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Research Article

Investigating the Validity of Climate Migration: Empirical Evidence from the Most Polluted Countries[a]

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The literature generally finds that lower air quality has been an important determinant of migration. This study builds a migration model employing annual data from 2010 to 2019 for the most polluted ten countries to test the validity of migration caused by air pollution through PM2.5 concentration. The Poisson Pseudo Maximum Likelihood method results show that air pollution is one of the most significant determinants of migration from the most polluted countries. Moreover, the low income level also pushes people to migrate more from their origin regions than richer ones. The study provides some policy recommendations for policy-makers in the countries where people breathe the most polluted air: (i) governments should follow growth-promoting economic policies; (ii) environment-friendly production techniques should be implemented to prevent worsening environmental quality; (iii) climate-induced mass migration should be considered while making security policy arrangements.

JEL codes: F22, Q53, Q56

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1 Introduction

Environmental pollution has been widely debated on a global scale. Similarly, international migration[1] has become one of the most significant issues worldwide. However, in early migration theories, the question *"Do people migrate only for better economic conditions?"* was rarely uttered. Instead, they assumed that people migrated primarily for better economic conditions to achieve higher welfare. In the 21^{st} century, this question has gained considerable attention among scientists in the relevant fields. Today, it is undoubtedly accepted that international migration is a more complex issue than previously thought. As

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[1] The term migrant is usually understood to cover all cases where individuals freely decide to migrate for reasons of "personal convenience" and without the intervention of an external compelling factor. It, therefore, applies to persons and family members moving to another country or region to better their material or social conditions and improve the prospects for themselves or their family (IOM, 2011).

part of this complex structure, migration induced by climate change has become a serious topic in international security discussions, albeit there is disagreement over the definitions of migration caused by climate change (Filho et al., 2023).

Migration occurring as a result of climate change is a security problem for humanity. It is a sharply increasing phenomenon estimated to affect millions of people in the future. Consequently, it leads to a rising number of people migrating away from their regions and communities. According to Bilak et al. (2016) and IPCC (2023), more than 20 million people have been displaced annually due to climate change since 2008. This effect is projected to potentially displace hundreds of millions of people between 2050 and 2100.

Though climate change is crucial to human life, most major migration theories that were developed prior to the last two or three decades focused on the supposition that the reasons for international migration were based on income, distance, population, networks, and other indicators. Empirical findings for this relationship illustrated that these were notable reasons for both domestic and international migration. However, excluding environmental factors from the analysis of migration prevents a comprehensive understanding of the realities of migration. Consequently, with global developments in environmental protection, empirical studies have begun to consider environmental factors as significant push/pull factors in migration literature.

In the literature, international migration stemming from air pollution (as an indicator of climate change) can be associated with the theoretical study of Lee (1966), which indicated that people may migrate based on factors in both the origin and destination regions. Accordingly, conditions causing migration symbolize push and pull factors in the origin and destination regions. All conditions or situations that force or attract people to leave their own region are known as push factors (Siyal et al., 2019). At this stage, the equilibrium in favor of migration must be sufficient to overcome the natural inertia that always exists. In Lee's theory, factors in the origin region, such as unemployment, poverty, low wages, and human rights issues, are considered push factors (Zanabazar et al., 2021). Although there are other theories, such as human capital theory and assimilation theory, exploring population movements extensively and thoroughly, the most influential among those is the push-pull theory of Lee (Yu et al., 2022). Moreover, considering the negative effects of air pollution on human health, air pollution in a region can theoretically be assumed to be a push factor for migration. This theoretical background also supports the idea that indicators of air pollution can be matched with Lee's theory.

Environmental conditions are a key reason for migration, although they are not the only reason. While environmental factors can induce migration on their own, they often appear through the loss of livelihoods caused by environmental deterioration (Martin, 2013). This scientific trend can also be justified by the fact that weather and climate conditions significantly impact the incidence and geographical distribution of several diseases (World Bank, 2023). The effects of climate change and air pollution on respiratory diseases give rise to significant global health problems (Tran et al., 2006). Specifically, air pollution (especially from traffic) causes serious harm to both the physical and mental health of residents, leading to a significant increase in respiratory diseases and lung cancer (Brunekreef & Holgate, 2002; Yu et al., 2022). Air pollution also causes an increase in deaths among people with heart and lung diseases, significantly obstructing the expected trend toward improved health status and increased life expectancy (Chen et al., 2013). The air pollution map of the world is presented in Figure 1, where the most polluted countries are colored in red. Accordingly,

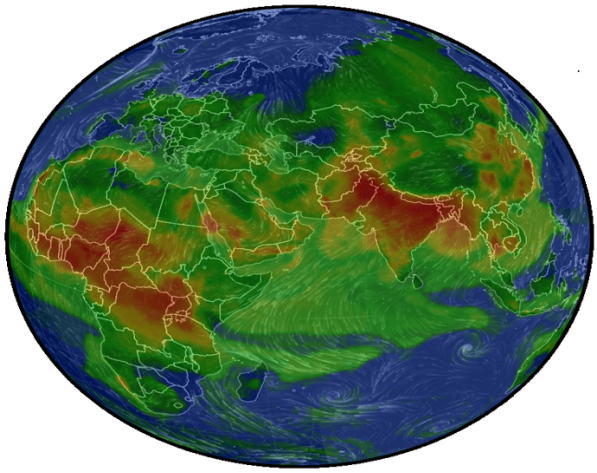

Figure 1: Map for PM2.5 Air Pollution on the World
Source: IQAir (2023)

regions with high air pollution include parts of East and South Asia, the Middle East (Arab region), and countries in Central and West Africa.

Regarding international migration, 3.3% of the world's population lived outside their country of origin in 2015 (UNPF, 2015); this rate increased to 3.5%, representing 276 million people in 2019. Moreover, in 2020, despite COVID-19 restrictions, 3.6% of the world's population, or about 280 million people, were in a migrant position (IOM, 2022). It can be stated that the tendency for migration in the world increased until 2020 and likely continued afterwards. International migration will seemingly continue to be a major reality around the world. A world migration map for origin countries, Figure 2, shows that the regions with high emigration are West and Middle Asia, the Middle East including the Arab Region, Middle and West Africa, as well as West America. Evaluating Figures 1 and 2 together clearly indicate that the most polluted countries worldwide also send the most migrants to other countries. However, this intuition needs to be investigated empirically.

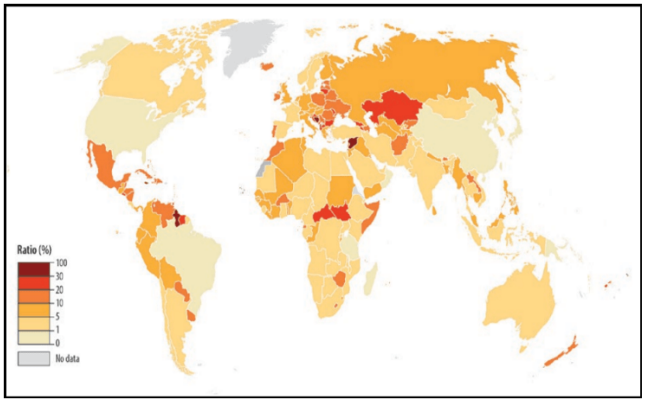

Figure 2: World Migration Map for Origin Countries
Source: World Bank (2023)

Permanent or temporary migration has been one of the most significant survival reflections adopted by people against natural or human-caused disasters. However, our knowledge of the complex two-way relationship involving environmental issues as both a reason and conclusion of migration is limited. Historically, the major part of migration that appeared by environmental conditions has occurred as internal migration resulting from population movements, and international dimensions of this nexus have been neglected until recently Hugo (2008). Excluding environmental factors -as a big deficiency- gives rise to missing potentially important causes and consequences of migration. Therefore, reflecting environmental qualifications within quantitative modelings makes interdisciplinary studies compulsory and precious (Hunter & Nawrotzki, 2016).

Through this study, we primarily aim to address the research question: Is air pollution caused by particulate matter 2.5 (PM2.5) concentration[2] a push factor for international migration? As such, this study does not include additional factors from other fields that might affect migration, as our goal is to isolate the effect of PM2.5 concentration.

The novelty of this study in the related literature and our motivation is to build an empirical model examining the issue that has not been established by early studies. Previous studies focus either on analyzing how migration affects air pollution or how air pollution affects people's migration or settling decisions. However, to the best of our knowledge, we are providing the first empirical findings regarding the impact of air pollution proxied by PM2.5 initiating migration movements from the most polluted countries. The difference between this study and others is including both the most polluted ten countries and the size of international migration from 2010 to 2019. Additionally, we present empirical evidence for countries on how they can manage international migration policies efficiently and explain how they can protect their social capital.

Our findings indicate that air pollution caused by PM2.5 concentration is a push factor for international migration from the most polluted countries; a 1% increase in PM2.5 concentration causes a 0.2% increase in population outflow from these countries. In addition, a 1% increase in per capita income level lowers the migration flows by 0.7%.

The remainder of the study is as follows. A review of the empirical literature is provided in Section 2. In Section 3, the econometric model, data and empirical procedure are introduced. Section 4 presents the empirical results and discussion, and Section 5 concludes.

2 Literature Review

Studies in the related literature generally look into the impact of pushing factors on migration by investigating their nexus. In those studies, indicators related to air pollution are used in addition to the economics and political factors. Therefore, we first discuss the effects of other pushing factors' effects on migration and subsequently review the effects of other environmental factors. Nonetheless, it must be noted that studies which include environmental push factors for migration seem very limited.

The first group studies claims that reasons or conditions decreasing life quality increases migration. Trummer et al. (2023) assembled data on Africa from migrant and refugee com-

[2] This includes microscopic solid or liquid droplets, of which inhalation brings about serious health problems. Of these, particles less than 2.5 micrometers in diameter, also known as fine particles or PM2.5, pose the highest risk to human health (USEPA, 2023).

munities and obtained strong results that worsening environmental conditions forced migration and displacement due to rising healthcare needs and deteriorating access to healthcare. The results of Khan et al. (2023), which examined migration from India's Bihar region to the Gulf countries for the 2018-2019 period, strongly accepted the hypothesis that unemployment, low wages and weak financial conditions are significant pushing factors for migration. Manzoor et al. (2021) found that economic factors such as unemployment and low-income level are pushing factors of migration from BRICS to OECD countries for the period 2000-2013. The results of a survey with 650 Mongolians living in various countries showed that lack of accessibility to healthcare, separation from family, and conflicts in family are pushing factors (Zanabazar et al., 2021). Roth & Hartnett (2018) researched why young migrants have a tendency to migrate to the United States of America (USA) by using survey data of young people in El Salvador who participated in Youth Outreach Centers and showed that young people would continue to settle in US borders due to violent neighborhoods. In other words, risky behavior in their living environment pushes them to migrate. In this direction, Wood et al. (2010) obtained similar results for Latin American migrants from 17 countries, such that crime victimization of people in Latin America is a reason for migration.

In the second group, there are studies on migration, migration intention and environmental nexus. By using the dataset from 2015 to 2017, Yu et al. (2022) investigated the link between air pollution and settlement intention and demonstrated that air pollution is a significantly negative function of the settlement intention of migrants. Namely, an increase in air pollution decreases migrant's intention to settle in China. Shen et al. (2023) used the 2012-2014 dataset from China Labor Dynamics Survey data and studied the effect of air pollution caused by PM2.5 concentration on the migrant decision to settle and significantly supported the assumption that air pollution decreased migration in China. Chen et al. (2022) found that an increase in air pollution caused by PM2.5 concentration reduces the population in the reference region. Namely, a 10% increase in air pollution rises up migration by 2.8%. Rahmandoust et al. (2011) concluded that restriction of religious activities, lack of hygiene, difficulties in getting financial support and high living costs are pushing factors for Iranian entrepreneurs in Malaysia. Chen et al. (2006) proved that bad environmental hazards pushed the population to other regions by following Dallas and Tacoma City census statistics. In some cases, on the other hand, the positive implications of better economic and social conditions can suppress the negative environmental problems in the destination country or region. For example, although Florida State is affected by hurricanes frequently and severely, it is still one of the very popular internal migration destinations in the United States (USCB, 2022). People keep migrating regardless of the hurricanes that hit Florida State because the strong institutional structure and insurance scheme minimize the risks. As another example, the Netherlands has been at risk of land subsidence and lowering the groundwater level for many years, it is quite a famous recipient country for international migration movements (Eurostat, 2024).

Another group of studies focuses on problems during the decision of migration, which can be called difficulties that prevent migration. According to this approach, climate change affects income sharing in countries and, thus, deepens inequalities, including unequal provision of economic, cultural, and social capital between genders. From the other perspective, we see a negative relationship between climate change and migration; climate change diminishes migration indirectly (Laczko & Piguet, 2014; Tischler & Haltermann, 2019). As an attempt to determine pushing and pulling factors by matching international migration

and environmental conditions, Mulligan et al. (2014) investigated migration flows between Europe and its neighbors and found that some environmental factors, such as air pollution and drought, that causing worsening in agricultural conditions, are determinants of migration. However, contrary to our review, Zanabazar et al. (2021) found that air pollution is not a significant factor for Mongolian migrants.

The general evaluation of the literature confirmed our claim that the focus of researchers is on explanatory factors. The studies seek the direct and indirect effects of pushing factors, which are factors causing and obstructing migration from the origin region to other destinations and to a new region, respectively. Furthermore, the common conclusion to be drawn from the studies is that people are more inclined to migrate from environmentally degraded regions. Therefore, indeed, we think that migration and environment nexus deserve more investigation to find out human life realities. In this scope, we create a model including a new reference period and country group with empirical analysis.

3 Econometric Model, Data and Empirical Procedure

This study was conducted using a model that accounts for the data on emigrants and PM2.5 concentration, as well as GDP per capita (as a control variable) in the most polluted countries from 2010 to 2019. Before proceeding with the analysis, we need to clarify a few critical issues regarding our model choice.

In the literature, some models provide an advantage in investigating social indicators such as trade, population or migration. The Gravity Model, the roots of which date back to the 17^{th} century but used in social sciences (for trade) first by Tinbergen (1962) and further extended by Linnemann (1966), is one of the most popular models. While the Gravity model uses variables belonging to origin and destination regions such as income, population and distance, Harris & Todaro (1970) investigated the relationship between various factors and internal migration. As the motivation of our model is to seek the effect of air pollution caused by PM2.5 concentration on migration decisions, we consciously drew a model including limited variables and chose countries which have the highest air pollution caused by PM2.5 concentration with the database of IQAir (2023). Since it includes international migration, air pollution, and control variables, it is coherent with the purpose of the study. Finally, by following Shen et al. (2023) and Chen et al. (2022), the model contains a pushing factor (PM2.5 concentration) and control variable belonging to the origin countries. Because we assume that migration caused by climate change means an escape from poor living conditions, and this assumption can be associated with only pushing factor(s). Besides, it can be stated that our model is a basic gravity model since we used income and population variables as well as an air pollution indicator. However, the distance could not have been placed in the model owing to one-way migration. Table 1 provides the definitions of variables, and equation (1) is the estimated model.

$$\begin{gathered} lnEMIG_{it} = A_0 \ + A_1 \ lnPM2.5_{it} + A_2 \ lnGDPP_{it} \ + u_{it} \\ i \in (1,10) \ and \ t \in (2010,2019) \end{gathered} \tag{1}$$

where $EMIG$ is the number of migrants, $PM2.5$ is the PM2.5 level, $GDPP$ is per capita GDP, u is the error term, ln expresses that all variables are in the natural logarithm, and i and t are number of selected countries and reference period, respectively. Climate change is proxied by air pollution indicators by many scholars (e.g., Yu et al., 2022; Shen et al., 2023;

Table 1: Information for Variables and Reference Countries

Variable	Definition	Source
Migrants	The number of migrated people includes refugees and asylum seekers in the origin country.	UNRA (2023)
PM2.5 Concentration	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.	World Bank (2023)
Gross Domestic Product Per Capita	GDP at purchaser's prices divided by population at current USD.	

Note: The most polluted countries are Chad, Iraq, Pakistan, Bahrain, Bangladesh, Burkina Faso, Kuwait, India, Egypt and Tajikistan (IQAir, 2023).

Chen et al., 2022; Mulligan et al., 2014), as the link between air pollution, which affects many environmental indicators, and migration were proven in empirical studies. Table 2 provides the descriptive statistics of variables used in the analysis.

Table 2: Descriptive Statistics

Variable	Observation	Mean	Std. Dev.	Minimum	Maximum
MIG	100	83,743.49	243,565.70	81.00	1,683,576.00
PMC	100	6,162,273.00	122,774.00	3,451,171.00	9,524,264.00
GDPP	100	6,682.44	10,081.42	5,639,268.00	33,427.86
Pairwise Pearson correlation test results					
Dependent variable: lnMIG		lnPMC 0.119		lnGDPP -0.319	

Accordingly, the maximum and minimum values of migration are 1.68 million people (from Iraq) and 81 (from Bahrain), respectively. The highest PM2.5 concentration data belongs to India, at approximately 95.25 micrograms per cubic meter, while the lowest PM2.5 concentration is in Chad, at 34.5 micrograms per cubic meter. Additionally, correlation results indicate a positive relationship between air pollution caused by PM2.5 concentration and migration, whereas a negative relationship between income level and migration. Although correlation results refer to some information, nevertheless, empirical evidence is necessary to make scientific extractions.

Equation (1) is estimated by using a static panel data approach as migration and PM2.5 concentration data include both time series and cross-section dimensions. The approach provides many advantages for researchers, such as controlling for individual heterogeneity, examining the tuning dynamics, detecting unobservable effects purely, testing complex behavioral models, and measuring micro-level variables representing individual decisions (Baltagi, 2005). Creating an increase in the degree of freedom by ensuring a broad number of observations and increasing the effectiveness of econometric estimations are other advantages of using panel data analysis (Hsiao, 2003).

After that, the Poisson Pseudo Maximum Likelihood (PPML) method was considered as the empirical approach by following Silva & Tenreyro (2006) since the non-linear least squares estimator emphasizes noisier observations, including higher variance. That makes this type of estimation inefficient. Therefore, the conditional variance in the PPML is

proportional to conditional mean (Bobková, 2012). In addition to being consistent against the heteroskedasticity problem, the PPML method helps to deal with zero values of the dependent variable (Silva & Tenreyro, 2006).

4 Empirical Results and Discussions

The results of the PPML estimation of equation (1) and Breusch-Pagan/Cook-Weisberg test to examine the presence of heteroscedasticity, are presented in Table 3. Evidence from the Breusch-Pagan/Cook-Weisberg test shows that using the PPML method satisfied the expectations. Seemingly, the pushing effect was confirmed by empirical analysis for the reference period and group.

Table 3: Empirical Findings from PPML Estimator

Dependent Variable: LMIG			
Variable	Coefficients	Robust Std. Err.	P > |z|
LPMC	0.225	0.111	0.043**
LGDPP	-0.689	0.016	0.000***
Constant	1816	0.440	0.000***
R^2 = 0. 1294 - Number of observations: 100			
Breusch-Pagan/Cook-Weisberg Test *(H_o: Variance is constant)*			*$\chi^2(1)$ = 10.69* *Prob> χ^2=0.001****

Note: ***, **, * indicate that variable is significant at %1, %5 and %10 critical value respectively

Table 3 reports that air pollution caused by PM2.5 concentration positively and statistically significantly affects international migration at a 1% significance level; a 1% increase in the level of air pollution generates a pushing effect and increases migration by 0.22%. On the other hand, the coefficient of $LGDPP$ indicates that a 1% increase in per capita GDP decreases migration by 0.61%. These results are in line with expectations as both of the explanatory variables are assumed to be pushing factors in the theoretical background. Our sample, except for Kuwait, consists of middle and low-income economies in addition to their feature of the most polluted (World Bank, 2022). Empirical evidence concerning income level provides clear insights regarding the pushing factors of migration from these countries: poor economic growth and employment, higher unemployment, and income inequality. As compared to empirical literature, our findings confirmed the result in previous studies (e.g., Trummer et al., 2023; Khan et al., 2023; Yu et al., 2022; Shen et al., 2023; Manzoor et al., 2021; Roth & Hartnett, 2018; Wood et al., 2010; Chen et al., 2006). On the other hand, our findings did not support the study of Zanabazar et al. (2021), which finds no significant relationship between migration and air pollution.

Worsening living conditions, including lower air quality, make people have a tendency for a better life (Shen et al., 2023). Vice versa, the lack of these conditions also created a reverse effect. Just as we proved in empirical results, it was clear that migration was essentially caused by pushing factors. Therefore, our conclusions highlight the need for policymakers and bureaucrats to alleviate pushing factors to reduce climate-induced migration (Khan et al., 2023). In terms of social capital, the outflow of high-income and highly educated migrants due to air pollution will affect the social dynamics (Yu et al., 2022). Based on our empirical findings, we can consider the demographic characteristics of the people who decide to migrate due to air pollution. As Wallerstein (2011) indicated in his well-known World

Systems Theory, migration occurs from peripheral (labour-abounded and poor) countries to core (capitalist and rich) countries and makes contributions to capitalist economies. Based on his theory, it can be argued that migrant population generally consist of people who have high education level and environmental awareness (namely migrant, not refugee or asylum seeker)[3]. Therefore, such a population flow brings about socioeconomic problems and hinders development in the most polluted and developing countries (Çakı, 2018). As each economy needs qualified people to achieve economic goals and development, the exodus of high-skilled people means a social capital loss and eventually, both economic and social conditions might be worse due to this migration. Furthermore, climate migration should be taken into consideration in the construction of environment security policy arrangements. Malthus (1798) stated that migration is a factor disturbing environmental conditions by virtue of population growth, albeit Boserup (1965, 1981) put forward that population growth improved the conditions in agricultural production with novelties. Otherwise, it can not be achieved to avoid potential mass migration in the international size.

5 Conclusion

Understanding the reasons for international migration and its effects on the host and source countries has been placed among the most critical issues. In this study, we attempted to explore the relationship between air pollution caused by PM2.5 concentration and migration for the most polluted countries from 2010 to 2019. We used the Poisson Pseudo Maximum Likelihood (PPML) method to empirically analyse a basic and restricted gravity model.

The empirical results significantly indicate the pushing role of air pollution and low-income levels on migration decisions from the most polluted countries. Intuitively, we can assume that individuals pushed by air pollution are generally migrants seeking better environmental conditions. We do not consider them refugees or asylum seekers since the main motivation for migration, for these groups is escaping from death, pressure, or restrictions on freedom of thought, and they do not choose to migrate consciously. Nevertheless, it can be stated that as migration indirectly shows the movements of refugees, we recommend that bad environmental conditions should be included in the definition of refugee.

In light of the overall results, we recommend policies promoting environmentally friendly growth technologies to foster economic growth in these economies to prevent the flow of people from low-income countries. The findings highlight that a group of people prefers to live in countries with lower pollution levels and higher income levels. The lack of one of those determinants will probably push people to other countries whose better economic and environmental conditions. Therefore, all government policies considering the protection of the environment should be applied to achieve economic goals. The way to ameliorate risk perceptions about migration is to provide contributions to help people not leave their home communities and prevent the push to migrate (Raimi et al., 2024). We believe that our

[3] A refugee is a person who, "owing to a well-founded fear of persecution for reasons of race, religion, nationality, membership of a particular social group or political opinions, is outside the country of his nationality and is unable or, owing to such fear, is unwilling to avail himself of the protection of that country". An asylum seeker is a person who seeks safety from persecution or serious harm in a country other than his or her own and awaits a decision on the application for refugee status under relevant international and national instruments (IOM, 2011).

findings are applicable not only to the most polluted countries but also to other countries with high air pollution.

Our study has two limitations. First, investigating the nexus of migration and air pollution in a broader context and with a sample of more homogenous countries can contribute to scientific literature. Second, alternative empirical settings with more explanatory variables and different environmental pollution indicators can be constructed to obtain more robust evidence concerning the nexus we examined.

References

Baltagi, B. H. (2005). *Econometric Analysis of Panel Data* (3rd ed.). Chester: John Wiley & Sons Ltd.

Bilak, A., Cardona-Fox, G., Ginnetti, J., Rushing, E. J., Scherer, I., Swain, M., ... Yonetani, M. (2016). *Global report on internal displacement* (Report). Internal Displacement Monitoring Centre (IDMC). https://api.internal-displacement.org/sites/default/files/publications/documents/2016-global-report-internal-displacement-IDMC.pdf.

Bobková, B. (2012). *Gravity Model Estimation Using Panel Data - Is Logarithmic Transformation Advisable.* https://dspace.cuni.cz/bitstream/handle/20.500.11956/47004/DPTX_2011_1__0_292020_0_119811.pdf?sequence=1&isAllowed=y.

Boserup, E. (1965). *The Conditions of Agricultural Growth.* Aldine Publishing Company, Chicago.

Boserup, E. (1981). *Population and Technological Change: A Study of Long-term Trends.* University of Chicago Press, Chicago.

Brunekreef, B., & Holgate, S. T. (2002). Air pollution and health. *The Lancet*, *360*(9391), 1233-1242. doi: 10.1016/S0140-6736(02)11274-8

Çakı, A. (2018). *Geçmişten Bugüne Türkiye'nin Göç Politikası ve Suriyeli Göçmenler Bağlamında Göç Yönetişimi.*

Cameron, T. A., & McConnaha, I. T. (2006). Evidence of environmental migration. *Land Economics*, *82*(2), 273-290. doi: 10.3368/le.82.2.273

Chen, S., Oliva, P., & Zhang, P. (2022). The effect of air pollution on migration: Evidence from China. *Journal of Development Economics*, *156*, 102833. doi: 10.1016/j.jdeveco.2022.102833

Chen, Y., Ebenstein, A., Greenstone, M., & Li, H. (2013). Evidence on the impact of sustained exposure to air pollution on life expectancy from China's Huai River policy. *Environmental Sciences*, *110*(32), 12936-12941. doi: 10.1073/pnas.1300018110

Eurostat. (2024). *First permits by reason, length of validity and citizenship.* doi: 10.2908/migr_resfirst

Filho, W. L., Ayal, D. Y., Chamma, D. D., Kovaleva, M., Alverio, G. N., Nzengya, D. M., ... Nagy, G. J. (2023). Assessing causes and implications of climate-induced migration in Kenya and Ethiopia. *Environmental Science and Policy*, *15*, 1-11. doi: 10.1016/j.envsci.2023.103577

Harris, J. R., & Todaro, M. P. (1970). Migration, Unemployment and Development: A Two-sector Analysis. *The American Economic Review*, *60*(1), 126-142. doi: 10.1038/s41598-021-00053-8

Hsiao, C. (2003). *Analysis of Panel Data*. Cambridge University Press, UK.

Hugo, G. (2008). *Migration, Development and Environment* (Migration Research Series No. 35). International Organization for Migration (IOM). https://publications.iom.int/system/files/pdf/mrs_35_1.pdf.

Hunter, L. M., & Nawrotzki, R. J. (2016). Migration and the environment. In M. J. White (Ed.), *Handbook of migration and population distribution* (p. 465-484). Springer, Dordrecht. doi: 10.1007/978-94-017-7282-2_21

Intergovernmental Panel on Climate Change (IPCC). (2023). Technical summary. In *Climate change 2022 – impacts, adaptation and vulnerability: Working group ii contribution to the sixth assessment report of the intergovernmental panel on climate change* (p. 37–118). Cambridge University Press.

International Organization for Migration. (2011). *World Migration Report 2011: Communicating Effectively about Migration* (Report). International Organization for Migration (IOM). https://publications.iom.int/system/files/pdf/wmr2011_english.pdf.

International Organization for Migration. (2022). *World migration report – 2022* (Report). International Organization for Migration (IOM). https://publications.iom.int/books/world-migration-report-2022.

IQAir. (2023). *World's most polluted countries & regions.* https://www.iqair.com/world-most-polluted-countries.

Khan, M. I., Alharthi, M., Haque, A., & Illiyan, A. (2023). Statistical analysis of push and pull factors of migration: A case study of India. *Journal of King Saud University – Science*, *35*(8), 1-12. doi: 10.1016/j.jksus.2023.102859

Laczko, F., & Piguet, E. (2014). Regional perspectives on migration, the environment and climate change. In F. Laczko & E. Piguet (Eds.), *People on the move in a changing climate, global migration issues* (p. 1-20). Springer Dordrecht. doi: 10.1007/978-94-007-6985-4

Lee, E. S. (1966). A theory of migration. *Demography*, *3*(1), 47-57. doi: 10.2307/2060063

Linnemann, H. (1966). *An Econometric Study of International Trade Flows.* Holland Publishing, Amsterdam.

Malthus, T. R. (1798). *An Essay on the Principle of Population.* J Johnson, London.

Manzoor, W., Safdar, N., & Mahmood, H. Z. (2021). A gravity model analysis of international migration from BRIC to OECD countries using Poisson Pseudo-Maximum Likelihood approach. *Heliyon*, *7*(6), 1-12. doi: 10.1016/j.heliyon.2021.e07357

Martin, S. F. (2013). *Environmental change and migration: What we know* (Policy Brief). Migration Policy Institute. https://www.migrationpolicy.org/sites/default/files/publications/Migration-EnvironmentalChange.pdf.

Mulligan, M., Burke, S., & Douglas, C. (2014). Environmental change and migration between europe and its neighbours. In F. Laczko & E. Piguet (Eds.), *People on the move in a changing climate, global migration issues* (p. 49-79). Springer Dordrecht. doi: 10.1007/978-94-007-6985-4

Rahmandoust, M., Ahmadian, S., & Shah, I. M. (2011). Iranian Entrepreneurs in Malaysia: Reasons for Their Migration. *World Applied Sciences Journal*, *13*(9), 2075-2081. https://idosi.org/wasj/wasj13(9)/19.pdf.

Raimi, K. T., Sarge, M. A., Geiger, N., Gillis, A., & Cunningham, J. L. (2024). Effects of communicating the rise of climate migration on public perceptions of climate change and migration. *Journal of Environmental Psychology*, *93*, 102210. doi: 10.1016/j.jenvp.2023.102210

Roth, B. J., & Hartnett, C. S. (2018). Creating Reasons to Stay? Unaccompanied youth migration. Community-based Programs, and the Power of "Push" Factors in El Salvador. *Children and Youth Services Review*, *92*, 48-55. doi: 10.1016/j.childyouth.2018.01.026

Shen, F., Wang, Q., Zou, J., Yan, H., & Wang, B. (2023). Air pollution and migration decision of migrants in low-carbon society. *International Journal of Environmental Research and Public Health*, *20*(1), 1-18. doi: 10.3390/ijerph20010870

Silva, J., & Tenreyro, S. (2006). The log of gravity. *The Review of Economics and Statistics*, *88*(4), 641-658. doi: 10.1162/rest.88.4.641

Siyal, G. E. A., Khalid, I. S., & Qaisrani, A. (2019). Internal Migration and Urbanisation: A Case Study from Semi-arid Regions of Pakistan. In S. S. Aneel, U. T. Haroon, & I. Niazi (Eds.), *70 Years of Development: The Way Forward* (pp. 164–187). Sustainable Development Policy Institute.

Tinbergen, J. (1962). *Shaping the World Economy; Suggestions for an International Economic Policy*. Twentieth Century Fund: New York. http://hdl.handle.net/1765/16826.

Tischler, J., & Haltermann, I. (2019). *Environmental Change and African Societies*. BRILL. https://brill.com/edcollbook-oa/title/54203?language=en.

Tran, H. M., Tsai, F.-J., Lee, Y.-L., Chang, J.-H., Chang, L.-T., Chang, T.-Y., ... Chuang, H.-C. (2006). The impact of air pollution on respiratory diseases in an era of climate change: A review of the current evidence. *Science of the Total Environment*, *898*, 166340. doi: 10.1016/j.scitotenv.2023.166340

Trummer, U., Ali, T., Mosca, D., Mukuruva, B., Mwenyango, H., & Novak-Zezula, S. (2023). Climate change aggravating migration and health issues in the African Context: The views and direct experiences of a community of interest in the field. *Journal of Migration and Health*, *7*, 100151. doi: 10.1016/j.jmh.2023.100151

United Nations Population Funds (UNPF). (2015). *Migration.* https://www.unfpa.org/migration.

United Nations Refugee Agency (UNRA). (2023). *Data finder.* https://www.unhcr.org/refugee-statistics/download/?url=sH5pnE.

United States Census Bureau (USCB). (2022). *State-to-State migration flows.* https://www.census.gov/data/tables/time-series/demo/geographic-mobility/state-to-state-migration.html.

United States Environmental Protection Agency (USEPA). (2023). *Basics of climate change.* https://www.epa.gov/climatechange-science/basics-climate-change.

Wallerstein, I. (2011). *Dünya Sistemleri Analizi: Bir Giriş* (3rd ed.; E. Abadoğlu, Trans.). Bgst Yayınları.

Wood, C., Gibson, C., Ribeiro, L., & Hamsho-Diaz, P. (2010). Crime Victimization in Latin America and Intentions to Migrate to the United States. *International Migration Review*, *44*(1), 3-24. doi: 10.1111/j.1747-7379.2009.00796.x

World Bank. (2022). *Countries and economies.* https://data.worldbank.org/country.

World Bank. (2023). *World development indicators.* https://databank.worldbank.org/source/world-development-indicators.

Yu, X., Liang, J., & Zhang, Y. (2022). Air pollution and settlement intention: Evidence from the China migrants dynamic survey. *Environmental Research and Public Health*, *19*(8), 4924. doi: 10.3390/ijerph19084924

Zanabazar, A., Kho, N. S., & Jigjiddorj, S. (2021). The push and pull factors affecting the migration of Mongolians to the Republic of South Korea. *SHS Web of Conferences*, *90*, SHS Web of Conferences. doi: 10.1051/shsconf/20219001023