
THE ECONOMIC DRIVERS OF ENVIRONMENTAL MIGRATION

Os impulsionadores econômicos da migração ambiental

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Resumo: A migração ambiental pode ter um grande impacto econômico tanto para os migrantes quanto para as comunidades receptoras, incluindo perda de renda e empregos, aumento de despesas, e impactos nos recursos e infraestrutura locais, além de consequências econômicas mais amplas. Isso exige a formulação de políticas e programas efetivos. O objetivo deste artigo é explorar os impulsionadores econômicos das migrações e deslocamentos ambientais por meio de uma revisão bibliométrica e sistemática da literatura. Os instrumentos metodológicos incluem medidas de análise de performance e mapeamento científico utilizando o pacote bibliometrix no R, além de uma revisão bibliográfica dos artigos mais impactantes. Os principais resultados mostram que os estudos sobre os impulsionadores econômicos da migração ambiental podem ser categorizados em cinco grupos: i) fatores políticos e outros intermediários; ii) meios de subsistência, resiliência e adaptação; iii) determinantes, questões de gênero, redes e fluxos migratórios; iv) secas, chuvas e emigração; e v) pobreza, saúde, atividade física e questões relacionadas à redução de emissões de gases de efeito estufa. Os resultados enfatizam a necessidade de políticas que aumentem a resiliência aos choques climáticos e reduzam as barreiras aos movimentos populacionais que promovem o bem-estar, considerando que a relação é complexa e específica ao contexto.

Palavras-chave: Migração, Adaptação, Impulsionadores, Bibliometrix, Clima.

Abstract: Environmental migration can have a significant economic impact both on migrants and on receiving communities, including income and job losses, increased expenses, impacts on local resources and infrastructure, and broader economic consequences. This necessitates the formulation of effective policies and programs. The objective of this article is to explore the economic drivers of environmental migration and displacement through a bibliometric and systematic review of the literature. The methodological tools include performance analysis and scientific mapping using the bibliometrix package in R, as well as a bibliographic review of the most impactful articles. The main findings indicate that studies on the economic drivers of environmental migration can be categorized into five groups: i) political factors and other intermediaries; ii) livelihoods, resilience, and adaptation; iii) determinants, gender issues, networks, and migration flows; iv) droughts, rainfall, and emigration; and v) poverty, health, physical activity, and issues related to the reduction of greenhouse gas emissions. The results highlight the need for policies that enhance resilience to climate shocks and reduce barriers to population movements that improve well-being, given that the relationship is complex and context-specific.

Keywords: Migration, Adaptation, Drivers, Bibliometrix, Climate.

1 INTRODUCTION

Environmental migration refers to the movement of people from their homes or places of usual residence due to environmental factors such as natural disasters, drought, and other climate-related events (Black et al., 2011). The economic burden of environmental migration can be significant both for the migrants themselves and for the countries and communities they are moving to (Adams, 2016).

For the migrants, environmental migration can lead to lost income and employment opportunities, as well as increased expenses related to relocation, housing, and healthcare. In many cases, environmental migrants are forced to leave behind their homes, land, and possessions, which can further exacerbate their economic hardship (Bardsley; Hugo, 2010). Migration can be more directly driven by environmental factors in the context of extreme environmental events, and economic drivers such as fluctuations in agricultural production, rural employment, and household income of farmers can also play a significant role (Black et al., 2013).

Environmental migration can generate both localized and broader economic impacts, as receiving communities may benefit from the inflow of low-cost labor while simultaneously facing pressures on resources and infrastructure ill-prepared for sudden population growth (Sherbinin et al., 2008; Correia; Barbieri, 2019). At wider scales, such movements can produce labor shortages, disrupt supply chains, and even intensify political instability, thereby generating significant economic costs (Hoffmann et al., 2020). Overall, the economic burden of environmental migration is multifaceted and demands carefully designed policies that support migrants and host communities while mitigating adverse economic effects (Hugo, 1996; Black et al., 2013).

In this context, the objective of this article is to explore the economic drivers of environmental migration and displacement through a bibliometric and systematic review of the literature. The methodological tools include performance analysis and scientific mapping measures using the bibliometrix package in R (Aria; Cuccurullo, 2017), as well as a bibliographic review of the most impactful articles. The research question guiding this study is: What are the economic drivers of environmental migration and displacement? The hypothesis is that economic factors, such as income loss, job opportunities, and increased expenses due to environmental changes, significantly influence migration patterns. The specific objectives of this article are to categorize the economic drivers of environmental migration, analyze the impact of these drivers on both migrants and receiving communities, and identify policy implications and suggest measures to mitigate the economic burdens of environmental migration.

This task is necessary, as environmental migrations represent an important component of forced displacement, with the latter being one of the fastest-growing forms of displacement in the world (Guedes; Zapata, 2017), bringing challenges to regions of origin and destination. At the same time, climate change tends to intensify climate shocks and economic inequality between regions and countries, accentuating environmental migrations (Barbieri et al., 2010). Understanding the economic drivers of environmental migrations in this regard can help policymakers develop more effective adaptation policies.

2 DRIVERS ECONOMICS LINKING ENVIRONMENT AND MIGRATION

Environmental migration is a complex phenomenon that involves people leaving their regions of origin due to environmental factors such as climate change, natural disasters, resource scarcity, and environmental degradation (Hugo, 1996). Environmental migration can have significant impacts on both destination and origin regions, and understanding these impacts is crucial for the formulation of effective and sustainable public policies (Black et al., 2011).

Economic approaches to environmental migration focus on analyzing the costs and benefits associated with environmental migration, as well as the economic decisions of migrants and their implications for the labor market and economic development. Environmental migration can have both positive and negative effects on the economy, depending on how it is managed and the types of migration that occur (Lee, 1966; Stark; Bloom, 1985; Nawrotzki et al., 2013).

An important economic approach to environmental migration is the theory of migration costs, which examines the financial barriers and costs involved in environmental migration, such as transportation costs, the cost of establishing oneself in a new region, the cost of housing reconstruction, and the loss of human capital. Another approach is the analysis of return migration, which considers the decisions of migrants to return to their regions of origin after an environmental disaster or other environmental factors occur (Hugo, 1996; Black et al., 2011).

In addition, economic approaches to environmental migration can examine the role of remittances in the economy, that is, the money that migrants send back to their regions of origin. Remittances can have a significant impact on the local economy, helping to reduce poverty and promote economic development, but can also create dependence and economic destabilization if not managed properly. Economic approaches to environmental migration are important to understand the impacts of environmental migration on the economy and to develop effective and sustainable public policies to deal with this complex phenomenon.

There are various economic drivers that can contribute to environmental migration, including:

2.1 Loss of livelihoods

Environmental degradation can cause significant economic losses, particularly in agricultural-dependent communities. For example, droughts or floods can destroy crops and farmlands, leaving farmers without a source of income. As a result, people may be forced to leave their homes to seek alternative livelihoods (Sherbinin et al., 2008). Research has shown that natural resources are important for the economic subsistence of families in Latin America. Some families may engage in deforestation to pay off debts incurred during illnesses, and when disease risks are high and formal insurance markets are rare, families may sell forest products to cover treatment costs. This line of research can help understand how demographic and environmental changes are interconnected. Border migration can lead to environmental changes that affect the health of families, which in turn may affect the use of natural resources (Barbieri et al., 2005; Castro et al., 2006; Vittor et al., 2006).

2.2 Resource competition

Environmental degradation can lead to competition for scarce resources such as water, fertile land, and forest resources. This competition can exacerbate conflicts between communities and even lead to violence, forcing people to leave their homes to seek safety (Hoffmann et al., 2020).

2.3 Economic inequality

Environmental degradation often disproportionately affects poor and marginalized communities who have limited access to resources and infrastructure to cope with environmental changes (Sherbinin et al., 2008). In such situations, the wealthier segments of society may be able to migrate to safer areas, leaving the poorer sections behind (Barbieri et al., 2010; Correia; Ojima, 2019).

2.4 Job opportunities

Environmental degradation can create new job opportunities in certain areas, such as environmental conservation and restoration, renewable energy, and disaster management. This can attract people to migrate to areas with better economic prospects (Sherbinin et al., 2008; Gray; Mueller, 2012).

2.5 Government policies and subsidies

Government policies and subsidies can also drive environmental migration. For example, subsidies for the extraction of natural resources can lead to environmental degradation, which in turn can displace communities. Similarly, policies that encourage the development of certain areas can also displace people living in those areas (Black et al., 2011).

Overall, environmental migration is a complex phenomenon with various economic, social, and environmental drivers. Addressing the economic drivers of environmental migration requires a comprehensive approach that involves improving access to resources and infrastructure, reducing economic inequality, and promoting sustainable economic development practices (Sherbinin et al., 2008). One trend is that, with climate change, periods of drought are likely to become more intense, which may also accentuate environmental migrations and displacements (Barbieri et al., 2010; Correia, 2021). This reinforces the importance of understanding the economic drivers of environmental migration to guide more effective adaptation policies.

3 DATA AND METHODS

This article has been divided into four stages. The first stage comprised defining the research question, where relevant terms related to the economic drivers of environmental migration and displacement were identified. In the second stage, data collection was conducted in the Scopus and Web of Science (WoS)¹ databases, with a preference for English terms due to the higher volume of scientific production in this language. Searches were carried out between December 17, 2022, and April 15, 2023, limiting results to the period from 2012 to 2023 (the most recent publications available as of April 13, 2023), aiming to reconcile search mechanisms in both databases. In Scopus, 159 publications were found, while in WoS, 1,318 documents were found, totaling 1,477 publications.

The third stage involved importing the data into the R environment, an open-source programming language that supports contributions. Using the bibliometrix package developed by Aria and Cuccurullo (2017), the two databases were converted into tables, and duplicate publications (98) were excluded, resulting in a total of 1,379 publications. Then, bibliometric analysis was performed, including both performance analysis (identifying the most relevant authors, number of articles published, citations, institutions, and prominent research areas) and mapping (creating conceptual maps involving collaboration between countries, institutions, co-authors, and common keywords used).

The fourth and final stage consisted of a thorough review of the most impactful literature, using the bibliometric analysis conducted in the previous stage as a tool. By identifying the 10 most impactful articles, a more detailed bibliographic analysis was carried out, allowing for the presentation and discussion of the most significant results in studies on environmental migration. This stage also included a classification of studies by thematic area, countries of origin and destination of displacements, methodological approach employed, and the economic variable chosen by the study as the economic intermediary in the relationship between environmental shock and human displacement.

4 ECONOMIC APPROACHES TO ENVIRONMENTAL MIGRATION

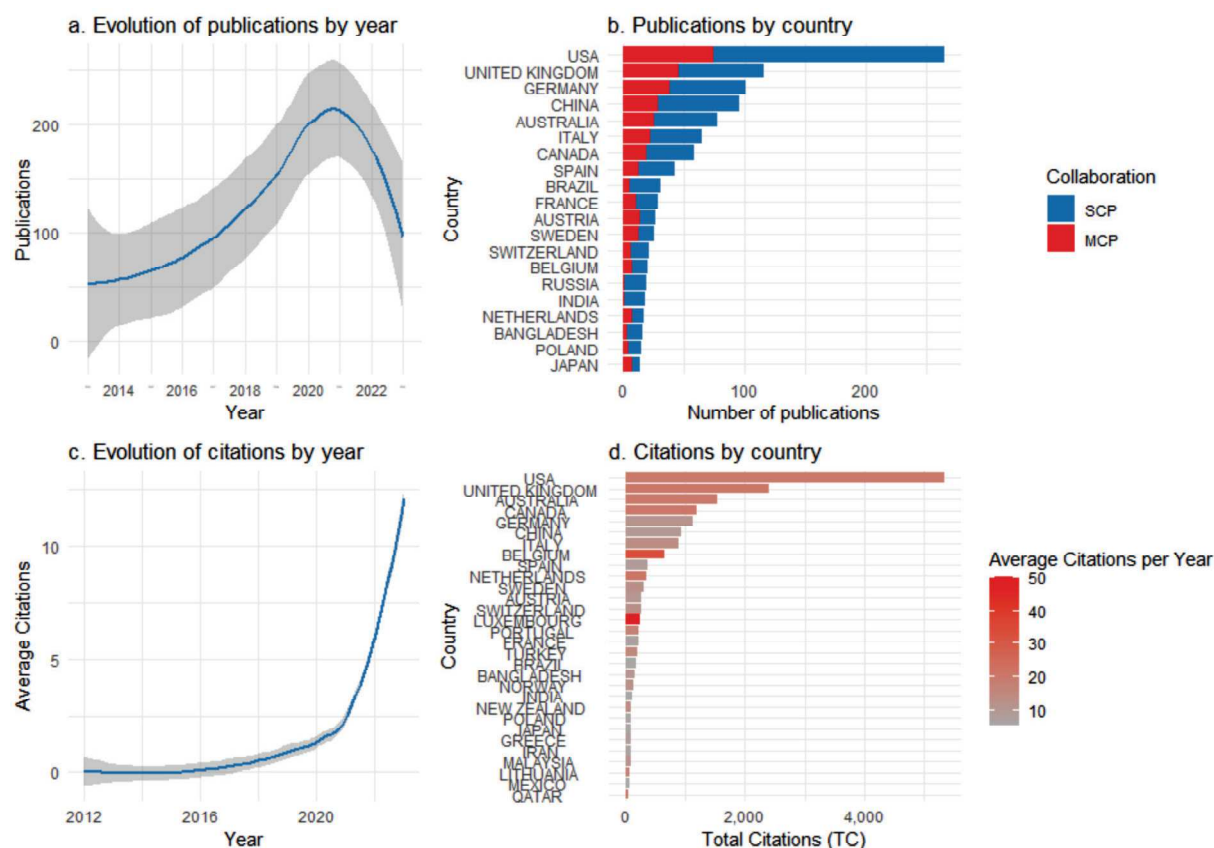
4.1 Performance analysis

Performance evaluation examines the contributions of different authors to research in a particular field (Aria; Cuccurullo, 2017; Kumar et al., 2021), based on a dataset comprising 1,379 documents. Scientific production on the economic drivers of environmental migration and displacement has grown significantly in recent years, with a marked increase in publications related to the topic up to 2020, as shown in Figure 1. The United States is a major contributor to the overall production, along with several European countries such as the United Kingdom and Germany, as well as China, Australia, Italy, and Canada, which also have many authors. The list of countries with the highest number of publications remains consistent for both single-country publications (SCP) and those involving collaboration with other countries (MCP).

¹ Scopus (159): TITLE=ABS-KEY (environmental AND migration OR climate AND migration OR environmental AND refugee OR climate AND refugee OR environmental AND displacement OR climate AND displacement OR environmental AND mobility OR climate AND mobility) AND PUBYEAR > 2011 AND PUBYEAR < 2024 AND ABS (economy OR economic OR poverty OR livelihood OR market OR income OR employment) AND TITLE (migration OR refugee OR displacement OR mobility).

WoS (1.318): ((((((TI=(migration)) OR TI=(mobility)) OR TI=(refugee)) OR TI=(displacement)) AND AB=(environmental migration OR climate migration OR environmental refugee OR climate refugee OR environmental displacement OR climate displacement OR environmental mobility OR climate mobility)) AND AB=(economy OR economic OR poverty OR livelihood OR market OR income OR employment)) AND DOP=(2012-01-01/2023-04-13).

Figure 1 – Annual Evolution and Distribution of Publications on Economic Drivers of Environmental Migration by Authors' Countries, 2013-2023.



Source: Scopus and Web of Science (WoS) databases.

Countries that receive migrants and environmental refugees are interested in understanding forced migration for various reasons. Environmental refugees, although not exclusively forced migrants, represent one of the fastest-growing forms of displacement in the world (Zapata; Guedes, 2017). Migration can create social, political, and economic pressures, as well as humanitarian challenges, such as providing shelter, food, and medical care to migrants. Additionally, migration flows cannot be explained solely by individual motivations or migration policies; they are also influenced by the interaction between these factors and other explanatory elements associated with intermediaries involved in the migration process, such as employers, traffickers, civil society organizations, host authorities, and immigrant communities (Triandafyllidou, 2017).

The prominence of the US and European countries in scientific production on the intermediary economic factors of the relationship between environmental shocks and migration and displacement is evident in the affiliations of the authors, indicating that this issue is a frequent concern for countries that receive migrants. Table 1 shows the distribution of publications on environmental migration by authors' affiliations from 2013 to 2023. The table includes information on the country of the institution, the name of the institution, the number of publications, and the percentage of total publications.

Table 1 – Distribution of Publications on the Economic Drivers of Environmental Migration by Authors' Affiliation, 2013-2023

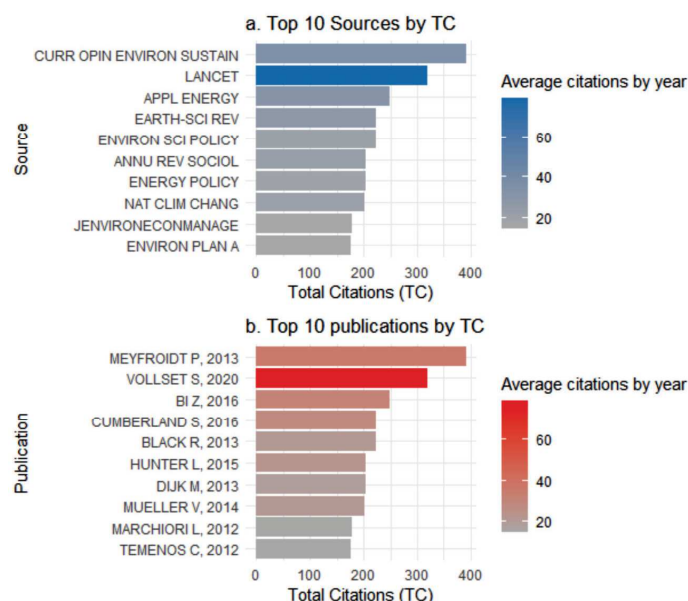
Affiliation	Country	Publications		
		Number	Percent by University	Accumulated by Country
University of Colorado	United States	37	13.1%	-
University of North Carolina	United States	35	12.4%	-
Arizona State University	United States	27	9.6%	-
University of Wisconsin	United States	22	7.8%	42.9%
University of Exeter	United Kingdom	30	10.6%	-
University of Oxford	United Kingdom	30	10.6%	-
University of Sussex	United Kingdom	29	10.3%	31.5%
Australian National University	Australia	25	8.9%	-
University of Melbourne	Australia	22	7.8%	16.7%
University of Vienna	Austria	25	8.9%	8.9%
Total		282	100.0%	-

Source: Scopus and Web of Science (WoS) databases.

From the table, we can observe that most of the publications on environmental migration were produced by institutions in the United States (US) and the United Kingdom (UK), accounting for 42.9% and 31.5% of the total publications, respectively. The University of Colorado and the University of North Carolina produced the highest number of publications, representing 13.1% and 12.4% of the total, respectively. Australia and Austria were also notable contributors, with the Australian National University and the University of Vienna each producing 8.9% of the total publications. The total number of publications was 282. This table suggests that research on environmental migration is concentrated in a few institutions in the US and UK. It also highlights the need for more diverse research collaborations across different regions and countries to gain a more comprehensive understanding of the issue.

As observed in Figure 2, the number of citations has shown exponential growth in recent years, with a particular emphasis on publications from *The Lancet* and *Current Opinion on Environmental Sustainability*. This indicates that both environmental aspects and health issues have become increasingly prominent in studies on migration and population displacement. The most cited publications are by Meyfroidt P (2013), Vollset S (2020), and Bi Z (2016). Notably, although Vollset S (2020) is the most recent article on the list, it has the highest average citations per year.

Figure 2 – Top 10 Sources and Publications on Economic Drivers of Environmental Migration by Number of Citations and Annual Average Citations, 2013-2023



Source: Scopus and Web of Science (WoS) databases.

Table 2 lists the most productive authors in studies on the economic drivers of environmental migration from 2013 to 2023. The table includes the number of articles published by each author, the fraction of co-authored articles, and their ranking. The most productive author is Adger W, with 9 articles published. In second place is Gray C, also with 9 articles, but with a lower co-authorship fraction of 3.5. Mueller V is in third place, with 9 articles and a co-authorship fraction of 2.9. McLeman R and Zhang Y occupy the fourth and fifth positions, respectively, each with 8 articles. The remaining authors on the list – Kelman I, Riosmena F, Sakdapolrak P, Black R, and Chen J – each have between 6 and 7 articles published.

Table 2 – Most Productive Authors in Studies on the Economic Drivers of Environmental Migration (2013-2023)

Authors	Articles	Authors	Articles Fractionalized	Position
Adger W	9	McLeman R	5.00	1st
Gray C	9	Gray C	3.50	2st
Mueller V	9	Randell H	3.00	3st
McLeman R	8	Mueller V	2.90	4st
Zhang Y	8	Van P L	2.83	5st
Kelman I	7	Islam M	2.67	6st
Riosmena F	7	Sakdapolrak P	2.51	7st
Sakdapolrak P	7	Mallick B	2.45	8st
Black R	6	Hoffmann R	2.37	9st
Chen J	6	Martinez-Zarzoso I	2.33	10st

Source: Scopus and Web of Science (WoS) databases.

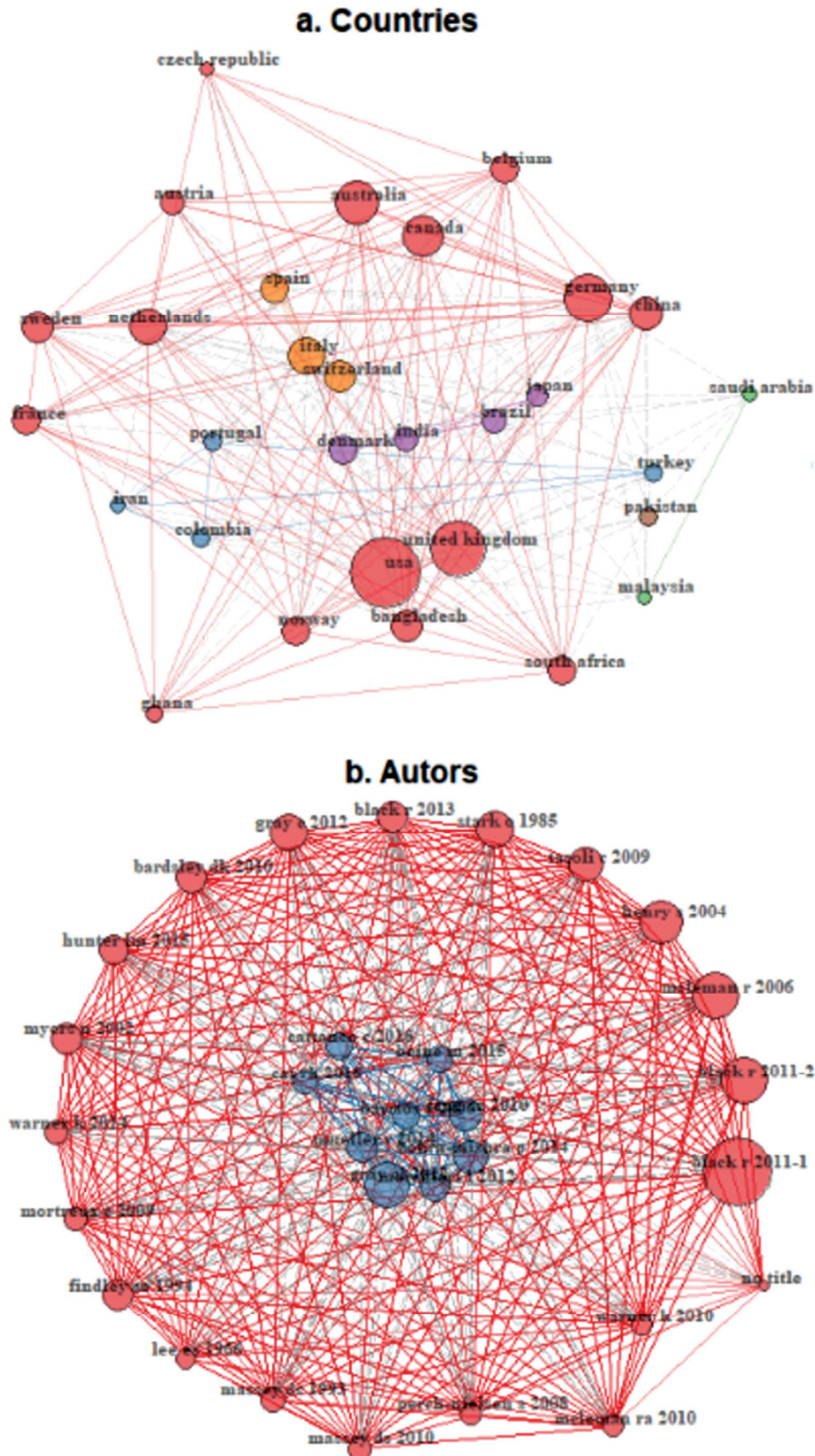
The table presented provides valuable information about the most productive authors who have worked on studies related to the economic drivers of environmental migration between 2013 and 2023. This analysis helps to identify which researchers have been the most active in this field and the specific topics addressed in their work. Additionally, the table serves as a useful reference for those seeking related research on environmental migration and the economic factors influencing it. The data provided help to identify experts in this field, their co-authorship collaborations, and their main areas of interest and contributions.

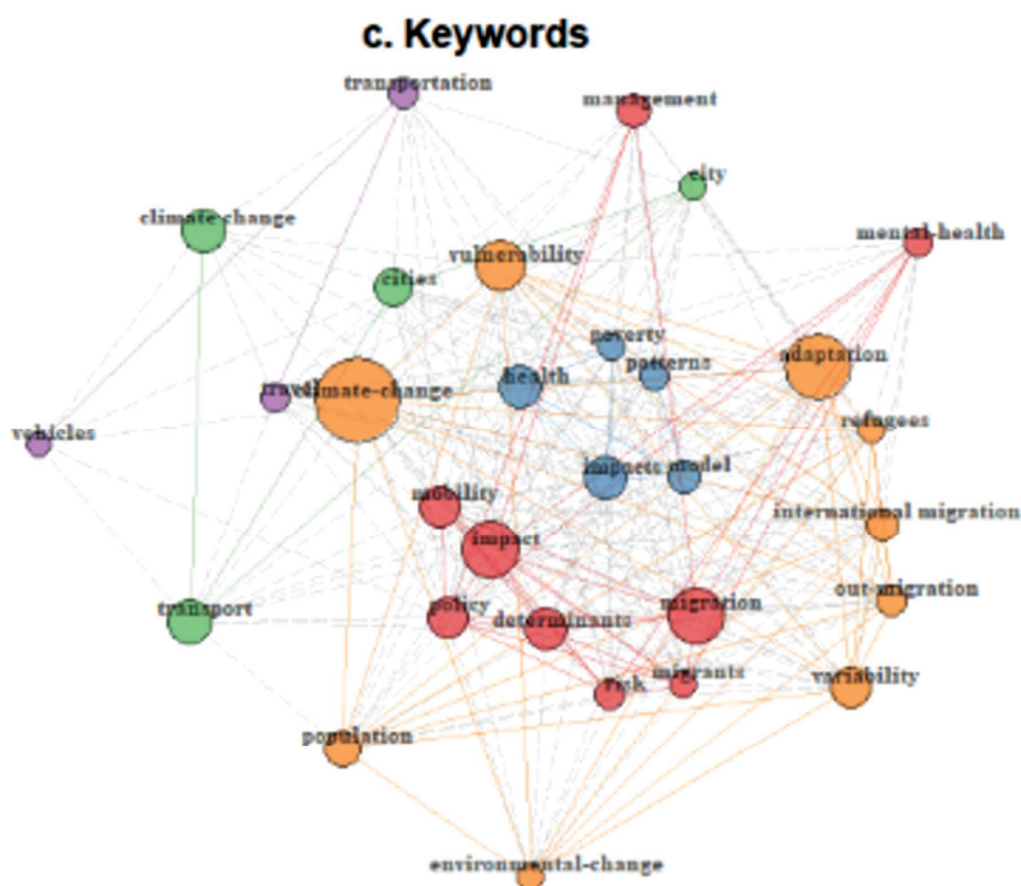
It is important to emphasize the relevance of presenting and sharing this type of data, as it can be a valuable resource for researchers, students, and others interested in understanding and advancing in this area of research. Disseminating this information can foster new collaborations and partnerships among authors and support the development of new research directions and future work.

4.2 Scientific Mapping

The process of scientific mapping involves examining the connections between different aspects of research, such as bibliographic references, authors, keywords, countries, and institutions involved (Aria; Cuccurullo, 2017; Kumar et al., 2021). As references are frequently cited in other publications, studies become interconnected in a meaningful way (Kumar et al., 2021). The networks of studies on the economic drivers of migration and environmental displacement, as shown in Figure 3, illustrate scientific collaboration among European countries (highlighted in red), reaffirming their concern with environmental migration. This group of publications is primarily led by countries such as the UK, Germany, Norway, the Netherlands, and other European nations.

Figure 3 – Mapping of the publication networks on the economic drivers of environmental migration by authors' countries, co-citations between authors, and keyword co-occurrence, 2013-2023





Source: Scopus and Web of Science (WoS) databases.

Another prominent group of publications is formed by Italy, Switzerland, and Spain (in orange). Other groups of countries are led by researchers from Denmark, India, Japan, and Brazil (in purple), and by researchers from Colombia, Portugal, Iran, and Turkey (in blue). There are also countries with a lower degree of collaboration, such as Saudi Arabia, Malaysia, and Pakistan.

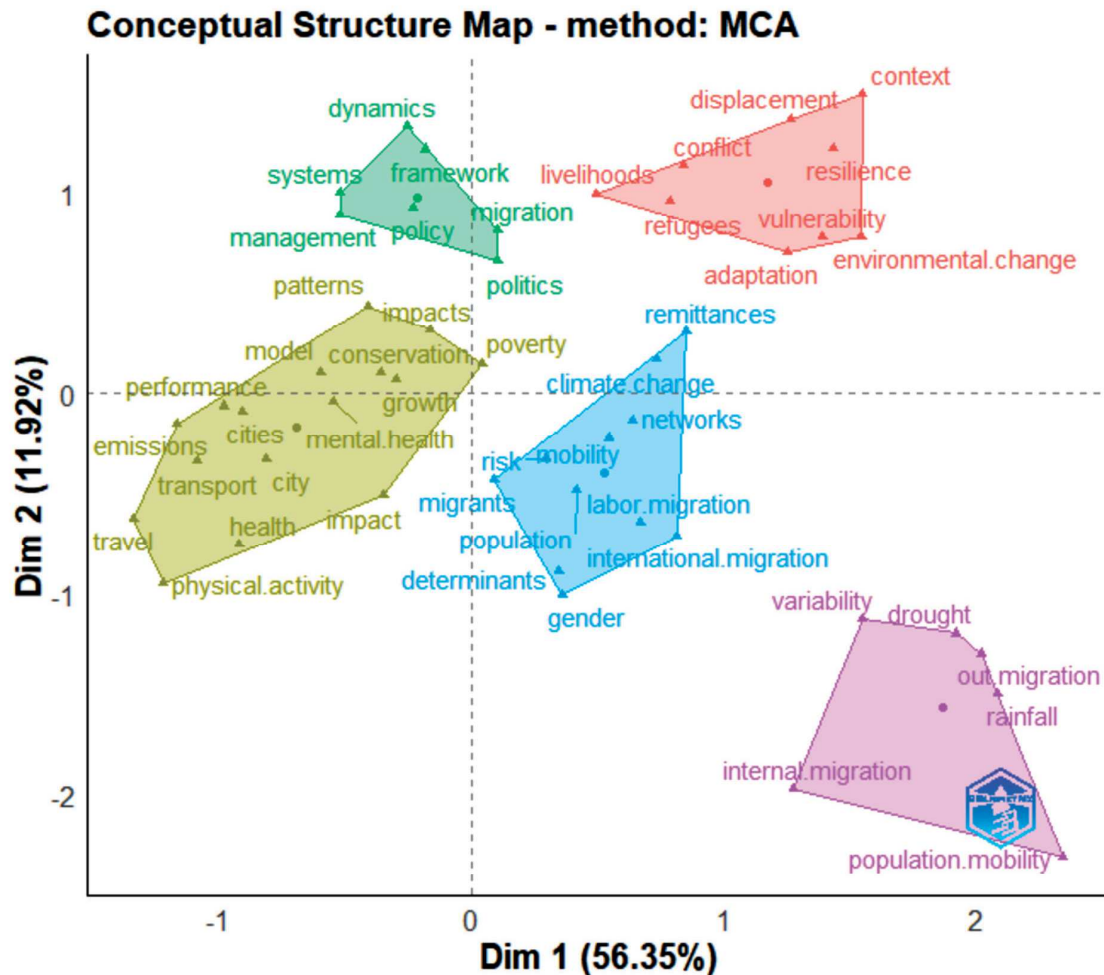
In addition, it is possible to identify a pattern of author co-citations (b) more linked to Gray and Mueller's work (2012) on mobility in rural Ethiopia due to droughts (in blue), while other publications form a group that cites the article by Black et al. (2011) on the drivers of environmental migration (in red). This article highlights the environmental, political, economic, and demographic aspects mediating the relationships between environmental shocks and migration. There is also a preference for keywords (c) that are grouped in green and lilac colors. Besides these, several other significant authors, such as McLeman, Henry, Hunter, Bardsley, Tacoli, and Myers, as well as earlier authors like Lee, Massey, and Stark, are highlighted in the network, emphasizing that their research serves as crucial references in the field of environmental migration studies.

Furthermore, the keyword network shows five groups. The orange nodes are highlighted, with a predominance of words related to climate change, adaptation, and the integration of environmental migrants. Another theme, observed in the red nodes, focuses on the determinants of environmental migration and the importance of policies to mitigate impacts. Relevant but less correlated terms are represented by nodes in green, lilac, and blue colors.

Figure 4 shows a Conceptual Structure Map using the MCA method for keywords in publications about environmental migration from 2013 to 2023. The Conceptual Structure Map by MCA is a feature in the bibliometrix package in R, used for bibliometric analysis. This method creates a map displaying the relationships between different terms (keywords) used in publications, based on co-occurrence frequencies or clustering patterns. The bibliometrix package in R provides various functions for analyzing scientific literature, such as co-authorship analysis, co-citation analysis, and bibliographic coupling

analysis. These analyses help researchers identify the main authors, institutions, and topics in a research field, as well as their relationships and trends over time. This graph contains information on the relationships between the keywords, such as co-occurrence frequencies or clustering patterns.

Figure 4 – Conceptual Structure Map using the MCA method for keywords in publications about the economic drivers of environmental migration, 2013-2023



Source: Scopus and Web of Science (WoS) databases.

The colors in Figure 4 correspond to the research themes presented in the conceptual map created using the MCA method. From this figure, it is possible to identify 5 clusters of keywords that are interconnected. The MCA method is a powerful tool for visualizing and analyzing bibliometric data, as it allows for the identification of patterns and relationships between different variables, such as keywords, authors, and publications, which can provide insights into research trends and collaboration networks (Aria; Cuccurullo, 2017).

Thus, the studies can be grouped into 5 categories: 1) political factors and other intermediaries in the relationship between environment and migration (green), 2) livelihoods, resilience, and adaptation of environmental migrants (pink), 3) determinants, gender issues, networks, and migratory flows (blue), 4) droughts, rainfall, and emigration (lilac), and 5) poverty, health, physical activity, and issues related to emissions reduction (olive green).

One advantage of bibliometric techniques is their ability to identify the most influential publications and those with reciprocal relationships, which can support other types of analyses, such as explaining citation patterns and scientific production within these thematic groups (Kumar et al., 2021). A limitation of this bibliometric technique is that it relies on the volume of publications and citations, which means that recent publications may be underrepresented in thematic groups due to having a lower number of

citations compared to older publications (Kumar et al., 2021; Gureyev; Mazov, 2022). To overcome this limitation and identify recent trends, a bibliographic review guided by bibliometric analysis can be conducted, considering the exposure time of publications. This can be done by dividing the total number of citations by the age of the publication. This procedure was performed in the penultimate column of Table 3, and the selected studies are discussed in the subsection below..

4.3 Literature Analysis

Bibliometric analysis enabled a literature review of the top 10 articles with the highest annual publication averages. The findings of these studies reveal a broad set of evidence on the economic drivers of environmental migration. The articles were grouped into different perspectives, as environmental migration and its drivers are complex topics that involve multiple viewpoints and approaches.

Table 3 shows the 10 most cited studies on environmental migration from 2013 to 2023, ranked by their total citations (TC) and their average citations per year (TC/~Age). The data were obtained from the Scopus and WoS databases. The first column of the table shows the author's last name followed by the initial letter of their first name, the publication year, and the source of the publication. The second column lists the publication year of the article, while the third column indicates the age of the publication as of 2023. The fourth column provides the total number of citations for each study, and the fifth column gives the average number of citations per year since the publication of the article.

Table 3 – Most Cited Studies on the Economic Drivers of Environmental Migration (2013-2023)

Publication (Autor, Year, Source)	Time (Year)	~Age (2023-Year)	Citations		Position
			Total	Mean	
Sloat L, 2020, <i>Nat Commun</i>	2020	3.333	95	28.50	1st
Chen J & Mueller V, 2018, <i>Nat Clim Change</i>	2018	5.333	121	22.69	2st
Mueller V, 2014, <i>Nat Clim Change</i>	2014	9.333	202	21.64	3st
Ahmad M, 2021, <i>Sustain Prod Consump</i>	2021	2.333	48	20.57	4st
Cattaneo C, 2016, <i>J Dev Econ</i>	2016	7.333	143	19.50	5st
Hoffmann R, 2020, <i>Nat Clim Change</i>	2020	3.333	64	19.20	6st
Adams H, 2016, <i>Popul Env</i>	2016	7.333	137	18.68	7st
Bohra-Mishra P, 2014, <i>Proc. Natl. Acad. Sci. U.S.A.</i>	2014	9.333	171	18.32	8st
Marchiori L, 2012, <i>J Environ Econ Manage</i>	2012	11.333	179	15.79	9st
Cai R, 2016, <i>J Environ Econ Manage</i>	2016	7.333	113	15.41	10st

Source: Scopus and Web of Science (WoS) databases.

Table 3 shows that the most cited study on environmental migration from 2013 to 2023 is “Sloat L, 2020, *Nat Commun*”, with a total of 95 citations. It has the highest average citation rate of 28.50 citations per year, indicating its high influence. The second most cited study is “Chen J & Mueller V, 2018, *Nat Clim Change*”, with a total of 121 citations and an average citation rate of 22.69 citations per year. The third most cited study is “Mueller V, 2014, *Nat Clim Change*”, with a total of 202 citations and an average citation rate of 21.64 citations per year.

The table also shows that the number of citations per year decreases as the age of the publication increases. This suggests that more recent studies are receiving more attention than older studies in the field of environmental migration. It is expected that, on average, newer publications will have a lower total number of citations compared to older publications. Therefore, it is important to consider the average citations per year rather than just the total number of citations to identify the most impactful publications, as the impact of publications is influenced by their age. The relationship between environmental change and migration is a topic of great interest, as evidenced by the several studies in Table 4.

Table 4 – Most impactful studies on economic drivers of environmental migration, categorized by method, origin and destination countries, type of shock, and main findings, 2013-2023

Publication	Tematic	Shock	Origin → Destination	Method	Level	Economic Variable	Results
Sloat et al. 2020	Agricultural channel	Temperature	Various countries in the world	Quantitative	Macro	Maize and rice production	In maize production, there is a relationship between temperature increases and a migration of the cultivation region. In rainfed rice cultivation, there is a shift towards cooler environments, suggesting some form of human mobility.
Chen & Mueller 2018	Agricultural channel	Sea level rise	Bangladesh (internal)	Quantitative	Macro	Agricultural productivity	Salinity has direct effects on both internal and international migration, even after controlling for income losses, with mobility being restricted to certain areas in Bangladesh.
Mueller et al. 2014	Agricultural channel	Temperature and Flood	Paquistan (internal)	Quantitative	Micro	Agricultural income	Thermal stress consistently increases long-term migration among men living in rural areas of Pakistan, primarily due to its negative impact on both agricultural and non-agricultural income. In contrast, floods have only modest to insignificant effects on migration.
Cattaneo & Peri 2016	Agricultural channel	Temperature	Various countries in the world	Quantitative	Macro	Mean income	Higher temperatures in middle-income economies have led to increased migration rates to urban areas and other countries, whereas in poorer countries, higher temperatures have reduced the likelihood of migration to cities and other countries.
Hoffmann et al. 2020	Agricultural channel	Slow-onset events	Various countries in the world	Mixed methods	Macro	Mean income	Income and conflict moderate and partially explain the relationship between environmental change and migration.
Cai et al. 2016	Agricultural channel	Temperature	163 countries → 42 destination countries (mostly OECD)	Quantitative	Macro	GDP per capita and cereal yields	The results indicate that only in the most agriculture-dependent countries is there a positive and statistically significant relationship between temperature and international outmigration.
Ahmad et al. 2021	Push and Pull factors	Environmental degradation	China (internal)	Quantitative	Micro	Energy consume and industrial organization	The study confirms the existence of Kuznets environmental curves in models that include the tertiary sector. Additionally, rural-to-urban migration more substantially mitigates environmental degradation in the model with industrial agglomeration based on the service sector.
Adams 2016	Push and Pull factors	Environmental changes	Peru (internal)	Quantitative	Micro	Income	Immobility is attributed to high levels of satisfaction, resource barriers, and low mobility potential.
Bohra-Mishra et al. 2014	Push and Pull factors	Sudden-onset events	Various countries in the world	Quantitative	Micro	Household assets	There is a significant non-linear effect of temperature on household asset values.
Marchiori et al. 2012	Push and Pull factors	Temperature	39 sub-Saharan African countries → World	Quantitative	Macro	GDP per capita, and wages in the urban and rural sectors	According to the results, by the end of the 21st century, there may be an annual increase of approximately 11.8 million people displaced due to climate anomalies.

Source: Scopus and Web of Science (WoS) databases.

Thus, the table provides a useful summary of the most influential studies on environmental migration in the last decade, which can guide further research and policy development in this area. These publications are analyzed in more detail later, including the methods used, the countries of origin and destination of migratory flows, the type of climate shock and economic variable of interest, and the main findings.

The results from articles in the table that focus on the economic drivers of environmental migration through the agricultural channel examine various types of shocks, including temperature increases, sea level rise, floods, and slow-onset events, and their impact on agricultural productivity and income. The

studies also explore the relationship between temperature and migration, with some finding that higher temperatures increase migration rates to urban areas and other countries, while others suggest that extreme heat drives migration, but extreme rainfall does not.

Sloat et al. (2020), for example, find that as temperatures increase, there is a migration of the cultivation region for maize production, and in rainfed rice cultivation, there is a migration towards cooler environments. Chen and Mueller (2018) study the impact of sea level rise on agricultural productivity in Bangladesh and find that salinity has direct effects on internal and international migration, even after controlling for income losses. Mueller et al. (2014) investigate the impact of temperature and floods on agricultural income in rural areas of Pakistan and find that thermal stress has a consistent effect on increasing long-term migration of men.

Cattaneo and Peri (2016) show that higher temperatures in middle-income economies have increased migration rates to urban areas and other countries, while in poorer countries, higher temperatures have reduced the likelihood of migration. Hoffmann et al. (2020) study the relationship between environmental risks and migration and find that most migration occurs internally or to low- and middle-income countries. Finally, Cai et al. (2016) investigate the impact of temperature on international outmigration and find that only in the most agriculture-dependent countries is there a positive relationship between temperature and international outmigration.

Another perspective relates to the push and pull factors of environmental migration. Ahmad et al. (2021) investigated these factors in China, specifically concerning energy consumption and industrial organization. Their study found a positive link between industrial agglomeration and rural-urban migration for energy use, with the most significant impacts observed in highly developed regions. They also confirmed the existence of Kuznets environmental curves in models with the tertiary sector, with rural-urban migration mitigating environmental degradation more substantially in the model with service sector-based industrial agglomeration.

Adams (2016) focused on the push and pull factors of environmental changes in Peru, particularly regarding internal migration. Using quantitative methods, the study found that immobility is due to high levels of satisfaction, resource barriers, and low mobility potential. The research also revealed that weather phenomena significantly impact the lives and livelihoods of people in the mountainous regions of Peru, affecting fertilizers, agricultural production, water availability, and the timing of household activities.

Bohra-Mishra et al. (2014) explored the push and pull factors of sudden-onset events that may trigger environmental migration, using household assets as a measure of mobility. Their study found a significant non-linear effect of temperature on the value of household assets. The inflection point is at 24°C; below this average temperature, any increase in temperature increases household assets, but above 24°C, an increase in temperature is associated with a decline in household assets.

Marchiori et al. (2012) examined the push and pull factors of temperature on migration patterns in sub-Saharan African countries using macroeconomic data. Their research found that by the end of the 21st century, there will likely be an annual increase in the number of people displaced due to climate anomalies, estimated at 11.8 million. The study also analyzed GDP per capita and wages in the urban and rural sectors to understand the economic drivers of environmental migration in the region. The studies highlight the complex relationship between environmental change and migration, with contextual variation depending on the origin and destination countries, level of development, and specific types of shocks. They emphasize the need for policies that increase resilience to climate shocks and reduce barriers to population movements that improve well-being.

Environmental disasters can promote short-term adaptive responses, such as short-distance mobility (Correia, 2021). However, in other cases, environmental shocks can reduce available resources, making mobility more difficult and resulting in immobility (Correia; Ojima, 2019). These dynamics highlight the complexity of human responses to extreme environmental events, demonstrating that while some disasters may stimulate short-distance movements in search of better conditions, others may inhibit the ability to relocate due to resource scarcity and increased mobility barriers.

5 FINAL CONSIDERATIONS

Environmental migration, triggered by natural disasters and climate change, is a complex phenomenon that significantly affects both migrants and host communities. This study, through bibliometric and systematic analysis, elucidates the main economic drivers of environmental migration and highlights the complexity of the relationships between the factors involved.

The results reveal that the economic drivers of environmental migration are intrinsically linked to political factors, subsistence, resilience, adaptation, social determinants, and specific climatic events such as droughts and intense rainfall. Additionally, issues of poverty, health, and the reduction of greenhouse gas emissions also play crucial roles. The analysis of the most impactful studies reinforces the diversity of methods used to understand this dynamic, showing that events such as temperature increases, soil salinity, thermal stress, and conflicts have varying impacts on migration, depending on the local context and economic and social conditions.

The studies highlight the complex relationship between environmental change and migration, with varying impacts depending on the type of shock, origin and destination countries, and economic variables. As the global community faces ongoing environmental challenges, such as rising temperatures, sea level rise, and more frequent and intense weather events, understanding the economic drivers of environmental migration will become increasingly important for creating effective policies and responses.

The findings also suggest that the agricultural sector is particularly vulnerable to the effects of climate change, with gradual increases in soil salinity, floods, and extreme heat all having significant negative impacts on agricultural productivity and income. This can lead to both internal and international migration, as people search for cooler environments or more viable economic opportunities. The studies presented address this issue in different contexts, including China, Peru, and various countries around the world.

The studies demonstrate that environmental disasters often exacerbate already unequal social, political, and economic situations, intensifying the need for migration as a survival strategy. Migration can be seen both as an adaptive response to climatic shocks and as a forced exit due to communities' inability to adapt to adverse conditions.

The diversity of impacts observed in different regions underscores the importance of public policies that increase resilience to climatic shocks and reduce barriers to population movements that promote well-being. It is essential that these policies recognize the structural causes of migration, addressing the underlying inequalities that drive migration, and not just the apparent motivations.

Measures such as adapting agricultural systems to new climate conditions, economic diversification, and improving water supply infrastructure are crucial to mitigating the negative impacts of climate change. The integration of climatic, demographic, and economic data is fundamental for an in-depth understanding of future impacts and for the formulation of effective adaptive policies.

The complexity and specificity of local contexts must be considered in the formulation of policies that promote resilience and the well-being of affected populations. Environmental migration, far from being a simple response to natural disasters, reflects deeper structural challenges that require integrated and multifaceted approaches to ensure sustainability and equity in addressing climate change.

Future research on environmental migration should focus on enhancing the understanding of localized impacts and responses to climatic changes. This includes investigating the nuanced effects of different types of environmental shocks – such as floods versus droughts – on migration patterns and economic outcomes. Additionally, there is a need to explore the intersection of environmental migration with other factors such as urbanization and socio-economic development, to assess how these dynamics interplay in shaping migration trends. Comparative studies across diverse geographic and socio-economic contexts will be essential in identifying best practices and designing targeted interventions. Furthermore, integrating advanced data analytics and climate modeling with demographic studies could provide deeper insights into predicting migration flows and developing adaptive policies. This holistic approach will help in addressing both the immediate and long-term challenges posed by environmental migration.

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