



ARTICLE



<https://doi.org/10.1057/s41599-026-06503-w>

OPEN

# Climate-induced migration in West Africa: a systematic review of the literature

Gema Gómez-Álvaro<sup>1,2</sup>✉ & Raquel Caro-Carretero<sup>1,2</sup>

This article presents a systematic review of academic literature on climate-induced migration in West Africa, a region often characterised as highly vulnerable yet comparatively under-examined in research. Using a PRISMA-based protocol, the review draws on searches conducted in Web of Science, Scopus, and JSTOR, applying predefined inclusion criteria to identify 42 peer-reviewed studies published between 2004 and 2024. Through qualitative thematic synthesis, the analysis explores recurring themes, methodological approaches, and empirical insights. The findings suggest that migration associated with climatic and environmental stressors tends to be shaped by multiple interacting factors, including socio-economic inequalities, political instability, and institutional constraints. In the studies reviewed, mobility frequently appears as a coping mechanism or adaptation strategy. The review additionally notes growing attention to climate-induced immobility, affecting populations with limited capacity to relocate despite increasing environmental risks. By focusing specifically on West Africa, the review offers a regional perspective that points to the predominance of internal and relatively short-distance movements. Key limitations concern definitional ambiguities surrounding “climate migration,” uneven geographical coverage, and reliance on indexed academic sources. Overall, the review underscores the value of moving beyond strict forced–voluntary distinctions and of considering both mobility and immobility within climate adaptation debates, helping to inform future research and policy discussions.

<sup>1</sup>Comillas Pontifical University, Madrid, Spain. <sup>2</sup>University Institute for Migration Studies, Madrid, Spain. ✉email: [ggalvaro@comillas.edu](mailto:ggalvaro@comillas.edu)

## Introduction

Migration in West Africa is a complex phenomenon shaped by multiple historical, socio-economic, political, and increasingly environmental factors. Climate variability, land degradation, poverty, and weak governance structures tend to combine to exert significant pressure on livelihoods, especially in rural areas. These challenges have been associated with various forms of migration, including seasonal, circular, and forced displacement. Climate change is increasingly altering the environmental foundations of livelihoods in West Africa, through intensified droughts, irregular rainfall and coastal flooding (Ibrahim and Mensah, 2022), thereby influencing mobility strategies at household and community levels. These environmental pressures interact with pre-existing socio-economic vulnerabilities to shape migration both a livelihood strategy and, for some, a coping necessity. Therefore, understanding how climate change may influence migration in this region is essential for developing more informed and context-specific responses.

In recent years, several reviews have explored the relationship between climate change and migration in Africa. Borderon et al. (2019) and Kwanhi et al. (2024) cover the entire African continent, including West Africa as a case within a broader analysis. Freeman (2017) and Goff et al. (2012) examine additional dimensions, such as the interconnections between migration, conflict, and security. Other studies, such as those by Lavallard (2022) and Osei-Amponsah et al. (2023), focus specifically on West Africa, although from more specific perspectives, such as agricultural adaptation or social transformation.

Similar research gaps appear to have been observed in other parts of the continent. A recent bibliometric analysis of climate-related risks in East Africa revealed a strong imbalance in scientific coverage across countries, with most studies focusing on single hazards rather than integrated, multi-risk assessments (Fekete and Subramanian, 2024). This suggests the value for more regionalized and interdisciplinary research approaches that address the complex interplay between climate change, urbanization, and vulnerability across Africa.

Previous reviews have synthesized research on migration and climate change in Africa, often adopting a continental scope or focusing on specific themes such as conflict, security, or agricultural adaptation. However, these studies do not provide a regionally concentrated, PRISMA-based systematic review of West Africa. Unlike these prior studies, this article conducts a systematic review focused exclusively on West Africa. By concentrating on the region as a distinct case, it identifies migration patterns, drivers, and vulnerabilities specific to this area. This regional approach seeks to update the state of the art within a defined geographical context, provides insights into the dynamics shaping human mobility in response to climate change, and can inform the development of policies better tailored to local contexts and vulnerabilities.

Beyond climate-specific drivers, migration in West Africa occurs within a broader pattern of human mobility across the African continent. According to 2020 data from the International Organization for Migration (IOM), there were an estimated 40.4 million African migrants, representing 3% of the continent's total population. Of these, around 12.1 million (30%) originated from West Africa, highlighting the region's significant role in Africa's overall migration trends. Notably, most African migrants move within the continent itself (51.6% relocated to another African country, while 48.4% migrated outside Africa) (IOM, 2024). Among those who moved beyond Africa's borders, 27% settled in Europe, 12% in Asia, and 8% in North America.

Within this context, West Africa remains a highly mobile region, with more than 10 million people migrating internationally in 2020 alone (UNDESA, 2020). However, many of

these movements are not entirely voluntary. In 2022, West Africa accounted for 8% of Africa's refugees and asylum seekers, with displacement driven by both conflict and environmental pressures. Internal displacement is also reported to be increasing, especially in coastal and Sahelian areas affected by desertification, flooding, and sea-level rise (IOM, 2024).

Although data beyond 2020 is limited, migration from West Africa has continued. The 2024 Africa-Europe Foundation Report notes a sharp rise in flows along the Canary Route, now one of the main irregular migration pathways to the Canary Islands (Africa-Europe Foundation, 2024). In 2024, Mauritania became a key departure point to the Canary Islands, with a rise in Atlantic crossings in precarious boats. Structural push factors and the lack of safe legal pathways continue to drive migration along this route (Africa-Europe Foundation, 2024). These data not only reflect the intensity of migration flows in West Africa but also suggest the uniqueness of its mobility patterns compared to other regions of the continent. Focusing the analysis exclusively on this region therefore allows for a more precise identification of contextual dynamics, specific climatic and structural drivers, and the social responses that shape migration in a particularly vulnerable setting.

However, it is difficult to determine to what extent climate change has influenced these movements or to quantify the phenomenon (De Longueville et al., 2020). This challenge arises partly because there is no clear, universally accepted definition of "climate migration." The literature uses various terms, including "climate migrants" and "climate displaced persons", the latter being more common in the case of internal displacement. There is also the more restrictive term "climate refugees", which is often considered inappropriate due to the absence of legal persecution. Furthermore, the terminology encompasses a wide range of different types of displacement, including both international and internal movements, temporary and permanent migration, and rural-to-urban migration. This diversity complicates measurement and the collection of sufficient data to accurately understand the phenomenon (Corti-Varela and Cabedo, 2024).

A large proportion of climate-related displacements occur within national borders. The Groundswell Report Part 2 by the World Bank (Clement et al., 2021) predicts that internal migration driven by climate impacts is likely to increase across all regions and countries. In West Africa, the Internal Displacement Monitoring Centre (IDMC) recorded 385,000 internally displaced persons in 2023 due to climate-related events such as flooding, erosion, droughts, and sea-level rise (IDMC, 2023). Over the past decade (2013–2023), internal displacements in the region have reached 6.6 million people. This mobility reflects the high vulnerability of the region, where a significant portion of the population relies on agriculture and livestock for survival (sectors that are particularly sensitive to climate change). This vulnerability is further compounded by macro-level stressors including economic challenges, terrorist violence in certain areas, and limited access to basic services. These factors are well captured by the Foresight framework developed by the UK Government Office for Science, which provides a structured multilevel approach to understanding the drivers of environmental migration (Foresight, 2011). At the meso and micro levels, family networks, social and religious connections, and personal experiences play a crucial role in shaping migration decisions, particularly in this region (Osei-Amponsah et al., 2023).

This paper provides a systematic review of the literature on climate-induced migration in West Africa. While several continental and thematic reviews exist, West Africa has been relatively underexplored in systematic, region-specific analyses, as most existing reviews address the African continent as a whole

rather than focusing specifically on this region. This gap was identified through an exploratory search conducted for this study, which confirmed the absence of previous systematic reviews on this topic. To fill this gap, the present study conducts a PRISMA-guided review of 42 articles published between 2004 and 2024.

The objective is to identify the main studies on climate migration in West Africa and to understand the key topics, methodologies used, findings achieved, and knowledge gaps. These objectives were formulated based on the following research questions: (a) What topics are addressed in studies on climate change and migration in West Africa? (b) What methodologies have been used in these studies, and what findings have they reached? (c) What are the knowledge gaps regarding climate-induced migration in West Africa?

The article is structured as follows. First, the methodology used for this study is explained, with a particular focus on the PRISMA method employed for conducting the systematic review. Second, the results of the literature review are presented, including the identified methodologies, key topics, and main findings. Third, a discussion is carried out, comparing these results with similar recent literature reviews. Finally, the conclusions of the study are presented.

## Methods

This section outlines the methodology used for the study. To ensure a rigorous and transparent process, the PRISMA method was applied. This approach is widely recognised for its ability to structure comprehensive reviews, ensuring reproducibility, traceability of methodological decisions, and minimisation of biases (Page et al., 2021). The use of the PRISMA method enabled the identification, selection, evaluation, and thorough synthesis of the available evidence from relevant academic publications.

The study was carried out in three stages: (1) planning the review, which involved identifying the research problem, developing the review method, and preparing the protocol (available for reference in Appendix 2); (2) conducting the review, following the phases outlined in the PRISMA method by Page et al. (2021) (search, selection, evaluation, data extraction, and analysis); and (3) presenting the results, highlighting the main themes and findings identified in the literature.

The first phase of the literature review was the search process. This was conducted across three main academic databases: Web of Science (WoS), Scopus, and JSTOR, chosen for their extensive availability of academic articles and their ability to provide access to reliable sources. To maximise results, Boolean operators (AND, OR, NOT) were used, along with keywords and phrases related to the research objectives. The search strategy was adapted to the syntax of each database to ensure consistency and comprehensiveness. In Web of Science, the following search string was used: TS= (“climate change” OR “climate variability”) AND TS= (“climate-induced migration” OR “climate migration” OR “environmental migration”) AND TS= (“West Africa” OR “Western Africa” OR “Sahel”). For Scopus, the query was: TITLE-ABS-KEY (“climate change” OR “climate variability”) AND (“climate-induced migration” OR “climate migration” OR “environmental displacement”) AND (“West Africa” OR “Western Africa” OR “Sahel”). In JSTOR, the search was simplified due to platform constraints: (“climate change” OR “climate variability”) AND (“climate migration” OR “environmental displacement”) AND (“West Africa” OR “Western Africa”).

The second phase, identification, involved retrieving a total of 602 records from the selected databases: 310 records from Web of Science, 198 from Scopus, and 94 from JSTOR. The searches were conducted between October 15 and November 13, 2024. The records were managed using Zotero, where 293 duplicates were

removed, leaving 309 records for the subsequent stages of analysis. The screening and eligibility assessment were conducted by a single reviewer, who applied the predefined inclusion and exclusion criteria throughout all phases of the selection process.

Next, during the screening phase, the titles, abstracts, and keywords of the 309 records were reviewed to determine their relevance to the study’s objectives. As a result of this preliminary review, 147 records were excluded for not aligning with the research topic, leaving 162 records for the eligibility evaluation phase.

Finally, during the eligibility phase, a full reading of the remaining 162 articles was conducted, applying specific inclusion criteria. These criteria were: (1) publication between 2004 and 2024, (2) a geographic focus on West Africa, and (3) direct relevance to climate-induced migration or events associated with climate variability and change. After this detailed analysis, 120 articles that did not meet the criteria were excluded, reducing the final number of selected studies to 42<sup>1</sup>.

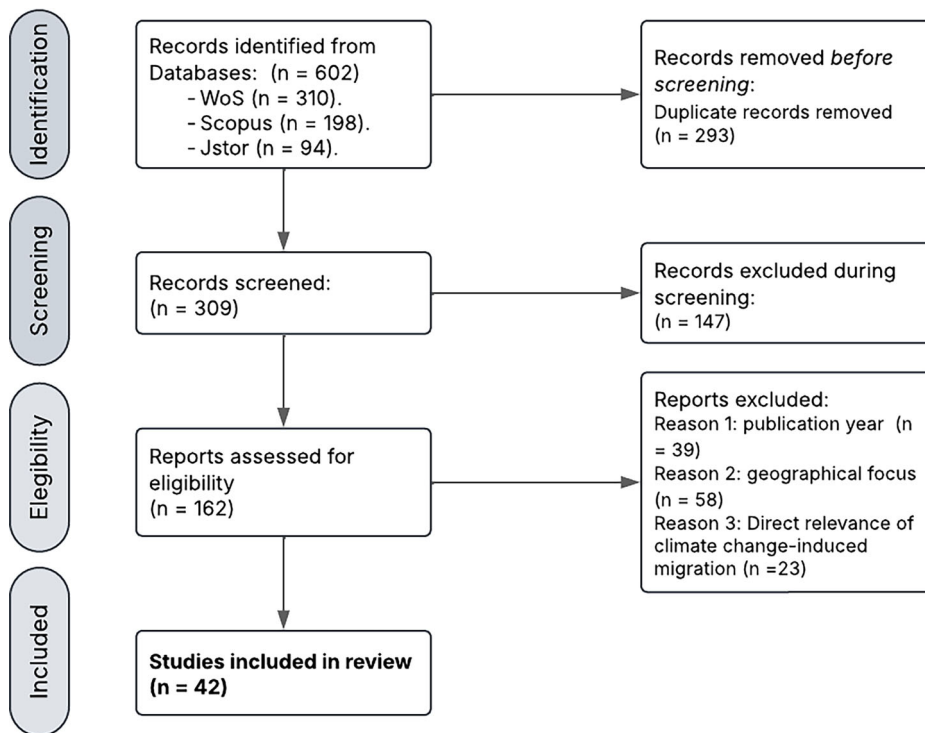
Figure 1 presents the PRISMA flow diagram, detailing the study selection process across the various stages of the review. It indicates the total number of records identified (602), the removal of duplicates (293), the records screened (309), the articles excluded during the screening phase (147), those excluded after the eligibility evaluation (120), and the 42 studies ultimately included in the analysis.

Once the 42 studies were selected, a thematic analysis was conducted to identify patterns and knowledge gaps regarding climate-induced migration in West Africa. Data extraction was performed manually by one of the authors, who reviewed all studies using a structured form covering authorship, title, geographical context, key themes, methodology, and main findings (see Appendix 1). No formal risk-of-bias assessment was conducted, as the review aimed to provide a qualitative synthesis of heterogeneous study designs. The single reviewer screened and extracted all data, and no automation tools were used.

A qualitative and inductive coding approach was applied. Themes were not predefined but emerged from full-text readings. The content was manually coded and grouped into seven recurring categories: (1) interaction between environmental, social, political, and economic factors; (2) adaptation and resilience strategies; (3) impact on livelihoods; (4) migration patterns; (5) conflict and resource tensions; (6) vulnerability and poverty; and (7) the climate–economic migration nexus. All relevant findings related to these seven thematic domains were extracted. No selective criteria were applied, and no automation tools or author follow-up were used during data extraction.

To enhance the transparency of this study, Appendix 1 includes a detailed table of the 42 selected articles, specifying their key characteristics (authors, title, methodology, theme, and findings). Additionally, Appendix 2 contains the complete protocol of the PRISMA systematic review.

This research faces a series of limitations that must be considered. First, the PRISMA method, by relying on predefined inclusion and exclusion criteria, may have excluded relevant studies that were not indexed in the academic databases used or that are found in grey literature, such as NGO reports and government documents. Second, the study encounters a challenge in defining the phenomenon, as the absence of a clear and universally accepted definition of “climate migration” complicates the selection of studies and the categorization of environmental factors as primary drivers of mobility. This lack of consensus in terminology affects the systematization of data and may introduce biases in the interpretation of results. Third, limitations in data access and availability have posed a significant challenge, as official migration records rarely differentiate between climate migration and other types of mobility, making it difficult to



**Fig. 1 PRISMA flow diagram.** Adapted from Page MJ, et al. *BMJ* 2021;372, n71. <https://doi.org/10.1136/bmj.n71>.

accurately quantify the phenomenon. These methodological, conceptual, and data access constraints must be considered when interpreting the study’s results and highlight the need to continue expanding research in this field.

**Results**

This section presents the results of the analysis of the articles included in the literature review. First, the methodological diversity and geographical distribution of studies conducted in the region are examined. Next, a brief analysis of the temporal evolution of the selected research is carried out, noting it to key regional events such as major droughts in the Sahel, the 2015 Paris Agreement, the escalation of armed conflict in Mali and Burkina Faso, and the intensification of extreme weather events between 2020 and 2024. Subsequently, the main themes identified are described. Finally, the most significant findings of the analysed studies are outlined.

On one hand, in terms of methodology, there is a predominance of mixed approaches, used in 42.8% of the studies. This includes the combination of in-depth interviews with data analysis (21.4%) and the use of complementary qualitative and quantitative tools. This approach tends to allow for a multifaceted understanding of the issues, capturing both contextual nuances and general trends. Quantitative methods account for 33.3% of the studies, with a focus on empirical analysis and the use of secondary data. Qualitative methods, used in 23.8% of the studies, focus on systematic and critical reviews, as well as ethnographic research.

On the other hand, from a geographical perspective, the review has intentionally focused on West Africa, with 76.2% of the studies dedicated exclusively to this region. More than half of these studies (54.8%) analyse specific countries, which is particularly important for capturing local particularities that may be overlooked in broader studies. The remaining studies examine regional dynamics or compare West Africa with other areas. To better understand the geographical distribution of case studies,

**Table 1 Number of studies focused on each West African country.**

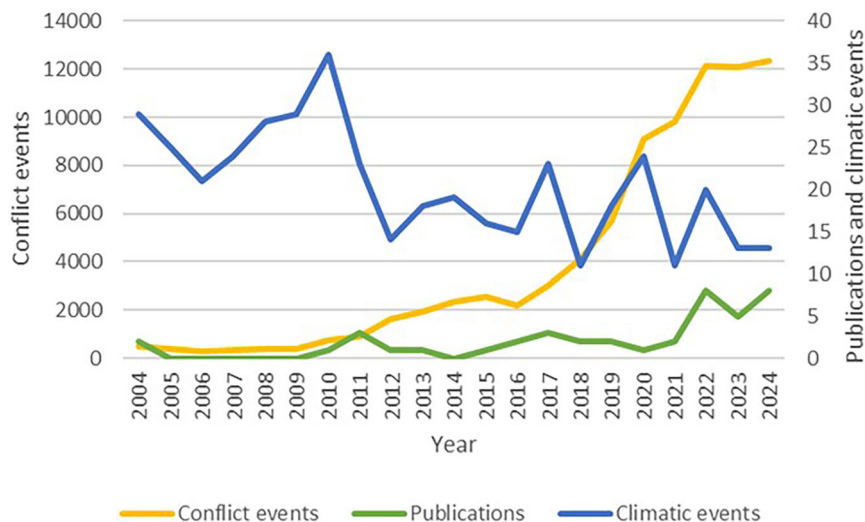
Country	Number of studies
West Africa (general)	15
Senegal	15
Mali	13
Niger	6
Ghana	6
Nigeria	5
Mauritania	2
Gambia	2
Guinea	2
Benin	2
Côte d’Ivoire	1

own work, 2025.

Table 1 presents the number of times each West African country is covered in the selected literature. This breakdown highlights which countries have received the most academic attention and provides a basis for identifying underrepresented contexts within the region.

As shown in Table 1, the studies are not evenly distributed but tend to concentrate on certain countries. Senegal and Mali emerge as the most frequently studied countries, followed by Niger, Ghana, and Nigeria. These countries have been central to regional debates on climate change and migration due to their high exposure to climatic stressors such as droughts, desertification, and floods, as well as their geopolitical relevance in migration dynamics within the region (Madu and Nwankwo, 2021).

However, the data also reveal significant gaps. Some countries, such as Sierra Leone, Togo, Liberia, and Guinea-Bissau, face recognized climate vulnerabilities and exhibit important mobility dynamics, yet they are scarcely represented or even absent in the literature reviewed. This underrepresentation may be explained by factors such as limited data availability, research access



**Fig. 2 Annual trends in publications, climate events and conflict events (2004-2024).** own elaboration based on data from ACLED and EM-DAT, 2025.

challenges, or lower visibility in the international scientific agenda. Nonetheless, their exclusion is analytically relevant, as it limits a comprehensive understanding of the region and may obscure local dynamics that deserve attention.

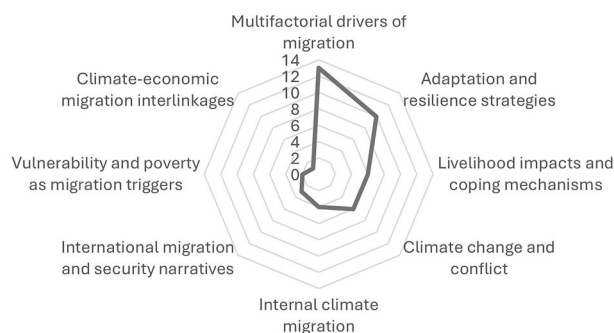
**Analysis of temporal distribution of publications.** The evolution of the number of publications on migration and climate change in West Africa can be partly understood in relation to historical factors, climate events, and the growing recognition of the relationship between these topics.

Figure 2 shows the annual trends in academic publications on migration and climate change, climate-related events, and conflict events in West Africa between 2004 and 2024.

The number of publications increased notably between 2011 and 2013, a period marked by recurring droughts and famines in the Sahel. These events had a significant impact on livelihoods dependent on agriculture and livestock, particularly due to the severity of the droughts (Affi, 2011; Hummel, 2012; Romankiewicz and Doevenspeck, 2014). The adverse climate conditions during this time drew attention to the relationship between environmental stress and human mobility, triggering a rise in academic interest.

A second increase in publications between 2016 and 2019 seems to be associated with several converging factors. The adoption of the Paris Agreement in 2015 sparked renewed interest in the impacts of climate change, especially in highly vulnerable regions. This promoted research on the interaction between climate adaptation, migration, and climate-related risks. At the same time, conflicts in the Sahel intensified, particularly in Mali (Freeman, 2017; Benjaminsen, 2016; Bendani and Venier, 2017). Security crises worsened across Burkina Faso, Niger, and Nigeria (Bendani and Venier, 2017; Liehr et al., 2016; Teye, 2018; Van der Land et al., 2018). The overlap between environmental stress and rising insecurity likely contributed to the surge in academic output during this period.

More recently, new peaks in 2020 and again from 2023 align with renewed cycles of droughts and floods, rising resource conflicts, and the socioeconomic impacts of the Covid-19 pandemic (Kwanhi et al., 2024; Lavallard, 2022; Enríquez de Salamanca, 2023). These publications trends appear closely related to regional developments, as shown in the graph. While conflict events show a sharp and sustained increase (especially after 2018) climatic events fluctuate, with peaks around 2010 and



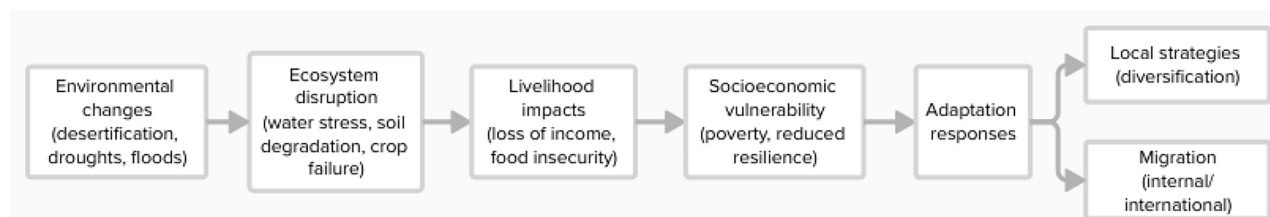
**Fig. 3 Main themes identified in the literature.** own work, 2025.

2020. Academic research, though more limited in volume, follows a pattern that reflects broader regional dynamics. The convergence of insecurity and climate variability appears to have driven growing attention to the nexus between climate change, migration, and instability in WAF.

In recent years, there has been a rise in publications analysing resource-related conflicts (Pantaleón Osuna, 2024). These studies address what has been termed “eco-violence” and show how environmental stress intersects with identity dynamics, contested land tenure regimes and weak local institutions, particularly in interactions between farmers and herders (Olumba et al., 2022). More recent contributions extend this perspective highlighting how climate-related risks and internal frontiers shape both mobility and expressions of violence (Dominguez et al., 2024; Sartori and Fattibene, 2019).

**Main themes identified.** The literature review allows identifying several fundamental themes that explore the relationship between climate change and migration. These topics are explained below. Figure 3 provides a visual overview of how frequently each theme appears across the reviewed articles, helping to contextualise the discussion that follows. Specific information on all authors and articles dealing with each topic can be found in the table in Appendix 1.

The main theme in many of the analysed works is the interaction between climate change and economic, political, and social factors. This topic is addressed in 13 out of the 42 articles. The literature generally suggests that climate change alone is



**Fig. 4 Environmental change and migration mechanisms.** own work, 2025.

rarely the primary trigger for migration; instead, it operates in combination with other factors, highlighting the complexity of migration decisions. The studies indicate that these factors include environmental degradation, the interaction with historical conflicts and development policies, as well as the role of social networks and economic aspirations. Additionally, socio-economic barriers, such as unequal access to resources and opportunities, limit the adaptive capacity and mobility of affected populations.

Another key focus is adaptation and resilience strategies, which are covered in 10 articles. These studies note that adaptation is crucial to mitigating the impacts of climate change. They emphasise that migration, although it can serve as an adaptive strategy, might be reduced if effective public policies were implemented to strengthen communities' ability to cope with environmental changes.

The impact of climate change on livelihoods is also a recurring topic, addressed in 6 of the reviewed articles. The studies show that sectors such as agriculture, fishing, and livestock farming, which are highly dependent on rainfall patterns, soil fertility, and ecosystem stability, are particularly vulnerable to extreme weather events such as droughts, floods, and irregular rainfall. These disruptions can reduce agricultural yields, destroy grazing areas, and deplete fish stocks, which in turn lead to income loss, food insecurity, and increased vulnerability. In response, affected households may turn to mobility as a coping mechanism, either by sending individual members to urban centres or by relocating seasonally in search of alternative income sources. In some cases, migration is part of a planned adaptation strategy; in others, it is a last-resort measure in the face of collapsing local subsistence systems.

The role of climate change as a driver of conflict is examined in 6 studies. Tensions are reported to arise both in areas of origin, due to competition for limited resources, and in destination areas, particularly in urban centres that are unprepared for rapid population growth. These situations are worsened in contexts with limited adaptive capacity.

Regarding migration patterns, internal climate migration is analysed in 4 articles. This type of migration is mainly characterised by movements from rural areas to urban centres or coastal regions. Many of these movements are temporary or cyclical, influenced by seasonal climate variability or periods of drought and rainfall.

International migration is less prominent and is discussed within the context of movements towards Europe. The predominant narrative, addressed in 3 articles, revolves around "security". This approach contributes to narratives that portray migration as a potential threat to receiving countries.

Two of the analysed studies focus on vulnerability and poverty as their main theme. They propose that climate change may exacerbate pre-existing inequalities, increasing migration as a survival strategy in highly vulnerable contexts.

Finally, the literature highlights the interconnection between climate migration and economic migration, particularly

emphasised by Afifi (2011). It points out the difficulty of separating these categories due to the multitude of factors driving displacement, reinforcing the idea that both types of migration are deeply interconnected. In this context, distinguishing between climate and economic migration is complex, especially when considering the element of voluntariness typically associated with the latter. Traditionally, economic migration is perceived as a voluntary decision driven by the search for better employment or living conditions. However, in contexts where climate change degrades livelihoods, communities may feel compelled to move. In these cases, although migration may have an economic motivation, environmental pressure challenges its voluntary nature. This interconnection blurs the line between voluntary and forced migration, highlighting the need for more nuanced approaches that acknowledge the influence of climate change on migration decisions.

**Main findings.** This section presents the results from the analysis of the 42 articles included in the literature review, providing insights into how the interaction between environmental, economic, social, and political factors shapes complex migration dynamics in West Africa (Black et al., 2022; Sanfo et al., 2016).

On one hand, environmental changes, manifested through processes such as desertification, prolonged droughts, and flooding, disrupt the ecosystems that agricultural and livestock activities depend on (Bendani and Venier, 2017; Bossard and Trémolières, 2010; Teye and Nikoi, 2022). This issue is discussed in 38 out of the 42 studies, making it one of the most widely addressed themes. These disruptions lead to economic losses, increasing the vulnerability of rural communities (Bendani and Venier, 2017). Migration emerges as a critical adaptive response to these challenges (Liman et al., 2024). However, the recurrence of such environmental events weakens communities' resilience, limiting alternatives to mobility. Figure 4 illustrates this chain of impacts, showing how environmental changes translate into ecosystem disruption, livelihood impacts, socioeconomic vulnerability, and ultimately adaptation responses such as diversification or migration.

On the other hand, economic factors are closely interconnected with environmental ones. Studies indicate that extreme climate events, such as droughts or floods, can exacerbate economic inequalities. This situation helps explain the prevalence of interregional displacement (Lavallard, 2022; Leal Filho et al., 2022).

Similarly, significant socio-economic barriers may limit the adaptive capacity of certain social groups, particularly women and agro-pastoralists, who face challenges in accessing resources such as land (Kwanhi et al., 2024). 8 out of 42 studies specifically address these barriers, noting the roles of gendered access, insecure land tenure, and resource distribution. These issues are further compounded by inadequate public policies, the lack of formal recognition of migration as a legitimate adaptation strategy, and insufficient access to climate information (Abawiera Wongnaa et al., 2024).

Regarding geographical contexts, the literature reveals that the effects of climate change on migration vary depending on local factors. In countries such as Senegal, Niger, and Côte d'Ivoire, droughts during the agricultural season appear to increase the likelihood of internal migration. However, in other countries, like Mali and Burkina Faso, these events do not trigger the same level of displacement (Bertoli et al., 2022). This regional variation is explored in at least 12 studies. Similarly, demographic patterns influence migration decisions: young men are the most frequent migrants, while this trend appears to decrease among older populations (Bertoli et al., 2022). In the case of women, their presence in migration flows is increasingly significant, although they face specific barriers such as limited access to resources, exposure to risks of exploitation, and the burden of family responsibilities (Maduforo et al., 2024). Seven studies examine these gender-based challenges, which affect both the ability to migrate and the opportunities available at destinations, highlighting the need for more inclusive mobility policies and improved protection in receiving areas.

Another important aspect is the type of climate events that influence mobility. Rapid-onset disasters, such as floods, often lead to temporary and large-scale displacements, while more gradual environmental processes, such as droughts or land degradation, are generally associated with planned, permanent migrations (Teye and Nikoi, 2022; Hammer, 2004). Nine studies distinguish clearly between the types of events and their different implications for migration timelines. This evidence supports the view that migration is not merely an immediate reaction to climate events but, in many cases, forms part of a long-term adaptation process (Doevenspeck, 2011).

Finally, the relationship between migration, climate change, and security is another interaction identified in the literature. Resource scarcity creates tensions both in places of origin and in destination areas, particularly in urban centres. This link between environmental stress, displacement, and conflict is addressed in at least six studies, which warn of the compounded effects of climate vulnerability and socio-political instability (Mbaye et al., 2021).

## Discussion

In the discussion section, the study's results are analysed in relation to previous research, specifically the systematic reviews by Ofori et al. (2023) and Borderon et al. (2019). The findings of this study correspond with and further develop the themes identified by Ofori et al. (2023) and Borderon et al. (2019) in two recent systematic reviews on climate change-induced migration in Africa. In line with the main findings of these two literature reviews, the analysis conducted in this study emphasises the complexity and multifaceted nature of the factors driving migration. However, this analysis focuses on West Africa, offering a more regional perspective that delves into the contextual dynamics shaping migration in an area of high vulnerability.

Regarding the effects of climate change that drive migration, Ofori et al. (2023) and Borderon et al. (2019) emphasise that environmental factors are significant but highly context dependent. In this study, evidence from articles such as those by Afifi (2011)[17], Rain et al. (2011), Hummel (2012) and Sanfo (2017) confirms that environmental degradation, including desertification and erratic rainfall patterns, disrupts livelihoods, leading to both temporary and permanent displacement.

However, as suggested by Borderon (2019), these factors do not operate in isolation but interact with social, economic, and political pressures, making it difficult to identify climate change as a primary factor. The results of this study show how political instability, conflicts, and economic insecurity intensify migratory pressures. Naz and Saleem (2024) document that resource

scarcity, worsened by climate change, increases tensions between pastoral and agricultural communities in the struggle for resources.

One of the main themes identified was migration as an adaptive strategy in response to climate shocks. This theme is also a central part of the reviews conducted by Ofori et al. and Borderon et al. (2019). In West Africa, articles such as those by Liehr et al. (2016), Bendani and Venier (2017) show that migration (sometimes circular and seasonal) helps communities diversify income and reduce pressure on resources. However, the present analysis highlights structural barriers that limit adaptive capacity, including land tenure (Abawiera Wongnaa et al., 2024) and lack of access to financial resources. Borderon et al. (2019) support this perspective, noting that socio-economic barriers affect the effectiveness of migration as an adaptation mechanism.

Additionally, research by Black et al. (2022) reveals that aspirations for social and economic mobility significantly influence migration decisions, particularly in contexts of socio-economic uncertainty. However, these aspirations are often constrained by access to resources and opportunities. Some individuals may wish to migrate but lack the means to do so, while others are able to use migration strategically to improve their livelihoods.

Moreover, as Erdal and Oeppen (2018) have argued, binary classifications such as "forced migration" and "voluntary migration" not only oversimplify the inherent complexity of migratory trajectories but also fail to accurately reflect the lived experiences of migrants, who rarely fall at either end of the spectrum and instead move within an intermediate zone shaped by varying degrees of voluntariness, agency, and constraint. A more nuanced understanding of "voluntariness" makes it possible to highlight the intersection between structural factors, contextual conditions, and individual decisions. In the case of West Africa, this perspective is essential for understanding how phenomena such as resource scarcity, political violence, or economic restrictions shape migration decisions that cannot be interpreted exclusively as climatic, economic, or voluntary. This critical lens allows for questioning not only reductive analytical frameworks but also the institutional mechanisms that define access to rights and protection and opens the way for an analysis more attuned to local dynamics and the diversity of migratory experiences.

A growing body of scholarship has further advanced this effort to move beyond the forced-voluntary divide. Concepts such as crisis migration and active immobility provide analytical tools to understand how individuals navigate adversity through varying combinations of agency, constraint and strategic decision-making (Ayebe-Karlsson et al., 2020; Toyin-Thomas et al., 2023). These perspectives are particularly relevant for West Africa, where climate pressures intersect with political and economic uncertainties, producing complex situations in which mobility and immobility coexist as adaptive (or constrained) responses. Incorporating these frameworks strengthens the interpretation offered in this review and situates the findings within ongoing theoretical developments in migration studies.

Regarding migration patterns, the two reference reviews confirm that migration (including climate migration) occurs predominantly within national or regional borders. However, public discourse tends to exaggerate the scale of international migration. In this study, an analysis of the literature confirms that more than 70% of displacements are internal. Articles such as those by Lavallard (2022) and Goff et al. (2012) show that, although less common, international migration from West Africa to Europe has gained attention due to security concerns and the management of migration flows. This highlights a significant difference in the perception and treatment of internal versus international migration.

Climate-induced immobility is well established in the broader climate–migration literature, but within the studies reviewed here it remains only briefly mentioned and insufficiently explored. While these studies hint at the existence of populations trapped by adverse climatic conditions, they do not delve deeply into analysing this phenomenon. Similarly, in the studies reviewed for this analysis, immobility is mentioned only tangentially, without systematic exploration or specific policy proposals to support those unable to migrate. This gap presents a significant challenge for the design of strategies that acknowledge the needs of both mobile populations and those who remain in their territories.

In conclusion, this study expands upon the recent literature reviews by Ofori et al. (2023) [42] and Borderon et al. (2019) by providing a more localised analysis of climate-induced migration in West Africa. While the general themes remain consistent, the findings highlight the need to delve deeper into specific contextual factors to design effective responses to the challenges posed by climate change in the region.

## Conclusions

Regarding the first question (what topics are addressed in studies on climate change and migration in West Africa?) the literature identifies five main themes. First, the interaction between environmental, economic, social, and political factors, noting that climate change is not an isolated trigger for migration. Second, adaptation and resilience strategies, highlighting how migration can serve as an adaptive response to climate shocks. Third, the impact of climate change on livelihoods, where sectors such as agriculture and livestock are described as experiencing significant losses due to phenomena like desertification and droughts. Fourth, the evidence reviewed suggests that mobility can be shaped by tensions associated with resource scarcity, giving rise to forms of conflict in both areas of origin and destination, as discussed in the previous sections. Lastly, migration patterns show a predominance of temporary or cyclical internal movements, while international migration is less common but draws attention due to security concerns.

For the second question (what methodologies have been used in the studies and what results have they reached?) the reviewed literature indicates that the combination of mixed, quantitative, and qualitative approaches can allow researchers to capture both macro- and micro-level dimensions of climate-induced migration. For instance, some studies use household surveys and remote sensing data to quantify the impact of rainfall variability on migration trends. Others apply interviews and ethnographic methods to explore how communities perceive climate risks and make migration decisions under conditions of uncertainty. Despite their different methodologies, these studies consistently highlight the interaction between environmental pressures and socio-economic vulnerability. They also reveal that migration often functions as a coping strategy shaped by factors such as gender, access to resources, and the presence or absence of institutional support.

Addressing the third question, (what are the knowledge gaps regarding climate-induced migration in West Africa?) two main gaps are identified. The first is the lack of comprehensive studies on climate immobility, referring to populations that are unable to migrate despite environmental impacts. The second is the need for greater conceptual clarity regarding climate migration, particularly concerning its distinction from economic migration.

This study offers a detailed regional perspective on climate-induced migration in West Africa, addressing the migration dynamics specific to the region. Unlike more general studies, this review underscores how the interaction of these pressures shapes migration decisions. It shows that vulnerability plays a central

role in these processes, as the most affected communities often depend on climate-sensitive livelihoods. Likewise, socio-economic inequalities and barriers to resource access reduce adaptive capacity and increase migratory pressure.

To advance this line of research, it is essential to promote discussions that acknowledge in migration processes, without underestimating its interaction with social, economic, and political factors. However, research on climate migration is limited by a lack of conceptual clarity, as there is no consensus on the appropriate term or its defining characteristics. This ambiguity complicates the collection of accurate data and, more importantly, hinders the development of adequate protection mechanisms for affected populations. This confusion is further exacerbated by the difficulty of drawing a clear line between climate migration (which is often considered forced) and economic migration (typically viewed as voluntary). Although the reviewed studies tend to classify migration related to climate impacts as forced, when it is associated with job loss or economic instability, it may be mistakenly perceived as voluntary economic migration, which can obstruct its recognition and the protection it requires.

Therefore, it is essential to adopt an approach that considers both climate and economic migration as expressions of global inequalities and as adaptation mechanisms to social crises. Future studies should also incorporate a multidirectional perspective that accounts not only for population outflows but also for returns and cycles of temporary displacement. Finally, it is important to recognize that migration decisions are influenced not only by macro-level factors such as conflict, insecurity, economic instability, or climate change, but also by key meso- and micro-level elements.

From a policy perspective, the findings of this review point to the urgent need to design targeted and context-sensitive strategies that support both mobile and immobile populations in climate-vulnerable areas. For mobile populations, this involves facilitating safe and dignified migration pathways, strengthening regional cooperation, and integrating climate mobility into national adaptation plans. In the case of immobile populations, it is essential to expand social protection systems, improve access to basic services, and invest in climate-resilient infrastructure at the local level. Recognising the diversity of migration responses and vulnerabilities is crucial to ensure that no group is left behind in the face of advancing environmental change.

In conclusion, this systematic review synthesizes existing evidence and invites a reconsideration of the notion of mobility as a uniform or unidirectional phenomenon. The findings call for a broader analytical approach that captures the diversity of experiences shaped by environmental vulnerability, socio-economic constraints, and structural inequalities. Recognizing the interaction between mobility and immobility, as well as the limitations of binary classifications such as “forced migration” and “voluntary migration,” is essential to guide both future research and policy responses. Ultimately, this study emphasises the need for conceptual, empirical, and policy frameworks that reflect the complexity of climate-induced mobility in one of the most affected and yet least studied regions of the world.

## Data availability

The datasets generated and/or analyzed during the current study are available in the OSF repository. The project is titled *Climate-induced migration in West Africa: a systematic review of the literature*. Anonymized data can be accessed at: [https://osf.io/uac5y/?view\\_only=a13942f348954d6caee0165e6fe9f189](https://osf.io/uac5y/?view_only=a13942f348954d6caee0165e6fe9f189). However, the datasets generated and analyzed during the current study are also available from the corresponding author upon request.

Received: 31 March 2025; Accepted: 7 January 2026;

Published online: 24 March 2026

**Note**

1 This number is comparable to other recent systematic reviews in the field, such as Osei-Amponsah et al. (2023), which included 38 studies, or Kawanhi et al. (2024), which focused on 16 selected articles.

**References**

- Ayeb-Karlsson S (2020) 'I do not like her going to the shelter': Stories on gendered disaster (im) mobility and wellbeing loss in coastal Bangladesh. *International Journal of Disaster Risk Reduction* 50. <https://doi.org/10.1016/j.ijdr.2020.101904>
- Abawiera Wongnaa C, Amoah Seyram A, Babu S (2024) A systematic review of climate change impacts, adaptation strategies, and policy development in West Africa. *Regional Sustainability* 5(2). Scopus. <https://doi.org/10.1016/j.regus.2024.100137>
- Afifi T (2011) Economic or Environmental Migration? The Push Factors in Niger. *Int Migr* 49:e95–e124
- Africa-Europe Foundation (2024) Africa-Europe Foundation Report 2024. Africa-Europe Foundation. <https://africaeuropefoundationreport.org/>
- Bendani B, Venier M (2017) Vulnerability and Resilience in West Africa: Understanding Human Mobility in the Context of Land Degradation. KNOMAD Working paper 25 Ca' Foscari University of Venice. [https://iris.unive.it/retrieve/e4239ddc-740f-7180-e053-3705fe0a3322/WP%2025\\_Vulnerability%20and%20resilience%20in%20West%20Africa\\_1.pdf](https://iris.unive.it/retrieve/e4239ddc-740f-7180-e053-3705fe0a3322/WP%2025_Vulnerability%20and%20resilience%20in%20West%20Africa_1.pdf)
- Benjamin TA (2016) Does climate change lead to conflicts in the Sahel? The end of desertification? Disputing environmental change in the drylands 99–116. [https://doi.org/10.1007/978-3-642-16014-1\\_4](https://doi.org/10.1007/978-3-642-16014-1_4)
- Black R, Bellagamba A, Botta E, et al (2022) Migration drivers and migration choice: interrogating responses to migration and development interventions in West Africa. *Comp Migr Stud* 10. <https://doi.org/10.1186/s40878-022-00283-3>
- Borderon M, Sakdapolrak P, Mutarak R et al (2019) Migration influenced by environmental change in Africa. *Demographic Research* 41:491–544
- Bossard L, Trémolières M (2010) West Africa: the dynamics and trends of international migration. OECD Journal: General Papers 2009:109–127
- Bertoli S, Docquier F, Rapoport H, Ruyssen I (2022) Weather shocks and migration intentions in Western Africa: Insights from a multilevel analysis. *Journal of Economic Geography* 22(2):289–323. Scopus. <https://doi.org/10.1093/jeg/lbab043>
- Clement V, Rigaud KK, de Sherbinin A, et al (2021) Groundswell Part 2: Acting on Internal Climate Migration. World Bank, Washington, DC. <http://hdl.handle.net/10986/36248>
- Corti Varela J, Cabedo C (2024) Climate-displaced people arriving in Spain. *Universidad del País Vasco = Euskal Herriko Unibertsitatea*, pp 597–602. <https://portalcientifico.uned.es/documentos/6657726dc744b3460991d04a>
- Doevenspeck M (2011) The Thin Line Between Choice and Flight: Environment and Migration in Rural Benin. *International Migration* 49:e50–e68
- Domínguez OG, Tavira NB, Tapia FH (2024) Cambio climático y migración: una relación compleja. *Interciencia* 49:680–686
- De Longueville F, Ozer P, Gemenne F, Henry S, Mertz O, Nielsen JØ (2020) Comparing climate change perceptions and meteorological data in rural West Africa to improve the understanding of household decisions to migrate. *Climatic Change* 160(1):123–141. Scopus. <https://doi.org/10.1007/s10584-020-02704-7>
- Enriquez de Salamanca A (2023) Influence of climate change, overfishing and COVID19 on irregular migration in West Africa. *Climate and Development* 15:215–228
- Erdal MB, Oeppen C (2018) Forced to leave? The discursive and analytical significance of describing migration as forced and voluntary. *Journal of Ethnic and Migration Studies* 44(6):981–998. <https://doi.org/10.1080/1369183X.2017.1384149>
- Fekete A, Subramanian S (2024) Multi-risks attributed to climate change and urbanization in East Africa: a bibliometric analysis of a science gap. *African Geographical Review* 43:735–757
- Foresight (2011) Migration and global environmental change. Final project report. The Government Office for Science. <https://assets.publishing.service.gov.uk/media/5a74b18840f0b61df4777b6c/11-1116-migration-and-global-environmental-change.pdf>
- Freeman L (2017) Environmental Change, Migration, and Conflict in Africa: A Critical Examination of the Interconnections. *Journal of Environment and Development* 26:351–374
- Goff L, Zarin H, Goodman S (2012) Climate-induced migration from Northern Africa to Europe: Security challenges and opportunities. *The Brown Journal of World Affairs* 18:195–213. <https://www.jstor.org/stable/24590873>
- Hammer T (2004) Desertification and migration: A political ecology of environmental migration in West Africa. In: *Environmental change and its implications for population migration*. Springer, pp 231–246. [https://doi.org/10.1007/978-1-4020-2877-9\\_11](https://doi.org/10.1007/978-1-4020-2877-9_11)
- Hummel D (2012) Climate Change, Environment, and Migration in the Sahel/Sahel region, focusing on Senegal and Mali, with emphasis on areas like Linguère (Senegal) and Bandiagara (Mali). Deutsche Nationalbibliothek. <https://www.iso-publikationen.de/fileadmin/redaktion/Downloads/Bevoelkerung/micle-wp1-2012-en.pdf>
- Ibrahim B, Mensah H (2022) Rethinking climate migration in sub-Saharan Africa from the perspective of tripartite drivers of climate change. *SN Social Sciences* 2:87
- Internal Displacement Monitoring Centre (IDMC) (2023) Global Internal Displacement Database - Disasters. <https://www.internal-displacement.org/database/displacement-data/>
- International Organization of Migration (2024) Africa Migration Report (Second edition)– Connecting the threads: Linking policy, practice and the welfare of the African migrant. IOM, Addis Abeba. <https://www.internal-displacement.org/database/displacement-data/>
- Kwanhi T, Modiba FS, Mago S et al (2024) Conceptualizing climate-induced migration in Africa. *Environmental Development* 52:101049
- Lavallard J (2022) Climate-induced migration in Western Sub-Saharan Africa: Improving the policymaking of the European Union. The case study of Senegal and Nigeria. Centre International de Formation Européenne. Institut Européen. School of Government. [https://www.ie-ei.eu/Ressources/FCK/image/Theses/2022/EUDIPL0\\_Lavallard\\_Thesis.pdf](https://www.ie-ei.eu/Ressources/FCK/image/Theses/2022/EUDIPL0_Lavallard_Thesis.pdf)
- Leal Filho W, Olaniyan OF, Nagle Alverio G (2022) Where to go? Migration and climate change response in West Africa. *Geoforum* 137:83–87
- Liehr S, Drees L, Hummel D (2016) Migration as societal response to climate change and land degradation in Mali and Senegal. In: *Adaptation to climate change and variability in rural West Africa*. Springer, pp 147–169. [https://doi.org/10.1007/978-3-319-31499-0\\_9](https://doi.org/10.1007/978-3-319-31499-0_9)
- Liman M, Nuhu Z, Halliru SL, Sodangi AB (2024) Migration as an Adaptation Strategy to Climate Change and Conflict Stresses: Exemplifying North-Western Nigeria. In: *Climate Change and Regional Socio-Economic Systems in the Global South: Resilience Strategies for Sustainable Development*. Springer, pp 233–248. [https://doi.org/10.1007/978-981-97-3870-0\\_13](https://doi.org/10.1007/978-981-97-3870-0_13)
- Maduforo AN, Taylor M, Ani-Amponsah M, et al (2024) Climate mobility and migrant health in West Africa: past norms, current challenges, and future projections. *Reg Environ Change* 24. <https://doi.org/10.1007/s10113-024-02271-y>
- Mbaye AA, Gueye A, Gueye F, et al (2021) Climate Change and Migration in West African Coastal Zones. African Economic Research Consortium. <https://aercafrica.org/old-website/wp-content/uploads/2021/11/Working-Paper-Series-CC-008.pdf>
- Madu IA, Nwankwo CF (2021) Spatial pattern of climate change and farmer–herder conflict vulnerabilities in Nigeria. *GeoJournal*, 86(6):2691–2707. Scopus. <https://doi.org/10.1007/s10708-020-10223-2>
- Naz U, Saleem MS (2024) Climate-Induced Vulnerabilities: Conflict and Migration Patterns in the Sahel Region of Africa. *Pakistan Languages and Humanities Review* 8:295–311
- Ofori DO, Bandaiko E, Kutor SK, et al (2023) A Systematic Review of International and Internal Climate-Induced Migration in Africa. *Sustainability*. <https://api.semanticscholar.org/CorpusID:265344127>
- Osei-Amponsah C, Quarmin W, Andrew Okem (2023) Understanding climate-induced migration in West Africa through the social transformation lens. *Frontiers in Sociology*. <https://doi.org/10.3389/fsoc.2023.1173395>
- Olumba EE, Nwosu BU, Okpaleke FNY, Okoli RC (2022) Conceptualising eco-village: moving beyond the multiple labelling of water and agricultural resource conflicts in the Sahel. *Third World Quarterly* 43(9):2075–2090
- Page MJ (2021) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 372:n71
- Pantaleón Osuna Á (2024) Climate change as a driver of migration? A comparative case study in eastern and northern Ghana. *Universität Passau*. <https://doi.org/10.15475/mitrawa.upa1>
- Romankiewicz C, Doevenspeck M (2014) Climate and mobility in the West African Sahel: Conceptualising the local dimensions of the environment and migration nexus. In: *Grounding Global Climate Change: Contributions from the Social and Cultural Sciences*. Springer, pp 79–100. [https://doi.org/10.1007/978-94-017-9322-3\\_5](https://doi.org/10.1007/978-94-017-9322-3_5)
- Rain D, Engstrom R, Ludlow C, Antos S (2011) Accra Ghana: A City Vulnerable to Flooding and Drought-Induced Migration
- Sanfo S, Fonta MW, Boubacar I, Lamers PJ (2016) Survey data on key climate and environmental drivers of farmers' migration in Burkina Faso, West Africa. *Data in brief* 9:1013–1019
- Sanfo S, Fonta WM, Diasso UJ et al (2017) Climate- and Environment-Induced Intervillage Migration in Southwestern Burkina Faso, West Africa. *Weather, Climate and Society* 9:823–837
- Sartori N, Fattibene D (2019) Human security and climate change. Vulnerabilities in the Sahel. EuroMeSCo policy brief 94. <https://www.euromesco.net/publication/human-security-climate-change-vulnerabilities-in-the-sahel/>

- Teye JK (2018) Environmental Change and Migration in Africa. In: Awumbila M, Badasu D, Teye J (eds) *Migration in a Globalizing World. Sub-Saharan Publishers*, pp 97–115. <https://doi.org/10.2307/j.ctvh8r2m4>
- Teye JK, Nikoi E (2022) Climate-induced migration in West Africa. In: *Migration in West Africa: IMISCOE Regional Reader*. Springer International Publishing Cham, pp 79–105. [https://doi.org/10.1007/978-3-030-97322-3\\_5](https://doi.org/10.1007/978-3-030-97322-3_5)
- Toyin-Thomas P, Ikhurionan P, Omoyibo EE, Iwegim C, Ukueku AO, Okpere J, et al. (2023) Drivers of health workers' migration, intention to migrate and non-migration from low/middle-income countries, 1970–2022: a systematic review. *BMJ Global Health* 8:e012338 <https://doi.org/10.1136/bmjgh-2023-012338>
- United Nations Department of Economic and Social Affairs, Population Division (2020) *International Migrant Stock 2020*. <https://www.un.org/development/desa/pd/content/international-migrant-stock>
- Van der Land V, Romankiewicz C, van der Geest K (2018) Environmental change and migration: A review of West African casestudies. In: McLeman R, Gemenne F (eds). *Routledge Handbook of Environmental Displacement and Migration*. Routledge, pp. 163-177

## Acknowledgements

The authors declare that this research was conducted without any external funding.

## Author contributions

The study was conceived and designed by G.G.-Á and R.C.-C. The literature search and selection were conducted by G.G.-Á. The data analysis was performed by G.G.-A and R.C.-C. The dataset was reviewed by R.C.-C. The manuscript was written by G.G.-Á. The manuscript revision was conducted by both G.G.-Á. and R.C.-C. G.G.-Á. prepared Figures 1 and 2. G.-Á. prepared both Appendix 1 and Appendix 2. All authors reviewed and approved the final version of the manuscript.

## Competing interests

The authors declare no competing interests.

## Ethics approval

This research did not involve studies with human participants, and therefore did not require ethical approval.

## Informed consent

This research did not involve human participants; informed consent was therefore not required.

## Additional information

**Supplementary information** The online version contains supplementary material available at <https://doi.org/10.1057/s41599-026-06503-w>.

**Correspondence** and requests for materials should be addressed to Gema Gómez-Álvaro.

**Reprints and permission information** is available at <http://www.nature.com/reprints>

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

© The Author(s) 2026