



Culture of Sustainability Culture della Sostenibilità International Journal of Political Ecology

ISSN 1972-5817 (print) 1972-2511 (online) web: culturesostenibilita.it

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To cite this article: Salvatori C., Maretti M. (2026). Geographical Insights into the Environment-Migration Nexus: Emerging Issues from Case Studies. *Culture della Sostenibilità*, 37. DOI 10.7402/CDS.37.1



2026 · Istituto per l'Ambiente e l'Educazione Scholé Futuro Onlus



Published on line: Giugno 2026



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Geographical Insights into the Environment-Migration Nexus: Emerging Issues from Case Studies

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Abstract

Climate change is a topic of great global importance, involving both the public and the international scientific community. Among its consequences, the impact on human population movements is of growing concern for researchers and policymakers. Environmental changes increasingly pressure communities influencing migration directly and indirectly by undermining the economic, social, and political balance. Environmental and climate migration is therefore a complex issue with significant implications on social inequalities and geopolitical stability. In this study, bibliometric techniques were applied to identify key trends surrounding environment-induced migration. Through a geographical approach, it highlights the regions which have garnered the greatest research attention, revealing specific regional vulnerabilities and adaptation challenges. The findings show a complex interplay between environmental risks and social vulnerabilities, exacerbating inequalities in fragile communities. They also highlight sharp disparities in resilience and policy responses between developed and poorer regions, underscoring the urgency of implementing equitable and participatory adaptation policies that promote sustainable solutions, strengthen local knowledge, and address the socioeconomic dimensions of environmental and climate migration.

Keywords: climate change, migration, social vulnerability, case studies, bibliometric analysis, semantic networks analysis

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Riassunto

Il cambiamento climatico rappresenta una questione di grande rilevanza globale, coinvolgendo tanto l'opinione pubblica quanto la comunità scientifica internazionale. Tra le sue conseguenze, l'impatto sui movimenti delle popolazioni suscita crescente attenzione da parte di ricercatori e decisori politici. I cambiamenti ambientali esercitano pressioni sempre più forti sulle comunità, influenzando le dinamiche migratorie sia direttamente che indirettamente, compromettendo gli equilibri economici, sociali e politici. La migrazione ambientale e climatica si configura pertanto come un fenomeno complesso, con profonde ricadute sulle disuguaglianze sociali e sugli equilibri geopolitici. Questo studio applica tecniche bibliometriche per individuare le principali tendenze nella letteratura scientifica sul tema utilizzando un approccio geografico con l'obiettivo di evidenziare le aree più investigate con le specifiche vulnerabilità regionali e sfide di adattamento. I risultati mostrano un intreccio complesso tra rischi ambientali e vulnerabilità sociali, con crescenti disuguaglianze nelle comunità fragili. Inoltre, ravvisano forti disparità nelle capacità di resilienza e nelle risposte politiche tra le regioni sviluppate e quelle più povere, sottolineando l'urgenza di attuare politiche di adattamento eque e partecipative, capaci di promuovere soluzioni sostenibili, valorizzare i saperi locali e affrontare le dimensioni socioeconomiche della migrazione ambientale e climatica.

Parole chiave: cambiamenti climatici, migrazione, vulnerabilità sociale, casi di studio, analisi bibliometrica, analisi delle reti semantiche

■ 1. Introduction

The escalating global climate crisis is fundamentally reshaping patterns of human mobility worldwide, presenting unprecedented migration challenges. Environmental dynamics have always profoundly impacted human population movements, with environmental changes and disasters historically acting as migration drivers. However, in the current era, anthropogenic climate changes are dramatically intensifying these pressures on vulnerable populations (McMichael *et al.*, 2012) either directly such as the need to flee in response to catastrophic events, or indirectly, through the gradual undermining of local community sustainability. As highlighted in the *Groundswell* report, climate change is projected to drive substantial increases in internal migration by 2050 (World Bank, 2021). Recent data from the Internal Displacement Monitoring Centre (IDMC) underscores the scale of this challenge, with 75.9 million people living in conditions of internal displacement in 2023, 56 percent of whom due to disasters.

The conceptualisation of human mobility in response to environmental changes has evolved significantly within academic discourse. A clear

theoretical distinction is often drawn between environmental migration, which encompasses all population movements influenced by environmental factors, and climate migration, which specifically examines mobility patterns resulting from the impacts of climate change (McLeman & Gemmenne, 2018). The Intergovernmental Panel on Climate Change (IPCC), in its Sixth Assessment Report (AR6), further develops this framework by outlining climate-related mobility along a continuum ranging from voluntary to involuntary movement, categorised into three principal forms: migration, displacement, and planned relocation.

International public opinion, along with organizations, generally agree that the acceleration of climate change will precipitate an increase in migratory phenomena (Kaczan & Orgill-Meyer, 2020; Boas *et al.*, 2019), thereby delineating new geopolitical scenarios and exacerbating existing inequalities. In this context, it is imperative to recognize that the factors influencing migration decisions are multifaceted, encompassing economic, demographic, social, political, and environmental-climatic stressors (Hoffmann *et al.*, 2022; Cattaneo *et al.*, 2019). As established by multiple studies (Bakaki, 2021; Hunter *et al.*, 2015; McMichael *et al.*, 2012), population movements are characterised by significant contextual heterogeneity and multi-causal complexity. This complexity presents substantial challenges for researchers attempting to isolate predominant push factors and elucidating their interconnections within the migration or adaptation strategies employed by the affected populations. Environmental changes, particularly those driven by climate change, significantly affect ecosystem goods and services, leading to social conflicts and economic consequences that intertwine with various push factors and exacerbate existing vulnerabilities. Consequently, individuals may resort to migration as an adaptive strategy (Wrathall *et al.*, 2019; Hoffmann *et al.*, 2022). However, due to the inadequate outcomes associated with migrants' limited resources and planning, forced displacement may represent a direct consequence of climate change rather than a proactive adaptation measure (Tabe, 2019; Thomas & Benjamin, 2018). The Intergovernmental Panel on Climate Change (IPCC, 2022) confirms that climate-related mobility increasingly represents both a necessary adaptation strategy and a manifestation of social vulnerability in the face of escalating climate risks.

As several researchers have observed, the extensive body of case studies available in the literature offers invaluable analytical insights for understanding the complex interrelationships among multiple push factors and their effects on local social ecosystems and individuals in specific contexts (Maretti *et al.*, 2019; Obokata *et al.*, 2014; Piguët *et al.*, 2018). Consequently, to address the inherent complexity delineated above, this study employs bibliometric methods to analyse emerging issues from geographically classified case studies with the aim of providing an overview of the development of this field, identifying the territories attracting the most attention from researchers, and reconstructing the predominant

issues characterising environmental and climate migration phenomena across different continental regions. This geographic classification enables us to identify regional patterns while acknowledging the contextual specificities that shape migration dynamics in response to environmental and climatic pressures.

■ 2. Methods and Materials

This research employs scientometric analysis techniques applied to literature, with geographical classification of case studies. Drawing on semantic network principles to illuminate conceptual structures (Carley, 1993; Drieger, 2013), the study utilised established analytical algorithms for qualitative semantic examination (Brandes, 2005; Newman, 2010). Primary bibliometric analysis was conducted using Biblioshiny, a web interface for the R package Bibliometrix (Aria & Cuccurullo, 2017), while computational text mining of titles and keywords was facilitated through the R package Quanteda. Semantic network analysis was performed in Gephi (Bastian *et al.*, 2009). The dataset comprised 1,410 records extracted from Scopus on 15 May 2024, selected for its comprehensive interdisciplinary coverage. The search query included the following terms, linked by the Boolean operator “OR” and using both singular and plural forms: “climate migration”, “climate migrant”, “environmental migration”, “environmental migrant”, “climate refugee”, “climate mobility”, “climate-induced migration”, “climate-induced migrant”, “climate displacement”, “environmental displacement”, “environmental refugee”. The scope was limited to English-language publications from 1975–2024. After excluding 215 irrelevant records and 18 duplicates, the final dataset consisted of 1,177 documents. From this, 489 regionally focused case studies were identified and subsequently classified according to the United Nations Statistical Commission (UNSD) geoscheme by continent, geographical area and state.

■ 3. Results

This analysis examines 1,177 scientific publications (686 articles, 274 book chapters, 87 reviews) from 659 journals published between 1985 and 2023, with an average citation rate of 18.73. Following Maretti *et al.* (2019), publication trends (Figure 1) show significant growth since 2008, peaking in 2016 ($n=75$) and accelerating recently from 79 publications in 2019 to 182 in 2023. Among the 2,087 contributing authors, a balance exists between individual (522) and collaborative research (655), with international collaborations comprising 24.21 per cent.

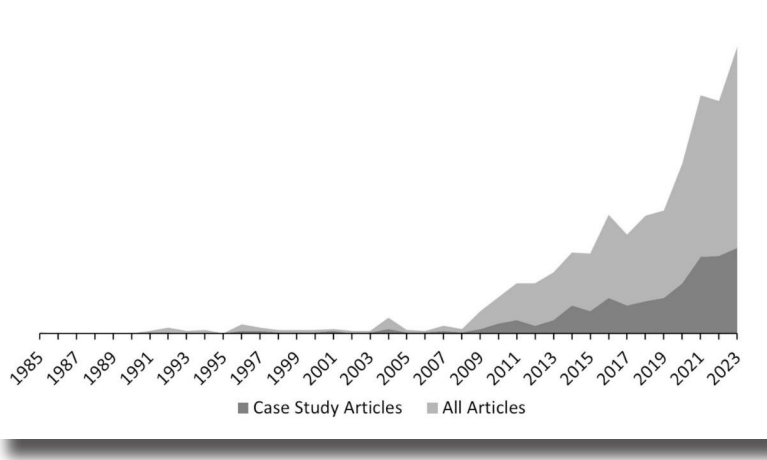


Fig. 1 - Annual scientific production over time: all articles and case studies

Figure 2 illustrates the evolution of key thematic concerns from 2009 to 2023. Recent discourse has increasingly encompassed mental health dimensions, mobility justice frameworks and gender considerations reflecting a critical turn in climate migration research. Notably, the concept of immobility has gained significant traction, offering a crucial counterpoint to conventional migration paradigms. This conceptual development complements established themes including climate change manifestations, community vulnerability assessment, and adaptation-resilience strategies. The intersection of human rights, governance mechanisms and international legal frameworks remains a consistent focus throughout the period analysed, with particular emphasis on policy development for addressing climate-induced displacement.

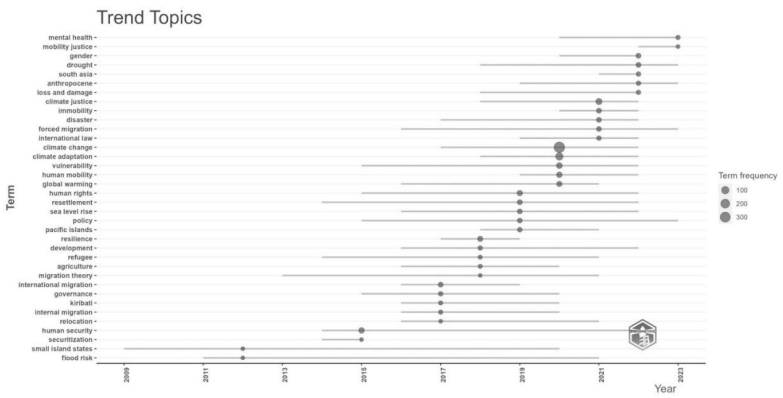


Fig. 2 – Trend topics

Following this broad analysis, our investigation narrowed to 489 case studies published between 1991 and 2023. As demonstrated in Figure 1, these case studies constitute a substantial proportion of the literature and exhibit particularly strong growth in recent years. Regional classification according to the United Nations Statistical Commission (UNSD) geoscheme revealed that Asia dominates research attention (43%), followed by Africa (20%), the Americas (18%), Oceania (14%) and Europe (5%). Figure 3 indicates that Bangladesh features most prominently (75 articles), followed by the United States (39), India (36) and China (20). Pacific Island nations have attracted considerable scholarly interest, particularly New Zealand (14), Tuvalu (13), Kiribati (12) and Fiji (11). In Africa, significant research has concentrated on Ghana (12), Senegal (9), Burkina Faso (9), Morocco (8) and Ethiopia (7). Latin American focus centres on Mexico (12) and Brazil (6), whilst additional Asian attention encompasses Vietnam (12), Indonesia (9) and the Philippines (7).

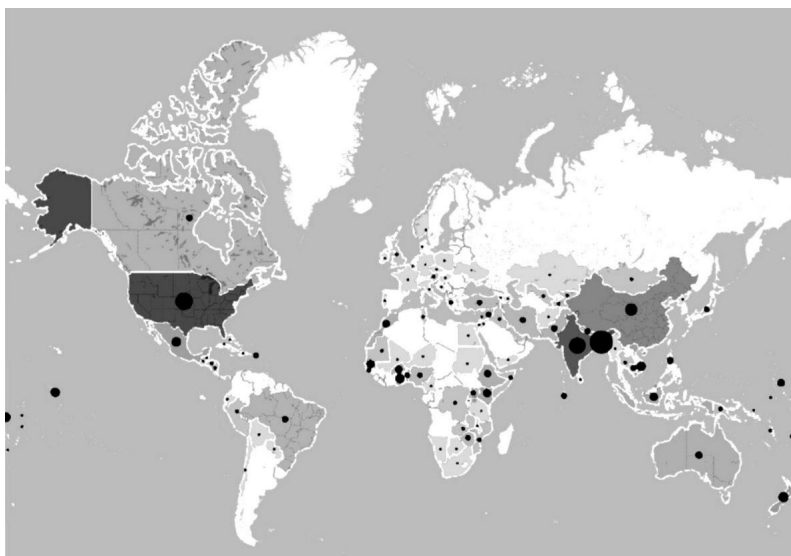


Fig. 3 – The most studied countries

Content analysis was performed on titles and keywords from 489 case studies, classified by continent. Following Danowski's (1982, 1993) proximal approach, semantic networks were created that translate text into interconnected word networks formed through co-occurrence. Using RStudio with the R Quanteda package, preliminary textual analysis was conducted including corpus pre-processing (tokenisation, normalisation, stopwords filtering, and pruning) and vocabulary analysis. Co-occurrence matrices were created for each continental dataset and imported into Gephi for network analysis. Words were divided into communities based on

modularity using Blondel's algorithm (Blondel *et al.*, 2008), with node size representing Freeman's (1979) degree centrality and connection thickness highlighting the strength of relationships between terms. The results revealed distinctive regional patterns in climate migration discourse.

The Asian network (4 clusters, 157 nodes, 2,322 connections) reveals significant complexity, reflecting the region's multifaceted vulnerability landscape. Here, climate mobility emerges as an existential challenge to socio-ecological systems where environmental degradation threatens not only material livelihoods but entire social structures, particularly in agricultural regions like the Sundarbans (Chakraborty & Satpati, 2019). Asian discourse frames climate displacement as permanent territorial loss rather than temporary relocation, especially for coastal communities in the Bengal region. Additionally, the conflict dimension associated with environmental degradation, such as drought, in Western Asia emerges as a critical issue (Dinc & Eklund, 2023). Bangladesh's prominence in policy cluster reveals how climate migration requires integrated urban planning to address rural-urban migration flows, as displaced populations often settle in informal urban areas, creating new vulnerability patterns (Huq & Shafique, 2023; Khanom *et al.*, 2022).

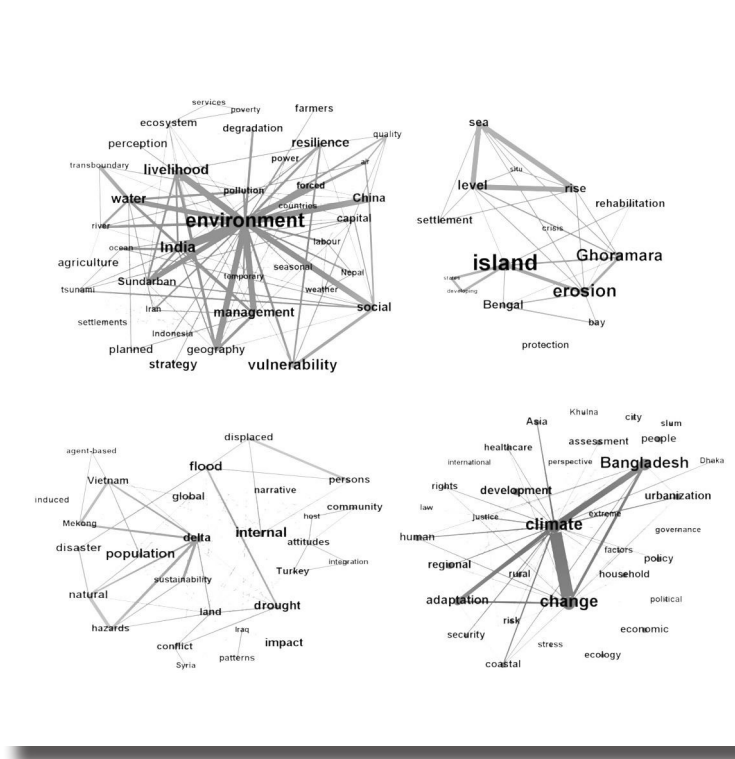


Fig. 4 – Semantic cluster network, Asia

African semantic network (4 clusters, 95 nodes, 887 connections) distinctively positions climate mobility within a food security framework rather than focusing solely on environmental degradation. This suggests that nutritional stability functions as a crucial mediating mechanism between climate change and migration decisions in African contexts. Research demonstrates how climate variability drives internal population movements, with agriculture functioning as the critical channel through which climate affects migration decisions (Mastrorillo *et al.*, 2016). The prominence of “trapped populations” in African discourse reflects how resource constraints limit migration as an adaptation strategy, creating contexts where the most vulnerable communities lack mobility options despite severe environmental pressure (Arnall, 2018). The Ghana case exemplifies a paradox where populations moving from drought-affected northern regions to southern coastal areas may exchange one form of climate vulnerability for another, creating cycles of precarity rather than resilience (Van der Geest, 2011).

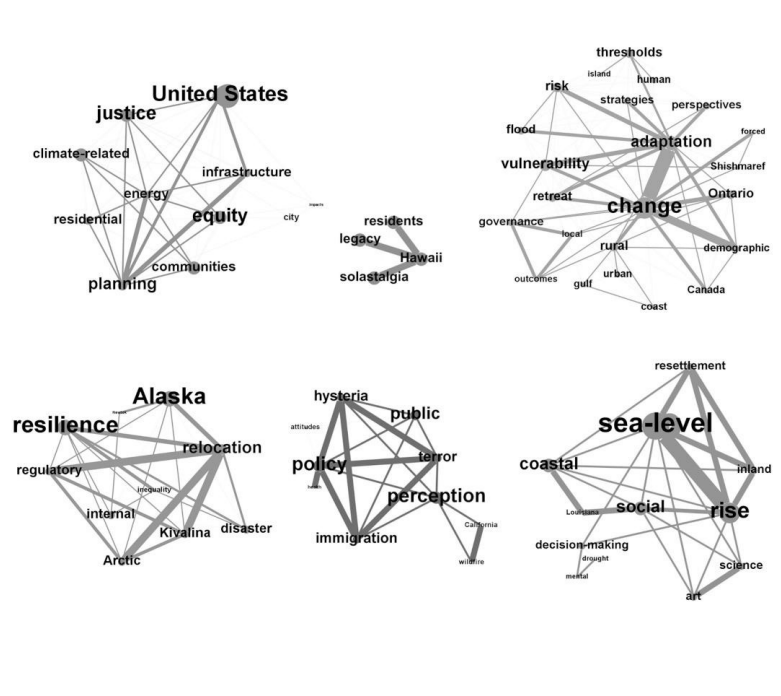


Fig. 5 – Semantic cluster network, Africa

The Americas present notable sub-regional differentiation, necessitating separate analyses for North, Central and South America. Firstly, North America's network (6 clusters, 71 nodes, 396 connections) is centred on social justice and infrastructure planning, particularly in urban contexts where equitable resource access determines climate resilience. The network also captures a significant focus on place-based emotional responses, particularly in Hawaii where environmental degradation generates profound psychological impacts conceptualised as solastalgia (Pucker *et al.*, 2023). Additionally, arctic communities face unique relocation challenges at the intersection of indigenous sovereignty, institutional barriers, and community resilience (Marino, 2012). Finally, public perception emerges as a critical factor in climate migration governance, with media framing significantly influencing policy receptiveness (Arias & Blair, 2022).

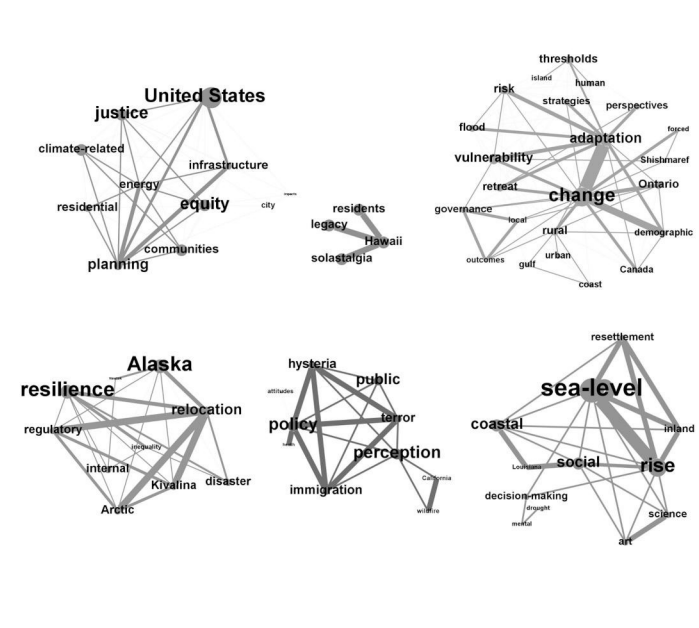


Fig. 6 – Semantic cluster network, North America

The semantic network of Central America's case studies (6 clusters, 78 nodes, 354 connections) reveals distinctive themes around disaster trauma, structural inequality, and recovery processes. Puerto Rico emerges as a critical case where hurricane impacts transcend immediate physical damage to create profound psychological consequences that drive migration (Salas-Wright *et*

planning that promotes social equity and sustainable resource management (Milanés *et al.*, 2020). Lastly, Chilean discourse presents labour migration as a normalised adaptation strategy accelerated by climatic pressure rather than initiated by it, while legal frameworks emphasise the tension between sovereign migration control and emerging human security obligations (Andrasko, 2022).

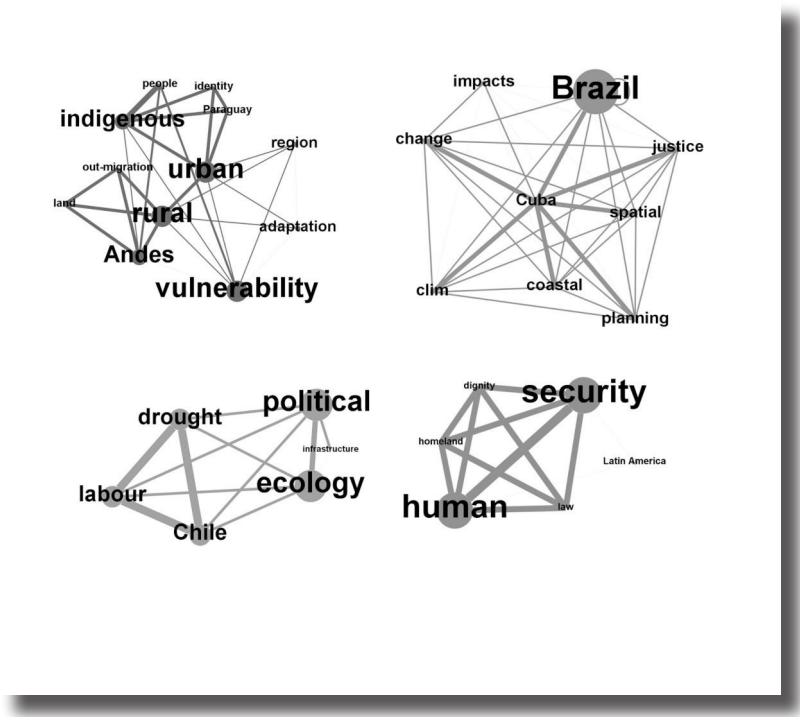


Fig. 8 – Semantic cluster network, South America

The Oceanian network (4 clusters, 66 nodes, 595 connections) articulates the most existential dimension of climate mobility across all regions. Unlike continental contexts where adaptation typically occurs within existing territories, Pacific discourse necessarily engages with questions of national survival as sea-level rise threatens the complete submergence of atoll states (McLeod *et al.*, 2019). This existential reality drives distinctive regional policy innovations, including bilateral migration agreements and frameworks that specifically recognize indigenous cultural heritage as integral to adaptation. Traditional ecological knowledge is positioned as a valuable resource, not merely for local adaptation but as cultural heritage requiring protection during displace-

ment processes. Geographical isolation emerges as a structural vulnerability factor (Roland & Curtis, 2020), while community-based perspectives reveal diverse understandings of mobility that challenge homogeneous climate migration narratives (Perumal, 2018). Pacific frameworks pioneer legal protection approaches that contest conventional refugee categories while emphasizing cultural continuity and dignity (Kleiman, 2022). Particularly significant are planned relocation initiatives where indigenous communities exhibit voluntary immobility despite climate risks, motivated by territorial attachments, kinship structures, and spiritual connections that form fundamental identity components (Yee *et al.*, 2022). These Pacific experiences offer crucial insights for global climate mobility governance, demonstrating the essential balance between physical safety and cultural continuity in effective adaptation responses.

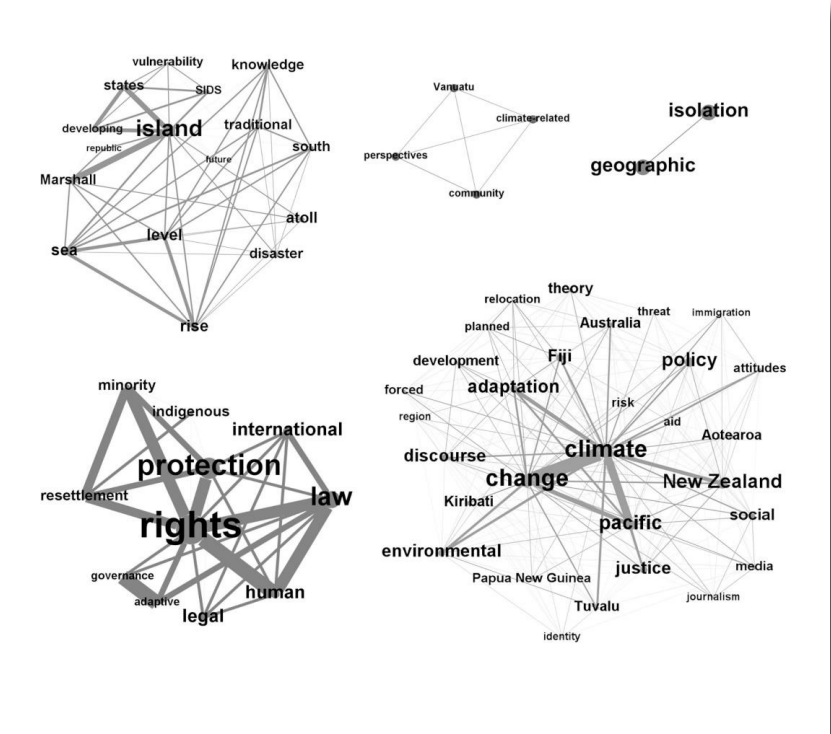


Fig. 9 – Semantic cluster network, Oceania

The European network (3 clusters, 37 nodes, 158 connections) positions the continent primarily as a receiver rather than producer of climate migrants.

Unlike other regions focused on displacement drivers, here the discourse emphasises reception challenges, particularly media representation of environmental migrants (Henning *et al.*, 2022) and institutional barriers to protection framework integration (Mayrhofer & Ammer, 2022).

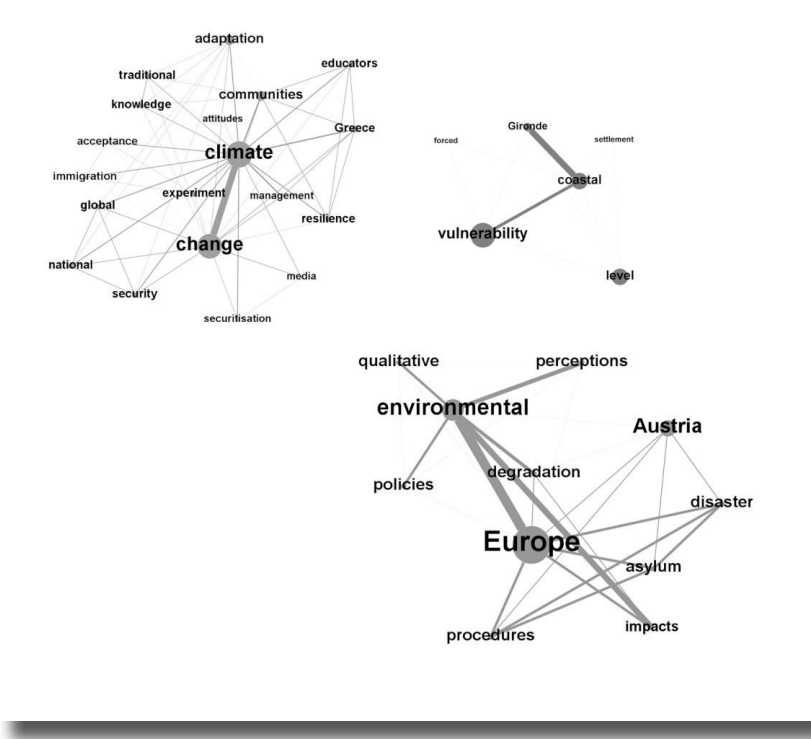


Fig. 10 – Semantic cluster network, Europa

■ 4. Conclusion

The comparative analysis of regional semantic networks reveals both distinctive regional patterns and significant cross-cutting dimensions of climate mobility. Each region presents complex, multifaceted manifestations of climate-induced mobility that resist simple characterisation, with regional differences emerging from unique geographical, historical, socioeconomic and cultural contexts rather than fundamentally different vulnerability mechanisms. Despite regional specificities, several cross-cutting dimensions emerge across all contexts. Climate changes rarely operate as isolated migration drivers, but rather intensify pre-existing socioeconomic conditions, creating complex vulnerability landscapes that disproportionately affect already marginalised com-

munities (Cattaneo *et al.*, 2019). This vulnerability intensification emerges as a universal pattern across all regions studied, though its specific manifestations vary considerably.

The importance of immobility alongside mobility emerges as a critical dimension in climate adaptation responses globally. Immobility manifests in distinct forms that reflect varying degrees of agency and constraint (Zickgraf, 2019). Particularly concerning is the situation of “trapped populations” who experience double vulnerability first through direct exposure to environmental hazards, then through socioeconomic limitations that prevent migration as an adaptation option (Black *et al.*, 2013; Ayeb-Karlsson *et al.*, 2018). Conversely, voluntary immobility represents a conscious choice to remain despite climate risks motivated by territorial attachments, kinship structures, and spiritual connections. These contrasting immobility patterns demonstrate how adaptive capacity operates along a spectrum of agency rather than through binary mobility/immobility frameworks.

When migration does occur, it often turns into short-range rural-to-urban flows rather than international movements due to limited resources (Rigaud *et al.*, 2018). These patterns accelerate urbanisation trends and present significant challenges in reception and integration as evident across multiple regions. The resulting demographic pressures often exceed existing infrastructure capabilities, creating new vulnerabilities through informal settlement expansion and essential service strain. This urban dimension necessitates comprehensive planning approaches that transcend mere migration management to facilitate effective socioeconomic integration through tailored housing programmes and livelihood support mechanisms (Bardsley & Hugo, 2010; Upadhyay *et al.*, 2017).

Another important aspect emerges from the comparison between high-income and low-income regions, particularly in terms of disparities in resilience capacity and policy responses. In developed nations, policies tend to be more structured and better resourced, enabling more effective management of climate-induced migration (Adger *et al.*, 2013; Bettini *et al.*, 2017). Conversely, economically challenged regions often face greater environmental impacts with insufficient resources to address them effectively (Heslin *et al.*, 2019).

These disparities reflect global inequality patterns where adaptation resources concentrate in regions experiencing less severe climate impacts (Thomas *et al.*, 2019). Colonial historical processes fundamentally altered indigenous environmental management systems that previously provided resilience against environmental variability. Beyond material livelihood threats, indigenous perspectives emphasise how climate change endangers cultural continuity, traditional knowledge, and spiritual connections (Ford *et al.*, 2020) – non-economic dimensions often overlooked in conventional frameworks despite their critical role in migration decisions (Barnett & McMichael, 2018). Traditional ecological knowledge offers effective adaptation pathways, with community-based approaches often outperforming centralised interventions. Meanwhile, vulnerable communities lack representation in climate governan-

ce, concentrating decision-making among those least affected (Klepp, 2017). This representation deficit ensures adaptation policies rarely reflect affected communities' needs and knowledge (Thomas & Benjamin, 2018; McNamara *et al.*, 2021). Addressing this justice dimension requires participatory governance mechanisms that elevate marginalized voices while integrating local knowledge to develop culturally sensitive solutions with community support.

This analysis ultimately demonstrates that effective climate mobility governance requires both the recognition of context-specific challenges and the acknowledgment of universal dimensions of vulnerability, justice, and resilience that transcend geographical boundaries. The interaction between climate vulnerability, migration decisions, and social implications demands nuanced policy approaches that extend beyond emergency responses to address underlying vulnerability factors (McLeman & Gemenne, 2018). Future research should advance beyond the mere documentation of migration flows towards examining how fundamental systemic changes can address the structural determinants of vulnerability while respecting the diverse cultural attachments and self-determined aspirations of affected communities (Mallick & Schanze, 2020).

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