on Climate Change, a specialized agency of the United Nations and was set up in 1988 under the joint sponsorship of the World Meteorological Organization and the United Nations Environmental Programme. Its role it is to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of human-induced climate change, its observed and projected impacts, and options for adaptation and mitigation.

International migrants: generally defined as the number (stock) of foreign-born in any country or territory other than the one in which they were born.

Median variant: the "standard" population projection produced by the United Nations Population Division. It uses medium estimates of fertility and mortality change and is updated every two years.

Migration transition: systematic shifts in the patterns of international labour migration that are generally seen to evolve from net emigration to net immigration for a country over time.

Ocean acidification: The absorption by the oceans of carbon dioxide that has been emitted to the atmosphere by human activities, making sea water more acidic.

PRSP: Poverty Reduction Strategy Paper, a major planning tool for public policy in developing countries.

Radiosondes: a unit for use in weather balloons that measures various atmospheric parameters and transmits them to a fixed receiver.

Salinisation: The accumulation of soluble mineral salts near the surface of soil that can reach concentrations that are toxic to plants, thus sterilising the land.

Stratosphere: the zone of the atmosphere above the troposphere and below the mesosphere and lying generally between 10 and 50 kilometres above the earth's surface. It is characterized by a temperature inversion of increasing temperatures with height caused by the absorption of ultraviolet sunlight by ozone that inhibits mass exchange within the stratosphere and between the stratosphere and other parts of the atmosphere.

Tipping point: the point at which change in a particular direction becomes unstoppable.

Water stress: occurs when the demand for water exceeds the available amount during any period or when poor water quality restricts its use.

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