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Demographic and migratory flows affecting European regions and cities

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Report on climate change and migration scenario

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ABSTRACT

This report constitutes a progress report on the development of an additional DEMIFER scenario to assess the impact of climate change on migration and hence the future population of Europe. The report reviews the British, European and international literature on this topic. This leads us to a design of the scenario model based on three impacts: sea level rise, temperature rise leading to water stress and additional winter storminess in winter affecting flooding risk. These factors operate in Europe and can be linked through overlap analysis in GIS to the NUTS2 demographic data. We will model additions to our three migration flows: internal migration, inter-country migration and extra-Europe migration. We are somewhat sceptical about the size of potential climate refugee flows to Europe because case studies show most displacement is local. However, to be thorough we will model the global migration flows using a simple but effective model by Joel Cohen of Columbia University. This can be adapted for use in combination with the Limited Social Europe scenario of DEMIFER, which is the most appropriate for exposure of climate change impacts.

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1 INTRODUCTION

In this document we report on progress on the development of a Climate Change and Migration scenario for the future population of Europe. Our strategy will be to develop some new migration assumptions to accompany one of our four policy scenarios (Growing Social Europe/GSE, Expanding Market Europe/EME, Limited Social Europe/LSE and Challenged Market Europe/CME). We will use the demographic inputs and assumptions of the LSE scenario for two reasons. First, the GSE and EME scenarios assume we have "solved" the Climate Change and the migration assumptions certainly account for any extra migrants generated by Climate Change events. Second, we choose our LSE scenario over the CME in the pair in which we assume that Climate Change challenges have not been successfully addressed because the LSE scenario has the lowest assumption for net immigration to Europe from the rest of the world. Any additional impacts of Climate Change associated migration will show up best, if they are present.

In the middle part of the DEMIFER project we have put together with Transnational Programme Group colleagues in IOM/CEFMR (Warsaw) and NEAA (The Hague) a system for analysing the future population of Europe. The system consists of an innovative demographic projection model (D4 Deliverable), a set of reference scenario projections for European NUTS2 regions based on a benchmark set of estimates of population dynamics in 2003-2006 (D5 Deliverable), a set of policy scenario inputs for each of five demographic components for driving the projection model (D6 Deliverable) and an analysis of the projection results using innovative graphics and mapping for the regional outcomes (D7 Deliverable). This is the system we will use for running an additional Limited Social Europe plus Climate Change Migration (LSE-CCM) scenario.

The plan for this document is as follows. In section 2 we review the literature on population displacement in general and assess to what extent it can be linked to Climate Change. In section 3 we look at the reverse literature, the Climate Change Scenarios of the world's climate scientists and evaluate the role that migration might play in those scenarios. In section 4 we report on data available for monitoring and modelling migration flows between countries of the world. In section 5 we summarise the findings of climate change research in Europe. In section 6 we design a climate change scenario for our projections which adds to our migration assumptions the possible effect of climate change at three levels: from the rest of the world (extra-Europe migration), within Europe between countries (inter-country migration) and internal migration within those countries which contain more than one NUTS2 region (inter-regional migration).

2. CLIMATE CHANGE AND POPULATION DISPLACEMENT (MIGRATION): A REVIEW OF LITERATURE

The objective of this section of the report is to identify key publications which evaluate the potential impact of climate change upon migration, both within countries and between countries. Of particular interest is the potential impact upon Europe, which includes the effect of climate change on European countries and the potential impact from displacement elsewhere in the world. The literature is reviewed at three levels: UK, European and International. In reviewing the literature, we try to understand who the Climate Change migrants are and what climate change processes might cause population displacement (global warming, floods, sea level rise). Climate change takes place against a background of continuing though slowing population growth in developing countries. Adaptation strategies are important to consider as well because mitigation actions (building a bigger dyke) may substitute for migration. The migration policies of European and of developing countries are germane and are assumed in our LSE scenario to be fairly restrictive.

Table 2.1 sets out the most inclusive estimate of future population displacement over the current half century. The estimates are very large indeed for the total numbers involved, about 22 million per year.

Table 2.1: Estimated population displacement to 2050 (in millions)

	Total (m)	Per year to 2050
Conflict and extreme human rights abuse	50	1.00
Natural Disasters*	50	1.00
Development projects (dams, mines) @ current rate of 15 million per year	645	15.00
Climate change phenomena such as floods, droughts, famines & hurricanes	250	5.00
People who flee their own country to be accepted as refugees	5	0.10
	1,000	20.00

Source: Christian Aid, 2007. Human Tide the Real Migration Crisis
http://www.christianaid.org.uk/Images/human-tide.pdf
See references within this report for an indication of the justification of the numbers provided.

This estimate puts climate change displacements second in rank after development project displacements (e.g. the 1.2 million official displaced migrants caused by the Three Gorges Project that dams China's Yangtze River/Chang Jiang). A figure of 250 million is proposed or about 5.5 million per year. All these estimates are based on huge assumptions and should really be regarded as equivalent to the numbers we use in our policy scenarios.

2.1 The UK literature

The Guardian (2007) reports that the UN predicts that 1billion people could be displaced by climate change with 155 million currently affected by conflicts, development projects and natural disasters. There is an 850 million increase figure expected and is based on the numbers expected to be experiencing water shortages, sea level rises and decreases in productivity. BBC News (2009) argued that climate migration fears were misplaced. The poorest people affected by climate change events will not migrate to richest countries due to displacement by climate change because they do not have necessary resources. Short term and short distance migration is more likely as it has always been an adaptation strategy of the poorest and must be seen as part of an international solution. The Times (2008) also commented on the UN predictions stressing the increase in fear of refugees displaced by conflicts and environmental degradation due to climate change and concerns over future conflicts over water due to climate change increasing droughts.

The online journal Nature Reports (11 June 2009) reviews the important research by Warner *et al.* (2009) on *In Search of Shelter*. This is the first piece of research conducted on climate driven migration which shows that that most migration will be *regional* rather than international in its impact. The reason is that people most affected by climate change events are unlikely to have the means to move very far. As climate change becomes more intense environmental degradation will occur and this will make the displacement permanent rather than temporary.

Government Office for Science (2010) in its *Foresight Land Use Futures Project* considered potential impacts of climate change on land use. One impact will be the move towards a low carbon economy which will influence land use decisions, settlement patterns, design of urban areas and transport infrastructure. Increased flood risk will have implications for building in coastal areas and on floodplains. Without any increased flood protection, the report estimates that 800,000 homes will be at risk rather than the current 500,000. Of course, policies for reducing carbon dioxide emissions will mean a significant increase in renewable technology needed to meet EU 2020 target of 20% energy generated from renewable sources with land use implications. There is a need for approval of more onshore wind farms and a need for more land to be converted to bio-fuel production (Mackay 2009).

However, very little of this impact of climate change is likely to generate more than a few very local migrations.

2.2 The European literature

European Commission (2008) examines the effects of climate change and highlights particular pieces of EU legislation, such as the need to manage flood risks, to help mitigate the potential effects. The document stresses the need for action at all levels from individuals to councils to regional strategies in the EU itself. EU strategy should be based on solidarity for affected member states and other countries outside of the EU. The report highlights a range of consequences of climate change from effects on natural ecosystems to climate refugees citing predictions of 1 billion people migrating due to climate change by 2050.

The European Commission has funded important research on the ground where climate change impacts are being felt. EACH-FOR (2008) looks at common problems within some European countries such as water shortages and desertification. The researchers indicate the problems of climate change will lead to out migration from areas within European countries as temperature increases. In Spain and Portugal rises of 5 to 7 degrees Celsius are projected, making the Iberian peninsula the most affected area in Europe. A case study of Turkey shows the effect of development projects on migrants. Some 28 villages and 48 hamlets affected by the building of the Ataturk Dam in central Turkey were given the choice of either compensation and self relocation or relocation by the state. Relocation occurred from the S.E. of Turkey and to the West of Turkey. The Ataturk dam also affected traditional agriculture that relied on groundwater leading to seasonal migration. Whether we can classify these events as a direct effect of climate change is debatable, but they do illustrate that the displacement effects occurred within the country not to Europe.

European Commission (2009) highlights two kinds of responses that are needed to adapt to the threat of climate change. The first is to reduce greenhouse gas emissions and the second is to adapt to unavoidable consequences of climate change. Increasing the resilience of Europe to climate change will involve investing in renewable technologies as part of the Economic Recovery Plan. The paper highlights the most vulnerable regions as Southern Europe and the Mediterranean basin, with coastal regions being most severely affected due to failing crops, lack of access to water resources and rising temperatures. The White Paper recommends action against climate change needs to be taken at local, national and regional levels but it requires support and integration for the EU to make a coordinated approach.

Lutz (2009) discusses the contribution that demographic analysis can make to understanding of the relationships between population and climate change. He highlights the need to strengthen human capacity through education which also reduces population growth and enhances economic growth. This is seen as the most promising investment for adaptation to climate change. He cites the *WHO Report on Climate Change and Human Health:* "In general, countries with more 'human capital' or knowledge have greater adaptive capacity. Illiteracy increases a population's vulnerability to many problems." Research has shown that changes in population growth, age structure and spatial distribution interact closely with the environment and with development. Rapid population growth has exacerbated freshwater depletion, climate change, biodiversity loss, depletion of fisheries and other coastal resources, and degradation of agricultural lands. Fertility decline, driven in part by women's increasing participation in education at all levels, slows population growth.

2.3 International literature

Boncour and Burson (2009), in their study of the South Pacific region accept that there is no definition of an environmental migrant. The term environmental refugee is in widespread use but does not have any basis in international law. Environmental impacts have long had an impact upon migration (e.g. floods), which makes it difficult to assess the role of climate change on migration. Migration has been seen as a problem yet it is an important part of the adaptation strategy and has been for millennia when societies are faced with environmental degradation. There is a need to understand the pattern of migration as both a fast process (in response to a climatic event such as a storm) and as a slow process of adaptation to a changing environment.

Brown (2009) points out that the prediction is of around 200 million people displaced by 2050 due to climate change is widely repeated (the Table 2.1 estimate was a little higher) but that it is really a very rough guess. He highlights the factors that affect the interaction of migration and climate processes such as sea-level rise and events such a floods that combine with human factors such as governance to increase vulnerability. Adaptation measures are needed globally: the problem needs to be recognized and policies designed that decrease vulnerability in developing nations and keep skilled labour in these countries. Emphasis on coastal defence and regional centre development in vulnerable location is needed, he argues.

We have already mentioned the important report by Warner *et al.* (2009). They research the extent to which climate change is already contributing to displacement and migration. Environmental, economic and political factors combine to force movements. Conflicts over resources such as water influence migration, particularly in the Sahel region. Disasters lead to shorter-term displacement and migration is a survival strategy. Seasonal migration is already a key adaptive measure used in many

countries affected. Climate change is likely to lead to long term migration when it affects whole livelihoods.

Bogardi (2007) highlights key areas of vulnerability due to climate change. His world desertification map shows a high risk in Southern Spain and a moderate risk in Greece. Maps in the report show the vulnerability of areas to sea level rise with the coasts of the Netherlands, Denmark, northern Germany and the east coast of Britain likely to be affected by a sea level rise of 1m.

The Refugee Studies Centre (2008) has published a report entitled *Forced Migration Review, Climate Change and Displacement*. The papers in the collection argue that climate and environmentally induced migration will become a key issue over the next century. Poverty, failing ecosystems, vulnerability to natural hazards and gradual climate-driven environmental changes are all linked to environmental migration. Warming will affect agricultural productivity, natural disaster such as floods will cause mass displacement and sea level rise will destroy productive low level lands leading to more mass displacement. The authors cite the UN prediction of 200 million migrants displaced by climate change. The authors identify a need to improve predictions and to solve the problem of distinguishing the role of climate change from other environmental, economic and social factors. Climate change is likely to increase numbers that migrate to urban areas. The report highlights the need for a clearer definition of environmental migration. It is widely believed that the majority of people who flee natural disasters remain in their own country. There is the obvious need of humanitarian assistance but they do not fear persecution so cannot be termed refugees. The European Court of Human Rights ruled that governments must enact laws to mitigate against risks posed by climate change.

IPCC (2007) discusses the key challenges Europe will face from climate change: winter floods are likely to increase, sea-level rise will affect an additional 1.6 million people a year, differences in water availability between areas with water stress increasing over central and southern Europe with 35% under water stress by the 2070s. The report also mentions a number of non climatic factors that will affect Europe with a prediction that the population will decline by 8% from 2000-2030. The proportion of the population of EU15 that is over 65 is expected to increase from 16% in 2000 to 23% in 2030. We, of course, have taken the view in our policy scenario projections that the worst case is that the European population remains stationary, principally because other projections have under-estimated the potential for improvement in life expectancy.

We have already cited the report by Christian Aid (2007) on *Human Tide: the Real Migration Crisis*. One additional estimate in the report which is relevant to building a LSE-CCM scenario is the

estimate that 5 million people will flee their own countries and be accepted as refugees. Spread over 45 years and all continents suggest that the numbers likely to come to Europe will be small.

The Environmental Justice Foundation EJF (2009) suggest that the majority of people caused to move as a result of climate change events will be internally displaced, migrating only short distances from home. Relatively few are likely to migrate internationally and settle permanently in other countries. With no internationally recognised legal term for people who migrate as a result of environmental degradation and climate change, the authors argue there is the need for a new protocol under the United Nations-Framework Convention on Climate Change to address the needs of climate refugees.

EEA (2008) summarises the key features of European climate change and future threats. Temperature is predicted to increase in Europe between 1.0 and 5.5°C by the end of the century, higher than projected global warming. Droughts and water stress will increase, particularly in the south and in summer due lower river flows. Annual precipitation changes are already exacerbating differences between a wet northern part (an increase of 10 to 40 % during the 20th century) and a dry southern part (a decrease of up to 20 % in some parts of southern Europe). The report estimates that 90 % of all natural disasters that occurred in Europe since 1980 are directly or indirectly attributable to weather and climate, representing about 95 % of the economic losses caused by catastrophic events. The large number of additional deaths during the 2003 summer heat wave (more than 70 000 excess deaths reported in 12 European countries) pointed to the need for adaptation actions, such as heat health action plans.

So what are the overall messages of this review of the literature on migration and climate change? The first is that the estimates of the number of global migrants caused by climate change are “guestimates” at best and guesses at worst. Measurement is difficult (who is a climate change refugee?) so figures are not reliable. The apparent consensus on a 200-250 million estimate is simply the result of repeating the UN figure. There is a sounder consensus, based on numerous case studies, that climate change migrants are unlikely to migrate very far because of poverty and as a result of mitigation through aid efforts. We will make an effort to estimate the likelihood that climate change migrants will come to Europe but anticipate that the numbers will not be “material”. There is firmer evidence about the effect of climate change in Europe and people are much freer to move between regions and between countries.

3. CLIMATE CHANGE MIGRATION SCENARIOS

It is anticipated that climate change (CC) will affect future demographic trends in various ways, the least in regards to morbidity, mortality and migration (Lutz, 2009). In the course of this project however, we will focus on exploring the impact of climate change induced migration on the European population in the course of the next 40 years.

Migration in Europe could be affected in two ways by the impacts climate change. Firstly, people affected by climate change from outside the European region will migrate into Europe. Secondly, people from areas affected within the European space might move into other regions of Europe.

To estimate additional, climate change induced migration into Europe, we would need to have good estimates on how many people will be affected by climate change to that extend that they will leave there homes to find livelihood somewhere else and in a second step we would need to establish how many people will actually enter the European region for that reason. To date, the numbers of worldwide predicted CC migrants varies greatly and is very uncertain. Warner *et al*. (2009) cite three sources which make very variable estimates between them 20 to 50 million climate change migrants by 2010 (Myers, 2001), 700 million by 2050 (Christian Aid, 2007) or 200 million (Brown, 2008). One problem in estimating CC migrants amongst others is to define what a CC migrant is. People will be directly or indirectly affected by climate change. Indirect effects, like food scarcity or water shortage might be by far more severe than direct effects (e.g. average temperature increase of 2-3 °C). But one would need to agree whether and to which extend migration induced by indirect effects of CC will be counted as CC migration to make proper estimates. We do not deem it necessary to dwell on this discussion in the course of this project. Case studies so far suggest, that people, directly or indirectly affected by climate change to an extent (e.g. Warner *et al*. 2009, reviewed in Barnett, 2009) that their livelihood is threatened do often not have the means to migrate to places far, and will rather migrate only short distances or even only seasonally. Additional important studies which focus on migration and climate change are Renaud *et al*. (2007) and EACH FOR (2009)

For that reason, the incorporation of climate change induced migration into our projection will mainly focus on European internal migration, influenced by the climate change predictions described in paragraph 5. To incorporate the impact of climate change into our projections, we first decide which of the of the IPCC (2007) Special Reports on Emission Scenarios (SRES) we assume to best describe the future we want to investigate. This is necessary, as the predicted extend of future climate change depends on the underlying assumptions which are used to run global climate models. Of the four scenario families adopted in the IPCC (2001, 2007) reports we reject two (A2 and B2) because of their assumption on world population growth, which would be a continuous increase in population

over time. Recent literature on world population growth suggests an 85% probability that world population will reach its maximum before the end of the century (Lutz, 2001). The SRES scenario we will adopt is B1: “The B1 storyline and scenario family describes a convergent world with the same global population that peaks in midcentury and declines thereafter, 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. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.” IPCC (2001), the scenario assumption has not changed for the IPCC 4AR.

To probe climate change induced migration effects in Europe, we will use downscaled climate change scenario data for Europe, which take B1 based global climate models (GCMs) as a base or downscaled GCM projections which are not emission based. Multi GCM models agree on climate change impacts in some regions, but disagree in others. For that reason our population projections will be labelled more certain for some European areas and less certain for others.

4. KNOWLEDGE ABOUT WORLD MIGRATION

It is a challenging undertaking to predict migration, often because of scarcity of data available. To estimate the number of additional, climate change, migrants into Europe we need to have solid knowledge of already ongoing worldwide migration. Data sources on worldwide migration are:

Worldmapper (2006) has assembled several data sets from international sources which measure worldwide population movements. Of interest to our work are 7 data sets which are originally sourced from the World Bank and the United Nations. The data sets are briefly described in Table 4.1.

Table 4.1: Worldwide population movement datasets available via worldmapper.org

Variable	**Data**
International Emigrants	Number of international emigrants which originate from a territory
Net Emigration	Only territories with emigration greater than immigration,
International Immigrants	Number of international immigrants which live in a territory
Net Immigration	Only territories with immigration greater than emigration,
Refugee Destination	Global proportion of refugees and internally displaced people living in a territory
Refugee Origins	Global proportion of refugees and internally displaced persons originating in a territory
Affected by Disasters	Proportion of people worldwide affected by disaster between 1975 and 2004

Stock data of migrants from various sources and years for countries worldwide are available from the United Nations Global Migration Database v.0.3.6 (2008).

Cohen *et al*. (2008) have constructed a generalised linear model to predict worldwide between country migration. This model needs only 4 independent input variables: the population and area of the originating country and the population of the receiving country and the distance between them. This model can also be incorporated into a population projection model (Cohen *et al*. 2008). The proposed formula results from data from 1960 and 2004, represented by 43,653 reports from 11 countries from 228 origins to 195 destinations (228*195= 44,460). The model has an overall R^2 of 0.59. If only the data from 2000-2004 is used the R^2 increases to 0.64. Even though, this model is a very simplified description of migration, we could use the formula for Climate Change (CC) induced migration. Given our scepticism that such migration from extra-European origins will be significant, a simple model will reduce research costs. The presence in the model of the country area has advantages for a

model of climate change migration. The area of a country at risk could be reduced over time in accordance to CC models, which in turns would impact on the migration flow from the country to other countries. We would still need to use an overall estimate of climate change migrants to scale the results of the model and a function to distribute them to origins. Cohen's model would give us the probabilities of CC migrants choosing destinations in Europe, which are ultimately grounded in the historic flows and channels of international migration.

5. CLIMATE CHANGE IMPACT RESEARCH IN EUROPE

In this section of the report we briefly inform on the current research done on climate change impact in Europe. Key literature on Europe and Climate change we consulted to date were Christens *et al.* (2007), which focuses on the regional impacts of climate change, with a special consideration of Europe in Chapter 11, this report presents results of models which downscale from high-resolution GCMs to European level. Also part of the IPCC's 2007 fourth assessment report is Chapter 12 of IPCC (2007) which is dedicated to Europe and discusses regional impact, adaptation and vulnerability. A recent publication of the European Environment Agency (EEA, 2008) also focuses explicitly on the impacts a changing climate will have on Europe. Figure 5.1(IPCC, 2007) gives a brief overview of the vulnerability of European regions. Important to point out is that different European regions will be affected in very different ways, therefore climate change models often distinguish between Northern Europe and the Mediterranean area (e.g. Christens *et al.* ,2007). The European region already experiences an increase in average temperature; a trend that very likely will continue in future. It is foreseen, that this will lead to a more pronounced increase in summer temperature in the south of Europe and to a more pronounced increase of winter temperature in the northern parts. Amongst other things, it is expected, that this will lead to more pronounced and severe droughts in Southern Europe, whereas in the more boreal parts will experience an increase in precipitation and river flooding (EEA, 2008, Christensen *et al* 2007). Also because of milder winters, a reduced winter snow cover can be expected. Worldwide temperature increase and the accompanying sea level rise also might affect Europe (see Paragraph 6).We anticipate the different regional impacts of climate will impact differently European internal migration, therefore we suggest a method how to quantify climate change impact on internal migration in Europe in the next paragraph.

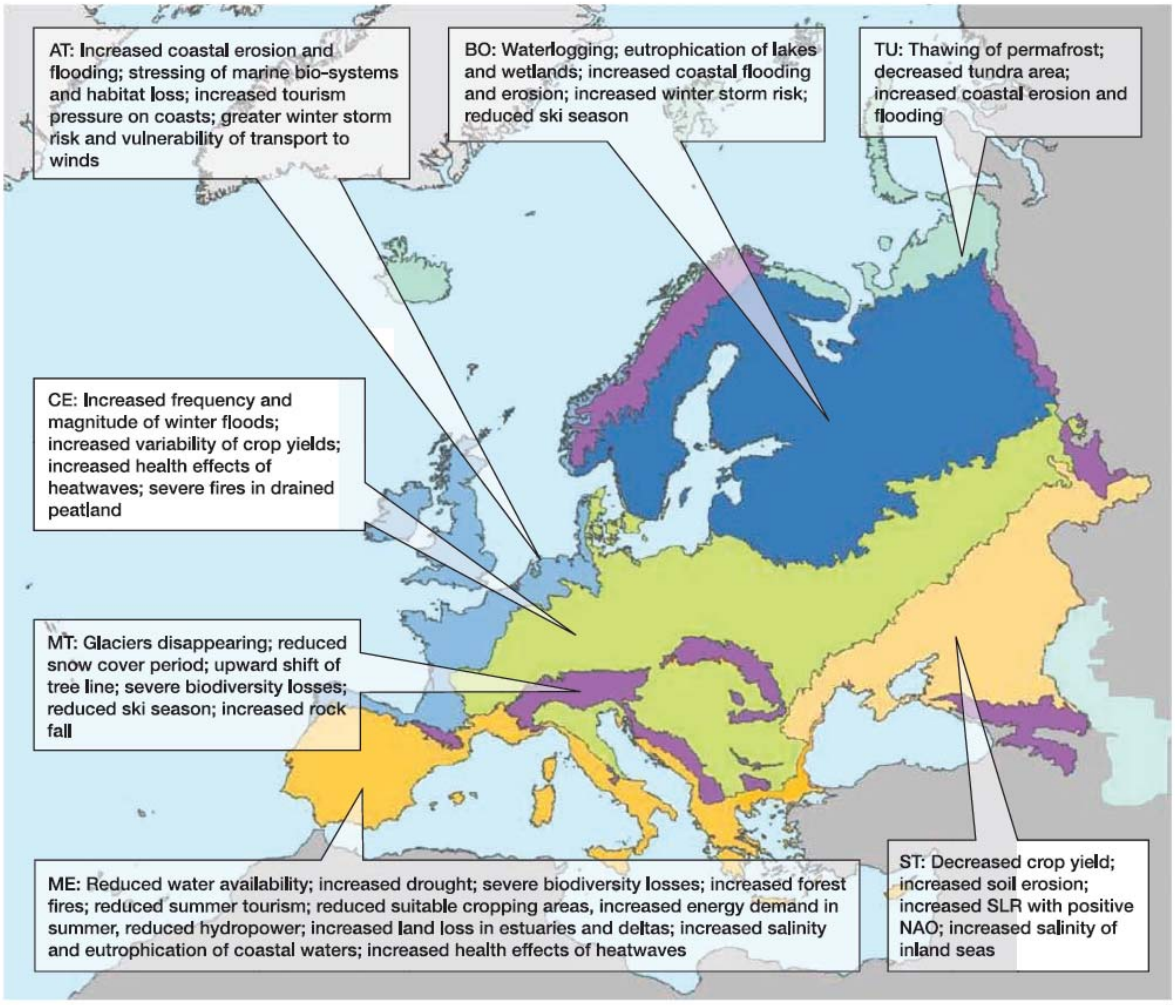

Figure 5.1 “Key vulnerabilities of European systems and sectors to climate change during the 21st century for the main biogeographic regions of Europe (EEA, 2004a): TU: Tundra, pale turquoise. BO: Boreal, dark blue. AT: Atlantic, light blue. CE: Central, green; includes the Pannonian Region. MT: Mountains, purple. ME: Mediterranean, orange; includes the Black Sea region. ST: Steppe, cream. SLR: sea-level rise. NAO: North Atlantic Oscillation. Copyright EEA, Copenhagen. http://www.eea.europa.eu” (Figure 12.3., IPCC 2007)

6. DESIGN FOR A CLIMATE CHANGE AND MIGRATION SCENARIO

The climate change and migration scenario will need two sets of building blocks: the demographic and environmental. We already have a full set of demographic inputs for the LSE scenario which we will modify to reflect the impact of climate change. We will focus on the effects of climate change on migration and ignore the effects on fertility and mortality. We quoted earlier the case of excess summer deaths in 2003. These were probably compensated for by lower deaths in the following year because the most vulnerable elderly had died the previous summer. This is the kind of effect we see with influenza epidemics. Mitigation of the effects of heat on human health can occur through better building design, air conditioning powered by solar generated electricity and more informed human behaviour ("only mad dogs and Englishmen go out in the midday sun").

6.1 Identifying regions environmentally impacted by climate change

We briefly described the anticipated environmental impacts of climate change on European region in paragraph 5. In this section we will lay out the method we will use to identify NUTS 2 regions impacted by climate change and how we will quantify there change in attractiveness to live there in the course of climate change. In a first approach, we decided look into three main climate change predictions which could affect inner European migration: sea level rise, increased temperature and increased storminess and river flooding.

To identify areas which are predicted to be impacted by the IPPC (2007) SRES B1 scenario, we will use a simple map overlay technique.

6.1.1 Sea level rise

Below is an example how to identify areas, which would be affected by a sea level rise of one metre. The areas are identified in blue and are found around the coasts of northern Europe, particularly the North Sea and the Netherlands. Note that we will need to import knowledge about the trade off applied in the different countries between mitigation and migration. The Netherlands, for example, has a long history of engineering barriers to keep out both river and sea flood waters. Nearly 25% of the country is already below sea level. On the other hand the UK Environment Agency plans to protect only the most valuable part of the UK's North Sea coast (the Thames Estuary and London) and to let the processes of wave erosion and sea flooding work through, learning from the experience of King Canute. Figure 6.2 is only an example of method suggested. Sea level to date in Europe rose between 0.8mm to 3 mm and is predicted to rise up to 0.3 m by the end of the century under the B1 scenario and not even 0.2 m by mid century.

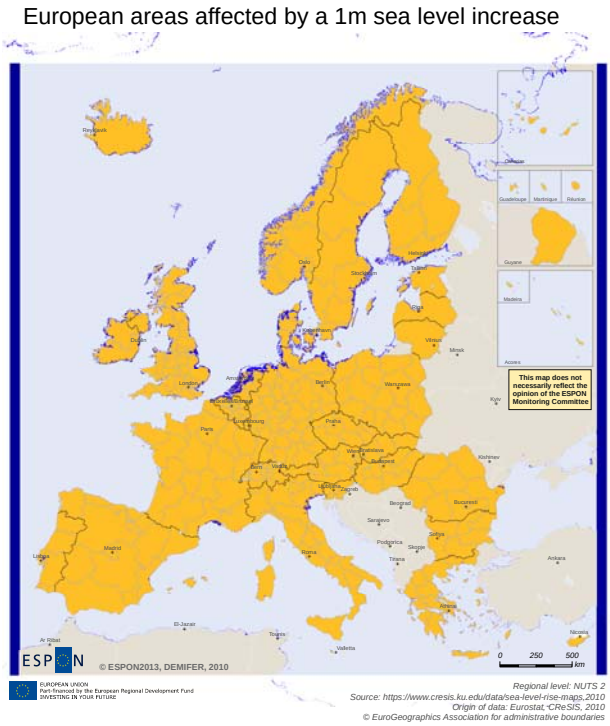

Figure 6.1: Espon 2013 map overlaid with CReSIS (2010) sea level elevation data

6.1.2 Temperature increase

Similar map overlays as shown in Fig 6.1 will be produced for the effects of temperature increase. It is not sufficient, just to look at temperature changes, but on the effects higher temperature will have on the European region. As described earlier, the anticipated increase of temperature will have opposing effects on Southern Europe (summer heat, drought) compared to the more Northern European regions (reduced snow cover, increased river flooding and more rain). For this reason we suggest to acquire maps of temperature changes, soil moisture changes, river discharge, crop yield, snow cover etc. It is anticipated to acquire those maps from European climate change models as presented in EEA (2008).

Climate change is a progressing process and happens over time. Areas affected will change with time. For that reason is necessary to produce a time series of map overlays with the variables considered.

Through identifying which NUTS2 regions might be affected how by the various impacts of climate change, we will develop a time series of attractiveness factors for each region.

Additional information will be introduced by a layer containing information on population numbers to estimate the number of people affected.

6.2 Altering the migration variables to respond to climate change risks

From the overlap analysis will be generated a set of scores indicating the impact of the three climate change factors. We will explore both the metrics for these scores and ways of transforming them into them into indexes that alter both the propensity to out-migrate and the destination attractiveness ratios for the regions. We will then model the climate migration induced by each of the three environmental factors: where the total number of migrants from a region, $O_{climate}$, is a sum of:

$O_{sea\ level}$ = f(area changes in sea level in NUTS2 region, population of region)

O_{temp} = f(changes in temperature and water stress, population of region)

$O_{river\ flooding}$ = f(changes in flood frequency and magnitude, population of region).

These migrants will then be distributed to destination regions using attractiveness factors which are modified as a result of the climate change impact, $A_{climate}$, is a sum of:

$A_{sea\ level}$ = f(area changes in sea level in NUTS2 region, population of region)

A_{temp} = f(changes in temperature and water stress, population of region)

$A_{river\ flooding}$ = f(changes in flood frequency and magnitude, population of region).

We will feed these new O and A values into a model that generates a new matrix of climate migrants by origin and destination for both the internal migration matrices and the inter-country matrix for Europe. The new migration flow will be:

$M^{ijnew} = M^{ijLSE} + M^{ijclimate}$

This is a very broad brush description of the method. We have developed more detailed specifications but they are experimental at the moment. The methods will be modified and adjusted as we developed the impact scores for NUTS2 regions through the overlap analysis.

6.3 Concluding remarks

In this report we have reviewed the literature on the impact of climate change on migration. It is a highly speculative literature with lots of interesting case studies but rather less in the way of reliable statistics on past migration linked to climate change. There are understandable reasons why this should be the case. However, it is worth finding out whether the impact of climate change is likely to be small or large by integrating a climate factors analysis with one of our policy scenarios. We will report on the results in the next version of this deliverable.

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