Honors Thesis:

International Migration from the Latin American-Caribbean Region:

Taking Environmental Indicators into Consideration

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ABSTRACT

International migration, the act of leaving one's country to permanently settle in another country, is driven by many socio economic/political factors, such as lack of economic opportunity, access to education, governmental corruption, and violence. These factors have proven to be the reason that many citizens within the Latin American-Caribbean region either choose or are forced to relocate internationally. While these factors are important to consider independently; these issues are often exacerbated by changes in the natural environment. The objective of my paper is to highlight the importance of considering changes in the natural environment. In doing so, I hope to shed light on the need for researchers and policymakers addressing international migration from the Latin American-Caribbean region to consider the impact of the natural environment.

For this research we completed a regression analysis analyzing the bivariate relationship between net migration, non-environmental indicators, and environmental indicators within 42 countries in the Latin American-Caribbean region over a 25-year period: 1990-2015. The non-environmental indicators that we focused on include unemployment rate, GDP per capita, intentional homicides, educational attainment, human development index, and employment rate in agriculture for both males and females. The environmental indicators that we focused on include arable land, PM2.5 air pollution exposure, renewable internal freshwater resources, carbon dioxide emissions, natural resource depletion, and forest area. We found that there was no significant relationship between the aforementioned indicators and net migration. This is an important finding and the explanation for these results is complex. For instance, while the prediction could be made that high levels of carbon emissions would correlate to environmental degradation at the site of emission, it is possible that these emissions have more of an impact

globally. In actuality, in our current economic system which relies heavily on production that releases high levels of carbon, higher carbon emissions may be more strongly correlated with economic prosperity which would make it appear as though increased carbon emissions lead to lower rates of negative net migration. It is also important to highlight that the variables chosen to analyze for this study may not be the correct variables, and further research should be conducted to assess which variables are the most useful for identifying correlations between causal factors of migration and migration flows.

INTRODUCTION

According to the United Nations Population Division, international migration is defined as, "The estimate of the number of people living in a country or area other than that in which they were born." As highlighted in the First Report of the Continuous Reporting System on International Migration in the Americas (SICREMI), international migration is one of the key topics on the policy agenda worldwide. Globalization, income disparities among countries, demographic, and economic imbalances- have all contributed to the increased international migration movements over the past twenty years, bringing people many benefits, but also posing challenges to governments in many countries.

One of the upsides of international migration is that it brings important benefits, fueling growth, innovation and entrepreneurship in both countries people come from, and in those they move to (Thompson 2014). This can lead to a multitude of economic benefits for both the migrant and the host country. Oftentimes the migrant receives a higher income, higher living standards, and is offered opportunities that they would otherwise be barred from in their home country. Furthermore, countries that have received some of the highest numbers of migrants, such as the United States, benefit from receiving migrants who help to sustain current population levels and support basic infrastructure and economic needs. These needs are heightened by declining birth rates in countries such as the United States.

Although there are benefits of international migration and it is inevitable that it will occur to some scale, the decision of an individual to migrate is often a response to external factors that could be mitigated through governmental aid and international cooperation. Some of these issues include economic instability, violence, educational availability, and overall level of human development. For example, migration from Latin America has recently received more attention but much of it focuses on the way migrants from this region are driven out by gang violence, corruption, and political upheaval. Economic changes stemming from these issues in the home community make it preferable for many to leave these unfavorable circumstances and find that the motivation to emigrate offers more opportunity for social mobility (Fussell 2010). A 2019 article states, "Migration is not a new phenomenon in Latin America. In 2017, almost 37 million Latin Americans (one in seven global migrants) lived outside of their native countries. Many emigrated to the United States and Europe, while others decided to set up roots in neighboring countries." (Estevadeordal 2019). This represented an increase from 25 million in 2010 and accounted for nearly 15% of the world's more than 250 million international migrants in 2017. (Bustamante 2019)

The aforementioned factors are important to consider and play a key role in the migration conversation, but displacement driven by climate change and other environmental factors is significant too (Hallett 2019). Environmental factors may also play a key role in influencing one's decision to migrate. While not explicitly stated, environmental factors often underpin and exacerbate the non-environmental factors. Research by a Pew Survey conducted in 2019 states, "Some reasons for these increases (in numbers of international migrants) include political and economic instability, conflict and violence, and climate-related events." For instance, a 2013 study analyzing environmental influences on human migration from Ecuador looked at environmental factors including the effects of land quality, topography, long-term climate, and rainfall variability. The study found that global climate change implications such as the frequency and severity of extreme weather events are likely to influence human migration; some people forced to relocate, and others trapped in dangerous situations. The study calls for climate assistance policies which acknowledge the fact that the motivations to migrate are nearly always multicausal; often influenced by environmental changes (Gray et al 2013).

The argument for the importance of exploring the impacts of environmental factors on international migration is further enhanced by the growing climate crisis. Whether in terms of limited access to clean water, food scarcity, agricultural degradation, or violent conflict, climate change will intensify these challenges and be a significant factor in human migration patterns (Podesta 2019). The impact of climate change on international migration will have immense consequences for human prosperity and dramatically change migration flow patterns. Many regions in the Pacific as well as Latin America and Sub-Saharan Africa will become uninhabitable no matter what action is taken toward climate change mitigation. As a result, the United States and other developed nations anticipate receiving a wave of millions of environmental migrants over the next fifty-to-one-hundred-year period. For example, many citizens in the Latin American- Caribbean Region will face a disproportionate level of vulnerability to climate change and will turn to the United States for help.

As a result, multilateral institutions, development agencies, and international law must do far more to thoroughly examine the challenges of climate change. Early efforts, like the World Bank's 2010 World Development Report on climate change, had little uptake at a time when few thought a climate crisis was around the corner. As a result, work on environmentally induced migration has surged in recent years. A 2009 resolution of the Committee on Migration, Refugees and Population from the Council of Europe states, “Already today, over 30 million people worldwide are displaced because of the increase in desertification, droughts, rising sea levels, industrial accidents, major infrastructure projects and extreme weather events, and this number is rising sharply.” However, a 2015 Report from the International Organization for Migration (IOM) states, “While the number of studies exploring the link between environment and migration has proliferated in recent years, consideration of the migration-environment nexus at the policy level is still at an early stage.” There is a clear necessity for environmental factors to be considered at the policy-level, and future policymakers must consider the migration-environment nexus when writing policy that addresses international migration.

International migration reporting and development fund allocations also still largely fail to recognize environmental indicators. A prime example of this is the 2018 World Migration Report from the International Organization for Migration. An excerpt from the report states, “Factors underpinning migration are numerous, relating to economic prosperity, inequality, demography, violence and conflict, and environmental change. While most people migrate internationally for reasons related to work, family and study, many people leave their homes and countries for other compelling reasons, such as conflict, persecution and disaster.” (UN Migration Agency 2018). We see here that environmental change is cited as a “factor underpinning migration”. The report also states that the shortage of quantitative data on movements associated with environmental change, including climate change, however, represents a key gap. The multicausal nature of such movements presents challenges. Better data on movement associated with environmental change, including the effects of climate change, are also required to properly deal with these challenges. Concomitantly, IOM has long recognized the need to support more nuanced understandings of migration, including through its focus on specific thematic areas (such as migration health and environmental migration). (UN Migration Agency 2018). We see that the need for further quantitative research is mentioned, yet action to address this need remains scarce.

The fundamental objective of this study is to examine the relationship between net migration and environmental indicators, an area where there is currently a dearth of research and compare it to the impact of commonly-cited non-environmental indicators for the Latin America-Caribbean region. The link between environmental instability and migration from the (Latin America-Caribbean region (Latin America-Caribbean) became apparent in the late 1990s and early 2000s (Hallett 2019). However, although research has been completed on the key drivers of international migration from countries within the Latin American-Caribbean region, research on the nexus between environmental threats and international migration remains limited. This is, in part, due to difficulties with theoretical methodological and statistical problems associated with analyzing environmental migration. According to a 2019 article by Lukyanets et al., "...the lack of precise definitions of terms related directly to environmental migration, such as "climatic migration", "climatic refugee", "environmental refugee", and "environmentally displaced person", creates difficulties in organizing the recording of such migrations and the comparability of the data obtained at the intercountry level...Difficulties (also) arise in identifying those cases of migration that resulted directly from changes in the environment, since along with factors of a natural nature, a combination of other socioeconomic factors, such as low living standards or poverty, often influence decision-making on resettlement." (Lukyanets et al. 2019).

As a result, funding that has gone toward the mitigation of international migration has focused on these non-environmental factors. A 2019 report from the U.S. Global Leadership Coalition exemplifies this point. The report states, "Violence, instability, and poverty in Central America are driving a new wave of migration. Dangerous levels of violence, political instability, and poverty are key factors driving families to make the risky journey…" Environmental factors are not focused upon. While these factors are important, and should not be ignored, research is needed to ensure environmental factors are also included in mitigation efforts so that funding can be used to its full potential and create lasting change. This research will provide opportunities to consider how funds could be allocated and reallocated to combat the root causes of migration, which, are increasingly, linked to the natural environment.

METHODS AND RESULTS

To better understand the environmental and non-environmental conditions that lead to international migration from the Latin-American-Caribbean region, I first completed case-studies analyzing the changing natural environment in six focal countries from the region. These case studies helped to identify environmental and non-environmental indicators to include in a large-scale analysis of net migration from the region.

Case studies to determine important environmental and non-environmental factors

Based on data from the Migration Policy Institute (MPI), the vast majority of countries within the entirety of the Latin American and Caribbean region have higher rates of emigration than immigration, or negative net migration. Negative net migration is defined as the number of emigrants (people leaving the country) exceeds the number of immigrants (people entering the country). As such, it is pertinent to closely examine a select group of countries who fall into the majority category (higher rates of emigration) as well as the minority category (higher rates of immigration). In doing so, we can offer a diverse set of examples of the changing natural environment throughout the Latin-American Caribbean region, in the context of migration flows.

These six focal countries were determined based on net migration flows, three countries with positive net migration flows: Chile, Panama, and Costa Rica and three countries with negative net migration flows: El Salvador, Dominican Republic, and Cuba. This was determined based on net migration data obtained from the World Bank. Although these 6 countries are not fully representative of the changes to the natural environment in the entirety of the Latin American-Caribbean region they serve as a benchmark for comparison and highlight some of the key environmental issues that are being faced in the region.

Table 1: Net Migration Flows 1992-2017 for Select Countries

Net Migration Flows						
Country	**Net Migration (1992)**	**Net Migration (1997)**	**Net Migration (2002)**	**Net Migration (2007)**	**Net Migration (2012)**	**Net Migration (2017)**
Chile	3610	19340	42330	107169	163730	558539
Panama	1954	9797	16119	22244	28105	56000
Costa Rica	69202	89527	41792	30339	19658	21000
El Salvador	-265152	-326853	-312786	-285671	-240415	-202694
Dominican Republic	-144154	-150146	-152553	-153773	-153000	-150000
Cuba	-120006	-132839	-145629	-240000	-80000	-72000

Countries with High Rates of International Migration

The relationship between environmental instability and periods of extreme violence in Cuba, has been traced back to the mid-1700s by a 2011 study in Sherry Johnson's book, *Climate and Catastrophe in Cuba and the Atlantic World in the Age of Revolution.* Some examples include the Siege, Fall and Occupation of Havana which coincided with extreme droughts in the Oriente and Havana province in 1765, and the period of Bankruptcy and the First Reorganization of the Asiento which paralleled with periods of extreme drought and hurricanes between 1773-1775. In recent years, Cuba has experienced great changes to the natural environment as a result of anthropogenic activities. Variability in precipitation patterns and amounts have caused drought and water supply concerns, regional climatic variability is a significant concern throughout Cuba. (Davis et al. 2009) Another study conducted by Centella et al. (1999) found that Cuba's particular sensitivity to changes in precipitation patterns will have a great impact on economic interests in the country; impacting regions plagued by drought that rely heavily on the agriculture industry. Given these changes, we included renewable internal freshwater resources per capita and male/female employment in agriculture as non-environmental factors to account for changes in Cuba.

Over the past 25 years, the Dominican Republic has experienced a plethora of changes to its natural environment which have, in turn, led to increased rates of international migration. Some of the main environmental changes that Dominican Republic is experiencing include deforestation, ecosystem loss and increased carbon emissions. Kauffman et al. (2014) found that deforestation and conversion of ecosystems such as mangroves have led to a significant increase in carbon emissions in the Dominican Republic. Forests, wetlands and mangroves serve as large carbon sinks, and in recent years have been converted to other land uses such as salt and shrimp ponds. To account for the environmental changes in the Dominican Republic we included indicators such as carbon dioxide emissions per capita, PM2.5 air pollution, forest area, and natural resource depletion.

El Salvador, a third country from the region with negative net migration flows has experienced high levels of land change as a result of urbanization and deforestation. Compounding these risks, many watersheds in El Salvador are experiencing increased rainfall frequency and intensity as result of climate change, making many areas particularly vulnerable to increased flooding. A 2014 study of watershed changes in El Salvador found that urbanization has shifted flood risk downstream which has left another 67 homes at risk for flooding large storms. The study suggested that community relocation, urban green infrastructure, and gray infrastructure such as levees or dams will be required to protect communities from the impacts of increased flooding in highly urbanized regions (Tellman 2015). Community relocation suggests that many people will be forced to migrate as a result of environmental land changes in El Salvador. Our data analysis included natural resource depletion and forest area to account for the changing natural environment in El Salvador.

Countries with Low Rates of International Migration

An analysis of the changing natural environment in countries with respectively low rates of international migration was conducted on three countries with positive net migration flows. This was determined based on net migration data obtained from the World Bank. The three countries highlighted are Chile, Costa Rica, and Panama, which each had positive net migration rates for the duration of the 25-year period (1992-2017). Positive net migration is defined as the number of immigrants (people entering the country) exceeding the number of emigrants (people leaving the country).

A study completed by Liu et al. on environmental degradation in the Atacama Salt Flat, Chile found that the lithium mining industry as well as other environmental stressors such as increased tourism and population increase may have negative impacts on the local natural environment. Some of these impacts include increasing drought conditions in soil and decreasing the normalized difference vegetation index (NDVI) (Liu et al.). However, the economic benefits of these activities may actually lead to increased positive migration. We included indicators such as natural resource depletion, arable land, and renewable internal freshwater resources to account for these environmental changes.

Environmental change in Costa Rica is largely attributed to human settlements between 1980 and 2005 which grew by about 525%. This growth has led to recent environmental issues such as conflicts over freshwater allocation, beach pollution, and forest removal (Irazabal et al.) and also suggests net migration may actually drive environmental issues. To account for these changes in Costa Rica's natural environment we included indicators such as PM2.5 air pollution, renewable internal freshwater resources, and forest area.

Environmental change has also impacted the natural environment in Panama. Even though Panama's economy is not heavily reliant on forestry; Panama has experienced high levels of degradation and forest loss with a net forest loss of 19,595 ha per year during the two-year period from 2000 to 2012 (Clare et al.). To account for these changes to the natural environment in Panama we included indicators such as forest area.

Analyzing relationship between environmental and non-environmental factors and net migration using large-scale data

Following the focused case studies, I carried out an analysis of how both environmental and non-environmental indicators influence net-migration data in the Latin America-Caribbean region. I gathered data from the Migration Policy Institute (MPI) on all countries within the Latin American-Caribbean Region as defined by the World Bank Data on net migration. I focused on seven environmental indicators and seven non-environmental indicators.

Non-Environmental Indicators

I obtained data on 7 non-environmental indicators between 1990-2015 for all countries, as defined by the World Bank, in the Latin American-Caribbean Region.

The first indicator that we focused on was the unemployment rate. This data was obtained from the open data provided by the World Bank Group. The unemployment totals were modelled by the International Labour Organization and express the percentage of the total labor force that is unemployed. They define unemployment as, "the share of the labor force that is without work but available for and seeking employment." (World Bank 2020). Historically, unemployment has been identified as a leading cause of international migration. The historical patterns in the relationship between the business cycle and migration are that: emigration is positively related to unemployment in the source country and negatively related to unemployment at the destination (Tilly 2011). This tells us that higher unemployment levels in the country of origin are thought to be correlated with higher rates of people exiting that country and migrating elsewhere.

The second indicator that we focused on was Gross Domestic Product (GDP) per capita. This data was obtained from the open data provided by the World Bank Group which is a compilation of datafiles from the World Bank and OECD National Accounts data files. The GDP per capita is measured in current US $ and is calculated as the gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. (World Bank 2020). I predicted that countries with lower GDP would experience higher rates of net negative migration.

The third indicator of focus was Intentional Homicides. Data was obtained from the World Bank Group and the UN Office on Drugs and Crime. Intentional Homicides are calculated per hundred people. They are defined as estimates of unlawful homicides purposely inflicted as a result of domestic disputes, interpersonal violence, violent conflicts over land resources, intergang violence over turf or control, and predatory violence and killing by armed groups. Intentional homicide does not include all intentional killing; the difference is usually in the organization of the killing. Individuals or small groups usually commit homicide, whereas killing in armed conflict is usually committed by fairly cohesive groups of up to several hundred members and is thus usually excluded. (World Bank 2020). I predicted that countries with more intentional homicides experience higher rates of net negative migration.

The fourth indicator of focus was Expected Years of Schooling. The data was obtained from the UN Development Programme's Human Development Reports. Expected Years of Schooling are calculated as the number of years of schooling that a child of school entrance age can expect to receive if prevailing patterns of age-specific enrolment rates persist throughout the child's life. (UN Development Programme 2019). I predicted that countries with less expected years of schooling would experience higher rates of net negative migration.

The fifth indicator was the Human Development Index (HDI). This data was obtained from the UN Development Programme's Human Development Reports. The HDI is defined as a composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, knowledge, and a decent standard of living. The technical indicators used to determine the HDI include life expectancy index, education index, and gross national income (GNI) index. I predicted that countries with lower HDI would have higher rates of net negative migration.

The sixth indicator was the percentage of female employment in agriculture. This data was obtained from the World Bank Group and the International Labour Organization. Employment in agriculture, female (% of female employment) (modeled ILO estimate). This indicator is defined as persons of working age who were engaged in any activity to produce goods or provide services for pay or profit, whether at work during the reference period or not at work due to temporary absence from a job, or to working-time arrangement. The agriculture sector consists of activities in agriculture, hunting, forestry, and fishing. (World Bank 2020). I predicted that countries with higher levels of female employment in agriculture would also have higher rates of net negative migration.

The seventh and final indicator was the percentage of male employment in agriculture. This data was obtained from the World Bank Group and the International Labour Organization. Employment in agriculture, male (% of male employment) (modeled ILO estimate). This indicator is defined as persons of working age who were engaged in any activity to produce goods or provide services for pay or profit, whether at work during the reference period or not at work due to temporary absence from a job, or to working-time arrangement. The agriculture sector consists of activities in agriculture, hunting, forestry, and fishing. (World Bank 2020). I predicted that countries with a higher percentage of male employment in agriculture would have higher rates of net negative migration.

Environmental Indicators

I obtained data on 7 environmental indicators between 1990-2015 for all countries, as defined by the World Bank, in the Latin American-Caribbean Region.

The first environmental indicator was Arable Land. Data on this indicator was obtained from the World Bank Group and is measured in hectares. Arable land is defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded. (World Bank 2020). I predicted that countries with less hectares of arable land would also have higher rates of net negative migration. Alternatively, increased migration could drive a reduction in arable land as populations increase.

The second environmental indicator was PM2.5 air pollution measured as the percentage of the total population that is exposed to levels exceeding the WHO guideline value. This data was obtained from the World Bank Group and the 2017 Global Burden of Disease Study. The percent of population exposed to ambient concentrations of PM2.5 that exceed the WHO guideline value is defined as the portion of a country's population living in places where mean annual concentrations of PM2.5 are greater than 10 micrograms per cubic meter, the guideline value recommended by the World Health Organization as the lower end of the range of concentrations over which adverse health effects due to PM2.5 exposure have been observed. (World Bank 2017). I predicted that countries experiencing higher levels of PM2.5 air pollution would have lower levels of net negative migration, because PM2.5 air pollution is often associated with higher levels of economic prosperity. While this is the case, it is important to note that high levels of PM2.5 air pollution also have negative impacts on the health and well-being of the citizens living in the polluted areas.

The third environmental indicator was PM2.5 Air Pollution measured as the mean annual exposure (micrograms per cubic cm). The data for this indicator was obtained from the World Bank and the 2017 Global Burden of Disease Study. Population-weighted exposure to ambient PM2.5 pollution is defined as the average level of exposure of a nation's population to concentrations of suspended particles measuring less than 2.5 microns in aerodynamic diameter, which are capable of penetrating deep into the respiratory tract and causing severe health damage. Exposure is calculated by weighting mean annual concentrations of PM2.5 by population in both urban and rural areas. (World Bank 2017). I predicted that countries experiencing higher levels of PM2.5 air pollution would have lower levels of net negative migration, because PM2.5 air pollution is often associated with higher levels of economic prosperity. While this is the case, it is important to note that high levels of PM2.5 air pollution also have negative impacts on the health and well-being of the citizens living in the polluted areas.

The fourth environmental indicator was Renewable Internal Freshwater Resources. This is measured in cubic meters per capita. The data was extracted from The World Bank Group and the Food and Agriculture Organization. Renewable internal freshwater resources refer to internal renewable resources (internal river flows and groundwater from rainfall) in the country and are calculated using the World Bank's population estimates. (World Bank 2014). I predicted that countries with less available renewable internal freshwater resources would also experience higher levels of net negative migration.

The fifth indicator was Carbon Dioxide Emissions. This is measured in tonnes as production emissions per capita. The data for this indicator is pulled from the UN Development Programme's Human Development Reports. Total carbon dioxide emissions are defined as the emissions produced as a consequence of human activities (use of coal, oil and gas for combustion and industrial processes, gas flaring and cement manufacture), divided by midyear population. Values are territorial emissions, meaning that emissions are attributed to the country in which they physically occur. (UN Development Programme 2020). I predicted that countries experiencing higher levels of carbon dioxide emissions would also have a lower rate of net negative migration because CO_2 emissions are strongly correlated to economic prosperity. It is important to note that high CO_2 emissions have detrimental impacts on the natural environment such as increasing the impacts of climate change within the region.

The sixth indicator was Natural Resource Depletion. This is calculated as a percentage of the gross national income (GNI) and the data was obtained from the UN Development Programme Human Development Records. Natural Resource Depletion is defined as Monetary valuation of energy, mineral and forest depletion, expressed as a percentage of GNI. (UN Development Programme 2020). I predicted that countries experiencing higher levels of natural resource depletion would also have a higher rate of net negative migration.

The seventh and final indicator was Forest Area. This is measured as a percentage of the total land area and the data was obtained from the UN Development Programme Human

Development Reports. Forest Area is defined as land spanning more than 0.5 hectare with trees taller than 5 meters and a canopy cover of more than 10 percent or trees able to reach these thresholds in situ. It excludes land predominantly under agricultural or urban land use, tree stands in agricultural production systems (for example, in fruit plantations and agroforestry systems) and trees in urban parks and gardens. Areas under reforestation that have not yet reached but are expected to reach a canopy cover of 10 percent and a tree height of 5 metres are included, as are temporarily unstocked areas resulting from human intervention or natural causes that are expected to regenerate. (UN Development Programme 2020). I predicted that countries with lower forest area totals would also experience higher rates of net negative migration.

Data Analysis

Although considering interactions among how multiple environmental and non-environmental indicators influence net migration would be useful, the lack of data precluded this approach. Instead, I considered bi-variate relationship among net migration and each factor so that impacts between oft- studied (typically non-environmental) and less-studied indicators could be compared. When multiple years of data existed for various countries for a given indicator, linear mixed-effect models were used to account for correlation among data points by considering random effects of year within each country. When a lack of data led to this not being possible, simple linear regression was carried out between net migration and the indicator (Zuur et al. 2009). All analyses were completed using the R software package (R Project 2021) using the car (Fox et al. 2019), lme4 (Bates et al. 2015), and ggplot2 (Hadley 2016) packages.

Results

After identifying important environmental variables through our analysis of the aforementioned 6 countries, we compiled data from the 25-year period between 1990-2015 from 42 countries in the region. Although we used the most up-to data from the World Bank and UN Human Development Records, we were missing indicator data for many countries. Given this data, our results (refer to Table 2, graphs in Appendix) showed that there was no significant relationship between net migration and the selected indicators. It is important to note that neither the environmental nor non-environmental factors proved to be significant in our study.

We found an inconsistent directional relationship between non-environmental and environmental indicators and net migration; some had a positive relationship with net migration flows and others had a negative relationship. Some of the positive linear relationships include male employment in agriculture, female employment in agriculture, human development index, and renewable freshwater resources. Increases in these factors corresponded to increases in net migration. Some of the negative linear relationships included intentional homicides arable land, and forest area. Increases in these factors corresponded to decreases in net migration. In each model we saw countries that were outliers, particularly in the relationships between net migration and natural resource depletion and net migration and renewable freshwater resources.

Table 2. Bivariate relationships between net migration and environmental/non-environmental indicators. Positive relationships are noted in green, negative in red.

Bivariate Relationships			
INDICATOR 1	**INDICATOR 2**	**P VALUE**	**ESTIMATE VALUE**
Net Migration	GDP per capita	0.27	0.394
Net Migration	Human development index	0.19	516836
Net Migration	% Female employment in agriculture	0.075	-8387
Net Migration	% Male employment in agriculture	0.052	-5609
Net Migration	Expected years of schooling	0.12	20663
Net Migration	Intentional homicides	0.52	-985.7
Net Migration	Unemployment rate	0.17	7919
Net Migration	Arable land	0.35	-0.345
Net Migration	CO2 emissions per capita	0.61	2635
Net Migration	Forest area	0.98	-39.86
Net Migration	Natural resource depletion	0.71	1933
Net Migration	PM2.5 pollution (percent)	0.67	1032
Net Migration	PM2.5 pollution (mean)	0.47	-3343
Net Migration	Renewable freshwater resources	0.93	0.378

CONCLUSION

After running the bivariate analysis on the selected environmental variables, many of the relationships did not demonstrate the anticipated effect.

This may be true to the previously mentioned issue with determining the driving force in these relationships. For instance, it could be predicted that high levels of PM2.5 pollution would lead to higher climate change impacts and negative impacts on human health, thus leading to net negative migration, which is what we observed. However, it could also be predicted that high levels of PM2.5 are associated with a robust manufacturing economy which could mean higher potential for economic opportunity. This is what we observed for the relationship between migration and the % of PM 2.5 pollution.

Thus, confounding factors make it difficult to discern the true impact that these pollution levels have on migration flows. Another example is regarding high CO2 emissions- these high emissions could be associated with high levels of global warming and negative climate change impacts as well as economic prosperity. Because each variable has the potential for such contradictory associations and predictions it is difficult to discern the impact that each one has on migration flows.

These relationships may be inconclusive due to a lack of data availability and the complexities of each indicator. As mentioned in the introduction, research has found that the relationship between international migration and environmental factors is often an indirect link. We would recommend running a future analysis to consider interactions among variables or focusing on those outlying countries. We were unable to complete a multivariate analysis due to a lack of data availability. This resulted, in part, from our data collection method, and, in part, due to a lack of existing open data. Given this, we recommend standardized data collection and reporting methods.

More robust datasets would allow researchers to conduct a multivariate analysis in future research. Analyzing the multivariate relationships and interactions among socioeconomic indicators, environmental indicators, and net migration rate would help researchers and policymakers better understand how environmental changes interact with other factors that lead to international migration from the Latin American Caribbean region. For instance, a 2011 study completed by Price et al. used multivariate linear models to analyze immigrant-environmental relationships, specifically focused on pollution level and immigration rates. This highlights the need for more robust data collection and importance of conducting further research on the environment-migration nexus. However, it is important to note our analysis showed that environmental indicators are not any more or less important than non-environmental indicators (although neither proved to be significant in our analysis).

It is important to note countries in the Latin America-Caribbean region are addressing climate change issues. For example, A 2015 report from IOM stated that, Haiti, who shares a border with the Dominican Republic and is facing similar changes to their natural environment, was the first country in the Latin American-Caribbean region to integrate environment and climate change in its migration policy and to mainstream migration into its position on climate change negotiations (States News Service 2015). The IOM held training workshops on migration, environment, and climate change policy in the Dominican Republic in 2015 in hopes that policymakers will soon implement environmental concerns in future migration policies, just as Haiti has done. Further research would also support these efforts.

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APPENDIX

1. Figure 1: Bivariate relationship between net migration and gross domestic product GDP
2. Figure 2: Bivariate relationship between net migration and human development index (HDI)
3. Figure 3: Bivariate relationship between net migration and female employment in agriculture
4. Figure 4: Bivariate relationship between net migration and male employment in agriculture
5. Figure 5: Bivariate relationship between net migration and expected years of schooling
6. Figure 6: Bivariate relationship between net migration and intentional homicides
7. Figure 7: Bivariate relationship between net migration and unemployment rate
8. Figure 8: Bivariate relationship between net migration and arable land
9. Figure 9: Bivariate relationship between net migration and CO2 emissions
10. Figure 10: Bivariate relationship between net migration and forest area
11. Figure 11: Bivariate relationship between net migration and natural resource depletion
12. Figure 12: Bivariate relationship between net migration and PM2.5 pollution (percentage)
13. Figure 13: Bivariate relationship between net migration and PM2.5 pollution (mean)
14. Figure 14: Bivariate relationship between net migration and renewable freshwater resources

Legend

Legend: 42 Countries included in bivariate analysis. Color coding used in Figures 1-14.

Figure 1

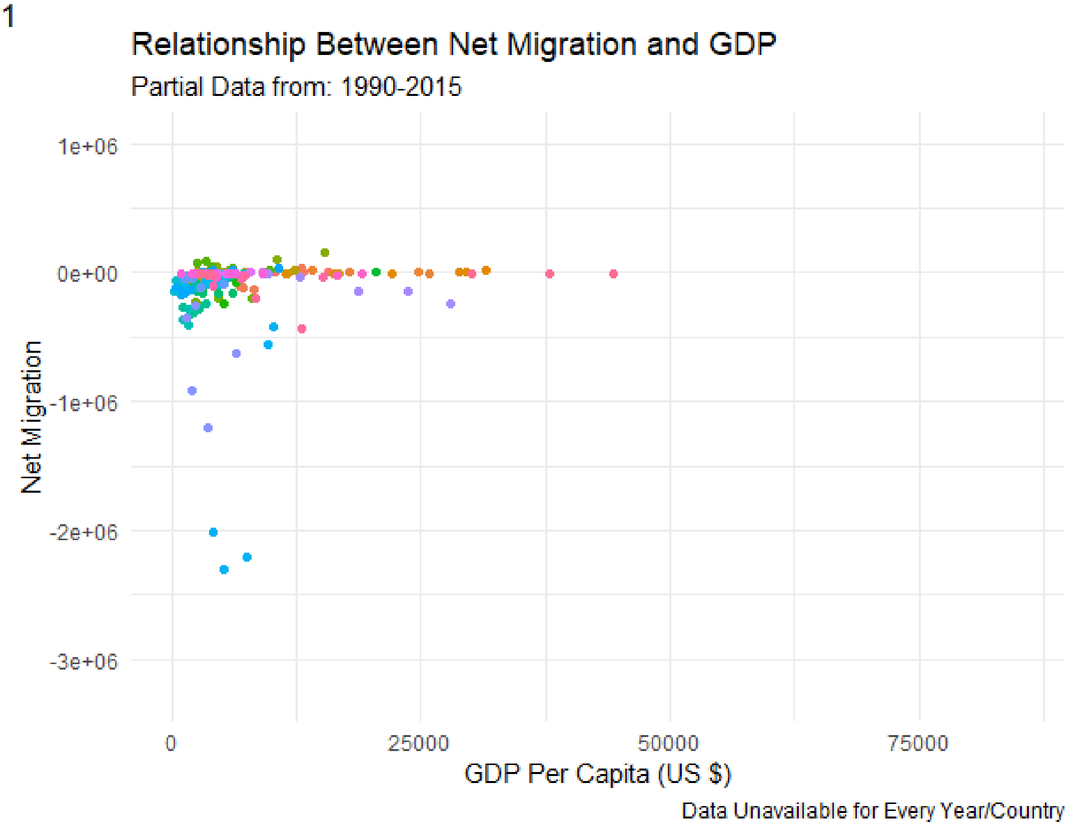

Figure 2

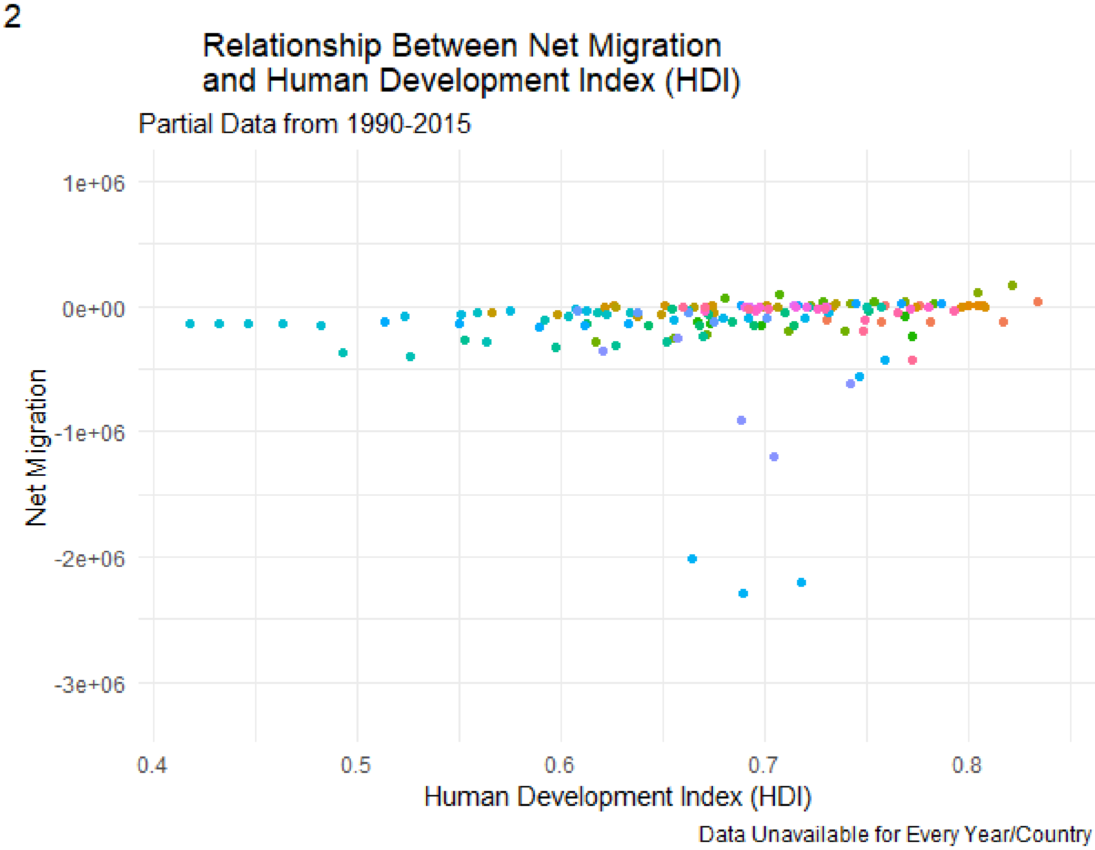

Figure 3

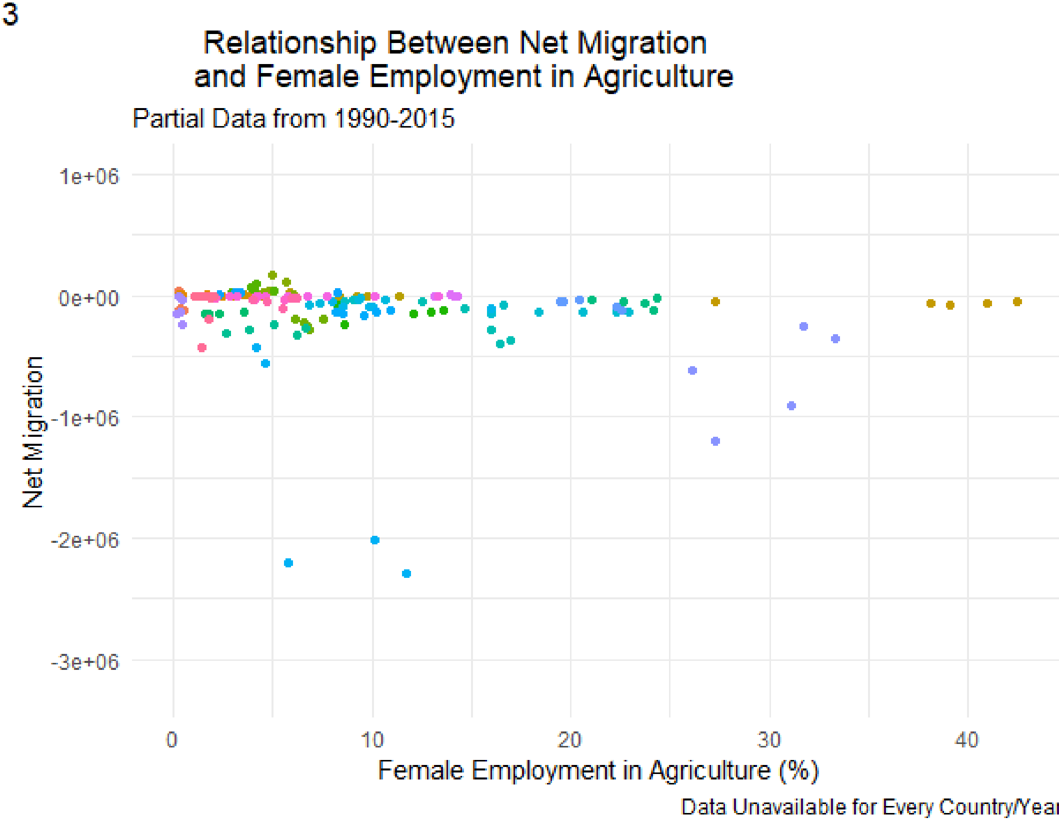

Figure 4

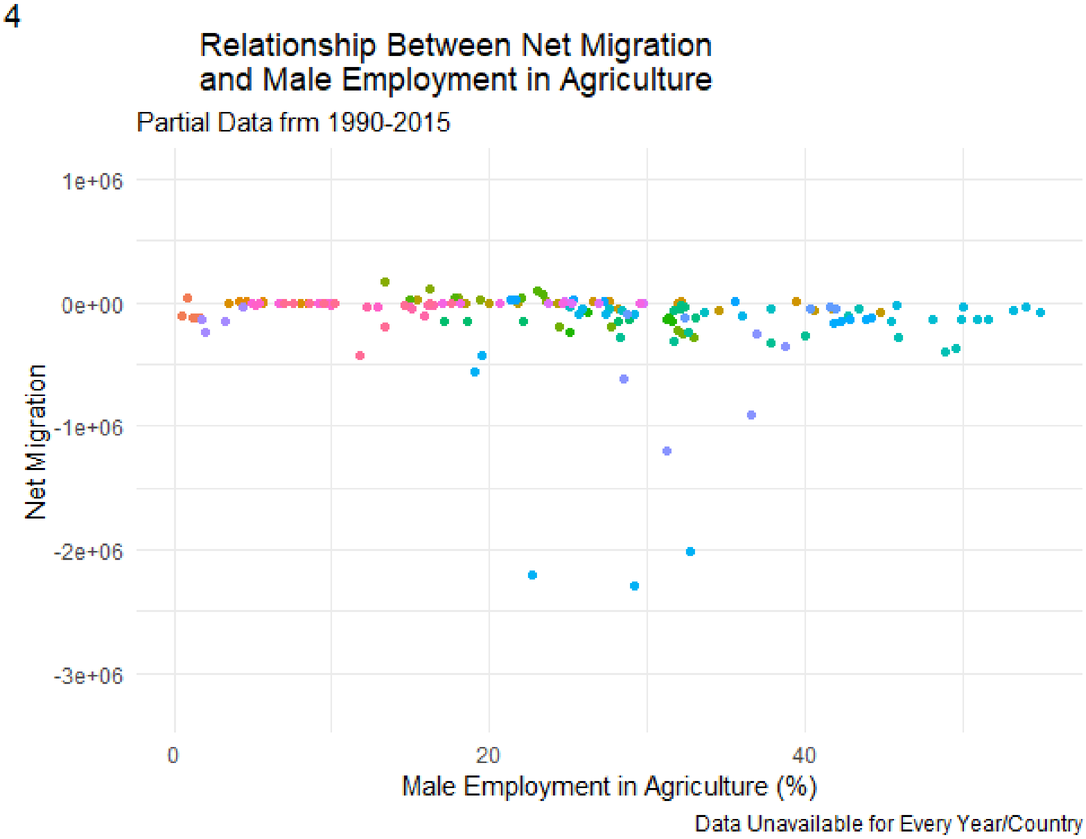

Figure 5

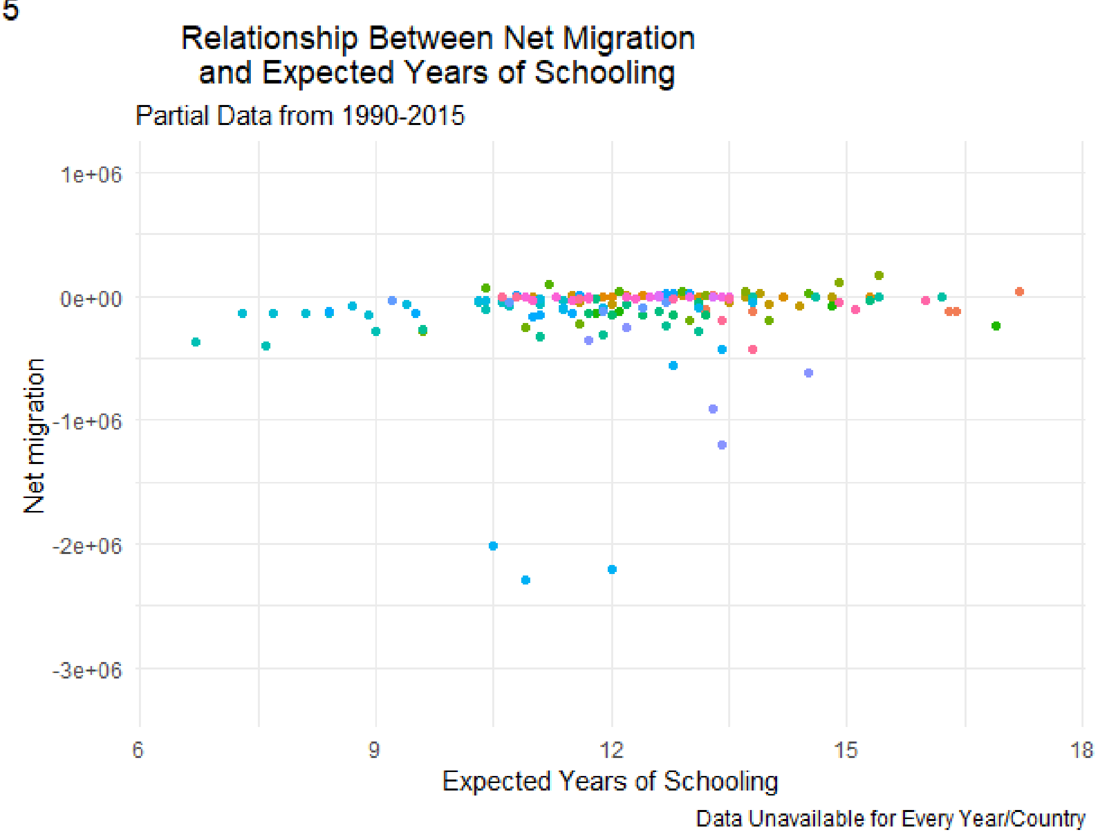

Figure 6

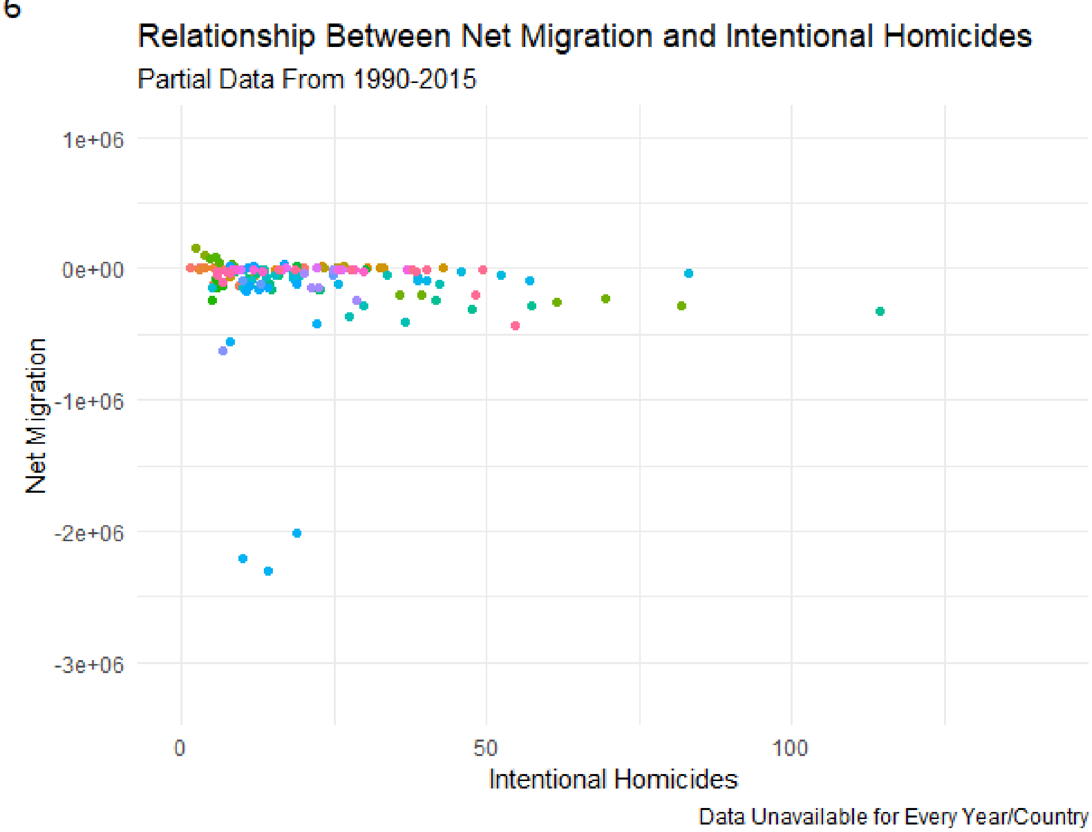

Figure 7

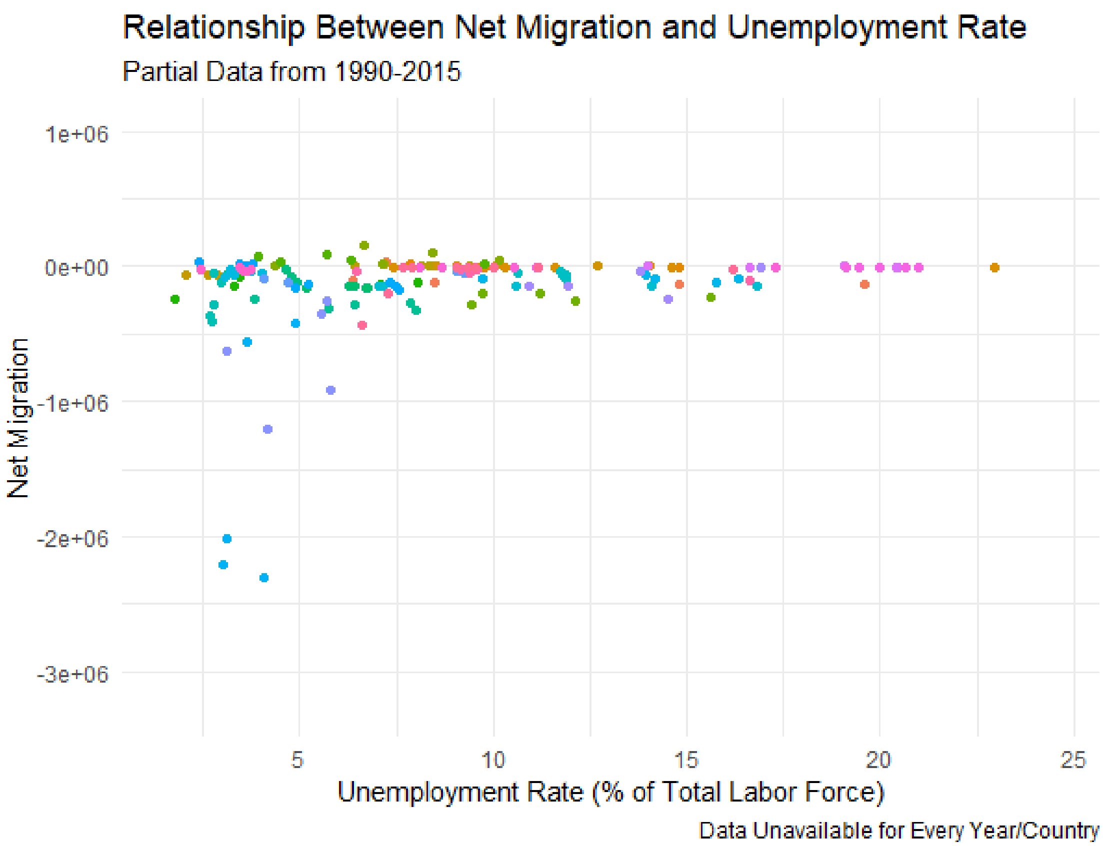

Figure 8

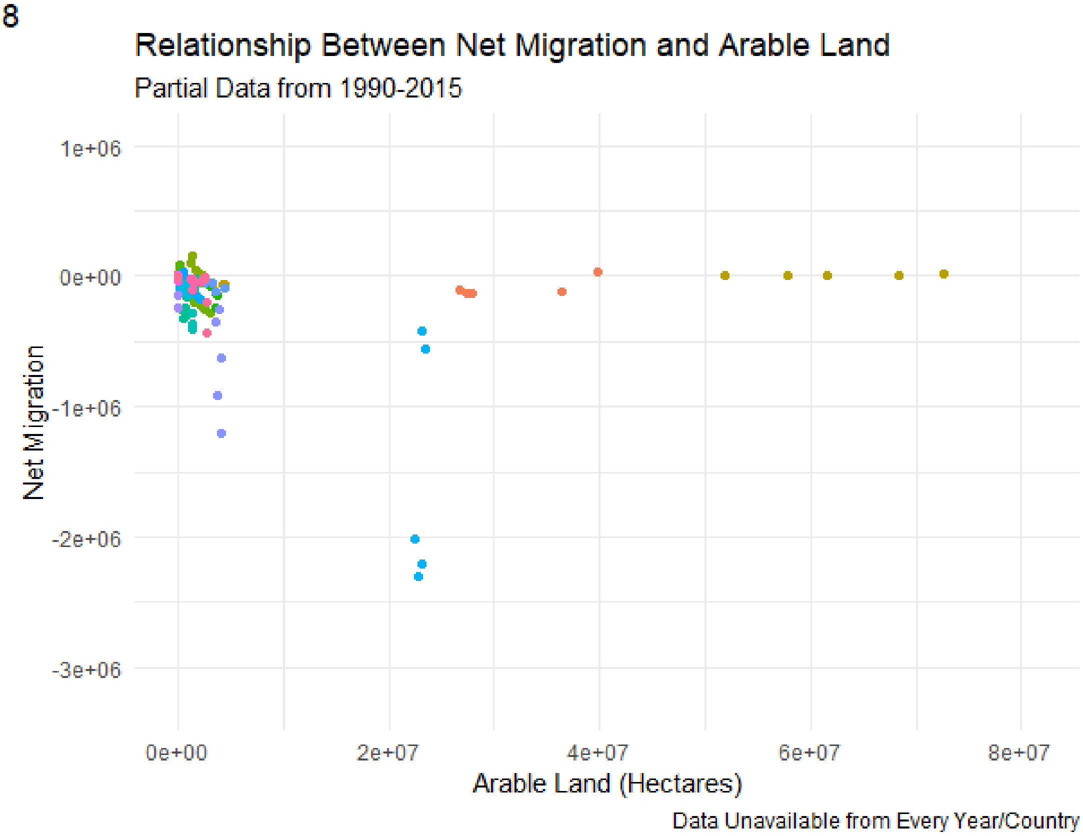

Figure 9

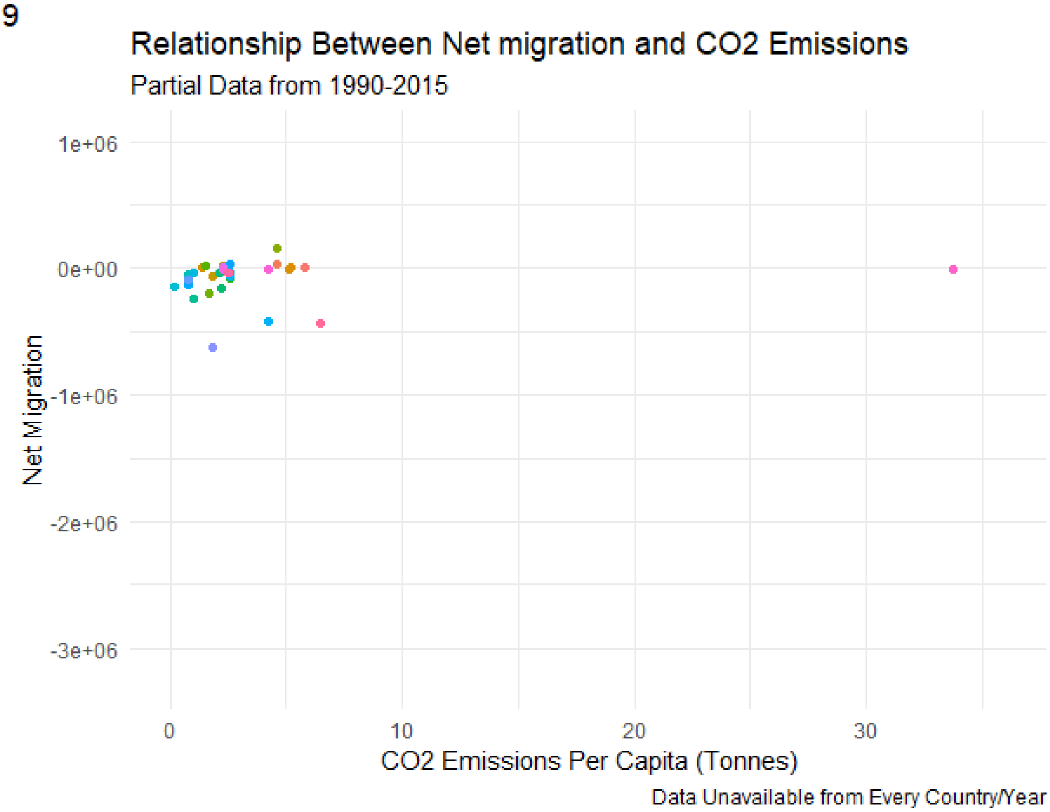

Figure 10

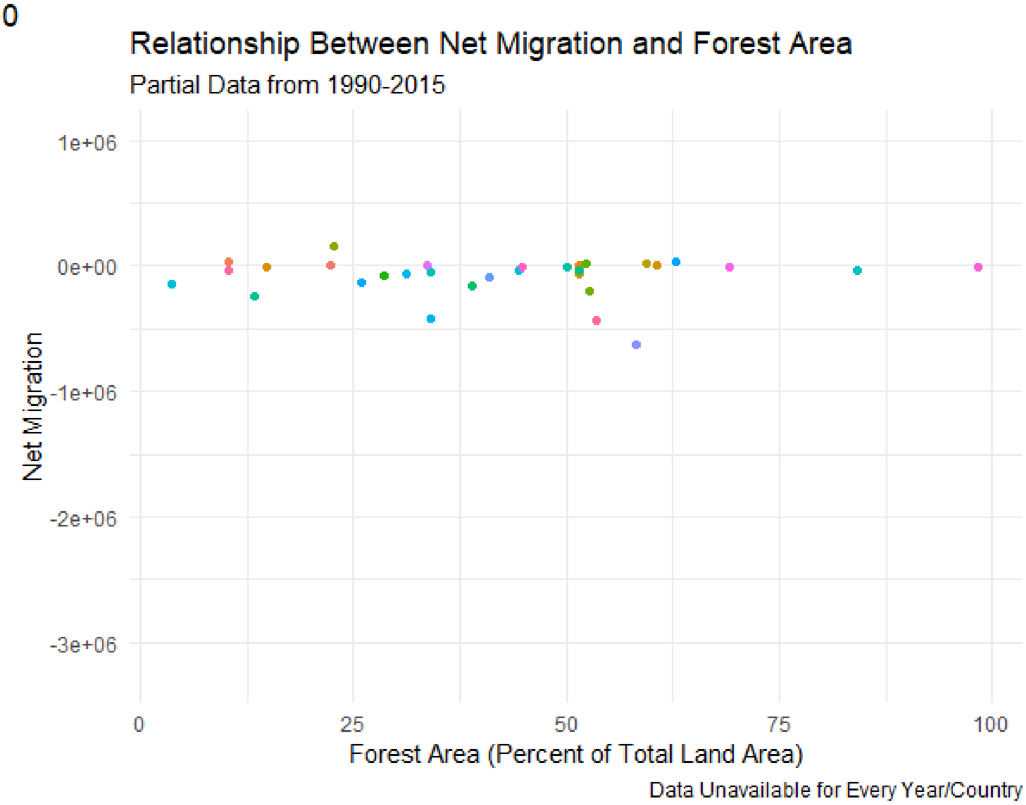

Figure 11

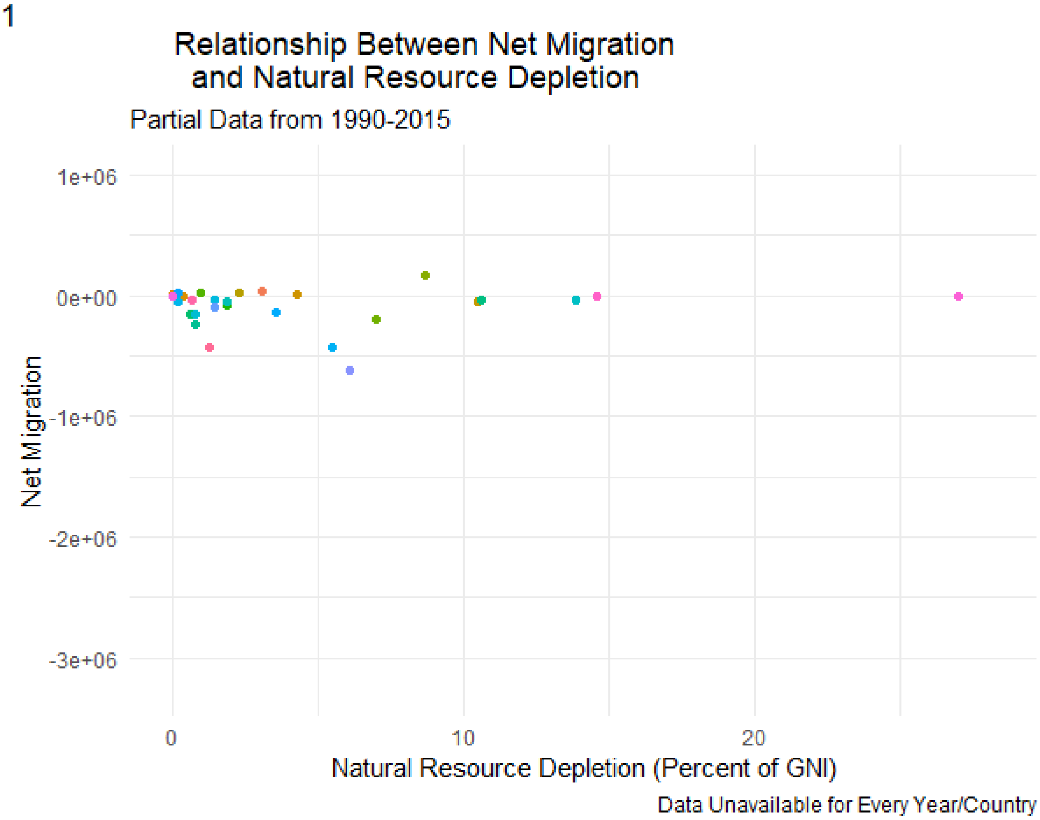

Figure 12

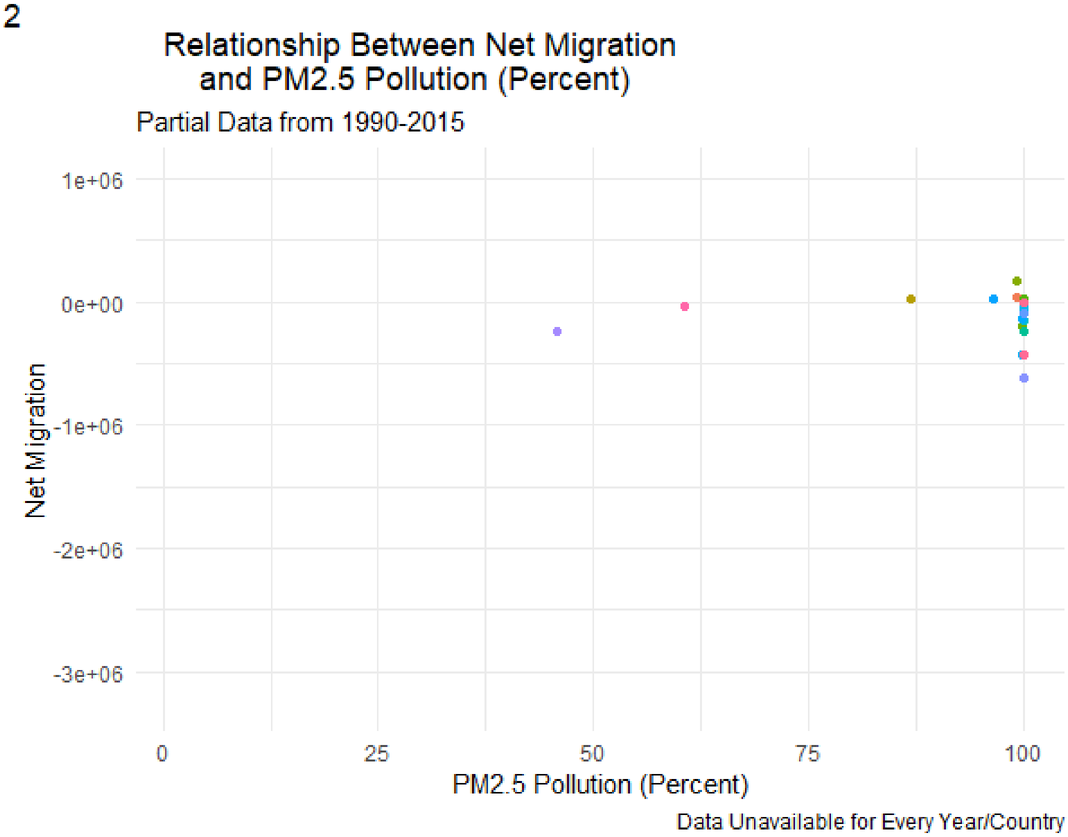

Figure 13

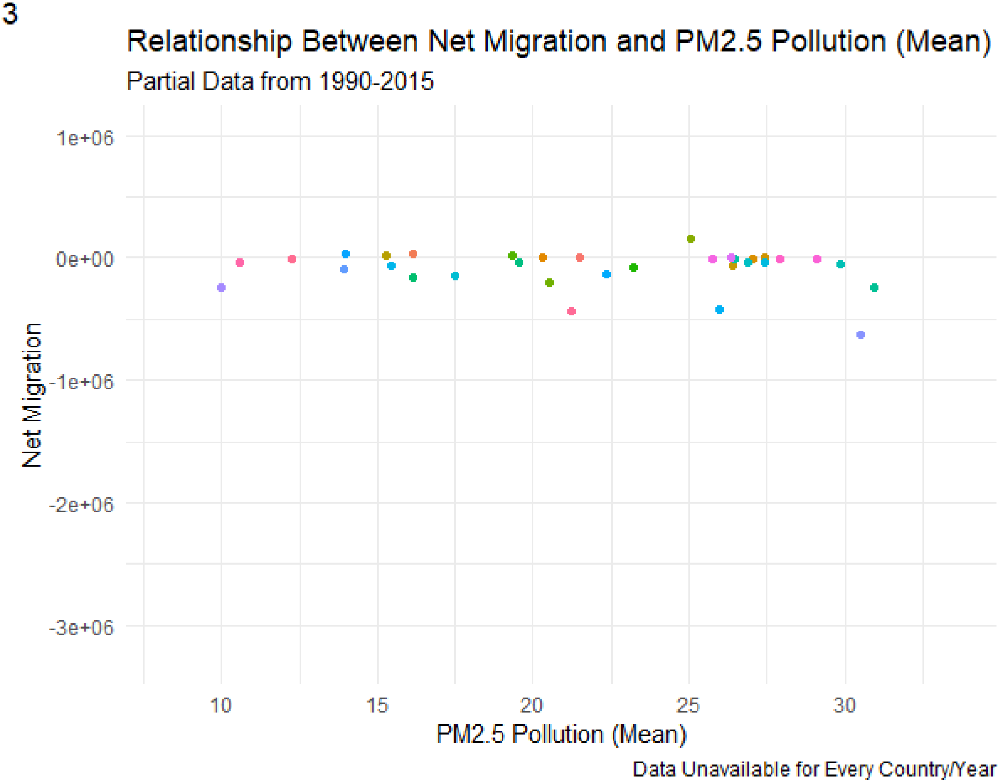

Figure 14