CLIMATE CHANGE IMPACTS ON MIGRATION IN THE VULNERABLE COUNTRIES

by

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ABSTRACT

CLIMATE CHANGE IMPACTS ON MIGRATION IN THE VULNERABLE COUNTRIES

This research focuses on the economic, demographic and environmental drivers of migration related with the sustainable development in the underdeveloped and developing countries, which are the most vulnerable to the climate change impacts through the panel data analysis. We have studied some countries namely Bangladesh, Netherlands, Morocco, Malaysia, Ethiopia and Bolivia. We have analyzed these countries according to their economic, demographic and environmental indicators related with the determinant of migration, and we tried to indicate that their conditions differ according to all these factors concerning with the climate change impacts. In order to achieve sustainable development by preventing or decreasing environmental migration due to climate change impacts, these countries need to maintain economic, social, political, demographic, and in particular environmental performance. This thesis argues about climate change impacts in the future to the vulnerable countries and its effects on the migration in these countries. There are some significant risks stemming from climate change, which is not under control. When the economic and environmental conditions are considered, we have to regard that climate change will be more destructive for those who are less defendable in terms of all risks and impacts of uncontrolled climate change. In this case, there are some crucial questions required to be responded. What should be the economic and environmental priorities? What are the contributions of these priorities to the vulnerable countries concerning with the climate change effects? Considering all these, geographic structure and also human population density (how and where population live) of these poor are very significant concepts.

ÖZET

KIRILGAN ÜLKELERDE İKLİM DEĞİŞİKLİĞİNİN GÖÇ ÜZERİNDEKİ ETKİLERİ

Bu araştırma, İklim Kalkınma Modeli aracılığıyla, iklim değişikliğine karşıkırılgan ülkelerde sürdürülebilir kalkınma kapsamında, ekonomik, demografik ve çevresel sürücülerin göç üzerindeki etkisini araştırmaktadır. Bangladesh, Morocco, Malaysia, Netherlands, Ethiopia ve Bolivya'yı içeren 6 ülke değerlendirildi. Bu ülkeler, göçün sürücüleri dikkate aınarak, ekonomik, demografik ve çevresel göstergeler kapsamında analiz edilmekte ve bu ülkelerin mevcut koşulları kapsamında, iklim değişikliğinin etkilerine karşı gösterdikleri farklılıkların önemine dikkat çekilmektedir. İklim değişikliğinin etkileri sonucu oluşacak çevresel göçün azaltılması ya da engellenmesi yoluyla sürdürülebilir kalkınmanın sağlanması için ülkelerin ekonomik, sosyal, politik, demografik ve belirli ölçüde çevresel performansı sağlamaları gerekmektedir. Bu tez, birçok yönden kırılgan ülkelerde iklim değişikliğinin gelecekteki etkileri ve bu etkilerin göçteki rolü üzerine yoğunlaşmaktadır. İklim değişikliğinden kaynaklanan ve kontrol edilemeyen bazı etkiler ve riskler bulunmaktadır. Ülkelerin mevcut ekonomik ve çevresel koşulları dikkate alğndığında, iklim değişikliğinin savunmasız ülkelerde çok daha yıkıcı olacağını kabul etmek zorundayız. Bu koşullar altında, iklim değişikliğine sebep olan insan aktivitelerine bağlı olarak göçün kaçınılmaz olduğu düşünülmekte, bu ülkeler için ekonomik ve çevresel önceliklerin ne olduğu üzerinde durulmakta ve bu önceliklerin kırılgan ülkelere katkısı vurgulanmaktadır. Tüm bunlar ışığında, gelişmemiş ülkeler açısından coğrafik yapının ve nüfus yoğunluğunun çok önemli olduğunu belirtmek gerekmektedir.

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LIST OF ACRONYMS/ABBREVIATIONS

ADF	Augmented Dickey Fuller
BAU	Business As Usual
COST	European Cooperation in Science and Technology
COASTD	Coastal Location
ECHAM	European Centre Hamburg Model
ECHAM5	European Centre Hamburg Model
FISHCAPT	Fish Capture in area 'i' and 't'
GDP	Gross Domestic Product
GNP	Gross National Product
HAZARDD	Occurrence of Natural Hazards
ICTP	International Centre for Theoretical Physics
IPCC	Intergovernmental Panel on Climate Change
LDC	Less Developed Countries
LSDV	List square dummy variable estimator
MIG	Migration in geographic area 'i' and 't'
NELM	New Economics of Labor Migration
PERMCROP	Permanent Cropland in area 'i' and 't'
POP	Population in area 'i' and 't'
PREC	Precipitation in area 'i' and 't'
RegCM	Regional Climate Model
SRES	Special Report on Emissions Scenarios
TEMP	Temperature in area 'i' and 't'
UNDP	United Nations Development Program
WB	World Bank
WHO	World Health Organization

1. INTRODUCTION

Climate change concept drives human migration since some natural events arising from climate change like tropical cyclones, heavy rains and floods, drought, deforestation, desertification, sea level rise have a significant impact on human migration. As a result, climate change will cause some environmental events like coastal flooding or agricultural disruption and millions of people will be forced to leave their homeland. It is widely considered that this figure will reach 200 million climate refugees by 2050 [1].

In this thesis, we comment on economic, demographic and environmental aspects of climate change impacts in the poor and developed countries which are most vulnerable to the climate change effects and the relationship between migration from the poor and developed and climate change stemming from anthropogenic climate change. In addition to these vital aspects arising from human activities, we emphasized some important questions including the possibly to prevent the uncontrolled migration which will be experienced in the poor and developed regions, and what can be done in order to hinder people to leave their homeland, and whether some investments recommended can be sufficient for people to live safely in their homeland. We underlined that all direct and indirect climate impacts, environmental change impacts and demographic and economical impacts in order to answer these questions.

In this research, we have created a model including current financial conditions for the regions , demographic structure (population size), climate change vulnerability due to temperature, precipitation, coastal zone, natural hazards and also changes in permanent cropland and fish capture data in countries which are most likely to suffer adverse effects of climate change. This research will proceed with another part of this study under COST Action. In the further research under COST Action-IS1101, we will examine the priority areas and investment recommendations in order to provide consumer and producer welfare

under climate change and by this means we hope that we will produce a solution for migration.

We have carried out this research for two reasons: The first is to demonstrate the relationship between climate change and sustainability, which will hinder the migration. Second, to compare same indices for 6 different countries which are used to measure different aspects of sustainability concept based on the integrity of the social, economic and environmental factors and which are thought to reduce the migration. This research is organized in to three chapters.

First chapter focuses on, the defining climate change, migration and related terms within the context of major set off problems about vulnerability such as income, population and exposure to natural hazards and the availability of ecosystem services in undeveloped, developing and developed countries. It approaches many economic, social, demographic, political and environmental issues of underdevelopment and development systematically from an institutional and structural (non-economic) as well as an economic perspective and it considers these with general principles, theories and policies.

Chapter two, focuses on taking into account the variables affecting migration and available method. This chapter shows that the GDP per capita that is very significant for all countries in development and adaptation level of vulnerable countries to the climate change impacts. But GDP is not merely important for struggling against natural hazards and extreme weather events due to climate change. Along with the GDP, some social, demographic, political and environmental factors are also vitally important to combat adverse effects of climate change. For example, population size as a demographic factor affects all resources required to live. When the population increases in a region, basic resources are consumed quickly and people need to displace to the new regions, which have more wealth in terms of resources and livelihood opportunities. Therefore we have demonstrated other substantial indices such as population size, climatic variables and variables which have

effects on agricultural productivity and fisheries.

Finally Chapter three, deals with comparative analysis of measurement associated with the variables affecting to the migration environmentally, demographically and economically of six countries including Bangladesh, Morocco, Netherlands, Malaysia, Ethiopia, Bolivia . This chapter demonstrates that good performers according to classic indices may be among the worst performance according to contemporary indices, which attach importance to the environmental factors. In this study, some correlation for data availability and the panel data analysis has been used. We tried to examine that which explanatory variable how to affect the migration and the link between environmental changes and migration and how to shape this situation in the future.

2. CLIMATE CHANGE AND MIGRATION

Governments in developed countries especially in Europe, North America and Australia call attention to increasing migrations and they stress that this case should be balanced with various policies. In this point, it is necessary that economists should calculate the income and expenses of migrations on countries and advise their governments. In this study, worldwide economic and demographic fundamentals in different historical periods are evaluated [2].

According to Boko [3], climate change will force people to migrate because of its lots of impacts such as extreme weather events and change in temperature and precipitation.

Urbanization and economic development occur with the migration from agricultural-rural areas to industry-based cities. In this study, changes in the agricultural sector due to urbanization, getting under control of trade and product prices with various policies have been studied. According to the findings, it has been put forth that increase in interregional infrastructure investments which will facilitate the interregional transportation will facilitate the urban distribution. The two main factors have been studied on: (i) Urbanization structure. (ii) Urbanization density. Increase in urbanization in a country becomes as follows: Development in the country causes an increase in technology. Thanks to this, workforce used in agriculture shifts to various working fields in production and industry. In this way, an increase occurs in the cities where these industrial fields exist. Increase in urbanization is determined with the increase in workforce density in the cities. In this study, Brueckner's model has been used. Long-term stability has been observed using the variables. These variables are income before taxes in the region, national taxes, the number of democratic institutions and cost of living in the region. Transport infrastructure is also an important factor in ensuring the urbanization. Development of urbanization has an important role in the economic structure of a country. Political factors have no direct

effects on urbanization, but they have direct effects on income and formation of sectors and they also have an important role on the formation of urbanization. Furthermore, making roads for transport and making interregional investments on waterways ensure the migration routes to be improved [4].

According to Black [5], long term environmental variables for migration. It can be asserted that when it is examined at the long-term environmental variables, it can be used the standard deviations of temperature and precipitation values and the averages of their differences.

In Barrios' study [6], he has analyzed how climate change will affect the structure of urbanization in sub-Saharan African countries. The econometric analysis has put forth that climate change will change the structure of urbanization in sub-Saharan Africa. Urbanization in sub-Saharan Africa increased by about 140% between 1960 and 1990. This is not an indicator of the development of economy in that area, but it is an indicator of the development of cities. This case occurred by the migration of agriculture-based population. Its reason is that the modern sectors, which perform the production, are mostly in the cities. Climate scenarios show that climate change in Africa, especially decline in water resources will show too many effects in urbanization areas and areas in which people live. In this study, the impacts of climate change, especially the impacts of decrease in rainfall on agriculture and how climate change will affect the migration from rural areas to cities in Africa has been studied. It has been predicted that climatic conditions will force people living in agricultural and rural areas to migrate to the cities. According to the data of UN World Urbanization Prospects, a comparison between sub-Saharan African countries and the other countries in the world has been made based on how precipitation affected urbanization in these countries between 1960 and 1990. Although sub-Saharan countries receive less rainfall, they have worse conditions economically and have less population density compared with other developed countries, colonization rate has become more in those regions. Variables used in the determination of this are population of the country, popula-

tion density by the size of their country, income of the country, whether there is democracy in the country or not, civil wars, rainfall, rainfall intensity, colonization and its distribution over the country, determination of colonized regions according to the distribution of rainfall. During the colonial period, the native Africans was banned to migrate to eastern and southern Africa permanently. Therefore, in 1950, South Africa was the country in which a minimum level of urbanization occurred all over the world. These laws were changed after South Africa declared its independence and a sudden and rapid increase occurred in urbanization rate. In this study, it has been determined that decreased rainfall caused by climate change in the last few decades has lead to the occurrence of different urbanization ways and such an effect has not occurred in other developed countries.

In another study, the impacts of climate change in the last 50 years and the impacts of change in temperature and precipitation on the world economy have been analyzed. Findings reported are:

- While increase in temperature undermines the economic development in low income countries, it creates less effect in developed countries.
- Increase in temperature does not only cause a decrease in production, but also undermines all economic developments.
- The effects of high temperatures on low income countries are decreasing agricultural and industrial products, investments and political instability.

In Del's study [7], it has been shown that a 1 °C increase in temperature decreases the economic growth by 1.1%. The temperature and precipitation climate data used is 1900-2006 Gridded Monthly Time Series, Version 1.01. Here, the average monthly temperature and precipitation values getting from 20 different stations around the world were used. For economic data, Penn World Tables Version 6.2 was used. In this study, Dynamic Regression Model was used. In the model, general dynamic growth effects were formed using mathematical equations. In the results of this study, it has been put forth that low-

income countries will be affected by climate change much more than developed countries. It has been also introduced that this case will increase the gap between rich and poor countries more in the future and poor countries will be poorer .

In literature studies, migrations have been especially evaluated with hunger, poverty, wars and human rights violations. It has been also come onto the agenda that people forced to migrate due to the loss of water, loss of land and other environmental disasters are defined as “environmental refugees”, “environmental migrants” or “climate refugees”. Documentation proves that natural disasters such as the tsunami in the Indian Ocean in 2004 and Hurricane Katrina in New Orleans (US) in 2005 have increased. People living in areas where these disasters occurred will have to evacuate their territories in order to continue their lives. In this study, the effects of environmental degradation on migration have been assessed. 13 cultural and environmental factors have been analyzed with ”gravity regression model” on 172 countries around the world. Mentioned about international migrations, the most important factor in the decision to migrate is whether the countries are close to the seaside or not. Unemployment, job opportunities in immigration region, cultural differences, number of ethnic groups, languages spoken and the presence or absence of a common history are also significant issues that should be considered. All of these variables exist in the model used. All environmental factors used in the model are: GNP (gross national product) in the country of immigration, GNP in the country of migration, the distance between the two countries, unemployment rate in the country of immigration, being not on the seaside of the country of immigration, being not an island country of the country of immigration, common borders between the country of immigration and the country of migration, common official language between the two countries, common spoken language between the two countries, colonial relations between the country of immigration and the country of migration, whether the two countries were in the same region in the past or not, the status of fisheries in the country of immigration, tsunamis and earthquakes in the country of immigration, floods, drought and hurricanes in the country of immigration, lack of drinking water resources in the country of immigration, the amount of salt in the

soil, the fact of the trees being destroyed in the country of immigration, rise at sea level and air pollution, soil erosion and soil pollution. According to the Myers report [8], it has been stressed that Southern Africa, China, America's Center and South Asia will be most affected by these migrations. While Myers has asserted that people have no alternatives other than migration to avoid risky areas, Castles [9] has stressed that migration is not the main strategy and when the neighbourhoods of people was damaged, they move to another undamaged places in the same region. For instance, he has stressed that some regions will be protected by dams built because of the rise at sea level, other regions will be left and only a small minority will leave their own country. It is not enough that governments have only necessary economic sources to cope with these conditions. Corporate management, government policies, communication between groups in different regions and risk assessment will be also required. Gravity Model is a model that shows how different interactions occur in geography. For example, in this model, the interregional traffic, migration and trade flows can be studied. This model was used in order to determine the international trade routes in the past. In this study, it has been used for determination of the main migration interactions between countries.

In a study by Atifi, unexplained migration routes have been detected using gravity model. A new application of gravity model was discovered searching the effects of environmental degradation in international borders on migration. When several factors such as drought and floods were added to the model, it was arisen that migration between countries will increase. In the study, data of Development Research Centre on Migration has been used. Variables used are income of the countries of migration and immigration, distance between the two countries, unemployment rate in the country of immigration, number of ethnic identities, languages spoken and official languages, whether the country is by the seaside or not, previous colonial relationships between the two countries, whether there are some climatic events such as floods, drought, tsunami, desertification in the country of immigration or not, whether there is air, soil and water pollution in the country of immigration or not. With the variables used in the model, it has been put forth that

environmental conditions will be worse because of the impacts of climate change and this situation will cause the migrations to continue to increase [10].

Sub-Saharan Africa has the highest migration rate all over the world. In this report, the reasons for the occurrence of extensive migration from sub-Saharan Africa have been studied. According to the data collected from 45 countries between 1965 and 2005, the main reason for migration from sub-Saharan Africa to different regions is unemployment and conflicts in the region. The African continent is the region where civil conflicts are most commonly seen. These conflicts occur due to the reasons such as the degradation of environment where the people of region live and water scarcity. Half of the countries in sub-Saharan Africa experiences water scarcity severely. These countries are Burkina Faso, Eritrea, Lesotho, Namibia, Niger, Senegal, Somalia, South Africa, Sudan and Swaziland. The precipitation follows an irregular and continuously decreasing period in those regions. Climate change will be expected to increase this problem in the region, to cause extreme weather events more such as drought, floods and to further increase water stress. It has been put forth that migration rate of the local population increased by 1.3 out of 1000 in a year in which conflict is more. Demographic and environmental factors have been put forth to have less direct effects. Nevertheless, the increasing incidence of natural disasters has triggered the risk of occurrence of military conflicts in the country. Additionally, there is no evidence about being permanent of increase in migration from sub-Saharan Africa and causing to conflicts of people migrated form this region in the country of immigration. As a result of the report, economic factors that cause people to migrate from this region have been determined as the decrease in total income and wages, increase in unemployment, poverty and difficulty of life. In the country of immigration, there has been better job opportunities, social services, education opportunities and factors that facilitate the life. The demographic factors that affect the migration are the population density and structures of countries. The most significant reasons that affect the migration are political instabilities and military conflicts. In this study, data getting from the UN Population Division has been used. The natural factors that cause to migration and the migration factors in

international context (demographic, environmental, political and social factors mentioned above) have been added. In this model which was applied on Canada previously, only internal migrations have been evaluated. Damaging suddenly of the environments people live in due to the natural disasters has not been evaluated [11].

In another report by Docquier [12], how the educational gain has changed with the migrations for 195 countries in 2000 and 170 countries in 1990 has been examined. Data has been received from 36 independent regions. Educational gains of migrants have been analyzed. According to the results of the report, general migration rate exceeds 80% of people in regions such as Guyana, Jamaica, Haiti and Grenada. It has been found that the migration rate in African countries exceeds 50%. It has been also found that the education level of the most of the migrants who migrate from Europe (UK, Italy, Germany), South and East Asia (Philippines, India, Korea, China, Vietnam) and the central America (Mexico) is high. Given the rate of the workforce whose education level is high, it has been observed that most of the migration is from the Caribbean, Central America, West, Central and East Africa. It has been also observed that Islamic and Arabian regions are not mostly affected by brain drain. In the study, the migration rate for different countries has been analyzed in general and the rate of gained brain drain for every developed country has been examined.

It is a phenomenon observed so far that the warmer countries are the poorer countries. According to the analysis of the Earth's income values in 2000, it has been determined that every 1 °C rise in temperature decreased the national income by average 8.5%. In this study, firstly, the relationship between temperature and income change has been analyzed on 12 countries in North and South Africa. These countries are Bolivia, Brazil, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, US and Venezuela. The result achieved from these countries is that every 1 °C increase in temperature in in the local areas analyzed means a decrease in income by 1.2-1.4%. Secondly, when countries experienced usually hot or cold years, climate and the amount of income have been analyzed

during that period. According to DJO findings (2008), in a study carried out on low income countries between 1950 and 2008, a 1 °C increase in temperature caused to a decrease by 1.1% in economic development in the year which is hotter or colder than the average. In this study, according to the long-term observations, it has been stated that adaptation occurred during this time has halved the adverse impacts of climate change on economic growth. These adaptations have been derived from both the adaptation of climate and the adaptation of economic changes in a period long enough. Acemoglu and Dell data sets have been used for the data for all countries. For climate data, in 1 km resolution has been studied [13].

In Mayda's report [14], the factors that cause to migration on 14 developed countries between 1980 and 1985 have been studied on. The average income of the people and income distributions in the country of migration and immigration, the geographic, cultural and demographic factors in the country of immigration and changes in migration policies have been analyzed. It has been identified that the amount of migration in these developed countries was reduced between the specified years, but in some developed countries this number increased. For example, migration to Japan was reduced by 42% and migration to Canada increased 48%. In this study, the data of International Migration System (IMS) for developed countries has been used. For the data for macroeconomic variables, World Development Indicators dataset of 2001. and the Penn World Tables (versions 5.6 and 6.1) has been used. In these variables, significative cultural, economic and geographical factors such as the distance between the country of migration and the country of immigration, geographic boundaries, common languages and the cost required for the migration have been used. Information about young population of the countries has been received from United Nations. A change in the number of people who immigrated to a country is carried out by immigration policies and legally by immigration control in that country. As a result of the study, it has been introduced that the most important factor related to migration is the GNP (Gross National Product) in the country of immigration. A 10% increase in income per capita leads to a 20% increase in immigration to that country. In this study,

which factors trigger the increase in migration in developed countries has been introduced by using the data in the past. Based on these results, it is possible to study on how the change in these factors will affect migration in the future.

The link between environmental changes and people migration and how to shape this situation in the future has complied. According to the literature study, it is possible to describe the six general principles that determine the decisions of migrants. First of all, the vast majority of people can demand to be inactive about the migration. The reason for why they do not want to migrate is families, friends and values shared with the community. Secondly, it is a big possibility that migrations are in short distances. In the last 50 years, most of the effects of environmental change has been seen in the south of the world. It is estimated that regions vulnerable to the impacts of climate change will substantially send migrants to other regions. However, migration to another country will become impossible due to economic factors for some countries such as Bangladesh and North East India. Thirdly, people of the countries which are underdeveloped in social and economic areas find the destination country attractive due to its being better in terms of social, economic and cultural features. For example, considered the economics recession in labor markets in other countries, migration of people living in the West Africa to the city (internal migration) can provide a more advantageous case compared to the international migration. Fourthly, economic inequalities may be associated with changes in livelihood depended on environmental processes. For instance, the northern population mobility may be in favour of the southern population. However, migration policies allow this in rich countries according to their own labor market needs. It is stated that labor migration can be useful in some rich countries in terms of being source when work force is insufficient. Fifthly, it is estimated that some international links established for historical, cultural and some other reasons will create a powerful impact in order to connect people in complex international cases that contain international migration and communication of people. Sixthly, international movement can be increased in order to become rich and increase social capital. However, it is an impossible result for the most vulnerable countries. This article

also describes the reasons why Europe was affected by migratory flows. People living in the North Africa can probably migrate to Europe because of the losses in agricultural products and desertification. People living in the coastal zones in the South Africa, especially in India and Bangladesh (here, it is mentioned that these countries will be affected by floods) can probably migrate to Europe. Small islands in Pacific Ocean and Indian Ocean are under the danger of floods because of sea level rise and so people living in these countries must probably migrate [15].

In the study by Gemenne [16], it has been investigated how people migration will be shaped in the future due to the environmental changes. In the first part of the article, a compilation about the estimations of the past and present migration flows has been done. Every year, 10 million people are expected to migrate due to environmental degradation. In 2009 17 million people and in 2010 42 million people migrated because of natural disasters. The majority of them is people living in Asia (EMDAT) [17]. It was observed that 50 million people have been affected by these migrations. In the second part of the article, migration flows in the future have been estimated. It is estimated that almost 200 million people will migrate by 2050 because of coastal flooding caused by sea level rise, monsoon systems and changes in precipitation and drought. Such a prediction has been made in the countries at risk of flooding: 26 million people in Bangladesh, 12 million people in Egypt, 73 million people in China, 20 million people in India and 31 million people in small island regions will migrate. The rest 50 million people are expected to migrate owing to drought and climatic conditions. According to another estimation, 300 million people will migrate by 2050. 50 million of them will migrate due to droughts, poverty, floods and hurricanes caused by climate change. It is estimated that sea level will rise 38 cm in different regions by 2080. According to this, 82 million people in Africa, 141 million people in Asia and 2.5 million people in small island countries will be affected. It is estimated that a $2-3\,^{\circ}\mathrm{C}$ rise will occur in temperatures by 2085 and according to this situation, population living in Africa will be under the water stress. It is stated that 30 million people will face with the risk of coastal flooding every year. There are three ways in order

to make accurate estimations and carry them to the future. First of all, right framework should be created for research, in other words statistical systems and capacities of local research should be developed. Secondly, time interval and spatial dimensions should be re-configured for quantitative research. Thirdly, new methods and techniques should be developed and tested (for example longitudinal studies and scenarios).

Another study in the literature has explained the impacts of climate change for less developed countries (LDC), areas in which migration is expected and its economic impacts using drivers of migration determined by migration models. Three main migration models have been described with different economic drivers. The first and oldest model describes the economic drivers of migrations in two different areas. When the labor force is better in urban area, migrations occur from rural to urban areas. The second type of migration model has been developed by Todaro [18]. This model has asserted that considering the migrations from rural to urban areas, the unemployment and wage differences in urban areas do not affect the migrations. The third type of migration model is the New Economics of Labor Migration (NELM). According to this model, the description of rural risk as a factor has been expressed especially as individual migrations instead of sending potential migrants. These three models have been used in the drivers of income difference and income change. The first two model have been used in income difference drivers and NELM model has been used in income change drivers. The result obtained is that impacts of climate change on these migration drivers will increase the migrations, but scientific results are limited. In less developed countries (LDC), estimating the migrations is difficult because of the climate change. However, it is predicted that migrations derived from changing climate conditions will increase. It is also stated that increasing migrations will be especially internal and return migrations [19].

According to Seto [20], he has described the social and political common points and differences of the migrations in mega delta cities in Asia and Africa. For two migration types, areas outside the delta region, rural or urban areas and rural areas in mega delta

region has been considered. The relationship between migration drivers and environmental changes has been analyzed and how the drivers will be shaped by 2060 has been examined. 11 mega deltas; Yangtze River Delta and Pearl River Delta in China, Red River Delta and Mekong River Delta in Vietnam, Chao Phraya Delta in Thailand, Irrawaddy Delta in Myanmar, Ganges-Brahmaputra Delta in Bangladesh and India, Indus River Delta in Pakistan, Tigri-Euphrates Delta in Iraq, Nile River Delta in Egypt and Niger River Delta in Nigeria have been discussed. Economic drivers have been considered as the underlying economic drivers of migration in the mega delta cities, business opportunities, worker's wages and inequalities in education and economic development. Economic reform is the main theme in all eleven-delta regions. Comparing the impacts of economic reform with the rest of the country, it has been stated that these impacts are clearer in delta region. It has been understood that demographic drivers are much more than the others because of the economic factors of woman migration, marriage or family ties. It has been observed that political drivers such as migration policies, land ownership and prejudice to specific geographic areas can affect the migrations. Economic drivers are the factors, which can affect the increase of migrations. Another factor is affecting of the population because of climate change and increasing of migrations as a result of these. It has been stated that millions of people are under the risk because of rise in sea level and surge of water and the impact of this situation on migration have been discussed.

Another research by Raleigh [21] has investigated how conflicts and increasing poverty in developing countries will affect the migrations. Conflict effect and poverty are directly two main drivers for high-risk environments and poor regions. The first driver includes some political and physical dangers in terms of the effect of conflicts. Conflicts include civil war, common conflicts (common conflicts: it is the struggle between militias and people who objects for political purposes with ethnic, regional or religious identities), violence used by the government, popular uprising and protests. Poverty drivers are expressed as the lack of financial and social resources and expected to affect the migrations. However, people having much less income cannot meet this and they are forced to migrate. Moreover,

environmental conditions also shape the conflicts. Environmental deterioration and water stress affect the civil wars slightly. Consequently, developing countries are faced with the migration because of conflicts, environmental risks and poverty.

Another remarkable work has analyzed demographic change as a migration driver in context of climate change. Demographic change is the change in population area. The world's population has changed greatly in recent years. In the article, it has been stated that there is a simple relationship between population and migration. Population growth causes to environmental deterioration and it triggers migrations. In addition to this, Hugo has also stated that migration is not only derived from population growth and environmental changes also bring about migrations in the article. Demographic change varies according to disease, death and poverty of the countries. As a result, impacts of climate change will increase population level and complexity. It has been emphasized that dealing with climate change may not be possible, but it is necessary to increase economic and social development in order to decrease poverty [22].

Another study has analyzed the problems, which can occur in the future because of the possibility of leaving the settlements due to the global environmental change. It has been stated that leaving the settlement has some negative impacts in a specific location such as decreasing of fertility, deaths and internal and external migration and this case will cause to a decrease in population. Leaving of settlements basically consists of many stages such as increase in vulnerability, population growth, population decline and growing external migration. Scaling the area left, number of people migrated, regional criteria of drivers (the size of region according to climatic event), organization level (the ability to make a sudden change in a sudden event), temporal characteristics of drivers, slow development of the population, the predictability of the unpredictable drivers have been used as a parameter. As driver, environmental drivers have been described. Environmental drivers are disease, natural disasters, climate variability, and climate change. Natural disasters, wars, diseases and deaths have been analyzed comparing with the events in the past. Consequently, it

has been stressed that change in environmental conditions can bring about displacement of people. According to McLeman, we are entering an era in which environmental changes will increase the migration potential. The probability of migration is high because of the global population growth, depletion of resources, deterioration of the soil and the expected effects of human-induced climate change. Increase in vulnerability will increase the number of people who will migrate and this case will cause to a decrease in population [23].

Black's research [24] has constituted a conceptual framework in order to understand and evaluate the impacts of the environmental factors on internal and international human migration in the article. While describing environmental migration, not only environmental factors have effect on environmental migration, but also other drivers cause to it. In this study, it is focused to develop a model in order to understand how the adaptation changes in addition to combine drivers of current migrations structurally and behaviorally, distinguish environmental change and understanding the response to migration. Most of the evaluations have primarily used environmental drivers for the impacts of environmental factors on migration. Here, it has been focused on how the environmental changes affect migrations generally and characteristically. There are five migration drivers. These are economic, politic, demographic, social and environmental migration drivers. Economic migration driver has direct impact on internal and international migrations, but income and wage differences are not directly effective on migration. Moving of people from a poorer region to a richer region is a specific process. In general, migration depends on the personal characteristics of the migrants. Some characteristics such as ethnicity, religion, language and education level determine the moving direction of the migrants. Political drivers have also direct effects on migrations. Creating new cities or managing rural lands (for instance, construction of a new dam) can drag people to migrate. Furthermore, civil wars also cause to migration. Effect of demographic drivers on migrations is partly related to economic drivers. With the migration of young people to the regions where job opportunities and living conditions are economically better, the demographic features of that region are affected. Moreover, natural disasters, birth and death rates and diseases also

affect the demographic characteristics of the people. Social drivers include the migrants searching for the opportunity of family, cultural heritage and education. The last one is environmental drivers and it means affecting of people according to the environmental feature of the region. People who often faced with the events such as flood, tsunami, earthquakes, volcanic eruption, landslides and forest fires are forced to migrate. As a result, it has been stressed that environmental factors have an important impact on migration and affect environmental drivers. Environmental factors will cause to much more migration in the future.

This research by Clark considers that recently, forcing of people to migration due to the environmental changes and natural disasters has become an issue that gains importance increasingly. On the other hand, there has been no study evaluated widely with all factors so far. In this study, long term population changes occurred as a result of climatic natural events in Bangladesh which is highly vulnerable to the environmental changes have been analyzed. The impacts of natural disasters on migration in Bangladesh have been studied using statistical model. Statistical model is used to estimate the impact of natural disasters on displacement of the population. The model bases the impacts of flood, the impacts of agricultural losses, damages to infrastructure and economic damages. It has been also analyzed using multivariate models that how the long term floods and scarcity affect the population changes in local regions. Consequently, natural disasters will affect the population mobility in urban Bangladesh in the long term considerably. Especially coastal flooding and drought will be effective [25].

Another significant study has collected the determinants of international migration macro-economically on climate change. The aim of this article is to test the overall impact of environmental change using panel data set. The Global South countries have been used in the panel data set. Events such as drought, earthquake, extremely high temperature, flood, storm, volcanic eruptions, epidemics and insect infestation from natural disasters have been taken for short-term environmental factors (these variables have been used taking

into account the number of natural disasters in a specific decade). These data of natural disasters have been received from The International Disaster Database collected by the Centre for Research on the Epidemiology of Disasters. The temperature and precipitation data has been provided from TS 3.0 data set for long-term environmental factors. TS 3.0 data set was improved by the Climate Research Centre of Anglia University. Annual observations and then monthly averages are computed and the years are compared to each other. The years between 1960 and 2000 have been tested. Consequently, climate change and climatic variables are stated to affect the long term international migrations slightly. The results do not assert that there is not an effect of climate change. Instead of this, it is stated that environmental changes have a direct effect on international migrations such as wage differences [26].

2.1. Vulnerability to the Climate Change

Climate change is the most significant environmental problem faced by societies all over the world. When we consider that the increases in greenhouse gases caused by human activities, we will realize that Earth's climate is rapidly changing. As it is known, climate change constitutes a major risk for most underdeveloped countries. These countries are indefensible in many ways including economic, social, demographic, politic and environmental factors. They are not strong enough to withstand the harmful effects of climate change. In this case, they will be affected adversely more than other countries which are economically and socially strong. Fragile environments like coastal zone and highly sensitive economic structure make it difficult and complicate for them to tackle climate change impacts. Each country will experience different effects of the climate change.Developing countries are the most vulnerable countries to physical effects of climate change because they have a vulnerable environment and an insufficient economic structure. The impacts of climate change on societies and economies vary considerably. The impacts of climate change vary socially, economically and environmentally according to the climate conditions, socio-economic status and growth prospects of each country. The vulnerability to

climate change can be classified as: exposure to the impacts of climate change, sensitivity and the adaptive capacity.

Geographical positions of the countries have an important role in growing economically and developing as a whole. Many developing countries are in the tropical regions. Consequently, these countries are exposed to annual precipitation changes and extreme climatic events including very high temperatures. Developing countries are hypersensitive to the direct impacts of climate change in terms of the density of people in the slums due to rapid population growth in these regions, poor health conditions and other ecosystem services about agriculture because of their being undeveloped socially and economically.

Dependence on agriculture and dependence on vulnerable ecosystems: In most developing countries, agriculture and agriculture related activities are very important for low income earners. For instance, 21% of GDP of India, whereas it was 61% of Malawi, but it has decreased to 39% in Malawi [27]. In South Asia, the subsistence of 64% of population is depended on agriculture [28]. Agricultural sector primarily has the risk of damage from the effects of climate change.

All of humanity need natural systems. Especially people in underdeveloped countries ensure their needs from the natural environment. People in underdeveloped regions are expected to be affected more by degradation of natural assets and systems due to climate change. For example, it is stated that an increase in temperature by more than 2 degrees will cause to drying of the Amazon rainforest and consequently, dissolving of subsistence of more than 1 billion people [29].

Population growth and rapid urbanization: It is expected that an increase about 2-3 billion in the world population will occur by the next few decades. As a result of this, it is question that natural resources and social structure will be damaged in most underdeveloped countries. It is considered that the largest effort in terms of the sustainability of

the population is some measures such as support of low population growth rate, ensuring the training of women in this regard, developing the seminal health and the creation of a source of income [29].

Food insecurity, malnutrition and health: Approximately 40% of the people are undernourished in sub-Saharan Africa [28]. Poverty impacts a person's standard of living, the environmental conditions in which they live, and their ability to meet basic needs such as food, housing and health care that in turn affects their level of nutrition.) In 2015, more than 400 million people are estimated to be exposed to hunger [30]. Today, the situation is also not different. In 2001, 54% of children population (10.8 million children) in developing countries died because of malnutrition [27].

Poor water-related infrastructure and management: Water is the greatest economic resource for growth and development of developing countries. Water is the most important factor in terms of agriculture, industry, energy, transportation and especially cleanliness and hygiene. The management of irrigation and effective water use will be very significant in terms of the effect of climate change on agriculture and helping for reducing this effect. Conversely, investments in irrigation systems, dams and underground waters are insufficient in most developing countries. For example, Ethiopia has less than 1% of per capita water storage capacity of North America. Most developing countries are insufficient for water storage depending on the average seasonal rainfall [28].

Poor public services: Insufficient resources and the presence of the government having insufficient economic resources usually mean poor public services. The establishment of early warning systems for extreme weather conditions, providing training for awareness of climate change and taking preventive measurements for common diseases are considered to be helpful for dealing with the impacts of climate change. However, today, there is low level of support and attention to developing countries in this sense.

The impacts of climate change will further increase poverty in underdeveloped and developing countries. Especially, it has many impacts on health, income and future growth prospects. Increasing poverty makes underdeveloped countries more vulnerable to the impacts of climate change. Poor households and governments will be poorer because of diminishing food and water supplies and increasing deficiency in health conditions arising from the impacts of climate change. The lack of financial resources of governments will decrease investments in developing countries due to these impacts. The impact of climate change is growing. Unless climate change is controlled, the hope of development of developing countries is decreasing day by day.

Adaptive capacity: It is the fact that countries adapt to climate change in accordance with their own resources and information to a certain extent. However, some factors are considered to hinder the adaptation of developing countries such as their infrastructure, economic conditions and the difficulty of access to public services. The number of poor people in most of the developing countries resists extreme weather events such as drought. This situation is hindered because of low income level, limited credit capacity and limited insurance policies. These restrictions become worse with the increase of rainy and dry seasons.

2.1.1. Climate Change Impacts

2.1.1.1. Temperature Rise and Precipitation Change. Change in temperature and precipitation threatens the basic elements of life such as access to water, food production, health and use of land and environment for the people around the world. According to the current trends, the average global temperature will increase by $2-3\,^{\circ}\mathrm{C}$ by the next 50 years. If the increase in emissions continues, the world will surrender to a few degrees higher temperatures [29].

There would be many of the serious effects of warming because of water [29];

- Melting of glaciers will increase the flood risks and water supply will be reduced. One-sixth of the world population, especially the Indian peninsula, parts of China and the Andes Mountains in South America are under the greatest threat.
- Agricultural productivity will be reduced especially in Africa. When the temperatures increased by average 4 °C, food production will be affected severely.
- At high latitudes, cold related deaths will decrease. However, climate change will increase worldwide deaths due to malnutrition and temperature. Epidemic diseases such as malaria and dengue fever will spread out.
- Hundreds of millions of people will be affected by the rise at sea level and floods. Especially South East Asia (Bangladesh and Vietnam), small islands, the Caribbean, the Pacific and the coastal countries and some locations such as Tokyo, New York, Cairo and London carry a great risk. Because of an increase in temperature by only 2 °C, marine ecosystems and fish stocks, especially 15-40% of the species will be considerably affected by climate change.

When globe warms gradually, the damages of climate change will also accelerate [29];

It is predicted that high temperatures will trigger sudden and large scale changes.

- The weather models will also vary with the increase in warming. There will be some changes in monsoon rains and in the events such as El Nino as known.
- A $2-3$ °C increase in temperature will occur in Amazon rainforest because of climate change and severe droughts will occur in this region.
- Melting or collapse of ice sheets will threaten one out of every 20 households.

The impacts of climate change around the world is uneven. It is estimated that underdeveloped countries will feel the effects first and suffer the most. These countries are under the greatest threat of climate change impacts. Firstly, underdeveloped countries have geographically disadvantages. Average temperatures in underdeveloped and develop-

ing countries are usually higher than developed countries and they receive heavy rainfall. Secondly, the economies of underdeveloped countries are based on agriculture and fisheries in many areas. Health conditions and public services in these areas are insufficient. Thirdly, adaptation to climate change of these countries are difficult due to economic disabilities because increase in death rates in developing countries owing to the low income and increasing diseases increases the sensitivity of the climate. A decrease in farming and fishing income increases poverty and reduces house hold income [29].

Developing countries are considerably affected by the current climate. Although there is an increase in temperature by less than $1\,^{\circ}\mathrm{C}$ now, these risks are likely to increase due to an increase in temperature by $3-4\,^{\circ}\mathrm{C}$ in the future. For developed countries, there are some small positive effects of climate change. However, according to BAU (business as usual) scenario, increase in temperatures after the mid-century would be more damaging.

It is estimated that in high latitude regions, in the countries such as Canada, Russia and Scandinavia, an increase in temperature by $2-3\,^{\circ}\mathrm{C}$ because of climate change will be beneficial for increase in agricultural productivity, decrease in cold related deaths and reviving of these regions in terms of tourism. The developed countries at lower latitudes are more susceptible to the impacts of climate change. For example, it is estimated that a $2\,^{\circ}\mathrm{C}$ increase in temperature in southern Europe will reduce the agricultural productivity by 20% [31].

The increasing extreme weather events will destroy the benefits of climate change and accelerate high temperatures even more;

- An increase by 5-10% in the wind speed of hurricane increases also the sea water temperature. This also means that American coasts will be doubly damaged [29].
- An increase by $3-4\,^{\circ}\mathrm{C}$ in global average temperature rises the annual flood losses from 0.1% up to 0.2-0.4% in England [29].

- In 2003, 35000 people died in Europe due to temperature fluctuations and 15 billion loss occurred in agricultural products. By the middle of this century. This will be a fact to express frequently [29].

According to BAU trend, it is estimated that a $2-3\,^{\circ}\mathrm{C}$ increase in temperature will occur by the end of this century due to the increase in the amount of the emission in the atmosphere. A $5-6\,^{\circ}\mathrm{C}$ increase in temperature in the future is a real probability. It is estimated that the loss in GDP will be by 5-10% when these cases have occurred. The loss of developing countries is estimated to be more than 10% of their GDP [32].

The amount of emission in the atmosphere has increased and it also continues to increase with economic growth. In some developed countries, economic growth has continued to increase and decreasing of emissions has been provided due to changing energy technologies. Economic growth is maintained due to strong and informed policy options. It is also possible that both developed and developing economies will decarbonize on necessary scale for climate stabilization.

2.1.1.2. Sea Level Rise. A serious level of migration is expected in small island countries and coastal settlements due to the expectation of sea level rise caused by climate change. In the coming years, the first internal migration movements are predicted to occur in the northern regions where sea level rise will occur as a result of melting of glaciers. After the mid-century, about 200 million people will migrate because of the impacts of climate change and sea level rise. According to the estimations in 2005, 50 million environmental refugees were expected in 2010. According to Christian Aid Organization [33], 1 billion people will migrate in the middle of the century. According to the observations of McGranahan [34] , 10% of the world population is living in 10 meters distance from the sea level. Correspondingly, when the sea level rose, the probability of migration increases in those regions.

Millions of people are expected to migrate because of rise at sea level and other climate changes. By the end of the century, 1 meter sea level rise will cause one-fifth of Bangladesh to stay under water [29].

2.1.2. Socia-Economic Development Paths

2.1.2.1. Economic Growth. Extreme weather events can affect the growth rate of the developing countries. It is stated that, climate change is the greatest threat for the economic growth of countries today.

Health conditions and labor productivity, loss of agricultural productivity, infrastructure of countries will be adversely affected by climate change. The decrease in agricultural and labor productivity is expected to affect the economy considerably. The potential effects of extreme weather events induced by climate change are expected to become on growth and production. For instance, too much rainfall affects the transportation and communication. For another example, 450 km of railway track, 30 bridges and canals, 1739 km of district roads, 1173 km of state highway and 328 km of state roads were damaged due to the flood in West Bangal in 2000 [35].

Other than climate change, slow development can also cause poverty and child deaths.

Relationship between growth and development

Growth is mainly represented by GDP. Development means integration of economics, social and environmental factors in accordance. Even if developing and underdeveloped countries provide growth partly, they cannot provide a unity because they cannot generate a balance in social and environmental factors.

In general, growth rate in the income of poor people in countries having high growth

rates is in a higher trend. Poor people are more advantageous in areas where economic growth rate is higher. East Asia has grown rapidly (by 5.8% in 1980s and by 6.3% in 1990s) [36] and have experienced the rapid decline in subsequent years. It is stated that the annual growth rate in Africa should be more than 7% in order to reduce the proportion of poverty by half until 2015 (5% of this rate is for only reducing the number of poors) [35]

By the year 2100, 100 million people in South Asia and 45 million people in sub-Saharan Africa, a total of 145 million people will have to live on an income of less than 2 per day. It is estimated that on the basis of loss of GDP, 35 million people will be living on an income of less than 2 daily according to the basic scenario and 220 million people will be living on an income of less than 2 daily according to the high scenario [37].

The estimates of the number of poor people here has been computed by the World Bank and it has been found that average household income and per capita GDP is growing with the speed of 0.8 times and income distribution has been determined to be constant. It is estimated that if this growth to be rapid, there will be a decline in the number of people who have to live on less than 2 per day and if the growth to be slow, there will be a rise in the number of people who have to live on less than 2 per day. A slow growth rate can increase the risk of poverty.

There is a relationship between low income and child deaths. Child deaths have been stated to increase in low-income areas because of insufficient health conditions, lack of safe water and food and insufficient cleaning and hygiene conditions.

2.1.3. Adaptation

While it is question that all regions will be affected by climate change, it is estimated that developing countries will be damaged more because of this change. Climate change challenges the tropical geography, agriculture, fast growing population and underdevelop-

ment. Extreme weather events and climate related disasters will affect the countries which are vulnerable to climate change. Some of impacts of climate change have been already seen as natural disasters. There are several ways for adaptation to climate change. These can decrease negative outcomes of climate change with adaptation process. Adaptation process has many options that can produce promptly positive response, although they cannot block all damages.

We shall examine adaptation options according to sectors and systems [38]. What can be done about the robust adaption of vulnerable countries to the climate change impacts?

Water Systems

- Consumption of water can be used more effectively by providing pricing incentives regulations and technology standards.
- Increasing water supply and its credibility is obtainable with construction of new water storage and diversion infrastructure.
- Promoting the transfer of water among users by altering institutional framework can be possible with establishment of water markets.
- Making new plans about the flood management to decrease the cause of maximum flood level.
- Using the firm surface for vegetation to reduce storm runoff.
- Redesigning dams, levees and other infrastructure for flood protection.

Food and Fibre Systems

- Selecting best timing for planting and harvesting activities.
- To prevent soil erosion, minimum farm land should be used.
- Animal rangelands can be changed.
- Promoting agroforestry in dry-land areas.

- Changing wrong policies such as subsidies, non-sustainable and risky farming.
- Supplying healthy food by promoting programs against local supply disruptions.
- Training rural workers about farming.

Coastal areas and marine fisheries

- Getting slower improvement of coastal areas vulnerable to flooding and erosion.
- Using hard and soft structures for protecting the coastal sides.
- Being trained in terms of warning systems such as storm.
- Efficient utilization of wetland is essential for fish habitats indirectly fisheries.
- Providing management plans and policies of benefit to fisheries.
- Establishment of better supporting and integrated managements for fisheries.

Human Health

- Health substructure should be improved or reformed.
- Early warning systems can be developed for epidemic diseases.
- Environmental and healthy issues can be observed and recorded.
- Making water quality better, housing and sterilization.
- Decreasing heat effects on lands by using light colours on surfaces.
- Promotion of the education about the healthy hazards.

Financial services

- Providing public and private insurance.
- Conducting plans for financial management during reduction of life standards.

Adaptation assumptions: Intelligibility of adaptation is significant for the studies

on impacts of climate change. In literature, no adaptation has been considered in some studies. While individual adaptation has been assumed in several studies, it has been assumed that adaptation is effective in other studies.

2.1.4. What are the human-induced causes of climate change

Climate is changing day by day and it is a supernatural fact. We can also say that it diversifies significantly all over the world. The reasons of climate change can be categorized into two main fields (Some important proofs such as ice cores evidences, sea residues, tree rings and pollen samplings). These proofs are natural reasons of climate change. Furthermore, natural dangers connected with extreme climatic events are an indicator of climate change throughout the world. Climate change derived from human causes to these extreme events. We shall examine human-induced climate change.

2.1.4.1. Human Activities. People have used significant amount of fossil fuels after the Industrial Revolution. They would have better job opportunities and living conditions and hence they have moved from rural to urban areas. Vegetation has decreased in order to construct buildings owing to the growing population. The number of people has significantly increased in the cities. This have increased the usage of natural sources for consumption, industrialization, construction and transport. These activities require more energy from fossil fuels. Consequently, burning of fossil fuels contributes to the concentration of greenhouse gases.

Another reason of climate change is human activities like the land transformation for forestry and agricultural activities and the combustion of fossil fuels. Human impacts on climate have significantly expanded since Industrial Revolution. The land surface was changed by these human activities together with other environmental influences and these activities also release different materials into the atmosphere. In addition to all of these

effects, human activities can also affect the incoming and outgoing energy amount and they have some climatic impacts such as warming and cooling. The major output of fossil fuel burning is carbon dioxide, which is a gas, causing Greenhouse Effect. Warming effect driven firstly by carbon dioxide emissions and increased by other greenhouse gases emissions has been the exact impact of human activities since the Industrial Revolution.

An increase in the natural greenhouse effect has been caused by the rise in greenhouse gases in the atmosphere. The increase of greenhouse effect due to human activities gives cause of apprehension because continuing greenhouse gases emissions can heat up the planet to the grade that has not been seen in human history. Such a climate change could have unforeseeable and comprehensive social, economic and environmental results.

Greenhouse Gases and their Sources: There is no doubt that the most significant greenhouse gas in the atmosphere is carbon dioxide. Deforestation, clearing and use of land, agriculture and other activities bring about increasing in the carbon dioxide emission. The major power requirement in urban areas is satisfied with electricity created commonly from thermal power plants. These thermal power plants using fossil fuels cause greenhouse gases emissions. Correspondingly, vehicles also use fossil fuels and lead to more greenhouse gases. Paper usage in the schools, work and offices leads to deforestation. Beside paper waste, wood, which is used in building of houses, causes deforestation.

Methane is another important gas existing in the atmosphere. Domestically animals like goats, pigs, and camels, horses and sheep cause one fourth of all methane gas during the rumination process. In addition to the rumination process, methane is also derived from rice and paddy plantations in the maturation durations. The bacteria and other organisms separate into their organic constituents in the land to create methane when the soil includes water and becomes anaerobic.

All of the countries in the world emit greenhouse gases owing to the activities de-

riving from nature and human. Developed countries have emitted more greenhouse gases than underdeveloped countries to use vehicles, warm houses and manage industries in the industrialization process for 250 years. Today's international rules do not entail underdeveloped countries to inform their greenhouse gas emissions steadily. Nonetheless, it is believed that greenhouse gas emissions of some underdeveloped countries have exceeded the emissions of developed countries.

It is estimated that the country, which emit most greenhouse gases in the world, is China today. In this regard, other important countries are USA, the EU, Russia, Japan and India. Canada emits almost 2% of the world's greenhouse gases [39].

Greenhouses Gases Impacts:

Energy coming from the sun gets from inside the glass as light rays in a greenhouse. Plants, soil and other matters in the greenhouse suck this energy. A big amount of this sucked energy is transformed to heat and used for heating the greenhouse. Due to the glass, this heat can be seized and greenhouse stays warm thanks to this.

The atmosphere of the world behaves similar to a greenhouses glass. The atmosphere and surface directly reflects nearly 31% of the radiance of the sun back to space (especially makes this through snow and ice) and the atmosphere sucks another 20% of this radiation. Oceans and land absorb the rest of the radiance and transform to heat. This heat warms the land surface and air. Specific atmospheric gases behave similar to the glass of a greenhouse and hinder the heat from getting away.

Heat is absorbed by the greenhouse gases and some of the heat is emitted to the world. It causes higher temperatures. Water vapor is the most significant greenhouse gas that occurs naturally. It also contributes to the natural greenhouse impact even if they consist in smaller amounts. Carbon dioxide, methane and nitrous oxide are these gases.

The heat of the world's climate is of great importance since water can be available in three of its stages: frozen, liquid and gaseous. Snow or ice is its frozen stage, water is its liquid stage and water vapour is its gaseous stage. The cycle of water refills the water existing in the world through the land-ocean-atmosphere system. Hence, this cycle of water from one stage to the other stage is so important for continuing life. The cycling of water is also critical in terms of driving the weather and the climate system in general.

According to current measurements, the value of the greenhouse gas CO_2 in the atmosphere is approximately 400 ppm. This value was 280 ppm before the industrial revolution. According to this concentration, the globe has warmed by more than 0.5 °C and by the next few 10 years it will be warmed 0.5 °C more. This value will be 550 ppm by 2050 and it will continue to rise steadily (BAU). In fast growing economies, increase in the need for high carbon infrastructure, energy and transportation and so increase in the investments accelerates the annual flow of emissions. In this way, it is a big probability that the level of 550 ppm will be reached by 2035[29]. According to the climate models, the probability of the future carbon dioxide is at least 77% and it is also probable that this level will rise to 99%. Accordingly, the global average temperature will exceed 2 °C. According to BAU (business as usual) scenario, the amount of greenhouse gas in the atmosphere will increase more than 3 times and the global average temperature will increase by 5 °C [29].

The world geography will change with the increase in temperature and accordingly, the human geography will change and the question of where and how people will live rise [29].

According to Table 2.1, atmospheric greenhouse gas emission is increasing due to human-induced causes.

Table 2.1. Greenhouse gas emissions in 2000 [29], by source.

ENERGY EMISSIONS	
POWER	%24
LAND USE	%18
INDUSTRY	%14
TRANSPORT	%14
AGRICULTURE	%14
BULDINGS	%8
WASTE	%3
OTHER ENERGY RELATED	%5

2.1.5. The Relationship between Sustainability and Climate Change

2.1.5.1. Climate Change and Sustainable Development. Sustainable development is the notion, which indicates the relationship between economic growth and environment. This concept considers the integrity of social, demographic, economics, politics and environmental policies. According to World Commission on Environment and Development, 1987 report, sustainable development was defined as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This definition suggests the need to balance two concerns, one having to do with present, or intra-generational needs and the other having to do with future. Sustainable development analysis differs from the standard economics growth and development by associating natural resources as a form of natural capital, defined as the value of the existing stock of natural resources such as vegetation, forests, land, fisheries, water, mineral deposits, and the environment in general scope. Natural capital provides goods and services to people as the ecosystem services. Therefore ecosystem services availability is very crucial in many ways related with the climate change impacts. The core of mainstream sustainability thinking has become the idea of three dimensions, environmental, social and economic

sustainability. These have been drawn in a variety of ways, as pillars, as concentric circles, or as interlocking circles in the following figures;

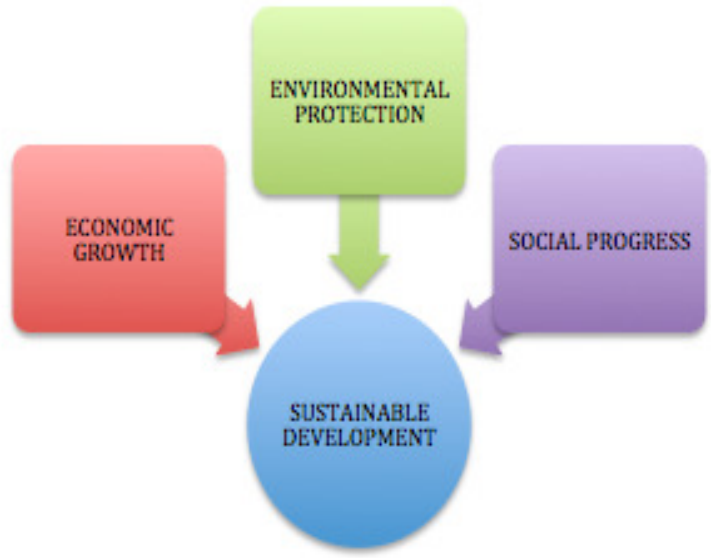

Figure 2.1. The Three Pillars of Sustainable Development.

The concept of the sustainable development is generally accepted and has become a standard model for thinking about the environmental, social and the economical studies. Therefore, the theory of sustainable development compares these three main subjects.

All in all, sustainable development is only possible when three main factors that are economical, social and environmental come together. We are beginning to recognize and understand the harmful effect of our actions on the natural environment. Until the recognize and understand our effects on environment, we are in the middle of both environment and social crises [40]. In today's world development is exploiting natural resource reserves at alarming rates. For example, the use of usable fresh water outstrips natural replenishment. Another example, approximately a quarter of the world's mammals are in danger

of extinction [41].

2.1.5.2. The difference between economic growth and development. Development is more extensive concept than economic growth although these two concept have been used together and are terms exchangeable in economic definition. Economic literature show us economic growth concept is comprised by the concept of development. For sure, these concepts definition are mixed by people that are forced to separate the theories of economic growth and development.

In other words, Economic growth is the rise in national or per capita income or product typically measured by gross domestic product (GDP) or gross national product (GNP) [42]. Put it differently, Economic growth is the expansion of a country's productive capacity. This leads to a rise in total national output. While theoretically having an increasing national output means greater material welfare and a rise in living standards, it does not equate to having higher levels of well being for individuals in that nation. Economic growth can, in fact, have negative impacts on a nation including environmental degradation and the loss of traditional cultural values. It also may mean there is greater inequality between different classes in society, that is, the gap between the rich and the poor may grow [43].

On the other side, economic development basically implies that individuals of that nation will be better off and takes into account changes in economic and social structures that will reduce or eliminate poverty. Economic development can be measured in a number of different ways including the Human Development Index, a Gender Empowerment Measure, a Human Poverty Index and Human Freedom Index. All of these measures were developed by the United Nations Development Program. The World Bank also has its own indicator called the World Bank Development Indicator [44].

If we only care about the increase per capita income or GDP (or GNP) increase, this does not show us the increase of people's standard of living. Hence, increasing GDP is not sufficient for people's increased wealth, high level of education, low level of mortality etc.. in shortly, economic growth not cover these instruments in development. Consider some of the oil-rich Middle Eastern countries that have experienced large increases in per capita GDP, yet lag far behind in areas of development [42].

Nowadays, to understand development we must compare these; (i) self-sustaining growth; (ii) structural changes in patterns of production; (iii) technological upgrading; (iv) social, political, and institutional modernization; and (v) widespread improvement in human conditions [45]. Therefore, this leads to adding together a lot of items such as; education, health, population growth, urbanization, agricultural reform [42] that form the biggest pie in the countries development.

2.1.5.3. Under Development and their common characteristics. Countries that have low standard of living because of their per capita incomes are known as underdeveloped countries. Underdevelopment takes place when resources are not used to their full socio-economic potential, with the result that local or regional development is slower in most cases than it should be. Furthermore, it results from the complex interplay of internal and external factors that allow less developed countries only a lop-sided development progression. Underdeveloped nations are characterized by a wide disparity between their rich and poor populations, and an unhealthy balance of trade [46]. It is difficult to find an underdeveloped economy possessing the representative characteristics of underdevelopment. They are diverse in culture, historical evaluation, physical and human resource endowments, and economical conditions, social, demographic and political structures. A further characteristic of underdeveloped countries is the important part of agriculture plays in their way of life. Therefore the important difference among underdeveloped countries is ranging from complete dependence upon subsistence agriculture to dependence upon agricultural

exports and the imports of some food-stuffs.

Table 2.2. Common Characteristics of Underdeveloped Nations.

Low levels of living, including described low incomes, inequality, poor health and inadequate education
Low levels of productivity
High population growth rate and dependency burdens
Substantial dependence on agricultural production and primary-product exports
Prevalence of imperfect markets and limited information
Domination, dependence and vulnerability in international relations.

In developing countries, there exists the low levels of living standards for the great majority of people. The existence of housing problem, inadequate education, health problem, high infant mortality, low life expectancy lead to low income in consequence poverty in these countries [47].

3. CLIMATE CHANGE, ENVIRONMENTAL DEGRADATION AND MIGRATION

3.1. The Nexus Between Climate Change, Environmental Degradation and Migration

It is expected that there will be instability and conflict among the people in vulnerable regions with the changes population and migration by the climate change stemming from human activities. In the recent studies, it is estimated that 200 million people will migrate in the middle of this century. According to another estimation, it is expected that 1 billion people will migrate in the middle of the century [33]. However, these estimations are not an analysis of the statistical or experimental data. According to the scientists studying this subject, migration is one way of people to adapt to the climate change. When we look at the climate change impacts, we can see that there will be some adverse effects of it for some regions. Some of these adverse effects, including river or coastal flooding depending on sea level rise resulting from melting of icebergs or changes precipitation and drought depending on temperature rise will force people especially living in littoral states to migrate from their homeland. It is expected that these effects will come up in Northern regions including Alaska Shishmaref, New Gine Cataret Islands and Chad Lake in Africa in the upcoming years. In the long term, it is estimated that the first migration movements will come up in the coastal regions which are physically affected and have high population growth. It is considered that the increasing scarcity of critical resources in the developed regions or due to the increase in the values of resources in the geographical region, for example, the presence of oil in that geographical area because of its geographic characteristics of the area in terms of sources, are thought to be experienced violent events and conflicts among people are expressed constitute a high potential for migration. It is considered that food and water sources in the most developing countries

will gradually lose their stability because of the climate change to be experienced due to increasing greenhouse gases emissions. It is estimated that climate change stemming from human activities will cause displacement of people and migration. Climate change-related migration or displacement of people is not only a threat to human, but also seen as a risk to international and regional security.

3.2. How Climate Will Affect People Around The World

Intensity of extreme weather events, changes in temperature and changes in precipitation give us very clear information in terms of the results of climate change. All these results are expected to affect a large population in the countries considered to be vulnerable to the impacts of climate change and it is stated that the majority of the population will be forced migration as a result of these effects [48].

Especially the population living in the coastal parts will search a different region in order to maintain their life as a result of the negative effects of climate change. However, it is also stated that the financial strength to handle this change of location constitutes a major problem for the population. Hence, to better understand the relationship between climate change and migration holds key for assessing the process of the solution for this population.

Considering climate change highly arises from human activities, it is possible to state that the most important human activities lead to climate change are combustion of fossil fuels and increase in atmospheric concentration of greenhouse gases as a result of land use change.

The projections express that there will be a decrease in habitable feature of our globe as a result of climate change caused by changes in temperature and precipitation, degradation of agricultural lands caused by the impacts of climate change and agricultural

practices, desertification and water pollution. The number of natural disasters in the last 20 years almost doubled and more than 20 million people have been forced to migrate in 2008 [17].

The impact of climate change will increase more with increasing temperature and it will force more people to migrate. In this context, some economic, social and environmental problems will be unavoidable.

At this point, the issues necessary to focus on are factors that will force which proportion of population in which region and because of this, how many people will have to migrate. Moreover, it will be necessary to answer some questions such as what is the cost of migration for people and country, can people cover this cost and what are the positive or negative effects of migration on people. As mentioned at the beginning of the paragraph, the answer of the question through which factors and how much environmental changes will cause migration is firstly important. The answer given to this question will be in the context of determining the population vulnerable to the impacts of climate change and determining their vulnerability points. Recommendations of solution are also developed in this context and it will be necessary to focus on studies about reducing these enforcers.

Now, let us respectively examine the factors which make the regions more vulnerable to the impacts of climate change and which force people to migrate.

3.2.1. Exposure to Natural Hazards

People living in underdeveloped regions will be the most affected by high temperature, water scarcity and infectious diseases. The number of people employed will be reduced due to malnutrition and malnutrition will affect the brain development and success in education life of children.

Over 96% of all disaster related deaths worldwide in recent years have occurred in developing countries. Climate shock affects the developing countries both socially and economically [29].

The occurrence of cold related deaths, heat stress and many diseases such as epidemics is expected. In Africa, 40 to 60 million more people will catch malaria as a result of a $2-3\,^{\circ}\mathrm{C}$ increase in temperature and 70 to 80 million more people will catch malaria as a result of $3-4\,^{\circ}\mathrm{C}$ increase in temperature.

The impacts of climate change on poor countries are extreme weather events and long-term environmental factors. Extreme weather events that have occurred previously are the results of potential climate change. Many developing countries struggle with the current climate. Economic losses of natural disasters increase from past to present. Global economic losses due to weather events were 83 billion in 1970 and 440 billion in 1990.

According to current data, the effects of droughts and floods as a result of extreme weather events on household income are clearly understood in the following example. Crop and livestock losses due to the drought in the North East Ethiopia is estimated to be 266 US dollar per household between 1998 and 2000. This loss is more that 75% of annual earnings.

It is expected that underdeveloped countries will be in a more destructive poverty in the long term because of the negative impacts of climate change.

3.2.2. Ecosystem Availability and Impacts on Human and Natural Systems

3.2.2.1. Water. People will perceive especially the seasonal and annual change in the distribution of water in the world among the impacts of climate change. Water is a necessary resource for life and health. 70% of global water resources is used for agricultural irrigation

and obtaining food. 22% of these resources is used for energy production and 8% of these resources is used for cleaning and drinking water in houses and workplaces.

Climate change will change the availability of water. In some regions, droughts and floods will become more severe. There will be more precipitation at high latitudes and less precipitation in dry subtropical regions. Surface temperatures in warmer regions will create some effects that increase strong vaporization, more severe precipitation and flood risk.

There will be differences in water availability between regions. Water availability will decrease in Mediterranean region part of South Africa and South America. Because there will be a 30% decrease in annual precipitation and 2 °C increase in annual temperatures and there will be a 40-50% decrease in annual precipitation and 4 °C increase in annual temperatures according to the estimation of the climate model. According to different models, water availability (runoff) in South Asia, a part of Northern Europe and Russia will increase by 10-20%, temperature will increase 2 °C, it is much less likely that temperature will increase 4 °C. Impacts of these changes will be year after year and seasonal. The benefits of increase in annual river flow in precipitation season are not important. Because;

(i) It is not suitable for storage of extra water for use in dry seasons (ii) River flood can be more frequent.

In dry regions, water flow may decrease by average 20% decennially. According to the study of Hadley Centre, drought rate will increase up to 40% from 10%, temperature will increase up to 4 °C from 3 °C and extreme drought rate will increase up to 30% from 3% at any time. Severe droughts will occur with 3 °C increase in temperature every ten years. [29]

Water scarcity is a useful indicator for water availability, but it is not so significant

for protecting of water. Population growth will limit the water availability of millions of people rather than climate change.

Exception of population growth, increase in temperature will affect the water availability in the background. According to the study, with 2 °C increase in temperature, 1-4 billion people will face water scarcity. This water scarcity will be effective especially in Africa, Middle East, Southern Europe, South America and in the center of Africa. In these areas, water management is important for growth and development of these areas. At the same time, 1-5 billion people in South and East Asia will surrender to much more water. The reason for this is rainy seasons, monsoons and El Nino to be effective.

Melting of glaciers and melting of snows in the mountains will increase the flood risk in rainy seasons. In dry seasons, water supply has threatened 1/60 of the world population (today, this number is over 1 billion people) [29].

Melting of glaciers in dry season will especially affect a part of Indian sub-continent, more than quarter of a billion people in China and ten million people in the Alps. Water flood will especially increase in the spring because glaciers melt more rapidly in this season. Melting of these glaciers is a great risk in glacial lakes, particularly in Himalayas-Hindu Kush region in Asia. 70% of the flow of the Ganges occurs owing to the melted glaciers in the summer. Water is provided for 500 million people around the river. 23% of the population (250 million people) lives in the western region in China and their water supply depends on the melting of the glaciers. Tropical Andes are surrounded by glaciers in South America, but glaciers have decreased in the last 30 years. Some small glaciers will completely melt in the next decade [29].

Meaning of water stress metrics:

Water scarcity is a useful indicator for water availability, but it is not so significant

for protecting of water. For the availability of water resources, average water flow in long period can be calculated by numbering the basin people live in. Water scarcity of a city occurs when the annual water supply per capita is below 1000 m^3 and extreme water stress of a city occurs when the annual water supply per capita is below 500 m^3. Threshold value of water is assumed as annual average according to the requirements of home, agriculture, industry and energy sector and the environment.

The threshold value of water stress is based especially on these three problems more than a simple water necessity:

(i) Spending too much water for direct human use. Globally, 70% of natural water resource is used for agriculture, 22% of this resource is used for energy production and 8% of this resource is used for cleaning, municipality and services. The purpose of spending of water varies from country to country. For instance, while the vast majority of water is used for cleaning, municipality and services in Europe, the majority of water is used for agriculture in Asia and Africa [29].

(ii) All river flows are not suitable for use. On average, approximately 30% of the river flows causes floods. 20-50% of the river flows is used in natural aquatic ecosystem. Considering all of these, 50-80% of the flows is useless for people. In other words, 50-200 mm^3 of 1000 mm^3 of water which is average annual per capita water is provided from flows [29].

(iii) 1000 m^3 of water that is average annual per capita water does not state the variability [29].

3.2.2.2. Food. In tropical regions, there will be a danger about the decrease in products. At high latitudes, agricultural products will increase, but they will decrease later due to the

increase in temperature. At higher temperatures, agricultural production will be reduced worldwide.

Food production will be affected by climate change because getting better products depends on climatic conditions. Today, the productivity of agriculture is 24%, 22% of the population work in the agricultural sector and 40% of the land area is used for agriculture worldwide. 75% of poor people are living in rural areas and earn a living from agriculture in the world [50].

The areas to the middle and high latitudes are under the danger at low level. These areas are America, Europe, Australia, Siberia and a part of China. High temperature rise reduces the yield of products.

The impacts of climate change on agriculture highly depend on carbon efficiency. Carbon dioxide is the basic constituent of plant growth. Increase in carbon concentration in the atmosphere is firstly useful for warming and it causes to decrease in the yield of products because of warming and water scarcity. Increase in carbon efficiency causes to an increase in temperature worldwide. A 2 °C increase in temperature brings about a 5% decrease in cereal production and a 4 °C increase in temperature brings about a 10% decrease in cereal production [29].

Agriculture and the carbon fertilization effect:

Carbon dioxide is one of the necessary constituents for growing of a plant. Increase in carbon concentration in the atmosphere is known as useful for agriculture because it increases photosynthesis and reduces water necessity. However, the amount of carbon varies according to the physiology of plants and other effective conditions (water availability, nutrient availability, plant pests).

Recent studies show that the positive effects of increase in carbon dioxide concentration in the atmosphere compensate the negative effects such as increase in temperature. Hundreds of studies according to many agricultural models show that the amount of 550 ppm carbon dioxide increases the agricultural productivity by 20-30%. Whether in any case, predicting that the effects of carbon efficiency can be low, higher temperature damage to the agricultural products. Increasing droughts and critical temperatures increase water scarcity and so agricultural production will be affected much more.

About 800 million people (12% of the world's population) are faced with the risk of hunger in the world. 4 million people have died annually due to the malnutrition. This number is almost the half of the population of Africa. According to a study [51]. if the impact of carbon efficiency is low, a temperature rise of $2-3\,^{\circ}\mathrm{C}$ will increase the hunger risk of 30-200 million people. It is estimated that a temperature rise of $3\,^{\circ}\mathrm{C}$ will face 250-300 million people with the risk of hunger. This number is the half of the population of Africa and population in West Asia. If agriculture gives a strong response and resists to carbon dioxide, the effect of warming on the risk of hunger will be substantially low [30].

Acidification of the oceans depends directly on the rise in the level of carbon dioxide. It has great impact on marine ecosystem and fish stock. While increasing the temperature of the ocean and increasing the growth rate of some fish, food supply reduces because of warming. Acidification of the oceans has increased for the last 200 years because chemical caused by excess carbon dioxide in sea water.

3.2.2.3. Health. Climate change will increase worldwide deaths due to malnutrition and temperature stress. If no measures are taken, some epidemics such as malaria and dengue fever (a viral disease mosquitoes transmit) will become widespread. Cold-related deaths will decrease at high latitudes.

According to the estimation of World Health Organization (WHO), in Africa and developing regions in which some epidemics such as diarrhea and malaria considered to be caused by malnutrition and temperature stress as a result of climate change, 150,000 million people have died since 1970.

Today, 450 million people are exposed to malaria in Africa. 1 million of them die every year. According to a study [52] a temperature rise of 2 °C will cause more than 40-60 million people to be exposed to malaria. Higher temperature rise will cause more than 70-80 million people to be exposed to malaria in Africa. Considering all of these, bringing malaria under control may not be possible.

It is also considered that change in water cycle affects human health significantly. It is stated that drought brings about the loss of liquid and floods bring about strangulation and these cause more deaths. It is also predicted that fungus and mosquitoes will increase because of floods and increasing of mosquitoes will cause to spreading of cholera.

3.2.2.4. Land (Sea Level Rise). It is estimated that sea level rise will increase the coastal floods and coastal protection costs, cause wetlands to erode and increase the salinity of groundwater and surface water in coastal regions.

In the last century, a significant correlation between warming and sea level rise has been observed. It has been also stated that sea level rise will continue with melting of glaciers due to the increasing temperature in the near future. Sea level rise is expected to increase land losses and displacements of the population depending on land losses. Coastal regions are the most densely populated areas in the world. Critical infrastructures, oil refineries, nuclear power stations, port and industrial facilities are usually concentrated around the coasts. Therefore, the cost of the loss of coastal areas is expressed to be quite high.

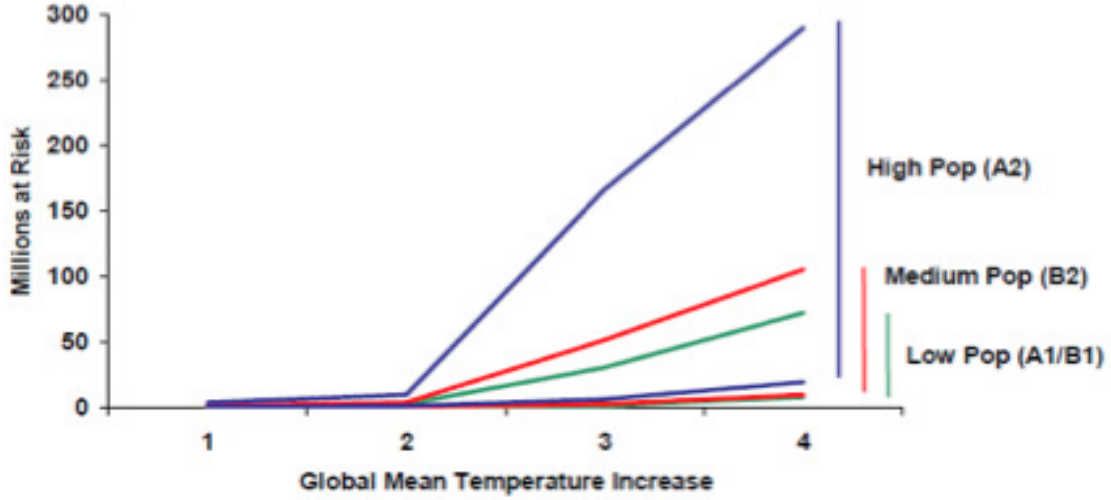

Figure 3.1. Risk of Coastal Flooding.

Today, more than 200 million people around the world live in coastal basins. 2 million km^2 of land and 1 trillion US dollar worth of assets are also approximately 1 meter high from the sea level. Quarter of Bangladesh's population (approximately 35 million people) live in the coastal basin [53].

Tens of millions of people will be affected by coastal storms due to rising sea level. The population living in South and East Asia and the population living in Africa and small islands will be the most affected ones.

Sea level rise will cause the homes of many people to remain under water. It is expected that $3 - 4\,^{\circ}C$ increase in temperature will cause the sea level to rise between 20 and 80 cm and accordingly, the population between about 7 to 70 million and 20 to 30 million will remain under the water every year [50].

South and East Asia is the region, which will be affected the most because the vast majority of the population lives in areas at risk of flooding. Vietnam, Bangladesh, parst of China, India, Africa and Nile delta, small islands, the Caribbean and the islands in the

Indian and Pacific Ocean (Micronesia and French Polynesia, the Maldives and Tuvalu) are at the risk of flooding.

The water of Nile River is shared by 10 countries (Ethiopia, Sudan, Egypt, Kenya, Uganda, Burundi, Tanzania, Rwanda, Republic of Congo and Eritrea). It is expressed that climate change will lead to a conflict between the countries fed by the Nile River because the growth rate of these countries is very fast. While the population fed by the Nile River was 280 million in 2000, this number is expected to be 860 million by 2080. It is estimated that the water of the Nile river will decrease by 40% by 2025 and decrease by 60% by 2050 [29].

It is stated that a reduction will occur in the amount of average annual rainfall in West Africa. Drying of the rivers is about 40% to 60%. The current increase in temperature is only $0.7\,^{\circ}\mathrm{C}$ and it is also estimated that the increase in temperature will be $3-4\,^{\circ}\mathrm{C}$ in the next 100 to 150 years [29]

3.2.2.5. Infrastructure. It is stated that infrastructure damages will increase significantly because of frequent storms induced by climate change. Moreover, it is said that the change in land structure caused by climate change will affect the status of buildings.

The cost of damages in infrastructure will increase considerably from even small increases in sea temperature because an increase in wind speed by 15-20% as a function of tropical storms [54].

3.2.2.6. Environment. Warming in the 20th century has directly affected the species. For the last 40 years, the species have moved 6 km to the north in every 10 years on average. Since 1980s, coral bleaching has gradually become more common. Polar bears, reindeer and white spruce have lost their resilience gradually in Artric and mountain ecosystems.

Climate change has led to the destruction of 1% of amphibians in tropical forests [29]

Let us examine the effects of temperature rise with a a few degree.

1 °C *warming:* At least 10% of land species will be endangered [55]. Tropical forests are very rich in species and species living in these forests are in danger of extinction.

2 °C *warming:* 15-40% of land species will be endangered. 25-60% of these species covers mammals in South Africa and 15-25% of the moths in Australia. Due to a 2 °C warming, it is likely to become extinct of almost half of the tundra forests and one-quarter of the cool conifer forests [56].

3 °C *warming:* 20-50% of land species will become extinct. Thousands of species may be lost in the world. For instance, 40% of some endemics species, particularly the species in African national parks and Queensland rainforest may disappear [57].

When temperatures increased by more than $4 - 5$ °C, the amount of carbon dioxide in the atmosphere continues to rise unabated. However, the results of such a warming are not known clearly.

By the year 2100, according to the basic climate change scenario of PAGE 2002 model [58] , in which global mean temperature increases to 3.9 °C in 2100), considering a world without climate change, India and South Asia, Africa and the Middle East seem to lose respectively 1.9% and 2.5% of their GDP roughly. According to high climate change scenario (Using the IPCC A2 SRES, baseline), India and South East Asia will lose 3.5% and Middle East will lose 2.7% of their GDP (Using the IPCC A2 SRES baseline).

4. DESCRIPTION OF THE SELECTED COUNTRIES AND VARIABLES

4.1. Sectoral Vulnerabilities and Adaptive Capacity for Selected Countries

In the fight against climate change, sectorial and systemic fragilities and vulnerabilities of the countries and their adaptive capacity is very crucial. It should be examined very carefully and solution recommendations should be systematic depending on long term-solution, not tentative ones. In this research, we studied the vulnerable countries to the climate change impacts. These are Bangladesh, Morocco, Malaysia, Ethiopia, Bolivia and Netherlands. We shall look at their vulnerable sectors and systems and adaptive capacities.

4.1.1. Bangladesh

Agriculture and food security:

- The risks of agricultural losses have increased in Bangladesh because of increase in frequency of of floods depending on climate change [59].
- Rice and wheat production in Bangladesh is expected to decrease by 8% to 32% by the year 2050 [59].

Health:

- Arsenic poisoning and tooth and bone diseases have emerged due to the chemicals such as arsenic and fluoride which is mixed with drinking water and agricultural products because of contamination of ground water caused by extreme rainfall (United Nations, 2006). More than 100 million people have been affected in Bangladesh,

china, North Africa, Mexico, Argentina and India [59].

- Death risks will increase due to the infections caused by malnutrition. Death risks due to diarrhea have increased because of drought and malnutrition in Bangladesh [59].
- Acclimatization in tropical regions do not remove the risks such as having temperature shock of foundry workers in Bangladesh [59].
- Due to the Southern Oscillation of El-Nino, there is a series risk of colera [59]. With the increase in sea temperature in Bay of Bangal region in Bangladesh, colera disease has emerged owing to the planktons [59].
- Diarrheal diseases will occur with the increase in floods [59].

Terrestrial Ecosystems:

- In the last 30 years, Mangrove forests and shrimp fishery products have emerged in a large scale along the coast of Bangladesh [59]. Starting to develop of a region in the coastline affects the biological diversity in the region considerably. For example, Mangrove forests support the creation of ecological communities such as fishes and shellfishes which create the basis of the food chain in coastal zones. Destroying the Mangrove forests along the coast of Bangladesh has caused a decrease in aquaculture (aquatic species) in the last 30 years.

Coastal Zones:

- The density of floods has increased in Bangladesh due to the increase in summer rainfall [59].
- In the last 20 years, 3 important floods occured in Bangladesh. About 70% of the country remained under the water as a result of the flood occured in 1998 [59].
- At least 23-29% of Bangladesh will remain under the water with a 2 °C increase in

temperature because of climate change [59].

- Most of the land of Bangladesh consists of the delta plains of Ganges, Brahmaputra and Meghna rivers. By 2050, more than 1billion people will be affected by the coastal erosion and soil loss in Ganges-Brahmaputra delta in Bangladesh, in Mekong delta in Vietnam and in Nile delta in Egypt which are three big deltas [59].
- The reason of more than 250.000 worldwide deaths between 1980 and 2000 is tropical cyclones. 60% of those deaths occurred in Bangladesh. The populations most affected by these events are coastal zone, the delta region and mega delta regions (China, Bangladesh, Philippines, Japan and India) [59].
- Occurrence of floods frequently has imposed major constraints on development. For example, Bangladesh has tried to improve infrastructures to prevent floods, but gained a limited success [59].
- The Netherlands and Bangladesh are under the risk of flooding because of sea level rise caused by increasing temperature [59].

Adaptive Capacity:

- Bangladesh is one of the world's poorest and densely populated countries. Bangladesh is expected to be affected too much and damaged by the climate change because of the weak economy, social development, education and health sectors, lack of institutional capacity and dependence on natural resources of people in the region.

4.1.2. Bolivia

Agriculture and food security:

- Increasing temperature due to climate change is predicted to disrupt agriculture, destroy forests and decrease water resources in Bolivia. Livestock are also expected

to decrease because of increasing temperatures and unproductive lands and consequently, livestock sector is expected to be frustrated.

Health:

- Most of the population in Bolivia will be affected by malaria and leisman diseases because of climate change.
- In 2002, hailstorm occurred in Bolivia and caused death of many people. Extreme weather events related to climate change will affect Bolivia seriously [60].
- The majority of the population will be under the effect of several diseases such as malaria and leisman because of some reasons such as increase in temperatures, degradation of the balance of ecosystem (for instance, increase in some species such as mosquito) and food and water scarcity.

Terrestrial Ecosystems:

- Melting of many small glaciers in Andes mountains due to increasing temperatures will affect the ecosystem and the people in Bolivia, Ecuador and Peru.
- The current water situation for consumption and hydro power will decrease because of the decrease in precipitation in Bolivia [59].

Adaptive Capacity:

- Improving agricultural, industrial and forestry sectors and with the effect of this improvement, decreasing the emissions of carbon dioxide should be supported.
- Environmental changes occurred with the impact of climate change should be observed and accordingly, necessary measures should be taken. Risk analysis should be made and precautions should be taken in this context. Food and water scarcity

programs should be organized [61].

4.1.3. Ethiopia

Agriculture and food security:

- Compared to climate change, land-use change has a small effect on annual water flow in the Nile river basin in Ethiopia [59].
- During the last century, precipitation has decreased in all seasons and if this keeps up, drought risk will become critical in Ethiopia [59].

Health:

- Climate change will increase the diseases in the region because of drought, floods and scarcity of food and water.(malaria)
- Incidence of malaria disease will increase in Ethiopia by 2050 and this case will continue to the year 2080 [61].

Terrestrial Ecosystems:

- Increase in temperature due to climate change has affected water flow and hydrological cycle and caused to a decrease in ground water resources in Ethiopia [61].
- We can say that forests, biodiversity and water resources are reasonably vulnerable to climate change in Ethiopia. Most of the population living in the region is in agricultural and rural activities. Drought and floods which will increase due to the impacts of climate change and it will make life more difficult [61].

Adaptive Capacity:

- Climate change will cause adaptation problem of population living in the region due to the decrease in resources and damaging of lands in which people live and agriculture in Ethiopia. Climate change will lead to being frustrated of educational sector, social life and economy and affect the life negatively. Required strategies should be determined and policies should bee made in order to cope with the extreme climatic events in the region. For example, people should be warned before the problem occurs, food security programs and social security policies should be prepared [59].
- According to a study, Afar, Somalia, Oromia and Tigray are more vulnerable to climate change because these regions are poorer than the others [62].

4.1.4. Malaysia

Agriculture and food security:

- Due to the change in climatic conditions, Nipah virus has spread out because of the forest fires and drought depending on ENSO, land use and change of land cover. This case has caused to epidemics in Malaysia and neighboring countries. This virus has been seen in foods [59].
- Climate change is expected to damage agricultural products seriously in the region. These changes are known to be substantially harmful for palm trees, rice, rubber and cocoa. Especially, floods derived from the rise at sea level are expected to fully destroy 6% of palm trees and 4% of rubber. The continual increase of the temperature is expected to hinder the growing and productivity of products in this region [63].

Health:

- Living of people in worse conditions, increase in food and water scarcity and pollution and too much increase in temperature in a short period are expected to affect human health negatively . For instance, mosquitoes are increasing due to rising temperatures and consequently, infectious diseases such as malaria and dengue fewer are spreading day by day [64].

Terrestrial Ecosystems:

- Mangrove forests and species will be reduced in Malaysia because of climate change [59]. Mangrove forests, mountainous forests and species living in them are expected to decrease in Malaysia because climate change increases temperature and precipitation [65].

Coastal Zones:

- Sea level rise threatens coastal zones. Seeing more climatic events such as storm and hurricane in these regions is expected due to the increase in sea surface water temperature besides the rising sea level. The coastline erosions are also expected to increase with climate change [65]. Coastal zones will be most affected by the risks created by climate change because they will be exposed to more floods and water overflows.

Adaptive Capacity:

- Making food stocks by improving agricultural practices and the development of water management and irrigation techniques are required. Trees should not be cut down

unnecessarily so as to control the loss of forest and available water resources should be investigated. Supporting the coastal zones infrastructure by making an analysis in these regions, making practices about human health, energy and the status of biological species, evaluating all of those and making required strategies are necessary [66].

4.1.5. Morocco

Agriculture and food security:

- Cereal products show a decrease by 50% in years of drought and a decrease by 10% in normal years [59].
- Water supply required for agricultural irrigation increases.

Health:

- Health sector is expected to be adversely affected by the climate change in this region because of the increase in temperature, lack of food and water scarcity.

Terrestrial Ecosystems:

- Increasing erosions cause to soil degradation in the region.
- Reduction of agricultural products along the coast occurs because of salinization in soil and water overflows occurred in the coastline.
- An increase in arid regions occurs northerly.

Coastal Zones:

- In Morocco, which has 3500 km coastline, 80% of people live in the risky region (on the coastline). People and the infrastructure are under the risk due to the rising sea level. Moreover, water in the region is faced with the risk of salinization.It is expected that precipitation cycles will change more in the future due to the impact of climate change. Flood risk will increase especially in the coastal zones. Drought is also expected to continue increasingly because of the extreme increase in temperature [59].

Adaptive Capacity:

- Improving of agricultural techniques,
- Refocusing on irrigation systems,
- Existing of irrigation techniques in high yield,
- Growing of drought-tolerant crops,
- Making an effort for finding water supplies, making available of in consumable polluted water and sea water,
- Managing of water resources using right strategies,
- Creating awareness with awareness-raising and educational methods related to the use of water,
- Making risk analysis in the areas along the coastline, defining of risky areas,
- Establishing of institutions in which drought can be observed and estimations can be made about future, are the most important steps in providing adaptation [67].

4.1.6. Netherlands

Agriculture and food security:

- The incidence of temperature-resistant species has increased in the Netherlands and Norway compared with the last 30 years [68].

Health:

- Temperature-related deaths, lime disease due to air pollution, food poisoning and the risk of allergic diseases will increase [59].
- It has been recorded that the number of temperature-related deaths were more than 35.000 in Belgium, Czech Republic, Germany, Italy, Portugal, Spain, Switzerland, the Netherlands and the United Kingdom in 2003 [59].
- By the year 2100, maximum 4 °C increase in summer temperature will cause to the increase of harmful planktons in the sea and therefore, human health will be adversely affected [59].

Coastal Zones:

- Ecosystems in the coastal zone are characterized as risky regions because of the impact of climate change, melting of glaciers and floods. Because it is expected that floods, storms and erosions occur frequently due to climate change in these regions. All of these extreme events are predicted to threaten the existence of ecosystems in the region and people will have food and water stress. The Netherlands is facing with such a risk.
- The Netherlands, and Bangladesh which are under the risk of flooding because of sea level rise caused by increasing temperature [59]. The Netherlands is affected by

floods and erosions because of being under the sea level and this effect is expected to increase in the future.

- Floods and storms will affect the coastal zones of the Netherlands. The Netherlands will become vulnerable to the floods and erosions.

Adaptive Capacity:

- Improvements and hydrological changes have occured in water sector in some countries due to the compliance procedures and risk management practices [59].
- Building weirs so as to prevent floods in Rhine River in the Netherlands is extremely difficult geo-technically and politically [59].
- The Netherlands has spent about £1 billion annually in order to protect from the climate change. £285 million of this amount has been spent for new reserve networks to manage national parks and £280 million of this amount has been also spent for new reserve networks to preserve the habitats under risk. Due to these new reserve networks, species, population and ecosystems are expected to increase their resistance against climate change by 2050 [59].
- Weirs and dams should be improved and designed due to the rise at sea level caused by climate change.

4.2. Definition of the Variables

In this study, using the data of migration of selected countries , including undeveloped, developing and developed for the period of 1970 - 2010, at a range of 3 and 4 years, and future period, the determiners of migration, in the countries which are vulnerable to the impacts of climate change are tested with the methodology of panel data analysis. The analysis indicates that some data which consists of GDP per capita as the economic variable, population as the demographic variable, temperature and precipitation as the climate

variable, natural hazard occurrence over the years and coastline located for countries as the dummy variable and permanent cropland and fish capture as the vulnerable variables while increasing the effects of climate change to the migration in the vulnerable countries.

Variables between 1970 - 2010 (1973,1977, 1980, 1983, 1987, 1990, 1993, 1997, 2000, 2003, 2007, 2010) The sheer number of variables and the width of the time period have limited the supply of data, and therefore also affect the selection of the country. Country selection is made among the most affected ones.

Previous studies on the determinants of migration in the literature have been used in a wide set of explanatory variables. The model in this research is formed according to all of these studies in the literature.

4.2.1. GDP per capita

The effect of GDP per capita on migration is related with the countries whether they can afford the cost of migration due to the climate change impacts. So in fact, when we compare two countries according to their GDP per capita in terms of climate change impacts on migration, we can see that high-income countries are more stable in some ways and can cope with climate change impacts and migration costs than other low-income countries, which are extremely vulnerable economically. This is an advantage for high-income countries, which will be affected similarly from extreme weather conditions. But GDP per capita is not enough solitarily in order to struggle with climate change impacts, so it should be evaluated together with demographic, social, political and environmental drivers.

We shall look at the classification of selected countries. Classification of selected countries as given in Table 4.1

Table 4.1. Classification of Countries [69].

COUNTRIES	CLASSIFICATION	LEVEL OF INCOME
Bangladesh	Low-income countries	$ 1.025 or less
Bolivia	Lower-middle income countries	between $ 1.026 - $ 4.035
Ethiopia	Low-income countries	$ 1.025 or less
Malaysia	Upper-middle income countries	between $ 4.036 - $ 12.475
Morocco	Lower-middle income countries	between $ 1.026 - $ 4.035
Netherlands	High-income countries	$ 12.476 or more

4.2.2. Population Growth

Population is a very significant factor as the demographic driver. Population size affects the migration seriously in the vulnerable countries. This relationship is based on the consumption of the natural resources very rapidly. If population increase rapidly in a low income country, people can encounter malnutrition and water scarcity problem. There are some statistics concerning the malnutrition and water stress and scarcity. When natural resources are consumed, the region's population cannot be fed sufficiently. Actually, this effect is double-sided. On the one hand, this situation will reduce the population depending on deaths from malnutrition and water scarcity. On the other hand also level of welfare of population will be adversely affected stemming from the inadequate resources by depending on the rapid growth, and this might trigger migration. According to the studies on climate change, water resources will be depleted, agricultural productivity will decrease, extreme weather events including temperature fluctuations, rainfall and storms will increase and biodiversity will decrease in many parts of the world. Due to future events that affect people's living conditions, environmental conditions will reduce people's adaptive capacity and increase the human vulnerability and will cause many people to migrate [29]. Population will rapidly grow in most regions. This rapid growth will trigger the displacement of population. Due to the physical effects on human of climate change,

people living in the countries which are based on agriculture and fisheries will experience the lack of livelihood because of the some adverse effects of climate change on land and ocean productivity. The most important subject related with the displacement of people or migration stemming from climate change, people migrating due to the climate change effects, environmental refugees, are not within the scope of international refugee law, but generally forced migrations due to changed environmental conditions are defined in the law. Many developing countries faced the rapid population growth have to improve the standard of living. Improving the standard of living means exhaustion of natural resources already quickly and this case poses a big danger for the future lives.

As of 2011, the world population is 6.9 billion. According to the world population projection of the United Nations in 2010, the expected world population is shown in Table 4.2 as of 2050 -2100.

Table 4.2. Population Projections [70].

Population Growth	**2050**	**2100**
Low Estimation	8.1	6.1
Medium Estimation	9.3	10.1
High Estimation	10.6	15.8

Another point necessary to focus on in terms of the population is the density of the population living in low elevation coastal zones. These areas are crucial because they are most affected by extreme weather events and sea level rise. These areas are only 2% of Earth's surface, but the population living in these areas constitutes 10% of the world population. In a study, it is stated that the population forced to migrate to higher elevations because of sea level rise and extreme weather events increases rapidly [32].

Demographical trends play an important role in countries' vulnerabilities to the impacts of climate change. At this point, the important point to note is to determine the

adaptation strategies well.

Keeping the population growth at a reasonable level is very significant in terms of protection of the environment and thereby reducing or preventing the migration. In the context of right match, in other words determining separate and accurate adaptation strategies for each of the regions considered to be affected mostly by environmental change, a sustainable level of population growth will allow to reduce and balance environmental problems due to renewable resources [71].

Effects of the population growth on environment:

Population growth has some negative effects on environment. Especially, considering environmental sectors, it is possible to observe much more negative effects of population growth.

Let us analyze these effects.

- Water stress and water scarcity
- Agricultural land degradation
- Vegetation and forest land degradation
- Land Use Change
- Damaging of fisheries industry
- Extinction of species
- Epidemics

Water stress and water scarcity: It is stated that global water consumption has increased by 600% between 1990 and 1995. I is expected that this demand will continue to increase due to population growth and industrial development. Average per capita water consumption in less developed countries is only 1-2% of a developed country such as

Canada.

Water stress: It is the case that the annual per capita water supply in a region has decreased to below 1700 m^3.

Water scarcity: It is the case that the annual per capita water supply in a region has decreased to below 1000 m^3.

Absolute scarcity: It is the case that the annual per capita water supply in a region has decreased to below $500m^3$.

Rapid population growth is a serious threat for limited fresh water resources in the world. Looking at the future population estimates, it is stated that 2.9 - 3.3 billion people will face water scarcity and water stress. It is also recorded that this number was 784 million people in 2005. According to these numbers, considering distribution of income, the policies of the right to land use and some other factors in addition to population growth rate, it will be impossible to ignore that billions of people are faced with the threat of future. All these facts have increased vulnerability to climate change impacts. Water scarcity and water stress projection are given in Table refwater.

Table 4.3. Water Scarcity and Water Stress Projections [72].

Water scarcity and water stress	**2005**	**2012**	**2025**	**2050**
Number of People	784 million	1.6 billion	2.8-3.3 billion	Over 4 billion

All over the world, the most water-consuming sector is the agricultural sector. Aquifers used as a drinking water supplies have been faced with excessive pollution because of pesticides, fertilizers and dangerous chemicals. Too serious environmental problems have occurred because of improper agricultural practices and irrigation techniques. In between

1960 and 2004, the water table of Aral Sea decreased for about 20 meters and it lost its surface volume almost 70% [73].

Land Use and Vegetation and Forest Land Degradation and Extinction of Species: In the context of the need for arable and permanent cropland depending on population growth, it is expected that additional 120 million ha lands will be added to these lands by 2030. At the same time, it is stated that these additional lands will be meet by removing forests and vegetation because expansion and construction in urban areas will continue depending on population growth. Land use projection are given in Table 4.4.

Table 4.4. Land Use Projections [74].

Forest Land Degradation	**2030**
Industrial round-wood consumption	2400 million m^3 (% 60 more of current level)
Additional land need for cropland	120 million ha
The number of people living in forest scarce countries	3 billion

Today, forestland for 1.8 billion people is less than 0.1 hectare. It represents a critical level. It is a big disaster in terms of both environment and the future of humanity [75].

Human activities come from industrialization affect the Earth's possible terrestrial productivity by about 40%. It is stated that forest surface in 1700s was more than current forest surface by approximately 24%. The vast majority of the lost forests has been eliminated as a result of the elimination of natural habitat. Many species have become extinct and natural habitat has been damaged as a result of transforming these areas into cropland. It is estimated that 14% of 242.000 plant species will face with the danger of extinction [76].

Epidemics: Millions of people die because of malaria in underdeveloped and less

developed countries. It is estimated that this number will increase owing to the fact that climate change will change environmental conditions and owing to the growing poverty. Comparing the life span in underdeveloped and developed countries, it is clear that there are serious differences between them [77]. Unfortunately, investments made for adaptation of regions is insufficient to meet the adaptation needs. At this point, global cooperation is of great importance. Developing such a cooperation is of vital importance in terms of providing national and global security and substantially reducing environmental migration.

At this point, the most important point to note is addressing the relationship between climate change and the rate of population growth and environmental migration depending on this seriously. Developing solution-oriented policies as a result of revealing this awareness will reduce the vulnerability to climate change effects.

4.2.3. Temperature and Precipitation Change

Change in temperature threatens the basic elements of life such as access to water, food production, health and use of land and environment for the people around the world. There are lots of studies including temperature and precipitation variables in the literature. When we examine these studies, we can see that the extreme weather conditions such as high temperatures and extreme precipitations can lead to some natural hazards. Natural hazards make it difficult for people to continue to live. People lose their families and homes. This is a big blow for them and forcing them to migrate. I mean, if natural hazards have higher frequency in a region, people find it difficult to adapt to this situation in many ways and this might trigger migration.

4.2.4. Natural Hazards

The impacts of climate change on underdeveloped and developing countries are extreme climate events and long-term environmental factors. Extreme climate events which

have occurred previously are the results of potential climate change. Many underdeveloped and developing countries struggle with the current climate. They have to suffer both deaths and economic losses increasing along with the natural disaster due to climate change impacts. Also these numbers differ from countries selected in this thesis work(Table 4.5). This variable is very important for understanding migration depending on the extreme climatic events.

Table 4.5. Natural Disaster Impacts for selected countries, 2010 [16].

Countries	**Number of Disaster**	**Number of Killed**	**Total Affected (number of people)**	**Total damage (US dollar)**
Bangladesh	289	631.691	416.106.812	18.170.780
Bolivia	67	1.721	6.485.915	3.101.500
Ethiopia	91	413.566	60.469.354	107.777
Malaysia	60	1239	642.394	1.867.500
Morocco	36	1840	726.869	1.596.159
Netherlands	29	2013	265.321	4.520.700

4.2.5. Coastline Zone

Coastline countries are under great risks in many ways. It is expected countries located in coastal zone to have more intensive effects owing to the flooding and sea level rise resulting from excessive rainfall and melting of glaciers. It is expected that millions of people will be faced with having to leave their countries because of the climate events such as floods, extreme weather events and sea level rise caused by climate change. It is estimated that changes in temperature and precipitation considered to affect water supply and agricultural production will force people living in some regions to migrate. An important study draws attention that, 10% of world population have lived in the areas where elevation is below 10 meters. This is one of the most important reason people to migrate.

Although coastal zone is 2% of earth's surface, 10% population of the world have lived in there. When we compare them, we can see that the density of the population in those areas is high. In this case, it can be asserted that when the sea level rise in those regions, the possibility of migration is very high [32].

4.2.6. Permanent Cropland

There is indirect relationship between permanent cropland and migration. When permanent cropland increases, it means that forest land is converting the permanent cropland, which means altering the balance of the ecosystem. Here again there is a double-sided impression. Increase in permanent cropland means experiencing population growth. It also affects adversely to the welfare of people in that region and they need more permanent cropland, in order to provide their livelihood. If there is not enough permanent cropland, this might trigger migration.

Agricultural Land Degradation: It is estimated that there will be a decrease in arable and permanent cropland per capita owing to the population growth. It is also stated that increasing of migration from rural to urban areas and consequently, increasing of construction due to urbanization cause to a decrease in arable and permanent cropland and in long run, scarcity problem will occur in these lands. In many countries, water and agricultural land degradation has occurred because of excessive production. In projections, it is expressed that agricultural production will be insufficient by 2050. It is also stated that serious decreases will be observed in the number of people farming the lands. Undernourished people are given in Table 4.6.

Table 4.6. Undernourished people [78].

Undernourished people	**2010-2012**
Number of people	868 billion (% 12 of World population)

When a decrease has occurred in cultivated areas, production will also decrease and this fact will affect food production. Therefore, health problems will occur as a result of undernourishment.

4.2.7. Fish Capture

Fish Capture is a significant indicator in terms of livelihood and consuming resources rapidly. Day by day, fish capture increases, it means that it almost came to the full capacity. If it reaches to the full capacity, there is no longer anything to do, so fact that the fish resources already consumed. When we look at the relationship between fish capture and migration, we can mention about the population growth again, because when population increases, the resources have depleted rapidly and people living there may seek to migrate better places in terms of livelihood.

Fisheries: Fisheries has started to decline because of the decrease in fish population as a result of approaching maximum fishing capacity depending on population growth. It is expected that this decrease caused by overfishing and consumption will negatively affect the regions which ensure their living due to fishery. Moreover, pollution of water resources owing to the growing population has also reduced fish population. Fish Production is given in Table 4.7.

Table 4.7. Fish Production (Consumption) [79].

Fish Production (Consumption)	**1970**	**1999**	**2030**
Number	65 million	125 million	160 million

5. RESULTS AND DISCUSSIONS

5.1. Methodology

In this research, using the data of 6 selected countries including underdeveloped and developed countries for the period of 1970-2010 at range 3-4 years between decades, the determinants of migration are tested using panel data analysis. The analysis indicates that the relationship between migration as the dependent variable and explanatory variables, including GDP, population, precipitation, temperature, natural hazards related with the climate change, arable and permanent cropland, while increasing the impacts of climate change to the migration.

The width of the large number of variables and the time period, which limits the supply of data, and therefore also affects the selection of the country. The choice of the countries most affected by climate change were considered. In the literature, studies on the determinants of migration seems to be using a large set of explanatory variables. In terms of better understanding of the determinants of migration within the context of the review of the literature and theoretical knowledge obtained variables and sources of the data set is given in Table 5.1.

The model established by utilizing the studies in the literature, created taking into account the relationship among the explanatory variables and between the migration as the dependent variable and the each explanatory variable.

This model is given below:

Migration (Y) = f (GDP, Population, Precipitation, Temperature, Natural Hazards, On coastline, Permanent Cropland, Fish Capture)

Table 5.1. Variables, Explanation, Expected Signs and Data Sources.

Variables	**Explanation**	**Expected Signs of the Variables**	**Sources**
GDP Growth	As the economic variable which affects to the migration	inversely	World Bank
Population Growth	As the demographic variable which affects to the migration	directly	World Bank
Temperature	As the climate variable, mean annually	directly	RegCM Modeling
Precipitation	As the climate variable, mean annually	directly	RegCM Modeling
Natural Hazards	Occurrence over the years Dummy Variable	directly	Emdat
On Coastline	Coastal Zone Located Dummy Variable	directly	Geographic Information
Permanent Cropland	As the variable representing agricultural vulnerability	inversely	World Bank
Fish Capture	As the variable representing fisheries vulnerability	directly	FAO-Fishstat

The proposed model is as follows;

Theorically;

$$MIGit = \beta_0 + \beta_1 GDP_{it} + \beta_2 POP_{it} + \beta_3 TEMP_{it} + \beta_4 PREC_{it} + \beta_5 PERMCROP_{it} +$$

$$\beta_6 FISHCAPT_{it} + \beta_7 HAZARDD + \beta_8 COASTD_{it} + \epsilon_{it} \quad (5.1)$$

Where;

MIG_{it} is the migration (data calculated) in geographic area i at time t

β_0 is the constant term

β_1 captures the causative effect of GDP per capita on migration, GDP_{it} is the per capita income in area i at time t

β_2 captures the causative effect of population on migration, POP_{it} is the number of people in area i at time t

β_3 captures the causative effect of temperature on migration, $TEMP_{it}$ is the average temperature in area i at time t

β_4 captures the causative effect of precipitation on migration, $PREC_{it}$ is the average precipitation in area i at time t

β_5 captures the causative effect of permanent cropland on migration, $PERMCROP_{it}$ is the sq km in area i at time t

β_6 captures the causative effect of fish capture on migration, FISHCAPT$_{it}$ is the tonnes of fish captured in area i at time t

β_7 captures the causative effect of natural hazards on migration, HAZARDD is the dummy variable which is represented 1 when it occurs in that year and 0 no occurrence in that year.

β_8 captures the causative effect of locating in coastal zone on migration, COASTD is the dummy variable which is represented 1 if a country is located in the coastline and 0 not in the coastline

ϵ_{it} is the error term in area i at time t

Pratically; (Panel Data Regression)

$$MIG = -1266577 + (= 329767)GDP_{it} + (0.0227078)POP_{it} + (13204.65)TEMP_{it} +$$

$$(93775.38)PREC_{it} + (-37.59512)PERMCROP_{it} + (1.314653)FISHCAPT_{it} +$$

$$(77676)HAZARD + (1174922)COASTD \tag{5.2}$$

5.1.1. Description of Panel Data Analysis and Related Contents

5.1.1.1. Stages of Model. We shall briefly mention about the stages of our model.

(i) First stage is that decision of the analysis type is based on that there are multiple

countries and time series data 1970-2010 period. Panel data analysis are suitable in these type analyses.

Panel Data

Panel data is basically multi regression analysis technique used in econometrics. Panel data analysis can be defined as to bring together the cross-section observations including firms, countries, households etc. within a particular time period. Panel data is defined as time-series of cross-sections or cross- sections of time-series [80] and can be interpreted to be expressed with time dimension of horizontal cross-sectional observations occurred such as companies, households, countries [80]. Panel data analysis is used in order to estimate the coefficient β_k and to find whether the data can be modeled efficiently.

General representation of panel data regression formula;

$$Y_{it} = \alpha_i + \sum \beta_k X_{k,it} + e_{it} \tag{5.3}$$

where;

$X_{it} = Explanatory\ (independent)\ variables$ in area 'i' and 't'

$Y_{it} = Dependent\ variable$

$\beta = Slope\ coefficients$

$\alpha_i = Constant\ term$

$e_{it} = error\ term$

As we see in the general representation formula of panel data regression, there are two sub-indices including i and t respectively represents the countries and years.

There are many different regression models including the combination of the horizontal cross-section and time series data set. Some of these are following;

- Random effects and fixed effects models
- Dynamic panel analysis
- Least Square Method

Panel data allows you to control for variables you cannot observe like cultural factors or variables which change over time but not change across countries (such as international agreements, etc.).

In this thesis, we focus on two techniques used in panel data analysis. And their results were compared according to the Hausman Test.

A. Fixed Effects Model

It explores the relationship between independent variables and the dependent variable for a country. Each country has its own individual characteristics that may or may not be influenced by the independent variables.The error term arises from the relationship between the independent variables within a country.

The variables in the panel data model, as opposed to time series and cross-sectional data, are represented by two sub-indices, signifying both time and cross-section.

Sub-indices including “i” and “t” respectively represents the cross-sections and the time.

Fixed effects models which provide the following basic assumptions, are estimated with in-group estimator and the least square dummy variable estimator (LSDV) [79].

$$Y_{it} = \alpha_i + \sum \beta_k X_{k,it} + e_{it} \tag{5.4}$$

where;

$i = 1, ..., N \;\; t = 1, ..., T, \; E(e_{it}) = 0, \quad Cov(e_{it}, e_{it}) = 0,$

$Var(e_{it}) = \sigma^2, E(X_{it}, e_{it}) = 0$

$X_{it} = Explanatory \; (independent) \; variables$

$Y_{it} = Dependent \; variable$

$\beta = Slope \; coefficients$

$\alpha_i = Constant \; term$

$e_{it} = error \; term$

In this model, it is assumed that constant term is fixed within the time, but it can change unit to unit (countries to countries). Moreover, the model assumes that constant term is fixed within the units, but it can change within the time period.

If you are only interested in analyzing the impact of variables that vary over time, you should use fixed effects model.

B. Random Effects Model

Another model is random effects model taking place in the literature. If individual effects have no relationships with explanatory variables and constant terms of units distribute randomly, building of model should be become available to this. The variation across countries is assumed to be random and uncorrelated with the independent variables included in the model.

In Random effects model, we do not know whether the individual characteristics of each country affects the dependent variables of other countries.

$$Y_{it} = \alpha_i + \sum \beta_k X_{k,it} + (u_i + e_{it}) \tag{5.5}$$

where;

$i = 1, ..., N, \quad t = 1, 1....., T, \; E(u_i) = (e_{it}) = 0, \quad cov(u_t, e_{it}) = \sigma_{u,e},$

$Var(u_i) = \sigma_u^2 \; and \; E(X_{it}, u_t) = 0$

$X_{it} = Explanatory \; (independent) \; variables$

$Y_{it} = Dependent \; variable$

$\beta = Coefficients \; of \; variables$

$\alpha_i = Constant \; term$

Here, it is assumed that it distributes identically and independent, where the variance of the error terms are equal to the "0". u_i = error term occurred in the units including random differences (it has no relationship between error terms explaining cross effects, within country error.) e_{it} = a term that contains the remaining errors (there is no relationship with panel data error term, remaining error).

Fixed or Random Effects Model

- If you can not observe individual effect of panels (between the countries), it means that model should be established through random effects.
- In other words, there is no correlation between panels (countries) and independent variables, in this case, it can be said that model should be established through random effects.
- To decide between fixed or random effects you can run a Hausman test where the null hypothesis is that the difference in coefficients is not systematic. If we can not reject the null hypothesis, we should use the random effects model (According to its p value, if it is smaller than 5% significance level).

(ii) Second stage is the filling of the data gaps for migration, as the dependent variable, has no suitable time series data for needed years. We have just four data points including 1970, 1980, 1990, 2000 within 40 years period. This is major problem for panel data because there must be more observations to obtain better results. We need at least two additional data points between two decades. Therefore, it is performed to fill data gaps by using ARIMA model used to forecasting. ARIMA model (forecasting model) is the lag model in order to obtain forecasting data by using past data. It is used to obtain data for migration from the population, birth and death numbers.

In this section, a relationship between migration and population using ARIMA model is established. Population is calculated in a country as follows:

Population = (Birth - Death) + (Emigrant - Immigrant)

We have data for population, births and deaths for every year, but we have only 4 decades data points for migration. Coefficients and migration data for selected countries are given in Table5.2.

Table 5.2. Coefficients and migration data for selected countries [17].

Countries	**Coefficient**	**Migration data, 1970**	**Migration data, 1980**	**Migration data, 1990**	**Migration data, 2000**
Bangladesh	1.018	235.705	5.047.223	5.068.368	4.987.708
Bolivia	1.020	139.100	166.734	226.404	361.475
Ethiopia	1.026	31.408	66.628	158.492	291.252
Malaysia	1.023	314.621	409.630	593.744	1.155.210
Morocco	1.016	831.467	1.242.563	1.646.517	1.615.047
Netherlands	1.005	697.401	726.627	737.092	774.792

Population data is separated from birth and death numbers and net migration is obtained according to the population formula. The relationship between net migration and migration is examined by using ARIMA model. We gained a coefficient explaining the relationship between them in order to fill in the gaps in the migration data. All time gaps were not filled, we fill in the gaps just two years between two decades. For example, 1973 and 1977 between 1970 and 1980. In this case, the important point is that why we do not take same range of years, we can explain this as follows: For example, There is a big difference between 1970 and 1980 for Bangladesh. While migration data for 1970 is 235,705 people and it is 5,047,223 people for 1980. As it is seen, there is big difference between them. Hence, It will not be logical filling the data periodically within the same range like 1970, 1973, 1976,...etc. We have to consider the increase of 1980 and we should back down from the 1980 data to 1977 in order to capture the increase.

(iii) Third stage is that unit root test is made for all variables including dependent variable. Whether all variables are stationary or not is considered, because they are tested in terms of availability of them for many econometric model. If variable is stationary in the level part as the result of unit root test, there is no problem, we can use the variables in the level part results, but they are not stationary in this part, we have to test them in the first difference part.

Panel Unit Root Test

In this study, to determine the stationary of the variables, the panel unit root test is made.Augmented Dickey Fuller test is used as the suggestion of Im-Peseran and Shin, 2003 and Levin Lin Chu.

Augmented Dickey Fuller Test (ADF)

ADF test removed the autocorrelation problem which may create. In this ADF test, we check all variables whether are stationary or not. We shall examine this test stated below as the Equation 5.5, 5.6, and 5.7.

$$\Delta Y_t = B_1 + ZY_{t-1} + a_i + e_t \tag{5.6}$$

In the first equation there is only **intercept**.

$$\Delta Y_t = B_1 + B_2 t + ZY_{t-1} + a_i + e_t \tag{5.7}$$

In the second equation there are both **intercept and trend**.

$$\Delta Y_t = ZY_{t-1} + a_i + e_t \tag{5.8}$$

In the third equation there is no trend and no intercept.

In ADF test;

Null Hypothesis: H_0 : Variable is not stationary

Alternative Hypothesis: H_1 : Variable is stationary

Level part: Firstly, we should use the level part for testing the variable whether stationary or not. When we take the results, we check the critical value first. If the absolute (absolute means that there is no negative sign) test statistic is more than critical value, we can reject the null hypothesis including H_0: Variable is not stationary (it means that it has a unit root) and we can accept the alternative hypothesis including H_1: Variable is stationary. On the other hand if the absolute test statistic is less than the critical value, we cannot reject the null hypothesis including H_0: Variable is not stationary and we can rather accept the null hypothesis.

In the second part of examining the results, we will look at the probability (P value), if the probability is less than 5%, we can reject the null hypothesis including H_0: Variable is not stationary and we can accept the alternative hypothesis including H_1: Variable is stationary. On the other hand if the P value is more than the 5% we can not reject the null hypothesis including H_0: Variable is not stationary and we can rather accept the null

hypothesis.

In order to make sure this result we have to check the coefficient of the variable (-1) in the ADF equation, for example, the coefficient of Y(-1). It must be negative sign. After checking it we can make sure that the variable is a stationary, in other words, it does not have a unit root.

The point here is the following, if the variable is not stationary, we have to make it stationary, it means that that variable is suitable for using in many different econometric models from now. Indeed, we can apply the stationary data to many econometric models because it is no longer a unit root. In order to provide stationary variable, we have to make the first differencing. The point here is that we have to take the same result in all three parts including intercept in the first equation, both trend and intercept in the second equation and no trend no intercept in third equation which is for example, "Y" has a unit root have to be in all parts.

First Differentiate part: When we go to the first differentiate, we will examine that whether the variable is stationary or not again. In the same way, we have to take the same result in all three parts including intercept, both trend and intercept and no trend no intercept part. We shall start with our hypothesis to examine this part. Null Hypothesis: H_0: Variable is not stationary (it means that it has a unit root)

Alternative Hypothesis: H_1: Variable is stationary (it means that it has not a unit root)

We will make the same steps, respectively with the level part and we will check all variables whether they all are stationary or not. Firstly we will examine the absolute test statistic and then we have to check the P value. If the absolute test statistic is more than all critical value, we can also reject the null hypothesis. Primarily, it means that the first

differentiate of that variable is a stationary, in other words, it does not have any unit root.

In order to make sure this result we have to check the coefficient of the variable (-1) in the ADF equation, for example, the coefficient of Y(-1). It must be negative sign. After checking it we can make sure that the variable is a stationary, in other words, it does not have a unit root.

(iv) Fourth stage is that establishing of the model in theory and practice with stata.

Theoretically;

$$MIGP_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 POP_{it} + \beta_3 TEMP_{it} + \beta_4 PREC_{it} + \beta_5 PERMCROP_{it} +$$

$$\beta_6 FISHCAPT_{it} + \beta_7 HAZARDD + \beta_8 COASTD_{it} + \epsilon_{it} \tag{5.9}$$

Note: Table 5.1 and 5.8 are the same equations.

(v) Last stage is to make the Hausman Test to have an understanding which model is more suitable for the analysis, including Fixed Effects Model and Random Effects Model. After the decision of the model, model outputs are evaluated in the light of literature and theoretical knowledge.

Hausman Test

In general, fixed effects model are preferable in the panel data analysis, because it gives the desired results in terms of statistical features of it. However, if random effects model give more significant results, it should be used the random effects model. Decision

of model will be using is based on the Hausman test in the literature. Between both of which are consistent, but the beneficial aspect of the two models is different, it should be selected a model which is more efficient. In the literature,Hausman test which is based on the chi-square with degree of freedom "k" is used. In the Hausman test, rejection of the null hypothesis which includes H_0 : difference in coefficients not systematic, with the coefficients obtained from the random effects model and the coefficients obtained from fixed effects model means that random effects model gives more efficient results.

5.1.2. Implication of the model respectively according to the stages

In this section, two test were used for unit root. One of them is Im Paseran and the other one is Levin Lin Chu. In Paseran, each variable is tested separately. It means that if one of the variables has a unit root, this test says that there is unit root and it should be used first difference. In Levin Lin Chu test, panel unit root test for all variables including migration, GDP per capita, population, temperature, precipitation, permanent cropland and fish capture. Levin Lin Chu test is more available for our model. In this test, even if one of panels has a unit root and others do not, this test says that there is no unit root in the panels for all variables. Levin Lin Chu test was used in our model before the panel data analysis. We shall start with describing our hypothesis.

Hypothesis are in the test ;

H_0 : Panels contain unit roots (panel variables are not stationary)

H_1 : Panels are stationary

Firstly, we should use the level part for testing the variable whether stationary or not. When we take the results, we check the critical value first. If the absolute (absolute means that there is no negative sign) test statistic is more than critical value, we can reject

the null hypothesis including H_0 : Variable is not stationary (it means that it has a unit root) and we can accept the alternative hypothesis including H_1 : Variable is stationary. On the other hand if the absolute test statistic is less than the critical value, we cannot reject the null hypothesis including H_0 : Variable is not stationary and we can rather accept the null hypothesis. In the second part of examining the results, we will look at the probability (P value), if the probability is less than 5% significance level, we can reject the null hypothesis including H_0 :Variable is not stationary and we can accept the alternative hypothesis including H_1 : Variable is stationary. On the other hand if the P value is more than the 5% significance level we can not reject the null hypothesis including H_0 : Variable is not stationary and we can rather accept the null hypothesis. As it is presented in the following table, p values of all variables are smaller than 0.05 significance level. In this case, it can be asserted that it does not have unit root for all variables and all variables are stationary. We reject the null hypothesis including H_0 : Variable is not stationary. Unit root test results are given in Table 5.3

Table 5.3. Unit Root Test Results.

Variables	**t statistics**	**Adjusted t statistics**	**p value**
migration	- 14.8232	- 13.1745	0.0000
gdp per capita	- 10.1251	- 7.4233	0.0000
population	- 6.0463	- 3.8772	0.0001
temp	- 9.4241	- 4.3516	0.0000
prec	-7.3632	- 2.8819	0.0020
cropland	-5.7049	- 2.8788	0.0020
fish capture	-5.5087	- 3.0073	0.0013

When we compare the fixed effects and random effects' results, we can see that, according to the Haussmann test, random effects analysis is very significant for our model. We shall examine each explanatory variable in the model. There are five determinants of migration in the literature. These are economic, social, demographic, political and envi-

ronmental. Explanatory variables in our model were selected from among these drivers including GDP per capita as the economic driver, population size as the demographic driver, temperature and precipitation as the climatic variable related with the environmental drivers including exposure to natural hazards and permanent cropland and fish capturing as the environmental drivers including ecosystem services availability.

Migration trend, which covers 1970 - 2010 is given in Figure 5.1.

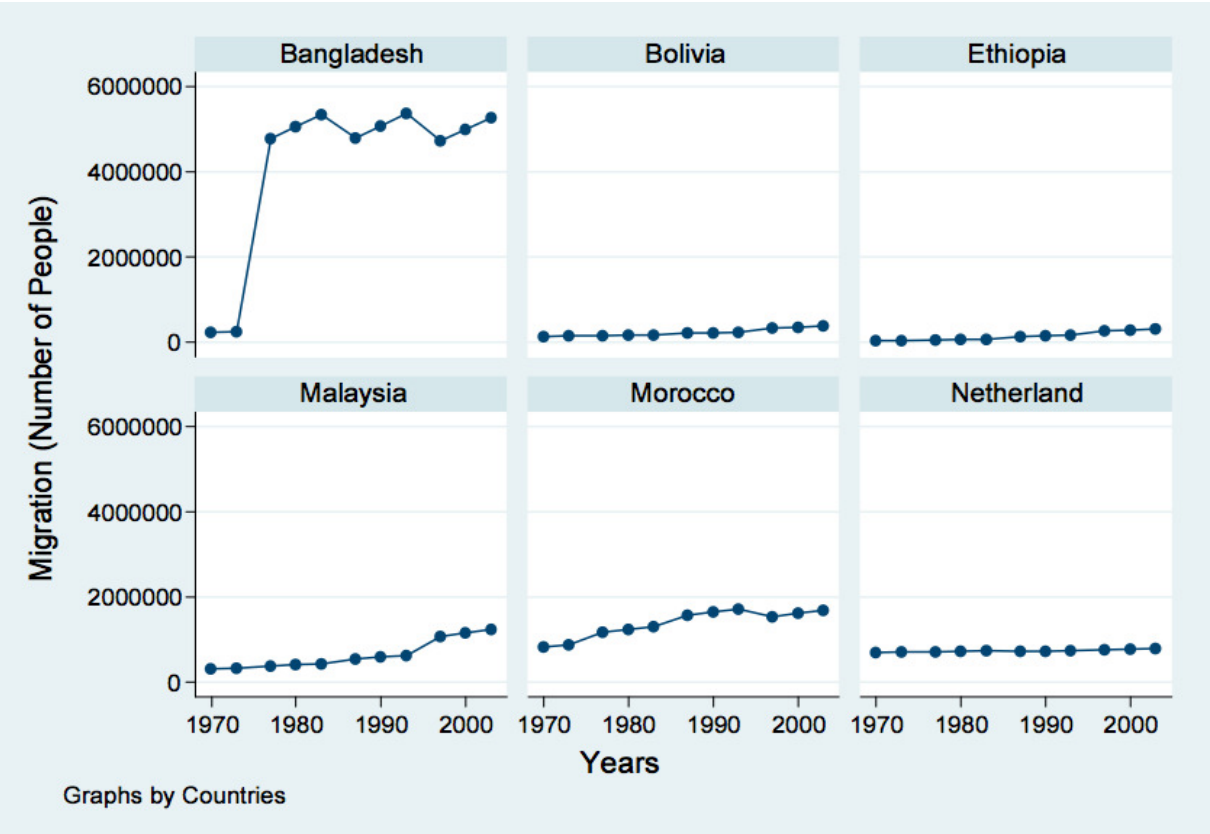

Figure 5.1. Migration trend, which covers 1970-2010.

5.1.3. Interpretation of model outputs

GDP per capita Output: When we look at the GDP per capita explanatory variable, its probability (p value) is 0.178, it means that it is not statistically significant in the practice, because if p value is bigger than the 0.05, meaning that not significant, but we

Table 5.4. Model Results.

Explanatory Variables	**Fixed Effects**	**Random Effects**
GDP	17.29562	-32.97687
	(0.540)	(0.178)
POP	0.0459565*	0.0227078*
	(0.000)	(0.000)
TEMP	-42295.9	13204.65
	(0.810)	(0.796)
PREC	11541.13	93775.38**
	(0.901)	(0.011)
PERMCROP	64.32117	-37.59512
	(0.113)	(0.006)
FISHCAPT	-1.50787	1.314653**
	(0.126)	(0.036)
HAZARDD	34619.66	77676.28
	(0.892)	(0.778)
COASTD	0	1174922*
		(0.005)
R2	0.3572	0.8016
F-test	4.53*	230.28*
	(0.0005)	(0.0000)
Hausman Test10.51(0.0327)H: difference in coefficients not systematic		

Model results are given in Table 5.4

$Note : Prob. < 0.01*, Prob. < 0.05**, Prob. < 0.10***$

can say that it is theoretically significant according to its sign. Its sign in the panel data analysis is expected sign (-). In theory, an increase in GDP per capita, prevents migration owing to the fact that people have enough income for their livelihood and welfare, they

do not need to migrate, if there is no any extreme climatic events which caused short or long-term effects. Migration is negatively related to the GDP per capita in a country. For example, this variable does not make sense for our model, although it has correct sign in theory, it does not mean that it will not affect migration as a number. According to our model, we could say that if it is statistically significant, 1 US dollar increase in GDP per capita prevents 32 person to migrate. But there is statistically no evidence for saying this. In this case, we can say that GDP per capita does not merely affect migration, it has to be evaluated with some other drivers such as demographic, environmental. As a result, this regression result shows that there is no direct relationship between GDP per capita and migration in practice. GDP per capita trend, which covers 1970-2010 is given in Figure 5.2.

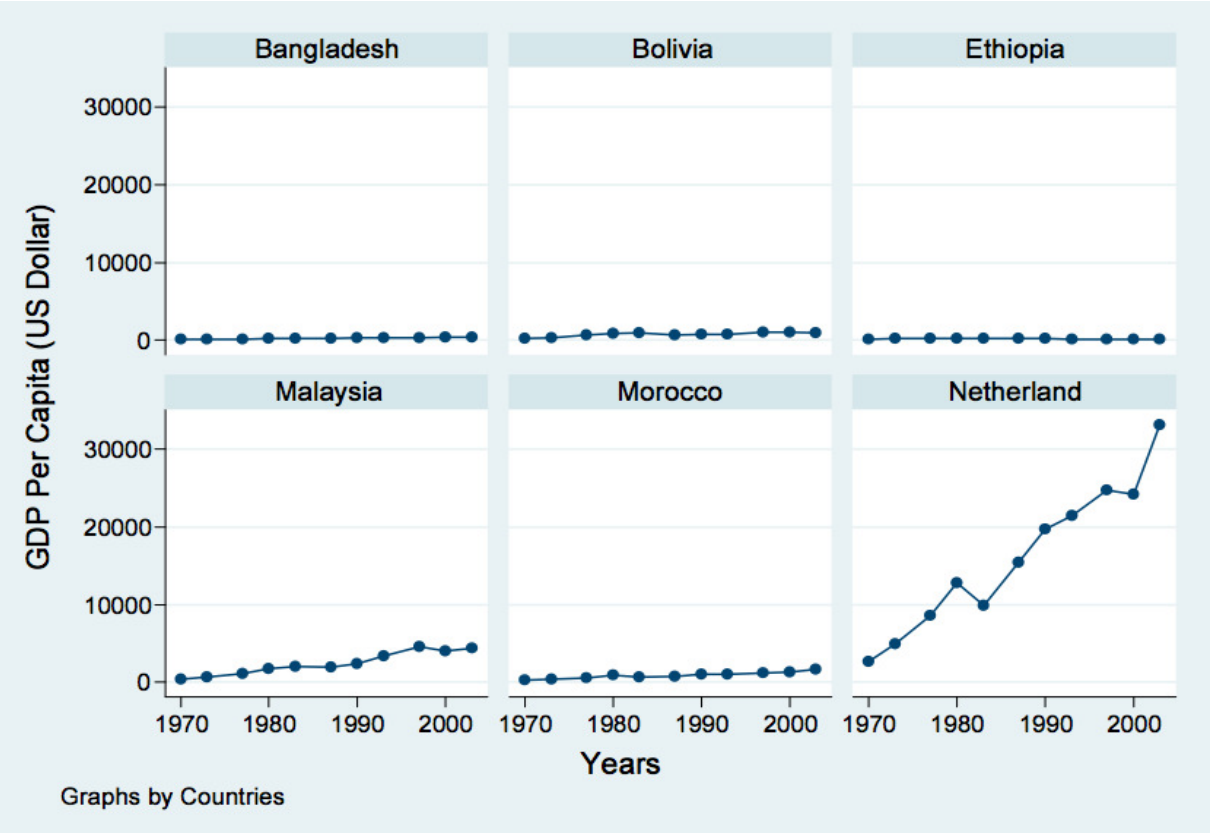

Figure 5.2. GDP per capita trend, which covers 1970-2010.

Population Output: Population growth is a serious threat to the environment. Even we can say it is the most important threat. Each person needs energy, habitat and natural resources in order to survive. Meeting these needs causes to some environmental losses and it makes people living in the region face some threats. Rapid population growth causes rapid exhaustion of resources and destruction of the ecosystem. Therefore, it is a key factor for migration caused by climate change. When we evaluate the population (POP) explanatory variables in the panel data analysis, we will consider p value of it. Its p value is 0.000, it means that it is significant statistically. In this case, it can be asserted that if the population increases 100 person, migration will increases extra 2 person in response to that. Population trend, which covers 1970-2010 is given in Figure 5.3.

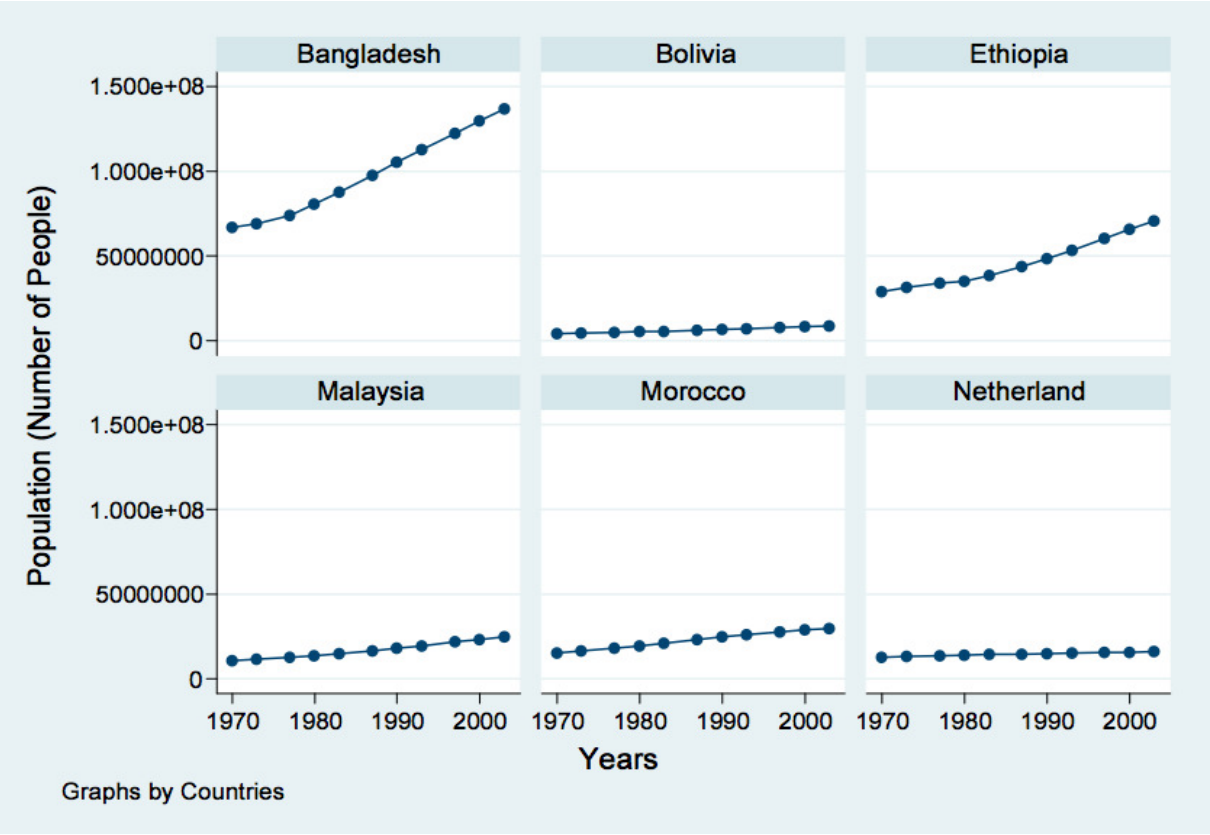

Figure 5.3. Population trend, which covers 1970-2010.

Temperature Output: Third explanatory variable is temperature as the climate in-

dicator. Temperature variable is very significant in understanding of climate change and its impacts. So while we evaluate the drivers of migration, temperature will be crucial indicator for our analysis. In this analysis, temperature is not expected to be statistically significant. Its p value is 0.796. As the p value is bigger than the 0.05, it indicates that it is not statistically significant. But point here is the following, temperature variable's sign is significant theoretically. In theory, there is a positive relationship between migration and temperature rise depending extreme whether events. Therefore, temperature parameter in our model is theoretically significant in terms of its sign, but statistically not significant in terms of its p value. As a result, this regression shows that although temperature result's sign explains the relationship between migration and temperature rise depending on extreme weather events in theory, each additional 1 °C rise does not mean any increase in migration in practice. Temperature trend, which covers 1970-2010 is given in Figure 5.4.

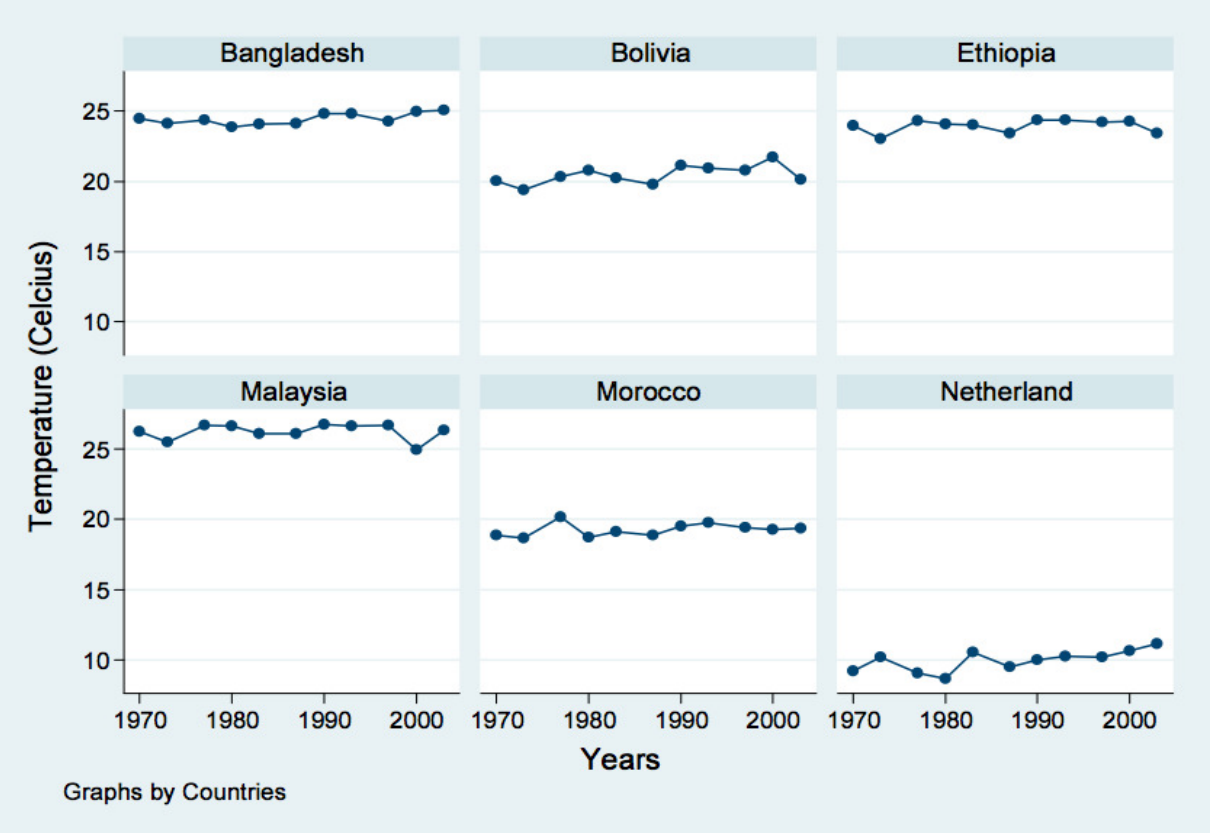

Figure 5.4. Temperature trend, which covers 1970-2010.

Precipitation Output: Another explanatory variable is precipitation. Precipitation data in considered as the annual mean obtained from the daily mean value. Precipitation is also very significant variable in understanding of climate change and its impacts due to extreme weather events. Hence while we investigate the determinants of the migration as a climatic indicator, precipitation is also substantial variable for our analysis. In our model's analysis, as we see in the table, this variable's p value is 0.011. It means that, as the p value is smaller than 0.05, this variable is significant statistically. In this case, it can be asserted that every one unit increase above-average realized in precipitation, can lead to the increase extra 93,775 person to migrate. Important point here is the following, every unit increase in precipitation, above - average, can lead to displacement for the population in that region. Precipitation trend, which covers 1970-2010 is given in Figure 5.5.

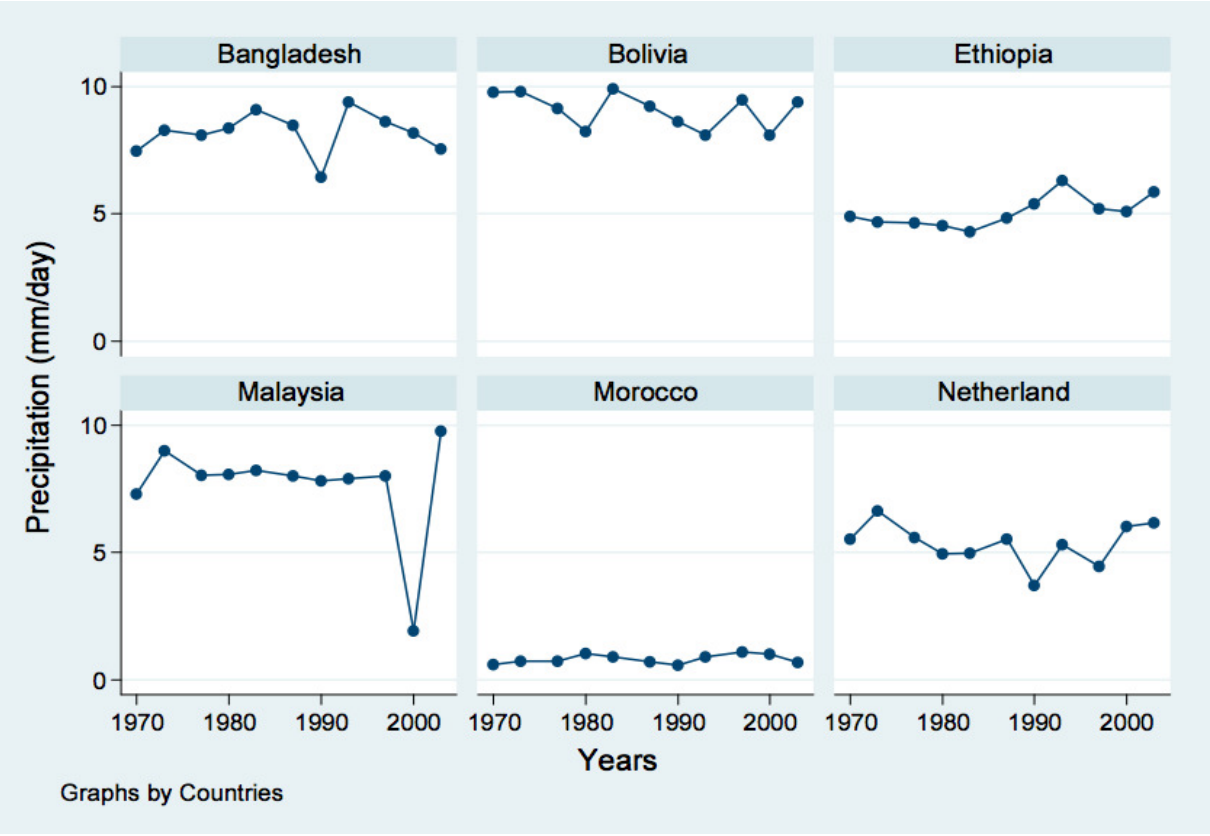

Figure 5.5. Precipitation trend, which covers 1970-2010.

Permanent Cropland Output: One remarkable variable of explanatory variables in the model is the permanent cropland. Permanent cropland data is obtained by land cultivated with crops including flowing shrubs, fruit trees, nut trees, vines and excluding trees grown for wood or timber for long periods in the country. When we look at the relationship between migration and permanent cropland, expected sign should be negative. When the permanent cropland decreases in square kilometer, it means that population size is growing and these areas are not enough to meet people's needs. Accordingly population living in that region will encounter the livelihood problem in many ways including malnutrition. So in this case, it can be asserted that when permanent cropland area decreases, it will cause people to migrate to wealthier regions. In our analysis, as we see in results table, there is a negative relationship between migration and permanent cropland. It's sign is negative. Which is to say in this case, if permanent cropland decreases 1 square kilometer, it might lead to extra 37 persons to migrate. When we look at the trend over the years of permanent cropland for selected countries. As we see in the following table, generally there is a growing trend in the permanent cropland for five countries including Bangladesh, Morocco, Malaysia, Ethiopia and Bolivia. Netherlands has a declining trend over the years in the permanent cropland. In underdeveloped and developing countries including selected five, when the permanent cropland increases, it means that forest and vegetation areas decreases. Because forest and vegetation area have converted to the permanent cropland in order to meet growing population's needs. Clearing forests for agricultural land have disrupted the balance of ecosystem and removed availability of ecosystem services. This is a vital issue to be dealt with. So in fact, it comes to a double-sided effect. If permanent cropland decreases, population does not get enough food to meet their basic needs, because these regions' livelihood is highly depends on the agricultural activities. In this situation, people have to make solution for survive. First solution is to find new permanent cropland and second solution is to migrate to the wealthier regions. This case causes people to migrate, this explains the negative relationship between them. If people prefer to clearing forests and vegetation areas, this is destroying the ecosystem services, it means that no trees no photosynthesis no healthy environment and more CO_2 in the atmosphere.

Table 5.5. Permanent Cropland Trend for decades within 1970-2010.

PERMANENT CROPLAND (square km) and LAND (square km)							
Countries	**1970**	**1980**	**1990**	**2000**	**2010**	**Land**	**% of Land**
Bangladesh	2,600	2,660	3,300	4,200	9,000	130,170	6.9
Bolivia	1,330	1,190	1,550	1,680	2,190	1,083,300	0.2
Ethiopia	7,200	7,150	6,620	7,288	11,417	1,000,000	11.4
Malaysia	35,100	38,000	52,480	57,850	57,580	328,550	17.5
Morocco	4,290	5,000	7,360	8,850	11,588	446,300	2.5
Netherland	430	320	300	340	364	33,730	1

Note: This trend was obtained by using the World Bank data including land and permanent cropland.

Permanent Cropland Trend, which covers 1970-2010 is given in Figure 5.6.

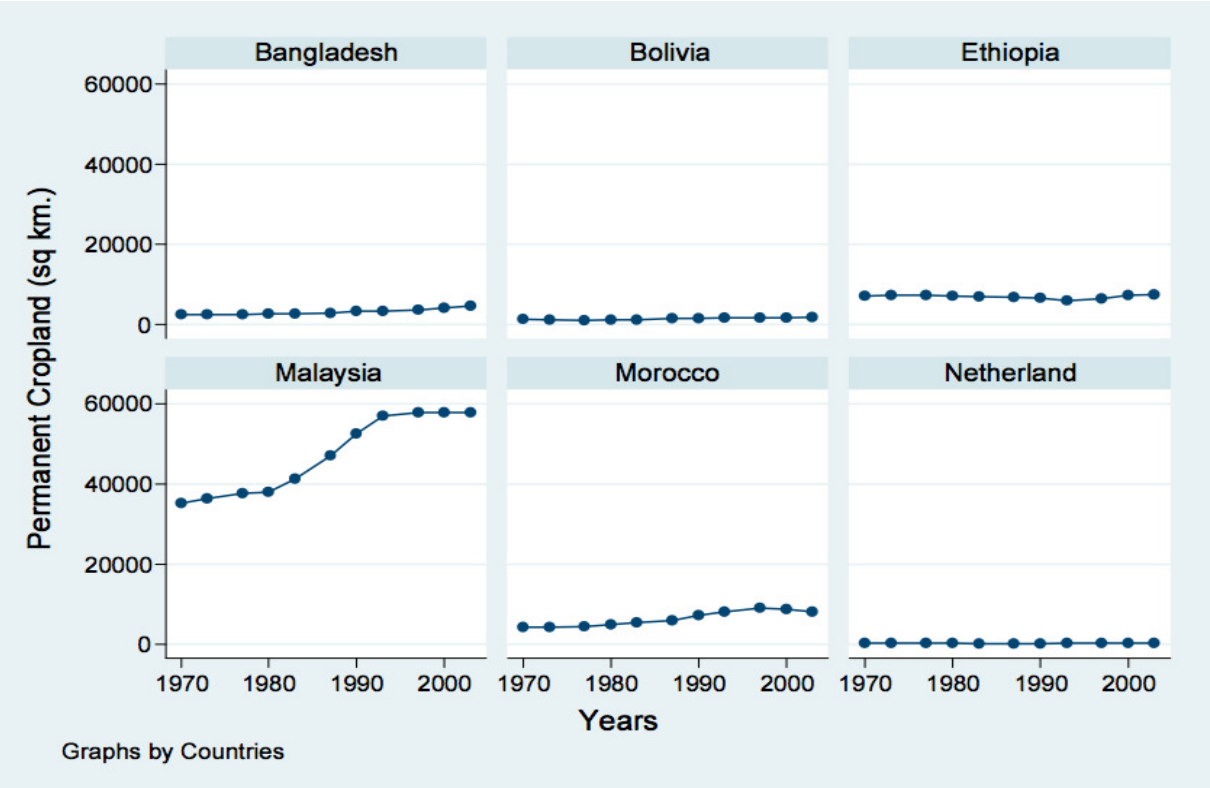

Figure 5.6. Permanent Cropland Trend, which covers 1970-2010.

Fish Capture Output: Another explanatory variable is fish capture. There is strong interaction between fishing and the impacts of climate. Biodiversity of marine ecosystem are more sensitive to an additional stress such as climate change impacts. Extreme climate events such as precipitation change have a significant impact on future fisheries. In addition to that overexploitation depending on rapid population growth is very dangerous for future generations, which will need food resources more than today owing to the climate change impacts. Also we can say that there is negative relationship between fish population and migration due to the climate change impacts. When we look at the fish capture data, if fish capturing increases on average, this means that fish population decreases and this reflects to the migration as an increase. This variable is related with the extreme weather events stemming from climate change and growing population size. According to our model output about this variable, it can be asserted that every additional 100,000 tones of fish capturing, it means an increase additional 131 person in the migration. In other words, a decrease in fish population reflects to the migration as an increase.

Studies conducted in recent years, it is highlighted that high possibility of climate change will affect the regional distribution of fish and the fish productivity. Some of the high-latitude regions, owing to the decrease in ice cover due to warming, depending some climate variables such as El Nino-Southern Oscillation, is expected an increase fish production. On the other hand, in low-latitude regions, a decrease in fish production is expected depending on a reduction of the vertical circulation of the water and a reduction on nutrient chain for the aquaculture population. In this case, the Netherlands, taking part in the higher latitudes, compared to other regions, growing fish production in the future in the Netherlands will be useful and this contributes to its adaptation process and further investment decision. Moreover when we compare the stable structure of fish capture, as we see in following graph, Netherlands and the other selected countries, Netherlands will be affected positively from the fish population. Fish Capture Trend, which covers 1970-2010 is given in Table 5.7.

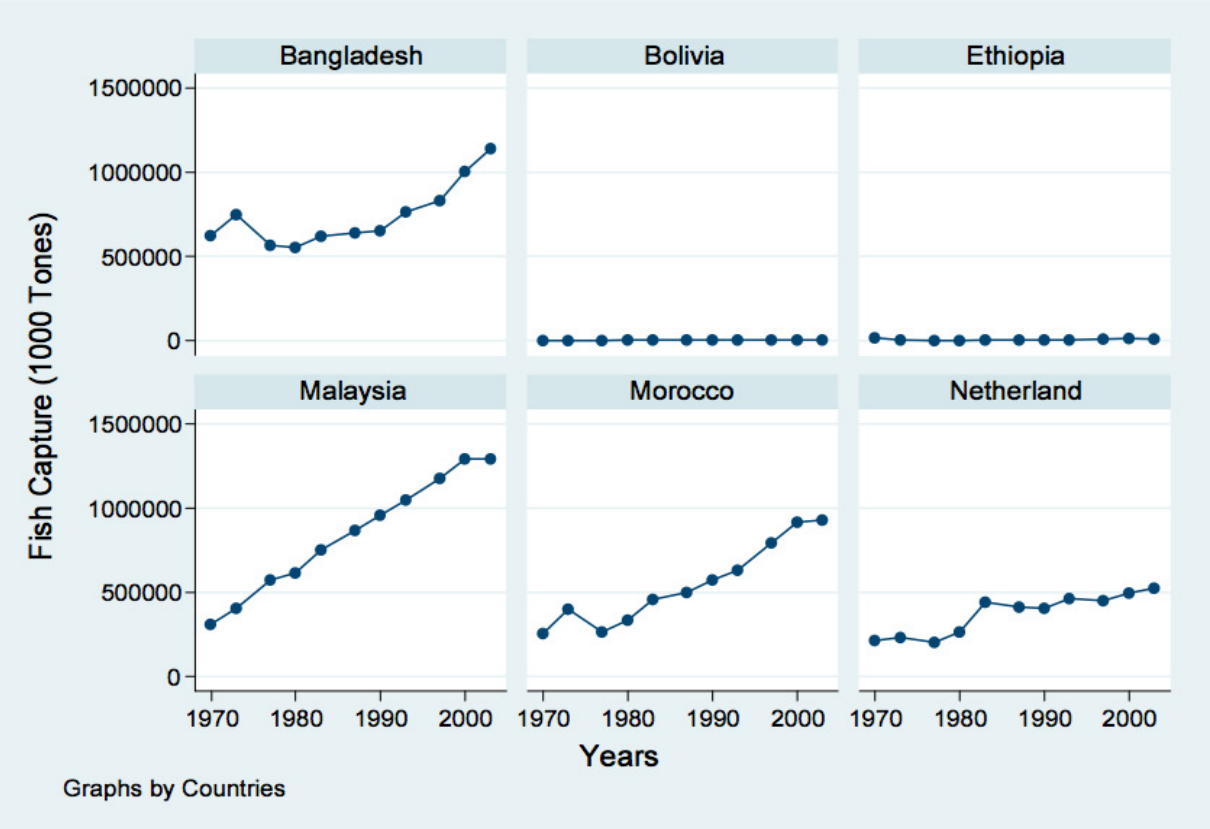

Figure 5.7. Fish Capture Trend, which covers 1970-2010.

Natural Hazard Output: Next variable is the occurrence of natural hazards over the years as a dummy variable. When we look at the relationship between occurrence of the natural hazards due to extreme weather events and migration, there is a positive relationship between them. Natural hazards for this variable is taken into account are drought, flood, storm, epidemics due to flood, extreme temperature, mass movement wet, mass movement dry, wildfire.

If a country has an experience of natural disaster which resulted of death of at least one for that year, it's value will be "1" otherwise it will be "0". This variable in the panel data analysis is not significant statistically, because its p value, 0.778 is bigger than 0.05, but here point is the following, its sign is significant theoretically, meaning that there is a positive relationship between them according to its sign. Here substantial point is that, if

we analyze separately both short term impacts and long term impacts of natural hazards to the migration according to the literature, we can obtain more accurate result for this variable. In the literature, many studies draw attention to the effects of natural hazards to the migration, which is short term, that is tentative.

Coastline Output: 4 countries within selected countries are located in the coastal zone. These are Bangladesh, Morocco, Malaysia and Netherlands. These countries are represented in the model with "1" as the dummy variable. Another 2 countries including Ethiopia and Bolivia are represented in the model with "0" as the dummy variable. Its p value is 0.005 and it is smaller than the 5% significance level meaning statistically significant. If a country is locating in the coastal zone, it means that it leads to an extra 1,174,922 person to migrate depending on the sea level rise and coastal flooding stemming from extreme precipitation. This coefficient can be different according to the countries' different demographic characteristics, for example while Bangladesh's population is 148 million, whereas Netherlands' population is 16 million. When we calculate the population mean of countries which are located in the coastal zone namely Bangladesh, Morocco, Malaysia, Netherlands, it is 38,261,897 (for 44 observations) and when the coefficient 1,174,922 is divided by mean result, we obtained the percentage of 3. In this case, we can say that about the coefficient for different countries, as it is the function of population, 3 percent of population of that country can migrate. It means that according to their current population 480,000 people from Netherlands, 4,440,000 people from Bangladesh, 840,000 people from Malaysia and 960,000 people from Morocco.

The Lack of Our Model

- There is no data availability for migration as dependent variable, so we had to find proxy values for migration data.
- There is no available time series data for panel analysis. We need observation more than 300 for analyzing countries separately. We have just 66 observations, so we

could not analyze countries according to their different characteristics such as GDP, population, etc.

- Panel data analysis is determining a sample value for all countries and it gives a result for average coefficients for each variables. This is a disadvantage for our model, because we cannot interpret countries separately according to their different features. But we can say that panel data analysis does not take arithmetic mean for regression coefficients, it determines a proxy value for all different characteristics. This is important feature of panel data analysis.

Future Works

Under IS1101 COST Action, we will make another side of this work. We examined the determinants of migration in this work. Under COST Action research, we will study future estimates of migration and we will examine sectorial determinants of it. Therefore, we will need precipitation and temperature projections and we will obtain them from the RegCM Modelling (a type of regional climate modelling by ICTP). For example future projections of precipitation and temperature of 3 countries namely Bolivia, and Morocco are shown in Figure 5.8, 5.9, 5.10, and 5.11.

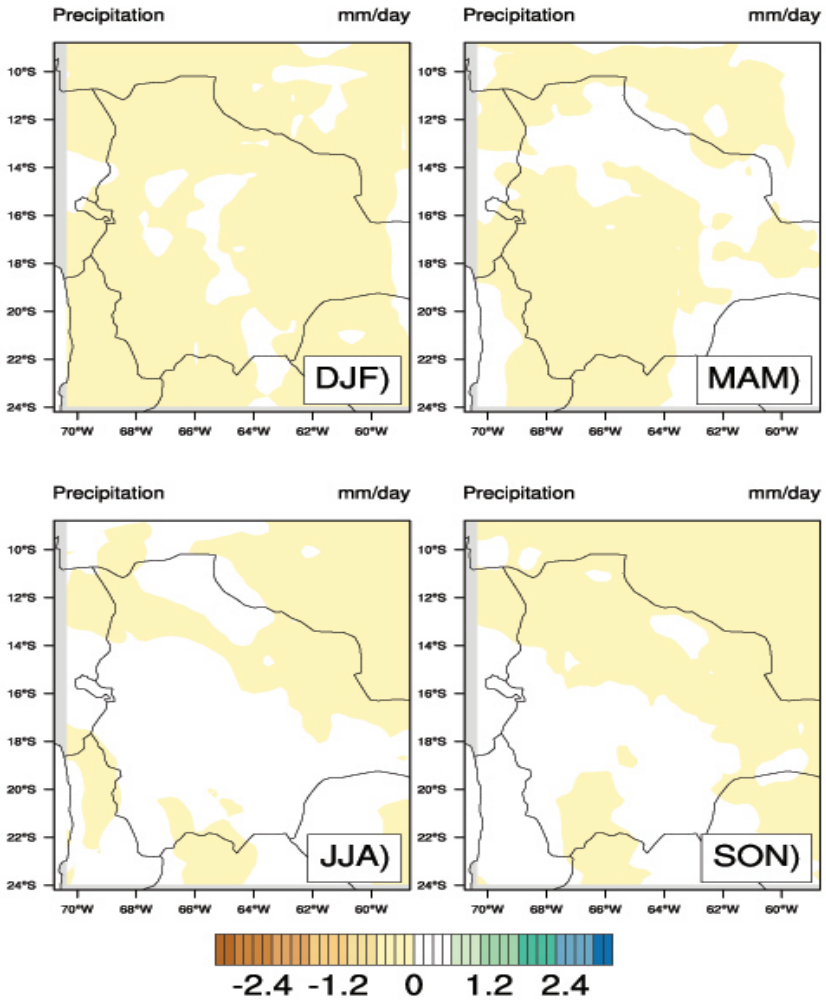

Figure 5.8. Seasonal Average Precipitation projection from RegCM 4.3.5.5 by forcing ECHAM5 A1B scenario data for the period 2020-2050, with respect to reference simulation model ECHAM5 for the period 1970-2000 in Bolivia.

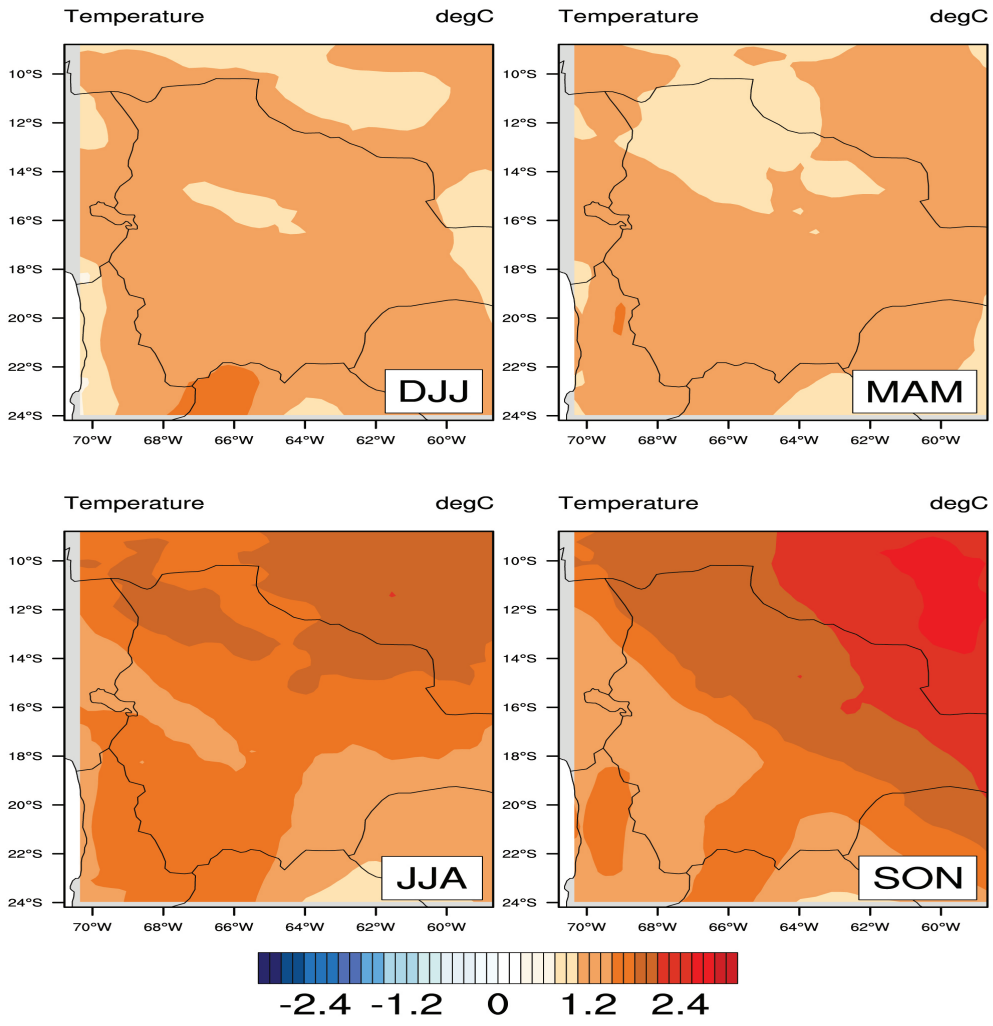

Figure 5.9. Seasonal Average Surface Air Temperature projection from RegCM 4.3.5.5 by forcing ECHAM5 A1B scenario data for the period 2020-2050, with respect to reference simulation model ECHAM5 for the period 1970-2000 in Bolivia.

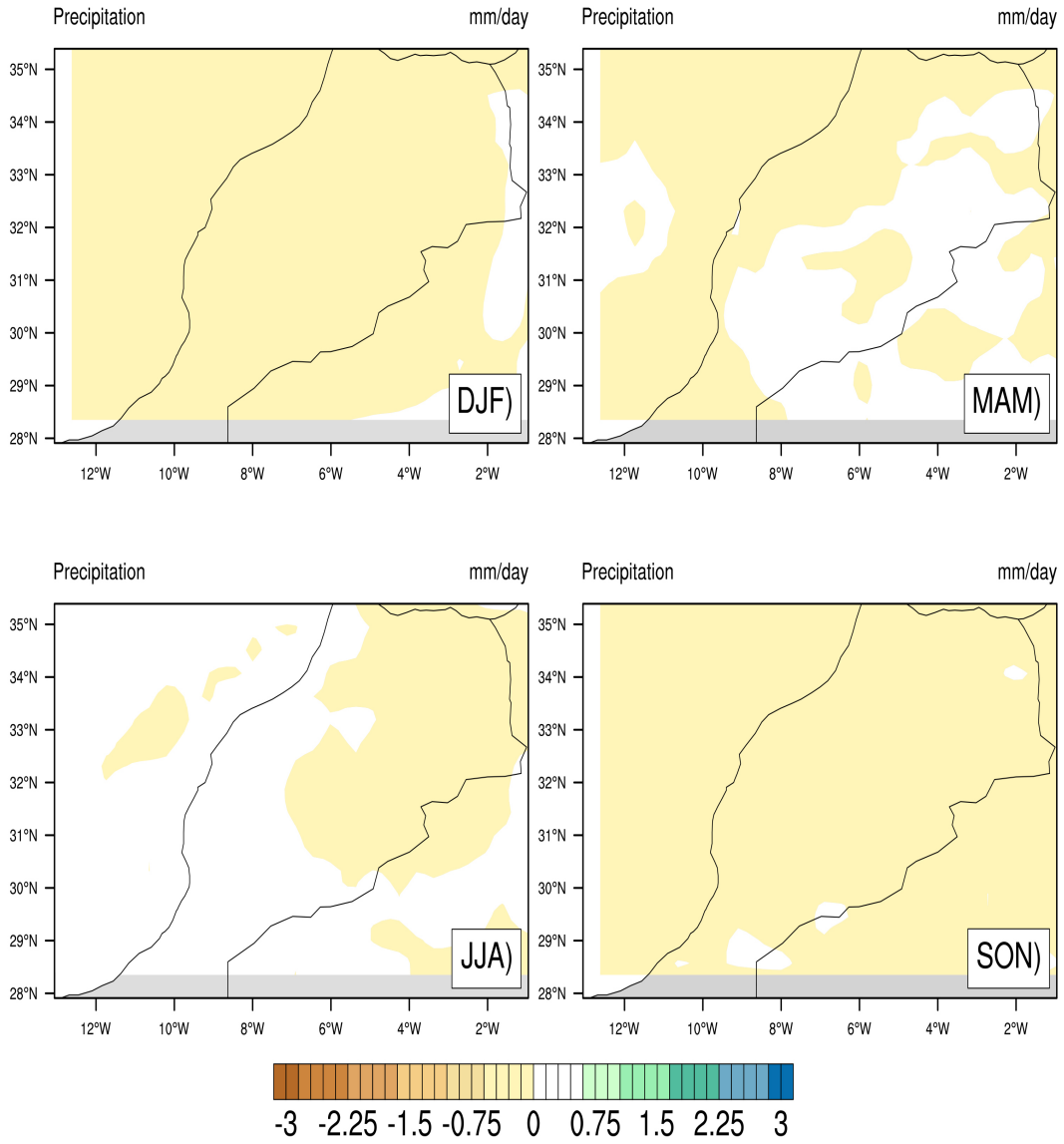

Figure 5.10. Seasonal Average Precipitation projection from RegCM 4.3.5.5 by forcing ECHAM5 A1B scenario data for the period 2020-2050, with respect to reference simulation model ECHAM5 for the period 1970-2000 in Morocco.

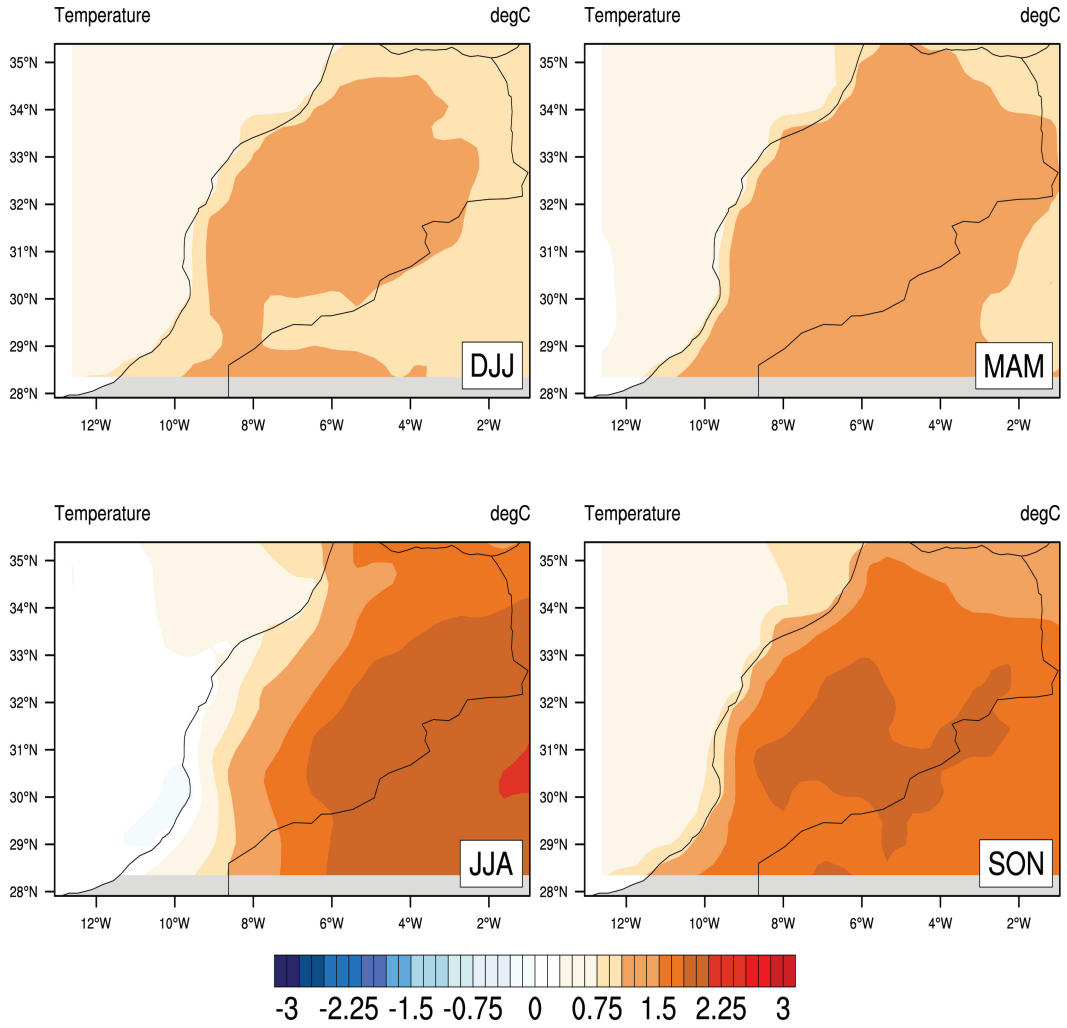

Figure 5.11. Seasonal Average Surface Air Temperature projection from RegCM 4.3.5.5 by forcing ECHAM5 A1B scenario data for the period 2020-2050, with respect to reference simulation model ECHAM5 for the period 1970-2000 in Morocco.

6. CONCLUSION

This thesis examines the potential impacts of economics, demographics and environmental drivers on migration for selected countries and covers the period 1970-2010. Each variable has affected these selected countries in different level. We investigate the role played by geographical, demographic, economic and environmental factors. Among the variables affecting the migration, location of countries (coastal zone location), population, fish capturing, precipitation and natural hazards appear to be of considerable importance. Their effects are positive and significant. Moreover, another variable affecting the migration, permanent cropland has negative effects and also statistically significant. On the other hand, there is no evidence statistically that economic variable GDP per capita and other climatic variable temperature plays a significant role on migration for selected countries. They are theoretically significant in terms of their signs. Firstly, when we compare the effects of variables, it can be asserted that, income and income distribution has a significant impact theoretically on the migration from the selected countries, but this variable has not intensive effect solitarily. Population growth is also important for migration, but again it does not have major impact on migration by itself. To talk about a significant effect on migration, it should be evaluated together with two drivers. Secondly, when we consider the effects of environmental factors including exposure to natural hazards and ecosystem services availability due to extreme weather events stemming from temperature rise and precipitation change, these factors have more intensive effects on migration than others, for example in model result, it is seen to have a much greater impact of countries located at coastal zone. There is no evidence statistically that temperature plays an important role solitarily and it affects the occurrence of natural disasters indirectly, but it can be said that this is merely significant theoretically due to its positive sign. This is also important indicator for explaining the theoretical relationship between migration and temperature. In order to prevent the displacement of people due to the climate change, which is assumed to be experienced in the future, one of the most important measures to be

taken is the investments to be changed sector or field for improving the defense capabilities of the vulnerable regions and reducing the greenhouse gases emissions.

APPENDIX-THE MODEL USED IN THE THESIS

```
. xtunitroot llc migration,trend

Levin-Lin-Chu unit-root test for migration
------------------------------------------------------------------------------
Ho: Panels contain unit roots                Number of panels  =      6
Ha: Panels are stationary                    Number of periods =     11

AR parameter: Common                         Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 7.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t       -14.8232
 Adjusted t*        -13.1745        0.0000
------------------------------------------------------------------------------



------------------------------------------------------------------------------
. xtunitroot llc gdp,trend

Levin-Lin-Chu unit-root test for gdp
------------------------------------------------------------------------------
Ho: Panels contain unit roots                Number of panels  =      6
Ha: Panels are stationary                    Number of periods =     11

AR parameter: Common                         Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 7.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t       -10.1251
 Adjusted t*         -7.4233        0.0000
------------------------------------------------------------------------------



------------------------------------------------------------------------------
. xtunitroot llc temp,trend

Levin-Lin-Chu unit-root test for temp
------------------------------------------------------------------------------
Ho: Panels contain unit roots                Number of panels  =      6
Ha: Panels are stationary                    Number of periods =     11

AR parameter: Common                         Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 7.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -9.4241
 Adjusted t*         -4.3516        0.0000
```

```
------------------------------------------------------------------------------
. xtunitroot llc prec,trend

Levin-Lin-Chu unit-root test for prec
------------------------------------------------------------------------------
Ho: Panels contain unit roots               Number of panels  =      6
Ha: Panels are stationary                   Number of periods =     11

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 7.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -7.3632
 Adjusted t*         -2.8819        0.0020
------------------------------------------------------------------------------



------------------------------------------------------------------------------
. xtunitroot llc cropland,trend

Levin-Lin-Chu unit-root test for cropland
------------------------------------------------------------------------------
Ho: Panels contain unit roots               Number of panels  =      6
Ha: Panels are stationary                   Number of periods =     11

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 7.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -5.7049
 Adjusted t*         -2.8788        0.0020
------------------------------------------------------------------------------



------------------------------------------------------------------------------
. xtunitroot llc fish,trend

Levin-Lin-Chu unit-root test for fish
------------------------------------------------------------------------------
Ho: Panels contain unit roots               Number of panels  =      6
Ha: Panels are stationary                   Number of periods =     11

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 7.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -5.5087
 Adjusted t*         -3.0073        0.0013
------------------------------------------------------------------------------
```

```
------------------------------------------------------------------------------
. xtreg migration gdp population temp prec, fe

Fixed-effects (within) regression               Number of obs      =        66
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.3413                         Obs per group: min =        11
       between = 0.7421                                        avg =      11.0
       overall = 0.6441                                        max =        11

                                                F(4,56)            =      7.25
corr(u_i, Xb)  = 0.0476                         Prob > F           =    0.0001

------------------------------------------------------------------------------
   migration |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |    5.212212   24.65923     0.21   0.833    -44.18617    54.61059
  population |    .0402504   .0075895     5.30   0.000     .0250469    .0554539
        temp |   -68206.94   172349.6    -0.40   0.694    -413464.7    277050.8
        prec |    7798.606   88986.64     0.09   0.930    -170463.1    186060.3
       _cons |     1187619    3454752     0.34   0.732     -5733081     8108319
-------------+----------------------------------------------------------------
     sigma_u |  767820.75
     sigma_e |  690659.28
         rho |  .55275773   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(5, 56) =    12.79                 Prob > F = 0.0000

. estimates store fe01


------------------------------------------------------------------------------
. xtreg migration gdp population temp prec, re

Random-effects GLS regression                   Number of obs      =        66
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.3412                         Obs per group: min =        11
       between = 0.7543                                        avg =      11.0
       overall = 0.6533                                        max =        11

                                                Wald chi2(4)       =     34.38
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
   migration |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |    3.695939   21.93753     0.17   0.866    -39.30083    46.69271
  population |    .0402251   .0069671     5.77   0.000     .0265698    .0538803
        temp |   -49469.29   98874.88    -0.50   0.617    -243260.5    144321.9
        prec |    7554.786   81177.59     0.09   0.926    -151550.4    166659.9
       _cons |    806845.4    2089008     0.39   0.699     -3287535     4901225
-------------+----------------------------------------------------------------
     sigma_u |  1641354.8
     sigma_e |  690659.28
         rho |  .84957369   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store re01
```

```
------------------------------------------------------------------------------
. hausman fe01 re01

Note: the rank of the differenced variance matrix (2) does not equal the
number of coefficients being tested (4); be sure this is what you expect, or
there may be problems computing the test.  Examine the output of your
estimators for anything unexpected and possibly consider scaling your
variables so
        that the coefficients are on a similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      fe01         re01        Difference          S.E.
-------------+----------------------------------------------------------------
         gdp |    5.212212     3.695939        1.516273        11.26155
  population |    .0402504     .0402251        .0000254        .0030098
        temp |   -68206.94    -49469.29       -18737.66        141167.1
        prec |    7798.606     7554.786        243.8198        36452.99
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        0.02
                Prob>chi2 =      0.9910



------------------------------------------------------------------------------

. xtreg migration gdp population temp prec cropland fish, fe

Fixed-effects (within) regression               Number of obs      =        66
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.3741                         Obs per group: min =        11
       between = 0.3574                                        avg =      11.0
       overall = 0.3559                                        max =        11

                                                F(6,54)            =      5.38
corr(u_i, Xb)  = -0.2433                        Prob > F           =    0.0002

------------------------------------------------------------------------------
   migration |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |   18.44836   26.53449     0.70   0.490    -34.75009    71.64681
  population |   .0459238   .0089465     5.13   0.000     .0279871    .0638604
        temp |  -39513.92   171941.2    -0.23   0.819    -384235.3    305207.5
        prec |   9618.725      90846     0.11   0.916    -172516.5      191754
    cropland |   64.34847    39.5428     1.63   0.109    -14.93006     143.627
        fish |  -1.500927   .9605607    -1.56   0.124    -3.426735    .4248815
       _cons |   268882.6    3482720     0.08   0.939     -6713550     7251315
-------------+----------------------------------------------------------------
     sigma_u |    1255026
     sigma_e |  685612.03
         rho |  .77015726   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(5, 54) =     5.15                 Prob > F = 0.0006

. estimates store fe02
```

```
------------------------------------------------------------------------------

. xtreg migration gdp population temp prec cropland fish, re

Random-effects GLS regression                   Number of obs      =        66
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.2036                         Obs per group: min =        11
       between = 0.9797                                        avg =      11.0
       overall = 0.7741                                        max =        11

                                                Wald chi2(6)       =    202.17
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
   migration |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -38.88763   23.66115    -1.64   0.100    -85.26263     7.48737
  population |   .0247629   .0056183     4.41   0.000     .0137511    .0357747
        temp |  -34640.65   44945.83    -0.77   0.441    -122732.9    53451.55
        prec |   73284.57   37595.57     1.95   0.051    -401.4017    146970.5
    cropland |  -34.19327   14.04698    -2.43   0.015    -61.72484   -6.661701
        fish |   2.474898   .4894169     5.06   0.000     1.515659    3.434138
       _cons |   114521.5   842506.9     0.14   0.892     -1536762     1765805
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  685612.03
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store re02



------------------------------------------------------------------------------

. hausman fe02 re02

Note: the rank of the differenced variance matrix (3) does not equal the
number of coefficients being tested (6); be sure this is what you expect, or
there
        may be problems computing the test.  Examine the output of your
estimators for anything unexpected and possibly consider scaling your
variables so
        that the coefficients are on a similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      fe02         re02        Difference          S.E.
-------------+----------------------------------------------------------------
         gdp |    18.44836    -38.88763        57.33599        12.00955
  population |    .0459238     .0247629        .0211609        .0069624
        temp |   -39513.92    -34640.65       -4873.274        165962.8
        prec |    9618.725     73284.57       -63665.84        82701.69
    cropland |    64.34847    -34.19327        98.54174         36.9637
        fish |   -1.500927     2.474898       -3.975825        .8265277
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        9.95
                Prob>chi2 =      0.0190
                (V_b-V_B is not positive definite)
```

```
------------------------------------------------------------------------------
. xtreg migration gdp population temp prec cropland fish hazardd, fe

Fixed-effects (within) regression               Number of obs      =        66
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.3743                         Obs per group: min =        11
       between = 0.3589                                        avg =      11.0
       overall = 0.3572                                        max =        11

                                                F(7,53)            =      4.53
corr(u_i, Xb)  = -0.2419                        Prob > F           =    0.0005

------------------------------------------------------------------------------
   migration |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |   17.29562    28.0724     0.62   0.540    -39.01049    73.60173
  population |   .0459565   .0090321     5.09   0.000     .0278404    .0640726
        temp |  -42295.93   174711.7    -0.24   0.810    -392723.3    308131.4
        prec |   11541.13    92752.7     0.12   0.901    -174497.2    197579.5
    cropland |   64.32117   39.90755     1.61   0.113    -15.72323    144.3656
        fish |   -1.50787   .9707356    -1.55   0.126    -3.454919    .4391793
     hazardd |   34619.66   252967.6     0.14   0.892    -472769.2    542008.5
       _cons |   295313.9    3520103     0.08   0.933     -6765119     7355747
-------------+----------------------------------------------------------------
     sigma_u |  1253048.6
     sigma_e |  691927.59
         rho |  .76633067   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(5, 53) =     5.03                 Prob > F = 0.0008

. estimates store fe03



------------------------------------------------------------------------------

. xtreg migration gdp population temp prec cropland fish hazardd, re

Random-effects GLS regression                   Number of obs      =        66
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.2029                         Obs per group: min =        11
       between = 0.9801                                        avg =      11.0
       overall = 0.7746                                        max =        11

                                                Wald chi2(7)       =    199.27
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
   migration |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -35.43665   25.83167    -1.37   0.170     -86.0658    15.19251
  population |   .0247402   .0056611     4.37   0.000     .0136447    .0358357
        temp |   -25922.6   51790.05    -0.50   0.617    -127429.2    75584.02
        prec |   71435.62   38252.11     1.87   0.062    -3537.137    146408.4
    cropland |  -35.36353   14.54933    -2.43   0.015    -63.87969    -6.84737
        fish |   2.480447   .4933659     5.03   0.000     1.513468    3.447426
     hazardd |  -98124.22   282843.5    -0.35   0.729    -652487.3    456238.9
       _cons |    17201.8   894010.6     0.02   0.985     -1735027     1769430
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  691927.59
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store re03
```

```
------------------------------------------------------------------------------
. hausman fe03 re03

Note: the rank of the differenced variance matrix (4) does not equal the
number of coefficients being tested (7); be sure this is what you expect, or
there may be problems computing the test.  Examine the output of your
estimators for anything unexpected and possibly consider scaling your
variables so that the coefficients are on a similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      fe03         re03        Difference          S.E.
-------------+----------------------------------------------------------------
         gdp |    17.29562    -35.43665        52.73227        10.99019
  population |    .0459565     .0247402        .0212163        .0070378
        temp |   -42295.93     -25922.6       -16373.33        166859.2
        prec |    11541.13     71435.62       -59894.49        84497.57
    cropland |    64.32117    -35.36353        99.68471        37.16086
        fish |    -1.50787     2.480447       -3.988317        .8360129
     hazardd |    34619.66    -98124.22        132743.9               .
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =         6.53
                Prob>chi2 =       0.1631
                (V_b-V_B is not positive definite)



------------------------------------------------------------------------------

. xtreg migration gdp population temp prec cropland fish coastd, fe
note: coastd omitted because of collinearity

Fixed-effects (within) regression               Number of obs      =        66
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.3741                         Obs per group: min =        11
       between = 0.3574                                        avg =      11.0
       overall = 0.3559                                        max =        11

                                                F(6,54)            =      5.38
corr(u_i, Xb)  = -0.2433                        Prob > F           =    0.0002

------------------------------------------------------------------------------
   migration |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |   18.44836   26.53449     0.70   0.490    -34.75009    71.64681
  population |   .0459238   .0089465     5.13   0.000     .0279871    .0638604
        temp |  -39513.92   171941.2    -0.23   0.819    -384235.3    305207.5
        prec |   9618.725      90846     0.11   0.916    -172516.5      191754
    cropland |   64.34847    39.5428     1.63   0.109    -14.93006     143.627
        fish |  -1.500927   .9605607    -1.56   0.124    -3.426735    .4248815
      coastd |           0  (omitted)
       _cons |   268882.6    3482720     0.08   0.939     -6713550     7251315
-------------+----------------------------------------------------------------
     sigma_u |    1255026
     sigma_e |  685612.03
         rho |  .77015726   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(5, 54) =     5.15                 Prob > F = 0.0006

. estimates store fe04
```

```
------------------------------------------------------------------------------
. xtreg migration gdp population temp prec cropland fish coastd, re

Random-effects GLS regression                   Number of obs      =        66
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.2294                         Obs per group: min =        11
       between = 0.9863                                        avg =      11.0
       overall = 0.8013                                        max =        11

                                                Wald chi2(7)       =    233.92
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
   migration |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -30.44601   22.57985    -1.35   0.178     -74.7017    13.80968
  population |    .022738   .0053626     4.24   0.000     .0122276    .0332484
        temp |    18832.9   46553.23     0.40   0.686    -72409.76    110075.6
        prec |   91869.28   36166.55     2.54   0.011     20984.15    162754.4
    cropland |  -38.42087   13.37099    -2.87   0.004    -64.62754    -12.2142
        fish |   1.345923   .6121311     2.20   0.028      .146168    2.545678
      coastd |    1147601   407113.5     2.82   0.005     349673.4     1945529
       _cons |   -1309709   943572.6    -1.39   0.165     -3159077    539659.2
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  685612.03
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store re04



------------------------------------------------------------------------------

. hausman fe04 re04

Note: the rank of the differenced variance matrix (3) does not equal the number
of coefficients being tested (6); be sure this is what you expect, or there may
be problems computing the test.  Examine the output of your estimators for
anything unexpected and possibly consider scaling your variables so that the
coefficients are on a similar scale.

                 ---- Coefficients ----
              |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
              |      fe04         re04        Difference          S.E.
-------------+------------------------------------------------------------
         gdp |    18.44836    -30.44601        48.89437        13.93663
  population |    .0459238      .022738        .0231857        .0071612
        temp |   -39513.92      18832.9       -58346.83        165519.1
        prec |    9618.725     91869.28       -82250.55        83336.53
    cropland |    64.34847    -38.42087        102.7693        37.21356
        fish |   -1.500927     1.345923        -2.84685        .7402516
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       11.12
                Prob>chi2 =      0.0111
                (V_b-V_B is not positive definite)
```

```
------------------------------------------------------------------------------
. xtreg migration gdp population temp prec cropland fish hazardd coastd, fe
note: coastd omitted because of collinearity

Fixed-effects (within) regression               Number of obs      =        66
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.3743                         Obs per group: min =        11
       between = 0.3589                                        avg =      11.0
       overall = 0.3572                                        max =        11

                                                F(7,53)            =      4.53
corr(u_i, Xb)  = -0.2419                        Prob > F           =    0.0005

------------------------------------------------------------------------------
   migration |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |   17.29562    28.0724     0.62   0.540    -39.01049    73.60173
  population |   .0459565   .0090321     5.09   0.000     .0278404    .0640726
        temp |  -42295.93   174711.7    -0.24   0.810    -392723.3    308131.4
        prec |   11541.13    92752.7     0.12   0.901    -174497.2    197579.5
    cropland |   64.32117   39.90755     1.61   0.113    -15.72323    144.3656
        fish |   -1.50787   .9707356    -1.55   0.126    -3.454919    .4391793
     hazardd |   34619.66   252967.6     0.14   0.892    -472769.2    542008.5
      coastd |          0  (omitted)
       _cons |   295313.9    3520103     0.08   0.933     -6765119     7355747
-------------+----------------------------------------------------------------
     sigma_u |  1253048.6
     sigma_e |  691927.59
         rho |  .76633067   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(5, 53) =     5.03                 Prob > F = 0.0008

. estimates store fe05



------------------------------------------------------------------------------
. xtreg migration gdp population temp prec cropland fish hazardd coastd, re

Random-effects GLS regression                   Number of obs      =        66
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.2305                         Obs per group: min =        11
       between = 0.9863                                        avg =      11.0
       overall = 0.8016                                        max =        11

                                                Wald chi2(8)       =    230.28
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
   migration |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -32.97687   24.46122    -1.35   0.178    -80.91998    14.96623
  population |   .0227078   .0054067     4.20   0.000     .0121109    .0333047
        temp |   13204.65   50982.12     0.26   0.796    -86718.46    113127.8
        prec |   93775.38   37076.19     2.53   0.011     21107.37    166443.4
    cropland |  -37.59512   13.79174    -2.73   0.006    -64.62643   -10.56382
        fish |   1.314653    .626898     2.10   0.036     .0859552     2.54335
     hazardd |   77676.28   274997.4     0.28   0.778    -461308.8    616661.4
      coastd |    1174922   421626.7     2.79   0.005       348549     2001295
       _cons |   -1266577   963327.9    -1.31   0.189     -3154665    621511.4
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  691927.59
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store re05
```

```
------------------------------------------------------------------------------
. xtunitroot ips temp,trend

Im-Pesaran-Shin unit-root test for temp
------------------------------------------------------------------------------
Ho: All panels contain unit roots           Number of panels  =      6
Ha: Some panels are stationary              Number of periods =     11

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Included

ADF regressions: No lags included
------------------------------------------------------------------------------
                                               Fixed-N exact critical values
                     Statistic      p-value         1%      5%      10%
------------------------------------------------------------------------------
 t-bar                -3.4689                     -3.030  -2.760  -2.620
 t-tilde-bar          -2.3486
 Z-t-tilde-bar        -3.5660        0.0002
------------------------------------------------------------------------------



------------------------------------------------------------------------------
. xtunitroot ips prec,trend

Im-Pesaran-Shin unit-root test for prec
---------------------------------------
Ho: All panels contain unit roots           Number of panels  =      6
Ha: Some panels are stationary              Number of periods =     11

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Included

ADF regressions: No lags included
------------------------------------------------------------------------------
                                               Fixed-N exact critical values
                     Statistic      p-value         1%      5%      10%
------------------------------------------------------------------------------
 t-bar                -3.2214                     -3.030  -2.760  -2.620
 t-tilde-bar          -2.1732
 Z-t-tilde-bar        -2.9754        0.0015
------------------------------------------------------------------------------



------------------------------------------------------------------------------
. xtunitroot ips cropland,trend

Im-Pesaran-Shin unit-root test for cropland
-------------------------------------------
Ho: All panels contain unit roots           Number of panels  =      6
Ha: Some panels are stationary              Number of periods =     11

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Included

ADF regressions: No lags included
------------------------------------------------------------------------------
                                               Fixed-N exact critical values
                     Statistic      p-value         1%      5%      10%
------------------------------------------------------------------------------
 t-bar                -1.3341                     -3.030  -2.760  -2.620
 t-tilde-bar          -1.1528
 Z-t-tilde-bar         0.4584        0.6767
------------------------------------------------------------------------------
```

```
. xtunitroot ips fish,trend

Im-Pesaran-Shin unit-root test for fish
------------------------------------------------------------------------------
Ho: All panels contain unit roots           Number of panels  =      6
Ha: Some panels are stationary              Number of periods =     11

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Included

ADF regressions: No lags included
------------------------------------------------------------------------------
                                              Fixed-N exact critical values
                     Statistic      p-value         1%      5%      10%
------------------------------------------------------------------------------
 t-bar                -2.4675                     -3.030  -2.760  -2.620
 t-tilde-bar          -1.7843
 Z-t-tilde-bar        -1.6667        0.0478
------------------------------------------------------------------------------
------------------------------------------------------------------------------
. xtreg dmigration gdp population temp prec, fe

Fixed-effects (within) regression               Number of obs      =        60
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.1221                         Obs per group: min =        10
       between = 0.1622                                        avg =      10.0
       overall = 0.0004                                        max =        10

                                                F(4,50)            =      1.74
corr(u_i, Xb)  = -0.9420                        Prob > F           =    0.1564

------------------------------------------------------------------------------
  dmigration |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -2.536227   23.34163    -0.11   0.914    -49.41928    44.34682
  population |  -.0185426   .0071014    -2.61   0.012    -.0328062   -.0042789
        temp |   128934.8   148514.4     0.87   0.389    -169365.1    427234.7
        prec |  -31283.86   76330.16    -0.41   0.684    -184597.5    122029.8
       _cons |   -1696599    2960739    -0.57   0.569     -7643418     4250220
-------------+----------------------------------------------------------------
     sigma_u |  858879.52
     sigma_e |  584141.24
         rho |  .68373106   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(5, 50) =     2.11                 Prob > F = 0.0801

. estimates store fe011
------------------------------------------------------------------------------
. xtreg dmigration gdp population temp prec, re

Random-effects GLS regression                   Number of obs      =        60
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.0922                         Obs per group: min =        10
       between = 0.7140                                        avg =      10.0
       overall = 0.0269                                        max =        10

                                                Wald chi2(4)       =      1.52
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.8232
------------------------------------------------------------------------------
  dmigration |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -.2318963   17.01198    -0.01   0.989    -33.57477    33.11098
  population |   .0020432   .0025412     0.80   0.421    -.0029375    .0070239
        temp |   6579.462   24402.46     0.27   0.787    -41248.47     54407.4
        prec |   6853.752   29346.39     0.23   0.815    -50664.11    64371.61
       _cons |  -125288.9   511396.1    -0.24   0.806     -1127607      877029
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  584141.24
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store re011
```

```
------------------------------------------------------------------------------
. hausman fe011 re011

Note: the rank of the differenced variance matrix (3) does not equal the number
of coefficients being tested (4); be sure this is what you expect, or there may
be problems computing the test.  Examine the output of your estimators for
anything unexpected and possibly consider scaling your variables so that the
coefficients are on a similar scale.

                 ---- Coefficients ----
              |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
              |     fe011        re011       Difference          S.E.
--------------+----------------------------------------------------------------
          gdp |   -2.536227    -.2318963       -2.304331          15.982
   population |   -.0185426     .0020432       -.0205857        .0066312
         temp |    128934.8     6579.462        122355.3        146495.9
         prec |   -31283.86     6853.752       -38137.61        70463.35
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        1.17
                Prob>chi2 =      0.7600



------------------------------------------------------------------------------

. xtreg dmigration gdp population temp prec dcropland fish, fe

Fixed-effects (within) regression               Number of obs      =        60
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.1235                         Obs per group: min =        10
       between = 0.1386                                        avg =      10.0
       overall = 0.0002                                        max =        10

                                                F(6,48)            =      1.13
corr(u_i, Xb)  = -0.9437                        Prob > F           =    0.3610

------------------------------------------------------------------------------
  dmigration |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -4.264485   25.12653    -0.17   0.866    -54.78475    46.25578
  population |   -.019219   .0084093    -2.29   0.027    -.0361272   -.0023109
        temp |   132415.9   152842.4     0.87   0.391    -174894.4    439726.1
        prec |  -26050.22    81015.2    -0.32   0.749    -188942.2    136841.8
   dcropland |  -17.23845    84.9313    -0.20   0.840    -188.0043    153.5274
        fish |   .0981557   .5661611     0.17   0.863    -1.040188    1.236499
       _cons |   -1804573    3049669    -0.59   0.557     -7936344     4327198
-------------+----------------------------------------------------------------
     sigma_u |  874821.54
     sigma_e |  595703.91
         rho |  .68320765   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(5, 48) =     1.95                 Prob > F = 0.1031

. estimates store fe021
```

```
. xtreg dmigration gdp population temp prec dcropland fish, re

Random-effects GLS regression                   Number of obs      =        60
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.0123                         Obs per group: min =        10
       between = 0.8305                                        avg =      10.0
       overall = 0.0343                                        max =        10

                                                Wald chi2(6)       =      1.88
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.9304

------------------------------------------------------------------------------
  dmigration |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -2.147487   19.24386    -0.11   0.911    -39.86476    35.56979
  population |   .0011569   .0029318     0.39   0.693    -.0045893    .0069031
        temp |   7459.424   28650.93     0.26   0.795    -48695.36    63614.21
        prec |   11228.57   31036.38     0.36   0.718    -49601.61    72058.76
   dcropland |  -44.68053    80.9981    -0.55   0.581    -203.4339    114.0728
        fish |    .135536   .2694417     0.50   0.615      -.39256     .663632
       _cons |  -168859.7   561948.8    -0.30   0.764     -1270259    932539.9
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  595703.91
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store re021



. hausman fe021 re021

Note: the rank of the differenced variance matrix (3) does not equal the
number of coefficients being tested (6); be sure this is what you expect, or
there
        may be problems computing the test.  Examine the output of your
estimators for anything unexpected and possibly consider scaling your
variables so
        that the coefficients are on a similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fe021        re021        Difference          S.E.
-------------+----------------------------------------------------------------
         gdp |   -4.264485    -2.147487       -2.116998        16.15599
  population |    -.019219     .0011569       -.0203759        .0078817
        temp |    132415.9     7459.424        124956.5          150133
        prec |   -26050.22     11228.57        -37278.8        74834.52
   dcropland |   -17.23845    -44.68053        27.44208        25.54667
        fish |    .0981557      .135536       -.0373803        .4979353
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        2.54
                Prob>chi2 =      0.4675
                (V_b-V_B is not positive definite)
```

```
. xtreg dmigration gdp population temp prec dcropland fish hazardd, fe

Fixed-effects (within) regression               Number of obs      =        60
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.1241                         Obs per group: min =        10
       between = 0.1378                                        avg =      10.0
       overall = 0.0002                                        max =        10

                                                F(7,47)            =      0.95
corr(u_i, Xb)  = -0.9430                        Prob > F           =    0.4770

------------------------------------------------------------------------------
  dmigration |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -5.766809   26.67762    -0.22   0.830    -59.43525    47.90163
  population |  -.0190959   .0085219    -2.24   0.030    -.0362398   -.0019521
        temp |   129637.4   155149.4     0.84   0.408    -182482.9    441757.6
        prec |  -24856.35   82102.92    -0.30   0.763    -190026.1    140313.4
   dcropland |  -16.68379     85.853    -0.19   0.847    -189.3978    156.0302
        fish |    .074435   .5864496     0.13   0.900    -1.105349    1.254219
     hazardd |   43556.24   237985.3     0.18   0.856    -435208.5      522321
       _cons |   -1775432    3084956    -0.58   0.568     -7981563     4430699
-------------+----------------------------------------------------------------
     sigma_u |  870760.66
     sigma_e |  601793.42
         rho |  .67675655   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(5, 47) =     1.91                 Prob > F = 0.1101

. estimates store fe031



. xtreg dmigration gdp population temp prec dcropland fish hazardd, re

Random-effects GLS regression                   Number of obs      =        60
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.0100                         Obs per group: min =        10
       between = 0.8286                                        avg =      10.0
       overall = 0.0348                                        max =        10

                                                Wald chi2(7)       =      1.88
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.9663

------------------------------------------------------------------------------
  dmigration |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -3.324607   20.51951    -0.16   0.871     -43.5421    36.89289
  population |   .0010639   .0030048     0.35   0.723    -.0048255    .0069533
        temp |   4819.921    32504.5     0.15   0.882    -58887.73    68527.57
        prec |   11675.36    31424.5     0.37   0.710    -49915.52    73266.24
   dcropland |  -41.67205   83.48119    -0.50   0.618    -205.2922    121.9481
        fish |   .1421947   .2745042     0.52   0.604    -.3958236     .680213
     hazardd |   40138.34   225752.5     0.18   0.859    -402328.4    482605.1
       _cons |  -143615.9   584655.5    -0.25   0.806     -1289520     1002288
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  601793.42
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store re031
```

```
------------------------------------------------------------------------------
. hausman fe031 re031

Note: the rank of the differenced variance matrix (4) does not equal the
number of coefficients being tested (7); be sure this is what you expect, or
there may be problems computing the test.  Examine the output of your
estimators for anything unexpected and possibly consider scaling your
variables so that the coefficients are on a similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fe031        re031        Difference          S.E.
-------------+----------------------------------------------------------------
         gdp |   -5.766809    -3.324607       -2.442202        17.04832
  population |   -.0190959     .0010639       -.0201598        .0079746
        temp |    129637.4     4819.921        124817.4        151706.2
        prec |   -24856.35     11675.36       -36531.71         75851.1
   dcropland |   -16.68379    -41.67205        24.98825        20.04066
        fish |     .074435     .1421947       -.0677596        .5182379
     hazardd |    43556.24     40138.34        3417.895        75318.21
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =    -0.03    chi2<0 ==> model fitted on these
                                        data fails to meet the asymptotic
                                        assumptions of the Hausman test;
                                        see suest for a generalized test


------------------------------------------------------------------------------

. xtreg dmigration gdp population temp prec dcropland fish coastd, fe
note: coastd omitted because of collinearity

Fixed-effects (within) regression               Number of obs      =        60
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.1235                         Obs per group: min =        10
       between = 0.1386                                        avg =      10.0
       overall = 0.0002                                        max =        10

                                                F(6,48)            =      1.13
corr(u_i, Xb)  = -0.9437                        Prob > F           =    0.3610

------------------------------------------------------------------------------
  dmigration |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -4.264485   25.12653    -0.17   0.866    -54.78475    46.25578
  population |   -.019219   .0084093    -2.29   0.027    -.0361272   -.0023109
        temp |   132415.9   152842.4     0.87   0.391    -174894.4    439726.1
        prec |  -26050.22    81015.2    -0.32   0.749    -188942.2    136841.8
   dcropland |  -17.23845    84.9313    -0.20   0.840    -188.0043    153.5274
        fish |   .0981557   .5661611     0.17   0.863    -1.040188    1.236499
      coastd |           0  (omitted)
       _cons |   -1804573    3049669    -0.59   0.557     -7936344     4327198
-------------+----------------------------------------------------------------
     sigma_u |  874821.54
     sigma_e |  595703.91
         rho |  .68320765   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(5, 48) =     1.95                 Prob > F = 0.1031

. estimates store fe041
```

```
------------------------------------------------------------------------------
. xtreg dmigration gdp population temp prec dcropland fish coastd, re

Random-effects GLS regression                   Number of obs      =        60
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.0146                         Obs per group: min =        10
       between = 0.8797                                        avg =      10.0
       overall = 0.0802                                        max =        10

                                                Wald chi2(7)       =      4.53
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.7167

------------------------------------------------------------------------------
  dmigration |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |   1.687449   19.10905     0.09   0.930    -35.76561    39.14051
  population |   .0001316   .0029578     0.04   0.965    -.0056657    .0059288
        temp |   35737.72   33238.05     1.08   0.282    -29407.67    100883.1
        prec |    19599.2   31017.06     0.63   0.527    -41193.12    80391.52
   dcropland |  -77.47166   82.35774    -0.94   0.347    -238.8899    83.94655
        fish |  -.4904381   .4704809    -1.04   0.297    -1.412564    .4316875
      coastd |   616659.7   382649.3     1.61   0.107    -133319.2     1366639
       _cons |    -904630     717632    -1.26   0.207     -2311163      501903
-------------+----------------------------------------------------------------
     sigma_u |           0
     sigma_e |  595703.91
         rho |           0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store re041



------------------------------------------------------------------------------
. hausman fe041 re041

Note: the rank of the differenced variance matrix (3) does not equal the
number of coefficients being tested (6); be sure this is what you expect, or
there
        may be problems computing the test.  Examine the output of your
estimators for anything unexpected and possibly consider scaling your
variables so
        that the coefficients are on a similar scale.

                ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fe041        re041        Difference          S.E.
-------------+----------------------------------------------------------------
         gdp |   -4.264485     1.687449       -5.951935        16.31522
  population |    -.019219     .0001316       -.0193506         .007872
        temp |    132415.9     35737.72        96678.15        149184.6
        prec |   -26050.22      19599.2       -45649.42        74842.53
   dcropland |   -17.23845    -77.47166        60.23321        20.74915
        fish |    .0981557    -.4904381        .5885938        .3149383
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        6.82
                Prob>chi2 =      0.0778
                (V_b-V_B is not positive definite)
```

```
------------------------------------------------------------------------------
. xtreg dmigration gdp population temp prec dcropland fish hazardd coastd, fe
note: coastd omitted because of collinearity

Fixed-effects (within) regression               Number of obs      =        60
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.1241                         Obs per group: min =        10
       between = 0.1378                                        avg =      10.0
       overall = 0.0002                                        max =        10

                                                F(7,47)            =      0.95
corr(u_i, Xb)  = -0.9430                        Prob > F           =    0.4770

------------------------------------------------------------------------------
  dmigration |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |  -5.766809   26.67762    -0.22   0.830    -59.43525    47.90163
  population |  -.0190959   .0085219    -2.24   0.030    -.0362398   -.0019521
        temp |   129637.4   155149.4     0.84   0.408    -182482.9    441757.6
        prec |  -24856.35   82102.92    -0.30   0.763    -190026.1    140313.4
   dcropland |  -16.68379     85.853    -0.19   0.847    -189.3978    156.0302
        fish |    .074435   .5864496     0.13   0.900    -1.105349    1.254219
     hazardd |   43556.24   237985.3     0.18   0.856    -435208.5      522321
      coastd |          0  (omitted)
       _cons |   -1775432    3084956    -0.58   0.568     -7981563     4430699
-------------+----------------------------------------------------------------
     sigma_u |  870760.66
     sigma_e |  601793.42
         rho |  .67675655   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(5, 47) =     1.91                 Prob > F = 0.1101

. estimates store fe051



------------------------------------------------------------------------------
. xtreg dmigration gdp population temp prec dcropland fish hazardd coastd, re

Random-effects GLS regression                   Number of obs      =        60
Group variable: countr                          Number of groups   =         6

R-sq:  within  = 0.0215                         Obs per group: min =        10
       between = 0.9106                                        avg =      10.0
       overall = 0.0898                                        max =        10

                                                Wald chi2(8)       =      5.03
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.7539

------------------------------------------------------------------------------
  dmigration |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |   -2.75789   20.12322    -0.14   0.891    -42.19867    36.68289
  population |  -.0004261   .0030662    -0.14   0.889    -.0064358    .0055836
        temp |   28828.21    34682.5     0.83   0.406    -39148.24    96804.67
        prec |   22813.62   31459.99     0.73   0.468    -38846.83    84474.08
   dcropland |  -69.68327   83.39885    -0.84   0.403     -233.142    93.77547
        fish |  -.5592071   .4817339    -1.16   0.246    -1.503388    .3849741
     hazardd |   171903.8   233741.6     0.74   0.462    -286221.3      630029
      coastd |   712498.8   405840.7     1.76   0.079    -82934.43     1507932
       _cons |  -910867.3   720871.2    -1.26   0.206     -2323749    502014.2
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  601793.42
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store re051
```

```
. hausman fe051 re051

Note: the rank of the differenced variance matrix (4) does not equal the
number of coefficients being tested (7); be sure this is what you expect, or
there
        may be problems computing the test.  Examine the output of your
estimators for anything unexpected and possibly consider scaling your
variables so
        that the coefficients are on a similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-
V_B))
             |     fe051        re051        Difference          S.E.
-------------+----------------------------------------------------------------
--
         gdp |   -5.766809     -2.75789        -3.00892        17.51432
  population |   -.0190959    -.0004261       -.0186698        .0079512
        temp |    129637.4     28828.21        100809.1        151223.2
        prec |   -24856.35     22813.62       -47669.97        75836.39
   dcropland |   -16.68379    -69.68327        52.99947        20.38063
        fish |     .074435    -.5592071        .6336421        .3344481
     hazardd |    43556.24     171903.8       -128347.6        44742.34
------------------------------------------------------------------------------
--
                           b = consistent under Ho and Ha; obtained from
xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from
xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        5.20
                Prob>chi2 =      0.2675
                (V_b-V_B is not positive definite)
```

REFERENCES

1. IPCC First Assesment Report: Climate Change 1990, May, 2013, `http://www.ipcc.ch/publicationsdata/publications/ipcc/firstassessment/1990wg1.shtml`.

2. Hatton, T. J. and J. G. Williamson, "What Fundamentals Drive World Migration?" *NBER Working Paper Series*, Vol. w9159, 2002.

3. Boko, M., A. Niang, Nyong, C., Vogel, A., Githeko, M., Medany, B., Osman-Elasha, R., Tabo, and O., Yanda, "Africa Climate Change 2007: Impacts, adaption and vulnerability", *Forth Assessment Report of the Intergovernmental Panel on Climate Change* ,Cambridge University Press, 2007.

4. Davis, J.C. and J.V. Henderson., "Evidence on the Political Economy of the Urbanization Process". *Journal of Urban Economics*, Vol. 53, pp. 98-125, 2003.

5. Black, R., Kniveton, D., Skeldon, R., Coppard, D., Murata, A., and Schmidt-Verkerk, K., "Demographics and Climate Change: Future Trends and their Policy Implications for Migration". *Development Research Centre on Migration, Globalization and Poverty*, Working Paper T-27, University of Sussex, Brighton, UK, 2008.

6. Barrios, S., L., Bertinelli, and Strobl, E., "Climatic change and rural-urban migration: The case of sub-Saharan Africa". *Journal of Urban Economics*, Vol. 60, No. 3, pp. 357-371, 2006.

7. Dell, M., B. F. Jones and B. A. Olken, "Climate Change and Economic Growth: Evidence from the Last Half Century". *NBER Working Paper Series*, Vol. w14132, 2008.

8. Myers N., "Environmental Refugees: An Emergent Security Issue", Green College, *13th Economic Forum*, Oxford University, UK, 2005.

9. Castles S., "Migration and Community Formation under Conditions of Globalization", The Center for Migration Studies of New York, *The Center for Migration Studies of New York*, Vol. 36, No. 4, 2002.

10. Atifi, T. and K., Warner.,"The Impact of Environmental Degradation on Migration Flows across Countries", *Working Paper , UNU-EHS, Bonn*, No. 5/2008, 2008.

11. Naud'e W.,Conflict, "Disasters and No Jobs: Reasons for International Migration in sub-Saharan Africa", *UNU-WIDER, Research Paper* ,No. 2008/85, 2008.

12. Docquier F., Lindsay B., Marfouk A.,"A Gendered Assessment of Highly Skilled Emigration", , 2009.

13. Dell, M., B. F. Jones and B. A. Olken,"Temperature and Income: Reconciling New Cross-Sectional and Panel Estimates", *American Economic Review* , Vol. 99, pp. 198-204, 2009.

14. Mayda, A. M.,"International migration: A panel data analysis of the determinants of bilateral", *Journal of Population Economics* , 2010.

15. Allan M. Findlay, "Migrant destinations in an era of environmental change", *Global Environmental Change* , Vol. 21, pp. 50-58, 2011.

16. Natural Disasters by country, May, 2013, `www.emdat.be/country-profile.`

17. Francois Gemenne, "Why the numbers don't add up: A review of estimates and predictions of people displaced by environmental changes", *Global Environmental Change*

, Vol. 21, pp. 41-49 , 2011.

18. Michael P. Todaro, John R. Harris, "Migration Unemployment and Development: A Two Sector Analysis", 1970.

19. Helene Bie Lilleor and Katleen Van den Broeck, "Economic drivers of migration and climate change in LDCs", *Global Environmental Change*, Vol. 21, pp. 70-81, 2011.

20. Karen C. Seto, "Exploring the dynamics of migration to mega-delta cities in Asia and Africa: Contemporary drivers and future scenarios", *Global Environmental Change*, Vol. 21, pp. 94-107, 2011.

21. Clionadh Raleigh, "The search for safety: The effects of conflict, poverty and ecological influences on migration in the developing world", *Global Environmental Change* , Vol. 21, pp. 82-93, 2011.

22. Graeme Hugo, "Future demographic change and its interactions with migration and climate change", *Global Environmental Change*, Vol. 21, pp. 21-33, 2011.

23. Robert A. McLeman, "Settlement abandonment in the context of global environmental change", Factors as Determinants of International Migration, *Global Environmental Change*, JEL Classification: Vol. F22, 2012.

24. Richard Black, W. Neil Adger, Nigel W. Arnell, Stefan Dercon, Andrew Geddes and David S.G. Thomas, "The effect of environmental change on human migration", *Global Environmental Change* , Vol. 21, pp. 3-11, 2011.

25. Clark L. Gray and Valerie Mueller, "Natural disasters and population mobility in Bangladesh", *PNAS* , Vol. 109, April 17, 2012.

26. Michel Beine and Christopher Parsons, "Climatic Factors as Determinants of International Migration", *Global Environmental Change*, JEL Classification: Vol. F22, No. 15, 2012.

27. World Bank : The Little Data Book, Washington, DC: World Bank, 2006a.

28. International Labour Office : "Global Employment Trends Model", Geneva: ILO, 2005.

29. N. Stern, "The Economics of Climate Changes", Cambridge University Press, 2007.

30. World Health Organization, "Malnutrition: Quantifying the health impacts at national and local levels", Environmental burden of diseases series, Washington DC: WHO, No. 12, 2005.

31. United Nations, *"The Millennium Development Goals Report"*, 2005, `http://millenniumindicators.un.org/unsd/mi/pdf/MD %20.`

32. Adaptation Process, May, 2013, `http://unfccc.int/adaptation/nairobi/workprogramme/knowledge/resources/publications/items/5447.php.`

33. Emergencies, May, 2013, `http://www.christianaid.org.uk/images/human-tide.pdf.`

34. G. McGrahanan, D.Balk, B.Anderson, "The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones". *Environment and Urbanization* , pp.17-37 , 2007.

35. Roy, J., "The economics of climate change: a review of studies in the context of South Asia with a special focus on India", Report prepared for the Stern Review, 2006,

http://www.sternreview.org.uk., http://econ.worldbank.org.

36. Poverty and economic Growth, May, 2013, http://econ.worldbank.org.

37. World Bank, "Global Poverty Monitoring Database", Washington DC: World Bank, 2003c.

38. J. Hougton, "Global Warming", Third Edition, 2004.

39. World's Greenhouse Gases, May, 2013, http://unfccc.int/national/reports/ items/ 1408.php/UNFCCC National Reports Web page.

40. Fergus, A.H.T. & Rowney, J.I.A.,"Sustainable Development: Lost Meaning and Opportunity", pp. 17 , 2005.

41. Climate Change Impacts on World' s Species, May, 2013, http://www.worldwatch.org.

42. Grabowski, R., "Economic Development : A Regional, Institutional, and Historical Approach", *Armonk, NY, USA: M.E. Sharpe Inc.*, pp. 5-6, 2007.

43. World Bank, "Economic Growth Database", Washington DC: World Bank, April, 2013.

44. Economics for Development, April, 2013, www.economics4development.com.

45. Adelman, Irma & Yeldan, E. : "Is this the end of economic development?". *Structural Change and Economic Dynamics* , pp. 11, 2000.

46. A. G. Frank, "The Development of Underdevelopment", Development: Critical Concepts in the Social Sciences, 2005.

47. Todaro,M. & Smith,S., "Economic Development", *8.Edition* , pp. 46 , 2003.

48. Migration and Cimate Change, 2004, http://www.iom.int/cms/en/sites/iom /home/ about-migration/facts--figures-1.html.

49. International Monetary Fund: "Fund assistance for countries facing exogenous shocks". Prepared by the Policy Development and Review Department (In consultation with the Area, Finance, and Fiscal Affairs Departments), *Washington, DC: IMF* , 2003.

50. Warren, R., N. Arnell, Nicholls, R., "Understanding the regional impacts of climate change", Research report prepared for the Stern Review, Norwich, UK, *Tyndall Centre Working Paper*, pp. 90, 2006, http://www.tyndall.ac.uk/publications/workingpapers/working/papers. shtml.

51. FAO World Agriculture Report, 2003, http://www.fao.org/docrep/004/ y3557e/ y3557e00.htm.

52. World Health Organization "Susceptibility of Plasmodium falciparum to antimalarial drugs- report on global monitoring 1996-2004", Geneva: World Health Organization. , 2005.

53. Ali, A. "Vulnerability of Bangladesh coastal region to climate change with adaptation options" : Dhaka: Bangladesh Space Research and Remote Sensing Organization (SPARRSO), 2000, http://www.survas.mdx.ac.uk/pdfs/3anwaral.pdf.

54. Nordhaus, W.D., "The economics of hurricanes in the United States, Prepared for Snowmass Workshop on Abrupt Climate Change", *Snowmass: Annual Meetings of the American Economic Association*, 2006, http://nordhaus.econ.yale.edu/hurricanes.pdf.

55. Thomas, C.D., A. Cameron, Green, R.E., "Extinction risk from climate change", *Nature 427* pp. 145-148, 2004a.

56. Leemans, R. and B. Eickhout,"Another reason for concern: regional and global impacts on ecosystems for different levels of climate change". *Global and Environmental Change 14*, pp. 219-228, 2004.

57. Third Assessment Report of the IPCC,"The baseline-climate-change scenario", , 2001.

58. Malcolm, J.R., C.R. Liu, R.P, Neilson, et al.,"Global warming and extinctions of endemic species from biodiversity hotspots", *Conservation Biology*, Vol. 20, pp. 538-548, 2006.

59. IPCC Fourt Assesment Report: Climate Change 2007, May, 2013, `http://www.ipcc.ch/publicationsdata/publications/ipccfourthassessment report/wg2report/impacts/adaptation/andvulnerability.htm.`

60. Programa Nacional de Cambios Climaticos Componente Salud et al., Chapter 8, 2000.

61. World Bank Country Notes on Climate Change Aspects in Agriculture, 24 May, 2010, `http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/LACEXT.`

62. Ministry of Water Resources and National Meteorological Agency [MWR & NMA]. Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change, 2001, `http:// unfccc.int/resource/docs/natc/ethnc1.pdf.`

63. Hilary H.,Echeverr, D., Parry, J.Ellen, "Review of Current and Planned Adaptation Action: East Africa", *Adaptation Partnership / International Institute for Sustainable Development* , 2011.

64. Ministry of Science, Technology and the Environment [MSTE]. *Malaysia Initial National Communication. Kuala Lumpur: Ministry of Science, Technology and Environment* , 2000.

65. Ministry of Natural Resources and Environment [MRRE].) *Malaysia Second National Communication to the UNFCCC. Malaysia: Ministry of Natural Resources and Environment* , 2011.

66. Gass, Philip; Hove, Hilary; Parry, Jo-Ellen. "Review of Current and Planned Adaptation Action: East and Southeast Asia", *Adaptation Partnership / International Institute for Sustainable Development* , 2011.

67. Initiation workshop Preparation of the Second National Communications from NAI Parties Tbilisi, 26-28 October, 2005.

68. Tamis et al., "Changes in vascular plant biodiversity in the Netherlands in the 20th century explained by climatic and other environmental characteristics", 2001.

69. Classification of Countries, April, 2013, `http://data.worldbank.org/about/country-classifications`.

70. Population Projections, May, 2013, `www.esa.un.org/wpp`.

71. Environmental Change, May, 2013, `http://populationaction.org/wpcontent/uploads/2012/01/climatemigration.pdf`.

72. Water Scarcity and Water Stress Projections, May, 2013, `http://unep.org/dewa/vitalwater/article141.html Worldbank.org`.

73. Irrigation, May, 2013, `http://water.worldbank.org/sites/water.worldbank`.

org/ files/FS23/Kazakhstan.pdf.

74. Land Use Projections, May, 2013, http://www.cleanwateractioncouncil.org/issues/resource-issues/population.

75. Land Use and Vegetation and Forest Land Degredation and Extinction of Species, 1997, World Conversation Union Report.

76. Population Growth and Environment, May, 2013, http://populationaction.org/wp-content/uploads/2012/01/climatemigration.pdf.

77. Environmental Conditions and Growing Poverty, May, 2013, http://www.fao.org/hunger/en

78. Undernourished People, May, 2013, http://www.fao.org/docrep/004/y3557e/y3557e03.htm.

79. Greenee, Wiiliam H., "Econometric Analysis", 5th Ed., pp. 293, 2003.

80. Baltagi, Badi, "Econometric Analysis of Panel Data", *UK: John Wiley & Sons Ltd. Third edition*, pp. 20, New York: Prentice Hall, 2005.