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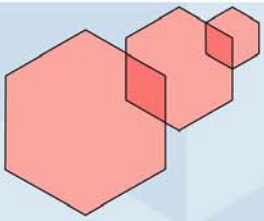

The Impact of Environmental Degradation on Migration Flows across Countries

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´When it got warmer, the Romans migrated to the North till they reached the British Islands. When it got colder, the Germanics migrated southwards from Scandinavia. The Vikings settled down in Greenland, only after it got warmer, and left it, only when the coldness came back´- Gerald Traufetter – der Spiegel 07.04.07.

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1. Introduction

Literature investigating forced migration focuses traditionally on factors such as hunger, poverty, war and violation of human rights. More recently, the question has arisen whether environmental degradation such as soil degradation, lack of water, environmental hazards, and other may contribute to forced migration. The concept has been vaguely described as “environmental refugees,” “environmental migrants,” “climate refugees” etc.

There are documented cases where rapid-onset natural hazards such as the 2004 tsunami in the Indian Ocean or the 2005 impact of Hurricane Katrina on the New Orleans area of the United States. It is estimated that up to 1.5 million people fled the New Orleans area, and today only an estimated 500,000 have returned, with the net outward emigration remaining at about 1 million people due to the 2005 hurricane and the ensuing flooding. For less dramatic events, however, it could generally be said that few people actually “flee” from the environment. Rather, deteriorating environmental conditions can so compromise livelihoods that people may be forced to migrate to sustain themselves. For example, a farmer who flees due to the degradation of his land, does that because there are no more livelihood alternatives available in his habitat, which means that s/he flees from poverty. A person who leaves her/his country/region due to ethnic conflicts that are mainly caused by ecological problems actually flees from war and violence (Biermann, 2001). A woman who abandons her job and makes her children sacrifice a certain level of education to accompany her husband who had to leave the country after a hurricane damaged his working area migrates for social reasons. Therefore, it is not surprising that a ‘standard environmental migrant’ runs a number of ‘parallel lives’. What is also not surprising is the difficulty of establishing the

relationship between the environment and migration, given the complex pathways that induce people to move. Little empirical research has occurred to establish the correlation between factors of environmental degradation and international migration.[1]

This paper is concerned with detecting the impact of environmental degradation on migration. Through a gravity regression model, the paper assesses the impact of thirteen global environmental factors on the migration flows across 172 countries of the world. After a general and brief overview of environmental degradation and migration and the current debates in the topic area, the paper discusses the use of the gravity model to explore the above mentioned impact. Finally, the gravity model is applied and the results are demonstrated.

A unique aspect of this paper is the fact that - to the knowledge to the authors - it is the first to include environmental variables in a gravity model, in addition to different economic, political, social, historical and cultural indicators, and relate all these factors to global human migration.

2. What Influences the Migration Decision?

This section reviews literature which lays the justification for the selection of the variables for the gravity model introduced below. In the 1880s migration research started to be considered through *Ernest George Ravenstein*, a demographer who published two articles in the 'Journal of The Royal Statistical Society' about the so-called 'Laws of Migration'. He connected 'migration' with the natural disposition of human beings to improve their material living conditions. Accordingly, the existence of places with different levels of development and different wage levels were from his point of view an incentive for the so called 'surplus population' in the places with low salary levels to migrate to places with higher salary levels (Ravenstein, 1889). In addition, the idea of the 'push' and 'pull' factors that influence migration decisions can be referred to *Ravenstein*. These factors can be economic, social, political, and environmental/ecological. Nevertheless, an important limitation of *Ravenstein's* work was that he overlooked the migration cost factor that might influence the decision, in addition to the chances of finding job opportunities in the receiving countries. Later, *Becker* (1964) involved the individual characteristics in migration calculations; he found out that 'risk-lovers' are more likely to migrate than 'risk-averse' individuals, and concluded hereby that potential migrants could no longer be considered a homogeneous group.

[1] The European Commission 6th Framework program has established the Environmental change and forced migration scenarios Project (EACH-FOR) to explore these issues. This paper is written as a contribution to EACH-FOR, with appreciation of the financial support of the EC FP 6 (PRIORITY [8.1] - Policy-oriented research) of the European Commission.

The migration theories of the 1980s and 1990s introduced the factor 'information costs' (Castles and Mill, 1998) as well as the term 'household' (Stark and Levhari, 1982). Information about the receiving countries, either through relatives, friends or other sorts of networking is an important factor that influences the migration decision. Moreover, the migration decision is usually not made by one individual but by the entire household, according to all the needs of the latter. Other community factors could also play an important role in this decision (Grote et al., 2006). The two factors 'violence' and 'insecurity' were introduced by *Engel and Ibanez* (2001) as important push factors in the sending countries. It is important to consider geographic factors as well, such as the distance between the places of origin and places of destination. Furthermore, when talking about international migration, it might be important to know whether the countries are landlocked or island countries, and whether there are common boarders between these countries. Unemployment could also be an important factor that impacts the migration decision, as well as cultural variables, including common languages and common history. These variables are included in the modeling approach introduced below.

3. Environmental Migration

In a report released by the UN Environment Program (UNEP), *El-Hinnawi* (1985) defined the environmental migrants as "those people who have been forced to leave their traditional habitat, temporarily or permanently, because of a marked environmental disruption….that jeopardized their existence and/or seriously affected the quality of their life".

Numbers and figures about environmental migrants worldwide differ depending on the definitions and hypotheses. UNEP former head, Klaus Töpfer, talks of 22-24 million environmental migrants (Biermann, 2001), whereas *Myers* (2005) reports 'at least' 25 millions in 1995 based on IPCC estimates of sea level rise scenarios at that time. Myers noted that the migration impacts would be felt especially in the African Southern Sahara, China, Central America and South Asia. Myers even expects the number to reach around 50 millions by the year 2010. Myers compares these 25 million environmental refugees to 27 million 'traditional' refugees (people fleeing political oppression, religious persecution and ethnic troubles).

Other international documents, such as the Declaration on Environment and Development of the 1992 Earth Summit in Rio de Janeiro, do not mention 'environmental migrants'. Agenda 21 of the Summit refers to the word only one time in the frame of the Sub-program for

droughts and desertification. The number of the environmental migrants in the 'law of nations' is not specified (Biermann, 2001).

The Geneva Refugee Convention of 1951 does not identify environmental degradation as a cause for flight and therefore does not offer migrants protection if their reason for leaving is some environmental degradation. As long as these migrants do not fulfill the criteria of the Convention, they do not qualify as "refugees," i.e. as long as they are not classified as people leaving their habitat due to their race, religion, nationality, membership of a social grouping and/or political opinion. By this definition, the Convention excludes intra-country migrants among which environmental migrants occur more often as compared to cross-border migration (UNHCR, 2006).

Regional agreements for protecting refugees in Africa and Latin America are more detailed and comprehensive than the Geneva Convention and include further categories of refugees. However, they still do not identify environmental degradation as a flight cause.

The 1949 established United Nations High Commissioner for Refugees (UNHCR) considers the problem of 'environmental migrants' as a minor issue, since environmentally vulnerable people usually enjoy the protection of their governments, and can therefore not be defined as 'refugees' in the strict sense of the refugee right.

Although UNHCR established an 'environment fund' and introduced an 'environment coordinator' in the early 1990s, the rationale was to prevent the ecological consequences of mass flight and not vice versa. Therefore, many informed authors avoid using the term 'environmental refugees' and rather talk of 'environmental migrants', in order not to weaken the status of the political refugees.

4. The Debate about Environmental Migration

The purpose of this paper is not to detail the debate about environmental migration, which was been done in previous papers[2]. Therefore, we discuss the issue only as a background for our modeling.

Myers (1997) talks of hundreds of millions of environmental migrants by arguing that people simply cannot find an alternative for protection anywhere else, no matter how their attempts

[2] See for example Renaud et al. (2007) and Castles (2001).

to escape to new places would be risky[3]. However, *Castles* (2002), also supporting *Black* (1998), disagrees on such 'horror scenarios'. He claims that migration is not the main strategy of such people; when their livelihoods worsen, they tend to move from one place to the other within the same region. They rarely cross the country borders. For example, the sea level rise in Bangladesh was not a sudden phenomenon. Therefore, he believes that some parts will be protected by dams and the others will have to be abandoned, but the majority of the people will stay in the country, and only the minority will leave for India.

According to *Traufetter* (2007), a focal point is the reaction of different governments to natural catastrophes. After the earthquake in Kobe, Japan most of the 300 000 displaced people returned back a few months after the incidence, whereas it took years for people to return after the Pinatubo Volcano in the Philippines. In addition to the loss of livelihoods and income opportunities, a second reason for 'environmental out-migration' is the fear that the impacted area may experience more natural disasters in the near future. While some people do not return after a disaster, the fear of disasters does not prevent some migrants from returning to their homes (Mileti, 1999).

The reaction of governments does not only depend on the financial resources available. Institutional management, including control of corruption, risk communication among different demographic groups, and aid assistance policies affect out-migration after a natural hazard event. The widely-discussed performance of the U.S. evacuation effort during and after Hurricane Katrina may have contributed to specific sections of the population not being able to resettle in their homes in the post-hurricane period (Renaud et al. 2007). For example, public housing in which many welfare-dependent African American families lived were deemed unfit for dwelling, yet the inhabitants were not offered local housing alternatives following the hurricane and moved elsewhere (Laska 2007). Disasters can also attract inward migration, as in the case of the tornado of 2004 in North-central Bangladesh. *Paul* (2005) found that emergency aid can compensate in monetary terms for damage caused by disasters.

Thomas Faist (2007) warns of statements concerning environmental migration that are 'too sharp'. He agrees that climate change is a considerable problem for the future. However, Faist notes that people leave their habitats due to ethnic, economic and political problems, and that climate acts more as a catalyst than a powerful causal force. Faist also expects that most of the people affected by environmental change are the poor, and therefore, are less

[3] Myers comes up with similar idea in Myers, Norman (2005).

likely to have the means to migrate across regions, rather than travel long, costly, and possibly dangerous international distances.

Turning attention now away from these debates, the paper uses the available macro level global data on migration and environmental degradation, in order to establish or negate an empirical link between migration and environmental degradation. To transform this debate into a quantitative analysis based on real data and numbers, we attempt to discover whether there is a direct impact of environmental degradation in one country on the migration flow out of this country by running a gravity regression model as will be shown in the following section.

5. The Gravity Model

The gravity model is aimed at formalizing, studying and predicting geography of flows or interactions. The gravity model can be used to estimate traffic flows, trade flows and migration flows. It can also be used to determine the sphere of influence of each central place. An example of this can be the point at which customers find it preferable, because of distance, time and expense considerations, to travel to one centre rather than the other. The distribution of interactions in a set of places depends on their configuration, i.e. the force of attraction of each one and the difficulty of communication between them. The model has first been formulated in analogy with ‘Newton’s Law of Universal Gravitation’ that states that "two objects attract one another in direct proportion of their masses and in inverse proportion of the distance separating them". In the same way, in a relatively homogeneous circulation space, exchanges between two regions or two cities will be all the more important that the weight of these cities or regions is consequent and all the lower that they are distant from each other.

The law holds that the attractive force between two objects *i* and *j* is given by:

$$F_{ij} = G\frac{M_i M_j}{D^2_{ij}}$$

where F_{ij} is the attraction force, Mi and Mj are the masses, D_{ij} is the distance between the two objects and G is the gravitational constant depending on the units of measurements for mass and force.

The multiplicative nature of the gravity equation means that we can take natural logs and obtain a linear relationship between flows and the logged country sizes and distances as follows:

ln (Fij) = α1 ln (Mi) + α2 ln (Mj) – θ ln (Dij) + εij

where F_{ij} is measured as flows between countries, M is usually the GDP of each location. Thus M can also be related with population, D_{ij} is the distance between the locations measured from centre to centre.

When applied to a wide variety of goods and factors moving over regional and national borders under differing circumstances, the gravity model usually produces a good fit (Anderson and Wincoop, 2003).

The gravity model has been used successfully to estimate flows in trade between countries. This study applies the gravity model to estimate a kind of flow - migrants - between countries[4]. In the following section, we briefly demonstrate the most important studies that used this model.

[4] One of the first studies that relied on the gravity model in the empirical literature was the one run by Tinbergen (1962) and Pöyhönen (1963). In fact, they ran the first econometric studies of trade flows based on the gravity equation, for which they gave some intuitive justifications. Linnemann (1966) added more variables and went further towards a theoretical justification in terms of a Walrasian general equilibrium system, but the Walrasian model tends to include too many explanatory variables for each trade flow to be easily reduced to the gravity equation. Leamer and Stern (1970) followed Savage and Deutsch (1960) in deriving this equation from a probability model of transactions. They applied their approach on trade. Leamer (1974) also used the gravity equation to motivate explanatory variables in a regression analysis of trade flows. These contributions were followed by several attempts to derive the gravity equation from models that assumed product differentiation. For example, Anderson (1979) was the first to do so, assuming Cobb-Douglas preferences. Jeffrey Bergstrand has explored the theoretical determination of bilateral trade in a series of papers. For example, in Bergstrand (1985) he derived a reduced form equation for bilateral trade involving price indices. Helpman (1987) used a correspondence between the gravity equation and the monopolistic competition model as the basis for his empirical work, i.e., he interpreted the close fit of the gravity equation with bilateral data on trade as supportive empirical evidence for monopolistic competition. Helpman applied his test to data on trade of the Organization for Economic Co-operation and Development (OECD) countries, where most would agree that monopolistic competition is possibly present. Hummels and Levinson (1995) decided to attempt a sort of negative test of the same proposition by looking for the same relationship in the trade among a larger variety of countries, including those where monopolistic competition is less visible. Anderson and Marcouiller (2002), de Groot et al. (2004) and Jansen and Nordas (2004) observed a positive and robust relation between the quality of institutions and countries' openness to trade as measured by their trade flows. In a study that examines the influence of political, economic and demographic factors on the size and composition of migration flows to North America, Karemera et al. (2000) modify, specify and adjust a gravity model to include all these factors.

6. The Rationale of the Gravity Model Used in the Paper

The gravity model has been used as a tool to analyze international trade patterns in past decades. This modeling approach has long been recognized as a successful tool in describing bilateral patterns empirically. The gravity model is a useful tool to assess the major migration interactions between any two countries, but also to indicate where anomalies lie. That is, the gravity model helps investigate what part of the observed migration pattern is *not fully explained* by established factors; variables such as GDP and distance between countries explain a large part, but not all, of the migration pattern.

6.1 Established Factors

In general terms, we assume that the less the GDP per capita in the sending countries, the more its people would be willing to immigrate to other countries to improve their livelihoods. At the same time, we expect the GDP per capita in the receiving countries to have a positive impact on the migration flows, since it would mean a pull factor or 'attraction for the emigrants. This goes hand in hand with *Ravenstein's* 'surplus population' concept mentioned above. Therefore, we expect the GDP per capita coefficient in the sending countries to have a negative sign and the GDP per capita coefficient in the receiving countries to have a positive sign. However, the GDP per capita in the sending countries is tricky, since richness indicated by a high GDP per capita could in itself be a means for people to leave their countries and to migrate to other countries where there are other pull factors than money [5]. Therefore, this variable can have an ambiguous effect on migration.

Typically, distance between countries is expected to be a hindrance for migrating from one country to the other. There are two kinds of distance measures: simple distances, for which only one city is necessary to calculate international distances; and weighted distances, for which we need data on the principal cities in each country. The simple distances are calculated following the great circle formula, which uses latitudes and longitudes of the most important city (in terms of population) or of the official capital. These two variables incorporate internal distances based on areas provided in the *CEPII* (2005)[6]. The weighted distance measure - which is used in this paper - uses city-level data to assess the geographic distribution of population inside each nation. The idea is to calculate distance between two countries based on bilateral distances between the largest cities of those two

[5] See for example Grote et al. (2006).

[6] Centre D'Etudes Prospectives Et D'Informations Internationales - CEPII (2005).

countries, those inter-city distances being weighted by the share of the city in the overall country's population. This procedure can be used in a totally consistent way for both internal and international distances[7].

Push factors in the sending countries, such as unemployment and the number of ethnic groups - which we take as an indicator for potential political conflicts - should have a positive impact on the migration flows. Theoretically, one would expect that being a citizen of a landlocked country would hinder migration (negative impact), whereas belonging to an island country would facilitate this process. Factors such as contiguity between two countries, common spoken and official languages, having a past colonial relationship, being colonized by the same colonizer, and being one country at a certain time of history are expected to have a positive impact on the movement of people across these countries. Through the regression, we examine the impact of the environmental factors on the migration flows, which is the main purpose of this paper.

6.2 Exploring other Factors (Environmental Variables)

This paper uses the gravity model approach to explore that unexplained portion of the migration pattern. For this paper, the hypothesis is that this unexplained part of the migration pattern is caused by documented environmental degradation. As this paper aims to examine the impact of environmental degradation on migration across international borders, the gravity model provides an innovative application.

The dependent variable of the regression is the migration flows between the different countries pair wise. The set of independent variables are 13 established indicators of environmental degradation. The main concern is estimating the coefficients of the environmental variables and detecting their sign and significance in the model. We add the basic independent variables of the gravity model: GDP for the pair countries and the geographic distance between them are used as control variables. Most of the authors mentioned above agree on the fact that it is difficult to establish the direct causality between environmental change and migration, and most authors agree that other factors - social, political, economic - are typically considered the strongest "push factors" [8] in migrant-sending countries. We control for these push factors by adding other complementary variables such as unemployment rate, and the number of ethnic groups as an indicator for potential political

[7] The latitudes, longitudes and population data of main agglomerations of all the countries included in the analysis and calculations of CEPII are available in the World Gazetteer Website.

[8] Examples for push and pull factors can be found in Bogardi and Renaud (2006)

conflicts and disorders in the sending countries of migrants. Other independent variables that influence migration flows between the different countries are included in the model. These are geographic, cultural and historical factors such as border contingency among the countries pair wise, common official language, common spoken language, and being colonized by a common colonizer, having a colonial relationship, and being a same country[9] at a certain time of history.

6.3 Introducing the Equation: Two Sets of Variables

In the following we set up an equation combining the two sets of variables – established factors and hypothesized factors, including environmental degradation. We then use this equation to test the hypothesis that environmental variables impact some part of the migration pattern.

The model includes 172 countries, one dependent variable (pairwise international migration), and 26 independent variables are 26 including 13 environmental variables. The model consists of 29756 observations.

The regression takes the following form:

$$log\_migr\_st = \alpha + \beta\ log\_gdp\_snd + \gamma\ log\_gdp\_rcv + \sigma\ log\_distwces + \delta\ log\_unempl\_snd + \eta\ log\_eth\_grps\_snd + \theta\ log\_lndl\_snd + \lambda\ log\_isl\_snd + \mu\ log\_contig + \nu\ log\_comlang\_off + \omega\ log\_comlang\_ethno + \rho\ log\_colony + \pi\ log\_comcol + \vartheta\ log\_smctry + \kappa 1\ log\_overfish + \kappa 2\ log\_earthqu + \kappa 3\ log\_tsun + \kappa 4\ log\_flood + \kappa 5\ log\_hurric + \kappa 6\ log\_desert + \kappa 7\ log\_pot\_wat + \kappa 8\ log\_soil\_sal + \kappa 9\ log\_defor + \kappa 10\ log\_sea\_l\_r + \kappa 11\ log\_air\_pol + \kappa 12\ log\_soil\_eros + \kappa 13\ log\_soil\_pol + \varepsilon$$

where:
migr_st is the migration flow between two countries
gdp_snd is the GDP per capita in the sending country
gdp_rcv is the GDP per capita in the receiving country
distwces is the distance between the two countries
unempl_snd is the unemployment rate in the sending country
eth_grps_snd is the number of ethnic groups in the sending country
lndl_snd is a dummy for the sending country being landlocked

[9] For example, Jordan, Lebanon, Palestine and Syria used to be considered one country called 'Bilad-Esham' before certain political divisions by Arab rulers took place.

isl_snd is a dummy for the sending country being an island

contig is a dummy for common borders between the sending and receiving country

comlang_off is a dummy for (a) common official language(s) between the sending and receiving country

comlang_ethno is a dummy for (a) common spoken language(s) between the sending and receiving country

colony is a dummy for a previous colonial relationship between the sending and receiving country[10]

comcol is a dummy for a common past colonizer of the sending and receiving country

smctry is a dummy for the sending and receiving countries being one country at any time of history

overfish is a dummy for the occurrence of over-fishing in the sending country

earthqu is a dummy for the occurrence of earthquakes in the sending country

tsun is a dummy for the occurrence of tsunamis in the sending country

flood is a dummy for the occurrence of floods in the sending country

hurric is a dummy for the occurrence of hurricanes in the sending country

desert is a dummy for the occurrence of desertification in the sending country

pot_wat is a dummy for the occurrence of lack of potable water in the sending country

soil_sal is a dummy for the occurrence of soil salinity in the sending country

defor is a dummy for the occurrence of deforestation in the sending country

sea_l_r is a dummy for the occurrence of sea level rise in the sending country

air_pol is a dummy for the occurrence of air pollution in the sending country

soil_eros is a dummy for the occurrence of soil erosion in the sending country

soil_pol is a dummy for the occurrence of soil pollution in the sending country

α is the constant term

β , γ , σ , δ , η , θ, λ, μ, ν, ω, ρ, π, ə, κ1… κ13 are the coefficients of the independent variables

ε is the error term.

[10] This variable shows whether one of the two countries was colonized by the other at any time of history.

7.1. Hypothesis and Assumptions

This paper hypothesizes that environmental degradation has a positive impact on migration, i.e. the occurrence of environmental problems in one country would lead to more people leaving their home and looking for other countries to settle down. The hypothesis is based on the literature that supports this idea and calls for more future research on the topic 'environmental migration'. Therefore, the paper expects to find a positive impact of environmental degradation on migration in the modeling approach used.

7.2. Data

The global data base of the Development Research Centre on Migration, Globalisation and Poverty (Migration DRC) consists of a 226x226 matrix of origin-destination stocks by country and economy. The data are generated by disaggregating the information on migrant stock in each destination country or economy as given in its census. The reference period is the 2000 round of population censuses, so the data do not refer to precisely the same time period. The data represent stocks rather than population flows in a strict sense but are, for international migration, the equivalent of "lifetime migration" in studies of internal migration.

Additionally, where data on "country of birth" totals were missing, the authors entered United Nations data. The authors used entropy measure to compare nationality and country of birth shares. Having confirmed that the series were highly correlated, the authors used the additional information content in the nationality matrix to supplement the foreign-born matrix with additional coefficients of interest. The authors disaggregated the remaining categories based on countries' propensity to send migrants abroad and used shares based on countries' propensity to send migrants abroad to fill all remaining bilateral coefficients. Countries included in this update where no data were previously available include China, Indonesia, Democratic People's Republic of Korea, Morocco, Algeria, Yemen Countries that had nationality data used to supplement the FB matrix include Japan, Philippines, Thailand, Vietnam, Italy, Mozambique.

7.3. The Results

Before running the regression, the correlation between the environmental factors was detected, in order to avoid the problem of endogenous independent variables in the model. The results are shown in table (1).

Table 1

Correlation Coefficients Between the Different Environmental Variables

	overfish	earthqu	tsun	flood	hurric	desert	pot_ wat	soil_ sal	defor	sea_l_r	air_ pol	soil_ eros	soil_ pol
overfish	1.0000	……	……	……	……	……	……	……	……	……	……	……	……
earthqu	-0.1005	1.0000	……	……	……	……	……	……	……	……	……	……	……
tsun	-0.0714	0.3255	1.0000	……	……	……	……	……	……	……	……	……	……
flood	-0.0207	0.1099	0.0349	1.0000	……	……	……	……	……	……	……	……	……
hurric	0.0862	-0.007	0.1466	-0.143	1.0000	……	……	……	……	……	……	……	……
desert	0.0304	-0.051	0.0549	-0.126	-0.082	1.0000	……	……	……	……	……	……	……
pot_wat	0.2524	-0.027	0.0890	-0.002	-0.008	0.1958	1.0000	……	……	……	……	……	……
	overfish	earthqu	tsun	flood	hurric	desert	pot_ wat	soil_ sal	defor	sea_l_r	air_ pol	soil_ eros	soil_ pol
Soil_sal	0.0726	0.0831	-0.044	-0.010	-0.065	0.0912	0.0193	1.0000	……	……	……	……	……
defor	0.1039	0.1147	0.1034	0.1435	0.0336	0.0412	-0.005	-0.172	1.0000	……	……	……	……
sea_l_r	0.0208	0.0426	0.1631	-0.050	0.1191	0.1213	0.0391	-0.014	-0.069	1.0000	……	……	……
air_pol	0.0830	0.0527	0.1167	0.1073	-0.071	-0.093	0.1267	-0.089	0.0558	0.0936	1.0000	……	……
soil_eros	0.0524	0.0340	-0.018	-0.056	-0.008	0.2514	0.0384	-0.069	0.3234	0.1060	-0.163	1.0000	……
soil_pol	0.0085	-0.092	-0.071	0.0203	-0.037	-0.082	-0.016	0.0658	-0.049	-0.022	0.0813	-0.159	1.0000

From the table it seems that there is no real correlation between the different environmental variables used in the regressions. The regression results in turn are shown in table (2).

Table 2

The Impact of Cultural, Political, Geographic and Environmental Factors on Migration Flows Across Countries

Source	*SS*	*df*	*MS*
Model	149060.164	26	5733.08322
Residual	136055.818	29729	4.57653529
Total	285115.982 29755	29755	9.58212003

Number of obs = 29756
F(26, 29729) = 1252.71
Prob > F = 0.0000
R-squared = 0.5228
Adj R-squared = 0.5224
Root MSE = 2.1393

log_migr_st	*Coef.*	*Std. Err.*	*t*	*P>|t|*	*[95% Conf.*	*Interval]*
log_gdp_snd	.4767321	.0068116	69.99	0.000	.463381	.4900832
log_gdp_rcv	.571421	.0047716	119.76	0.000	.5620685	.5807735
log_distwces	-.3840757	.0105698	-36.34	0.000	-.404793	-.3633585
log_unempl	.1445718	.014807	9.76	0.000	.1155494	.1735943
log_eth_grps	.072116	.0213475	3.38	0.001	.0302739	.1139581
log_lndl	-.0906215	.0928394	-0.98	0.329	-.2725906	.0913477
log_isl	-.1123437	.0893118	-1.26	0.208	-.2873986	.0627113
log_contig	6.370566	.2669732	23.86	0.000	5.847287	6.893845
log_comlan_off	.8606873	.1675603	5.14	0.000	.5322618	1.189113
log_comlan_ethno	1.970925	.162702	12.11	0.000	1.652022	2.289828
log_colony	5.882625	.2855163	20.60	0.000	5.323	6.442249
log_comcol	.5722701	.1126712	5.08	0.000	.3514297	.7931105
log_smctry	3.30404	.3835437	8.61	0.000	2.552277	4.055802
log_overfish	.548661	.1309796	4.19	0.000	.2919352	.8053867
log_earthqu	.4346097	.072518	5.99	0.000	.2924712	.5767481
log_tsun	.3964188	.1409338	2.81	0.005	.6726553	.1201824
log_flood	.1269831	.0708324	1.79	0.073	-.0118515	.2658178
log_hurric	.6633578	.0739554	8.97	0.000	.518402	.8083135
log_desert	.3023922	.0819841	3.69	0.000	.4630847	.1416998
log_pot_wat	.6687008	.0861606	7.76	0.000	.4998222	.8375794
log_soil_sal	.6562985	.1787346	3.67	0.000	.3059709	1.006626
log_defor	.4992765	.0679991	7.34	0.000	.3659952	.6325577
log_sea_l_r	1.7379	.4276085	4.06	0.000	.8997683	2.576031
log_air_pol	.9783325	.0806143	12.14	0.000	.8203249	1.13634
log_soil_eros	.664975	.0742909	8.95	0.000	.5193616	.8105885
log_soil_pol	1.356702	.1270344	10.68	0.000	1.107709	1.605695
_cons	-38.39872	.5619546	-68.33	0.000	-39.50018	-37.29727

The GDP per capita coefficients in the sending as well as the receiving countries have a positive sign at a five percent level, which indicates the positive relationship between the richness of the two countries and the migration flows between them. The GDP per capita in the sending countries having a positive impact on migration goes in contrast with

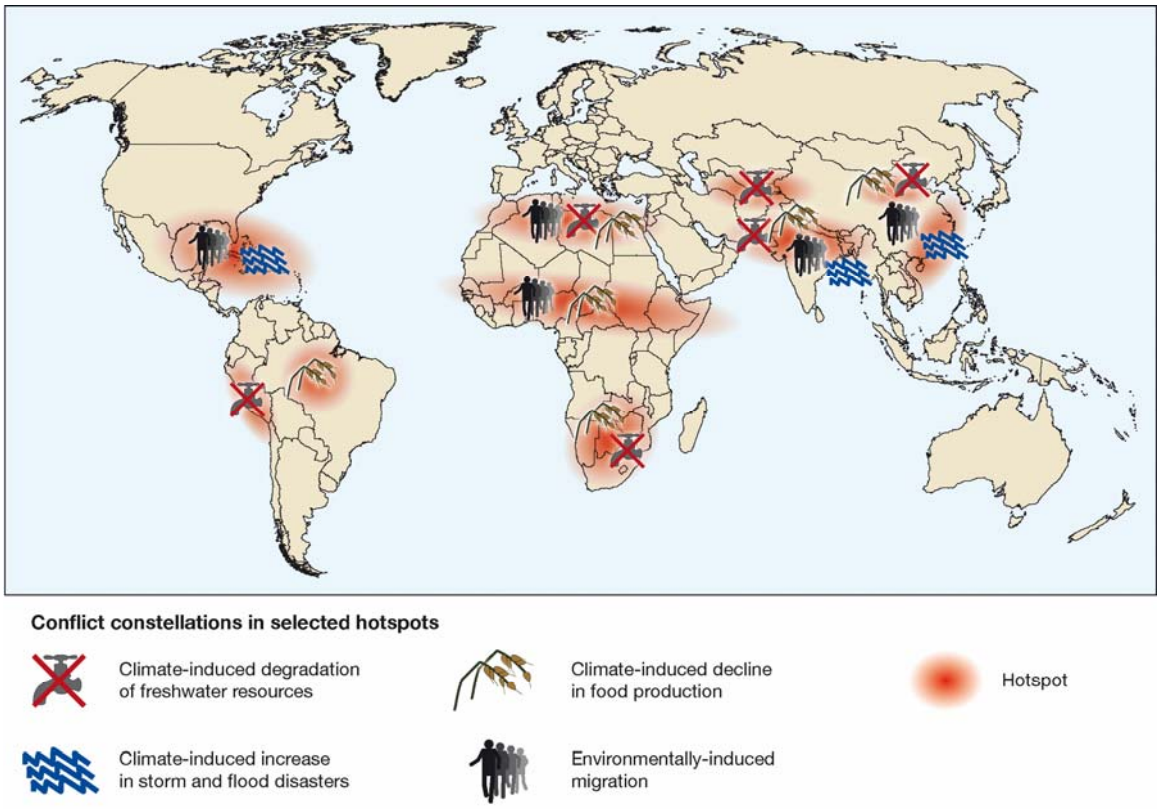
Ravenstein's 'surplus population' concept and confirms the ambiguity of this variable. As expected, the distance between any two countries has a significant negative impact on the migration flows between them. The social and political factors in the sending countries, which are in this case the unemployment rate and the political disorders represented by the number of ethnic groups, respectively, are significant push factors for the potential migrants.

The variables indicating that the country is an island or landlocked do not have a significant impact on migration flows. This might be explained by the fact that infrastructure as well as the quality and frequency of transportation today means between the countries are the factors that rather have a stronger effect on migration irrespective of these two variables. Nevertheless, the common borders between two countries seem to still have a significant positive effect on facilitating the migration between them.

Cultural and historical variables such as the past colonial relationships, all positively affect the migration flows. Having a common official/spoken language, having been colonized by the same colonizer, having had a colonial relationship in the past, having been a same country at any time of history, are all factors that amplify the migration between two given countries.

As for the environmental factors - which are the main concern of this paper, all of them - except for the floods (explained below) - have a significant positive impact on the migration flows. This means that environmental degradation does matter when considering migration. As the t statistics indicate in table 2, there is a good fit between the signs of the independent variables and the dependent variable of pair wise migration flows between countries. The most significant environmental factors are soil quality and availability of suitable water. Flooding did not show a significant relationship with migration, mostly a factor of data collection and the time period captured in the modeling. This and other limiting factors are discussed in the section below. Other literature suggests that areas facing environmental degradation may also experience migration pressures (See figure 1).

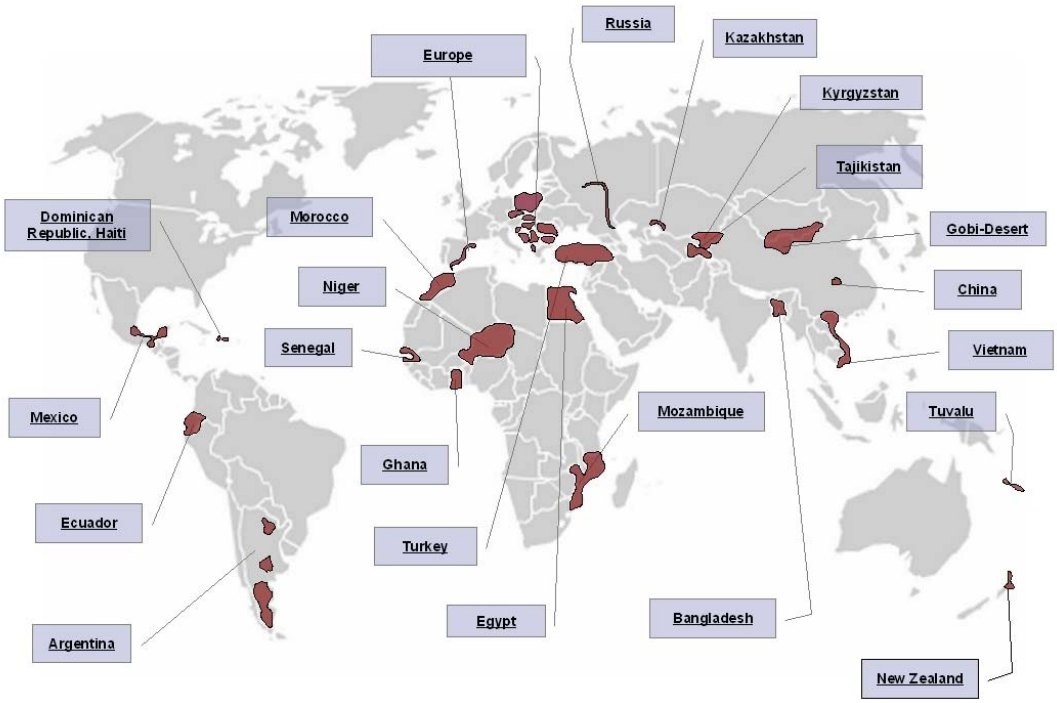
Figure 1 *A Map of Migration Induced by Environmental Stressors*



Source: German Advisory Council on Global Change WBGU (2007): Climate Change as a Security Risk

To obtain more in-depth regional analysis, current research supported by the European Commission project "Environmental Change and Forced Migration Scenarios" (EACH-FOR) is undertaking 24 case studies worldwide and conducting surveys among migrants and non-migrants in areas where environmental degradation is documented (Figure 2). More research is required to understand the mechanisms through which the positive impact of environmental degradation on migration actually works. It is expected, however, that field work results will support the hypothesis in this paper.

Figure 2 *A Map of the EACH-FOR Field Research Surveys Worldwide*



8. Limitations

The methodology has limitations that must be mentioned. First, the gravity model approach is based on theoretical rather than empirical observations. Critics of the gravity model approach suggest that the gravity model is biased towards historic ties and toward the largest population centres, making it a less suitable method for predicting future movement. The gravity model approach could thus accentuate the status quo instead of providing insight into dynamic relationships between variables. Further, critics claim that the gravity model approach lacks a strong theoretical foundation and its acceptance in geography was based on empirical fit in the absence of a null hypothesis. Such critics also state that the gravity model fails to take into consideration the 'congestion' that might hinder the flows and that it is an unfair method of predicting movement, because it leans towards historic ties and towards the largest population centres (Noronha, 1998). The authors of this paper recognize these concerns and have taken measures to address possible weaknesses, such as by including historical factors (such as political and linguistic ties) in the model to offset biases in the approach.

A question may also arise about the 'stock' and the 'environmental data' used in the model. Clearly the ideal situation would have been to take a particular year, quantify the environmental factors in that year, and take the migration flows from each country to the other in the same year (cross section analysis). More ideal yet would be to take a 30 year time series. Data availability and consistency constrained such an approach. Therefore, the current global study takes lifetime migration stocks (which indicate migration over several years) and then takes dummy indicators for the environmental phenomena of interest. The dummy indicators are useful to quantify phenomena such as, for example, desertification which cannot be meaningfully quantified for any given year. Processes of this kind gain their meaning when seen as a changing process over time, a fact which requires longer time series to capture the change that may take decades. For this reason, the authors chose to use a dummy for the occurrence / non-occurrence of the environmental problem in each country. The approach allows initial insights into possible positive impact of environmental problems on migration which has not been done before using models of this kind. In addition, some important factors that were mentioned in the literature, such as being ‘risk averse’ or ‘risk lover’ were not included in the model, since these are individual characteristics that are hard to tackle when using a macro-economic model and where the data are not on household but global basis.

On the point of capturing relationships between migration and certain types of environmental degradation, the authors acknowledge that the regressions may not capture factors that the model does not account for (Ciuriak and Kinjo, 2006). For example, in our model, the dependent variable (migration) can be seasonal, making it difficult to capture refined correlations between variables — the model used here only captures the stock of migration (updated by March 2007). The independent variables in our model can be seasonal, or erratic in occurrence through time — floods, earthquakes, droughts — and some such as drought require extended periods of time before they may become a major motivation in the choice to migrate. Our environmental data captures “events” from a certain one-year period. The environmental data used here is not specific to season, making it further difficult to obtain a refined understanding of the correlation between the dependent and independent variables. Finally, the authors checked for feedbacks between independent variables, such as deforestation and soil erosion. The authors found no significant correlation between such independent variables even though logic suggests there are likely feedbacks. This may be due to the fact that the data available is aggregated at the national level, whereas the actual processes recorded are likely to be locally specific. For example, deforestation may occur in mountain areas of a given country and reported in the data used in this model. At the same

time, the same country may report soil erosion in a different geographical area. For this reason, the model does not record possible feedbacks between independent variables that, if occurring in the same area, would otherwise be expected to influence each other.

In the next steps, the authors hope to address these concerns by observing multiple years on the independent and dependent variables to try to account for the temporal issues noted above. This initial modeling attempt will be complemented with in-depth qualitative field study, including a questionnaire and expert interviews in 15 countries across the globe. Following preliminary scoping work (done by the European Commission-funded research consortium "Environmental Change and Forced Migration Scenarios" project EACH-FOR). A more in-depth global analysis should be done with more significant resources and multi-year, multi-institution format.

9. Conclusions

Although the scientific debate about 'environmental migration' is in its early stages, and much must be done to quantify and understand the mechanisms that drive migration related to environmental degradation, this phenomenon cannot be neglected. Critics of the idea of 'environmental migration' claim that environment does not directly affect migration, but concede that environmental factors can magnify migration.

The gravity regression model presented in this paper illustrates that after controlling for the most important factors other than environment, the latter has a positive significant impact on the migration flows across countries, which would suggest a similar relationship for migration across regions within one country. Future research, both theoretical and empirical, is expected to corroborate with the findings of this modeling attempt. While the approach used here may be critiqued and refined in the future, the finding is significant and will hopefully be explored in great depth in future studies. This finding has important implications for environmental management, development policy, and migration policy. As environmental change becomes a more prominent issue, nationally and internationally, and as migration pressures continue to rank as the top national concern for many industrialized countries, research must rapidly move forward to discover the links between the two variables which until recently have been considered unrelated.

Opponents of the term 'environmental migration' claim that environment does not directly affect migration, but admit that it magnifies the problem, which in itself is a reason enough to

take the problem in serious consideration. As long as poverty exists and the adaptation skills are low, climate change will exacerbate the situation.

Therefore, actively addressing climate adaptation is indispensable, since climate change could lead to millions of additional environmental migrants in the world, due to droughts, desertification and sea level rise. Secondly, the legal status of the environment induced migrants - who are subject to becoming stateless - should be clarified. National, regional and international agreements should get extended to include this category of migrants and offer them protection. However, the role of these agreements should further be extended to help these people travel back to their countries/regions and restart their livelihoods and help them in re-construction and adaptation.

Coupling modeling approaches such as this preliminary attempt, with more extensive scientific and field research that addresses the phenomena of people moving for environmental reasons. Such research is now needed to tackle the problem of environmental change and migration in more depth.

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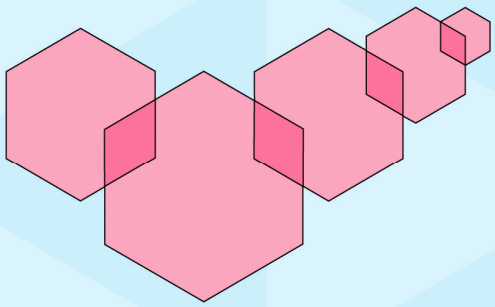

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