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Conceptualizing climate-induced migration in Africa

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ABSTRACT

Climate change has detrimental effects on the livelihoods of Africans, given their dependency on agriculture and subsistence farming. As such, when the environment is no longer conducive due to climate change challenges, migration is opted to seek better, more supportive living conditions. The study aimed to understand migration trends in the African region and to identify sustainable development strategies to mitigate migration by employing a bibliometric and systematic literature review. This systematic literature review of 16 studies conceptualized climate-induced mobility in African countries with evidence on how climate change has influenced migration decisions for most dwellers in vulnerable African areas. The results revealed a rural-urban migration as farming workers searched for other ways to secure livelihoods. Migration to other countries was also identified, especially in countries like the United States, France and the United Kingdom. However, the results also revealed that those who remained in rural areas would opt for other livelihood activities such as businesses. It was also observed that climate-induced migration is growing in Africa, particularly in Ghana, Uganda, Tanzania and Ethiopia. Therefore, to mitigate climate issues and manage migration, strategies are required to support communities affected by climate-induced problems.

This study recommends that governments and policymakers should consider strategies like climate development finance, capacitating communities depending on natural resources, conservation agriculture and innovative technology to help stabilize the economies in areas affected by climate change and to improve human security.

1. Introduction

Climate change is viewed as the worst global threat, and there will still be more dire impacts to come if humanity does not change its ways; that is, if it is not too late to do so (Birkmann et al., 2022). Fanzo and Miachon (2023) added that climate change negatively impacts food production, storage and transportation due to the intensive extreme events experienced worldwide. These authors estimated that about US$12.7 billion and US$10.8 billion per year is required to address the issue of water shortage and infrastructure development between 2015 and 2050. Future studies project that if not controlled, climate change will derail the elimination of hunger and lead to an additional 78 million people going hungry by 2050, mainly in the Sub-Saharan region of Africa (Sulser et al., 2021). With this backdrop, climate change is attracting the attention of researchers, research institutions, research funders and policymakers (da Silva et al., 2020).

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Vulnerable countries and regions have been identified and set as priority sites for climate-resilient development, and support has been given to reduce vulnerability and find adapting mechanisms to prevent a human catastrophe (da Silva et al., 2020; Birkmann et al., 2022). Climate change has become a threat to rural and global cities until the last individual in a household, and scholars have tried to address climate change by identifying migration and relocation as a temporary or permanent solution to this problem (Ekoh et al., 2023). Although little evidence links climate change to violent conflicts in Syria, which led to the migration crisis in Europe, one cannot rule out climate change as the cause (Abel et al., 2019). Africa has been the most vulnerable continent in the world regarding climate change and its impact on livelihoods. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (2012), Africa is a weak continent with a low adaptive capacity. This portrayal is due to the continent's lack of mitigation capabilities for the changing climate, such as technology, infrastructure and financial power (Trummer et al., 2023). Thus, livelihoods are affected because climate change affects food supply, causes diseases to spread, and induces migration from one affected area to another (Trummer et al., 2023).

Nevertheless, human migration has been happening for centuries and is regarded as an essential part of humanity (Silchenko and Murray, 2023; Bharadwaj et al., 2021). Migration is inspired by different drivers, such as employment, mostly moving people from rural to urban areas. Also, movement from one city to another in the same country or movement from one country to another for employment opportunities and other related aspects. In a study by Osei-Amponsah et al., 2023), it is believed that 10s of millions of people in Africa are expected to move because of challenges created by climate change, which are water scarcity, low crop productivity and rising sea levels.

In recent years, there has been a rise in climate-induced mobility, which is believed to have gained momentum due to the increase in climate vulnerability in most parts of the world (Stojanov et al., 2021). More attention has been paid to climate change's impact on most countries' livelihoods and economies, and more needs to be said about what happens to the dwellers of the affected areas. Africa is no exception, as it has high climatic conditions such as El Niño, floods and earthquakes (Matunhu et al., 2022). However, limited research has been conducted to conceptualize climate-induced migration in Africa.

Therefore, this paper aims to conceptualize climate-induced migration in Africa, thus adding to the body of knowledge. This review answers four primary research questions: (1) What are the critical drivers of climate-induced migration in Africa? (2) What are the patterns and trends observed in recent years regarding climate-induced migration in Africa? (3) What vulnerable communities are affected by climate change leading to climate-induced migration? (4) What coping mechanisms and mitigation measures have been implemented to allow smooth migration, if any?

2. Literature review

This section will explore the discussion on conceptualizing climate-induced migration by providing literature in line with the research questions and aiming to provide a comprehensive understanding of the current state of research on climate mobility in Africa. It begins by presenting the theoretical framework used in this study. It further contextualizes the link between climate change and migration, the key drivers that lead to climate-induced mobility and the most vulnerable groups directly or indirectly affected by it. The literature further highlights the migration trends regarding where the affected communities migrate after climate change. It will finally identify the various adaptive strategies that migrating communities adopt to ease the impact of climate mobility caused by climate change.

2.1. Theoretical framework

Theories used for climate change and mobility vary depending on the focus area of the climate issues researched. Some popular migration-related theories include the livelihood framework, life course analysis, social capital/networks, neo-Malthusian, structuralist, transnationalism, translocation, physical causation, human security and agent-based theories with arguments indicating that the environmental changes alone do not influence migration (de Sherbinin et al., 2022; Entwisle et al., 2020; Sakariyahu et al., 2024) as will be noted in sections 2.3 and 2.6. This study adopts the livelihood framework due to its focus on the African region, with many people living in poverty with limited resources and further exacerbated by climate change (Horwood et al., 2022). This framework is based on the financial, human, natural, physical and social assets instrumental in helping people meet their livelihood needs (Addaney et al., 2022; de Sherbinin et al., 2022). Climate change factors are both an enabler and an obstacle to securing livelihoods. Human security theory is also used as it suggests that protecting lives and their capabilities is important in ensuring that the quality of life is upheld in times of climate calamities (Adger et al., 2014).

2.2. Migration and climate change

Migration of people from one area to another or from one country to another has become an essential aspect of the global policy agenda since it has negative and positive social, economic, and cultural implications for communities and countries (Mago, 2018; Onafeso, 2020). Statistics show that there are over 200 million migrants across the world; 60% are found in developed countries, and the other 40% are in developing countries Onafeso (2020); Ahmed (2018), indicated that extreme climatic events have led to the vulnerability of most of the world's populations, and a call for preparedness to deal with the impact has been sent out.

Africa is dependent on agriculture, and on rainfall as a source of irrigation. However, due to climate change, agriculture production has reduced and, thus, most people have opted to migrate from rural areas to urban areas to seek employment (Onafeso, 2020). The effects of environmental degradation induced by climate change further led to poor quality of life due to the pressures experienced by

destination areas of migrators on population density and infrastructural facilities (Sakariyahu et al., 2024).

However, scholars like Onafeso (2020) stated that there is no link between human migration, mobility and climate change, and its impact can be expected to increase. Whereas Wolde et al. (2023) posits that the global warming trends, aridification and the intensification of extreme climate events, combined with underlying non-environmental drivers, may set millions of people on the move to other areas or cause intra-African migration, to date, there is little agreement within the scientific community on the extent to which climate and environmental factors influence human mobility.

2.3. Drivers of climate mobility

The main mobility drivers can be classified into six categories: food, water, economic, personal or political, energy and global environmental securities (Chazalnoël and Randall, 2022). Food and water security influence migrations because, in areas where climate changes have affected rainfall patterns and caused droughts, people may not be able to secure their livelihoods, thus opting to migrate to avoid food insecurity (Horwood et al., 2022; Chazalnoël and Randall, 2022). Economic drivers include the movement of people to seek employment opportunities due to unstable economies (Horwood et al., 2022). Politics are regarded as a driver because the lack of resources that the governments should provide impacts peoples' decisions to migrate (de Sherbinin et al., 2022). This driver can also link to water security, which in most countries is a basic service that the government must supply, but access to potable water for human and livestock consumption is a challenge (de Sherbinin et al., 2022; Fagariba et al., 2018).

The rising sea levels within global environmental security pose imminent risks that can cause migration without adaptation strategies (Badolo, 2024). For example, Lagos is one of many coastal African cities are exposed to rising sea levels (Osei-Amponsah et al., 2023). The global environmental driver extends to extreme weather conditions such as droughts, unpredictable rainfall and drying up of water wells (Fagariba et al., 2018). Countries like Somalia have experienced multiple droughts, and as a result, farming communities face difficulties tending to their crops and livestock (Horwood et al., 2022). Moreover, there is a lack of basic resources during natural catastrophes or conflict influences migration as people search for better living conditions (Chazalnoël and Randall, 2022). The authors also argue that climatic conditions influence internal migrations.

2.4. Vulnerable populations in Africa

Researchers such as Blocher et al. (2024) and Chetto et al. (2024) believe that in the African region, the most vulnerable groups affected by climate change mobility are agricultural rural poor and remote households. These rural dwellers in Africa primarily depend on agriculture, and changing temperatures and rainfall add more pressure to an existing rural-urban migration (Blocher et al., 2024). These climatic shifts significantly impact the livelihoods of populations dependent on climate-sensitive sectors such as agriculture, fisheries and pastoralism (Matunhu et al., 2022; Blocher et al., 2024; Chetto et al., 2024) . Different authors view climate-induced migration as an adaptive response to climate change, but risks are also involved with those migrating. Authors like Gilmore et al. (2024) stated that there are better solutions than migration since the already vulnerable people will be more vulnerable, especially in Africa where basic survival resources are scarce.

The world's most vulnerable groups to climate change are women and children. Women are more vulnerable because of a lack of education and access to climate change (Yadav and Lal, 2018). A study conducted by Eissler et al. (2019) also showed that not only does climate change affect the economic status of women, but it also affects fertility. The study found that women who dwell in significantly elevated temperatures caused by climate change have lower family sizes and reduced 69- + probability of desiring a first or additional child.

2.5. Migration patterns and trends

Sub-Saharan Africa is experiencing changes in precipitation patterns which are expected to change, where water availability may fall by 20–30%, under a conservative 2 °C increase by 2100, leading to stressed local freshwater supplies, reduced crop yields and desertification (Eissler et al., 2019). An increase in temperature is associated with a 2.66% reduction in agricultural output growth, leading to an average economic growth reduction of 1.3% points for each degree of warming (Onafeso, 2020). In 2019, Zimbabwe was affected by Cyclone Idai, which affected parts of Chimanimani and Chipinge; this led to pre-migration to safer areas. The cyclone affected 270,000 people, and at least 51,000 migrated, resulting in over 340 people losing their lives and some going missing (Trummer et al., 2023).

A study conducted by Chetto et al. (2024) shows that the three East African countries, Tanzania, Kenya, and Uganda, are among the most vulnerable countries in Africa and have the most mobile populations. Kenya also has experienced a high drought frequency rate that led the Kenyan government to declare the drought a national disaster from 2010 to 2011, 2016 to 2017, and 2021 to 2022 (Reliefweb, 2022; Samuel and Sylvia, 2019). Chetto et al. (2024) and Samuel and Sylvia (2019) stated that Ethiopia is another African country affected by climate change and has been experiencing severe drought for the past 40 years. It has experienced four consecutive failed rainy seasons since 2020, leading to a significant loss in livestock. Most farmers lost income, thus leading to food insecurity and poverty (Samuel and Sylvia, 2019).

According to Twinomuhangi et al. (2023), Western Uganda experienced flooding in 2020, which led to the migration of over 120, 000 people who lived near the riverbanks in urban areas. The heavy storms damaged many houses. Additionally, in the rural areas, heavy storms and prolonged droughts affected agricultural productivity and led to migration in search of places with better living standards. West Africa has the highest projected climate-related internal migrants (moving within countries) (Horwood et al., 2022). It

is projected that the migrants will potentially reach more than 50 million by 2050 for 2.5 °C global warming (Twinomuhangi et al., 2023). This forecast suggests that climate impacts will have a particularly pronounced impact on future regional migration.

2.6. Adaptive strategies

Literature shows increased research on climate mobility, and governments have started to notice the topic by producing policies, although scientific evidence still needs to be made more transparent (Stojanov et al., 2021). However, there is no uniform indicator of climate change and variability in how climate change affects rural communities. Thus, these communities have different adaptation strategies (Msimanga and Mukwada, 2022). Badolo (2024) argues that the capability to adapt in response to climate change is determined by households' adaptive capacity. For instance, those dealing with problems of drought, livestock and crop diseases may not migrate if they have supportive strategies to help them cope in their areas.

In Blocher et al. (2024) study, it is reported that some rural residents affected by climate change identified mechanisms to cope with the shock; however, these might only be temporary. Therefore, more substantive methods are required over time. Jellason et al. (2022) stated that local knowledge sources are key to farmers' adaptive strategy since they already understand their environment. There will be no need for induction, which will promote resilience since they are applying previous experience. Indigenous knowledge has been a method African people use as a coping mechanism to deal with climate change. However, this method is no longer applicable due to the severity of climate change, growth in globalized markets and population growth in the coming decade (Jellason et al., 2022).

Cultural activities such as prayer and traditional rituals have also been used as coping mechanisms for climate change. A study by (Mabuku et al., 2019) found that about 60% of the sampled rural communities in Mwandi District, Zambia, observed prayer as a long-term adaptation strategy against floods. Another example from Bongo District, Ghana, reports that rural communities took part in traditional cultural practices as a norm to reverse climate calamities like droughts (Aniah et al., 2019).

Furthermore, social protection can be another means of reducing climate-induced migration. Schwan and Yu (2018) define *social protection systems* as offering income or consumption handouts to people living in poverty to upgrade their livelihood and protect them from food insecurity, poverty and unemployment. Its main goal is to improve the social status and rights of the marginalized. Tenzing (2020) added that social protection is regarded by policymakers worldwide as a measure of protecting people with low incomes from stress and shock caused by climate change, which can prevent climate change-induced migration and promote a climate-resilient livelihood.

Some farmers adopted extension services as an adaptive strategy, which includes changes in the planting time due to changes in the rainfall patterns and the use of drought-tolerant livestock and crop seeds (Jellason et al., 2022). The use of drought-tolerant and early maturing crops, with the assistance of extension officers, has become the most common adaptive strategy in recent years.

3. Methodology

This study adopted a bibliometric and systematic review approach. It used the Preferred Report Items of Systematic Reviews and Meta-Analysis (PRISMA) guidelines.

3.1. Bibliometric approach

The bibliometric approach was used to achieve the scope of the third research question: to examine the patterns and trends of climate-induced migration. Knowledge mapping has been widely used in bibliometric analysis. It is used in this paper to assist researchers in better understanding the current research status on climate-induced mobility and future directions on the topic. Data from Scopus was used. Previous studies by authors such as Harzing and Alakangas (2016), Yang et al. (2023) and Archambault et al. (2009) revealed that there is no significant difference between bibliometric analysis results using Web of Science and Scopus because either could be used hence, this study chose Scopus. The search terms were "climate mobility", "climate-induced mobility", "climate-induced migration", and "Africa". The screening results led to 259 articles, and VoSviewer version 1.6.20 was used to analyze the data. The software was selected because it is user-friendly and shows bibliometric approach maps with various bibliometric indicators such as co-authorships between countries, citations, keywords and co-citation analyses of different sources. This software generates visualization maps relying on the data of networks. It utilizes clustering techniques and similarity mapping, which are mainly employed to analyze bibliometric networks (Wang et al., 2014; Zyoud and Fuchs-Hanusch, 2020; Zhang et al., 2024). Co-occurring analysis and

Table 1
Inclusion and exclusion criteria for articles in the review.

Criteria	Included	Excluded
Publication date	No year limit	No limit
Publication language	English	Non-English papers
Publication theme	Climate-induced migration	Papers which were not based on climate-induced migration
Availability of article	Full access	Incomplete papers
	Open access	Not fully accessible papers
Type of article	Peer-reviewed articles	Not peer-reviewed.
		Conference papers
Location of study	Africa	All papers which were not written about Africa

co-citation analysis are the primary analysis tools in bibliometric analysis. In the analysis of co-occurring, prominent authors, journals, institutions and countries in a research field can be illustrated clearly.

3.2. Systematic review approach

The systematic review approach includes quantitative and qualitative data from published scientific peer-reviewed literature sources. A systematic literature search was conducted in March 2024 using Web of Science, Scopus and Science Direct online search engines. The search terms included "climate change" and "mobility" or "climate-induced" and "migration" and "Africa.". The inclusion and exclusion criteria are shown in Table 1.

3.3. PRISMA (preferred reporting items for systematic reviews and meta-analyses)

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) systematic review standards were followed, and an expert group comprised of two researchers in the field manually screened all retrieved literature. This research followed the process of scholars such as Fan et al. (2022), Yang et al. (2023) and Abas et al. (2023), who used the primary techniques in systematic searching are identification, screening, and eligibility and these shown in Fig. 1.

4. Results

The section will highlight the results and discuss the findings from the bibliometric and systematic literature review, paying attention to emerging themes. Themes include the country where the study was conducted; however, it is limited to Africa, the concept of climate mobility, patterns and trends of climate-induced migration, critical drivers of climate-induced migration, vulnerable communities coping and mitigation strategies.

4.1. Bibliometric analysis

The Bibliometric analysis was used to examine the patterns and trends in climate-induced migration or climate mobility in Africa, and the type of analysis that was chosen was co-authorship, looking at the number of documents by country, co-occurrence keywords, citation and co-citation and distribution by knowledge area.

4.1.1. Co-authorship by country

The type of analysis chosen for this study was co-authorship, a unit analysis was used for countries, and the counting method was complete counting. A country's minimum number of documents was limited to 5; out of 77 countries, and 24 met the threshold. The total strength of the co-authorship links with other countries was calculated, and countries with the greatest total link strength were selected. The United Kingdom had the highest links (21) with a total strength of 76. It is followed by the United States, which had 20 links with a total strength 73. The most vital link strength was between the United States and the United Kingdom. South Africa has the highest link strengths among the African countries and is also in position 3 worldwide. Ghana is in position 8 and Kenya is in position 10. The collaborated countries are categorised into 5 clusters: red cluster with 8 items, green cluster with 6 items, blue cluster with 5 items, yellow cluster with 4 items and purple cluster with 1 item. The results are illustrated in Fig. 2.

The thickness of the link between any two countries indicates the strength of collaboration between the two countries. The volume of the circle around the item indicates the item's contribution (i.e., the larger the circle, the higher the country's contribution in terms

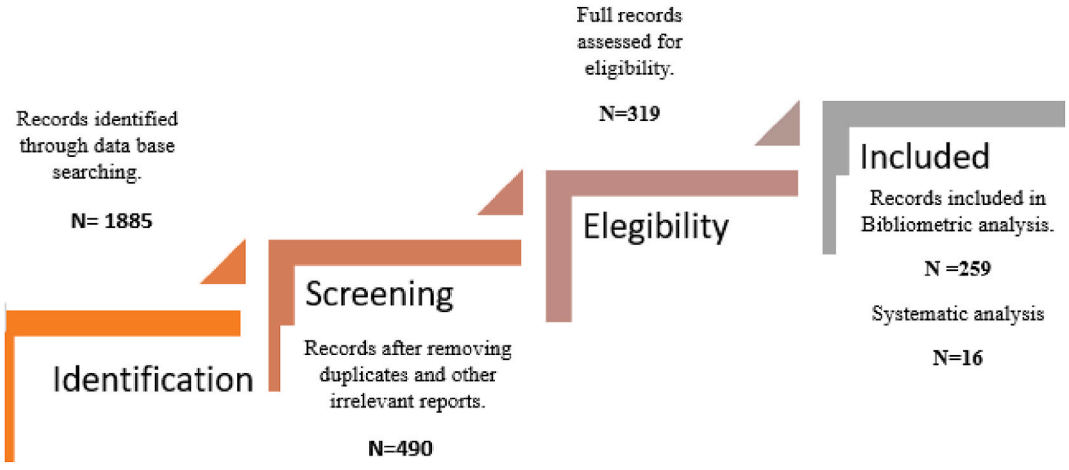

Fig. 1. PRISMA flow diagram summarizing the study selection process.

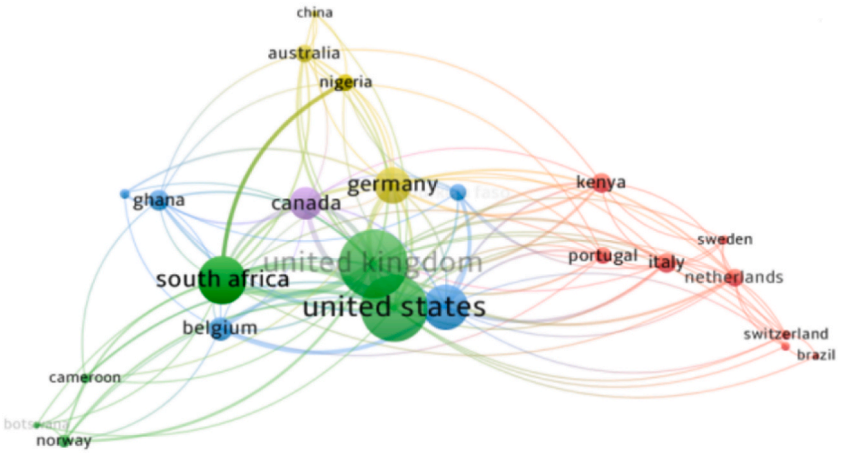

Fig. 2. Co-authorship by country.

of co-authorship). The items with the same colour indicate that these items are related to each other (i.e., within the same cluster).

The results further show that authors from different countries write in the same network, directly or indirectly. At the country level, the African countries showed different performance indicators. However, the results showed that most of the links are from the United Kingdom and the United States of America, which means they might have been in those countries but are still co-authoring with authors from Africa. South Africa is the most productive country in Africa, progressing in research and development. The results are not surprising since the government of South Africa has put effort into research and development. The primary funding sources for R&D in South Africa have been the government and business sectors. The government sector (including science councils and universities' funds) contributed 56,3% of R&D funding in the country; while business contributed 26,9%; foreign funding 13,3% and other South African sources 3,5% (Statistical Report).

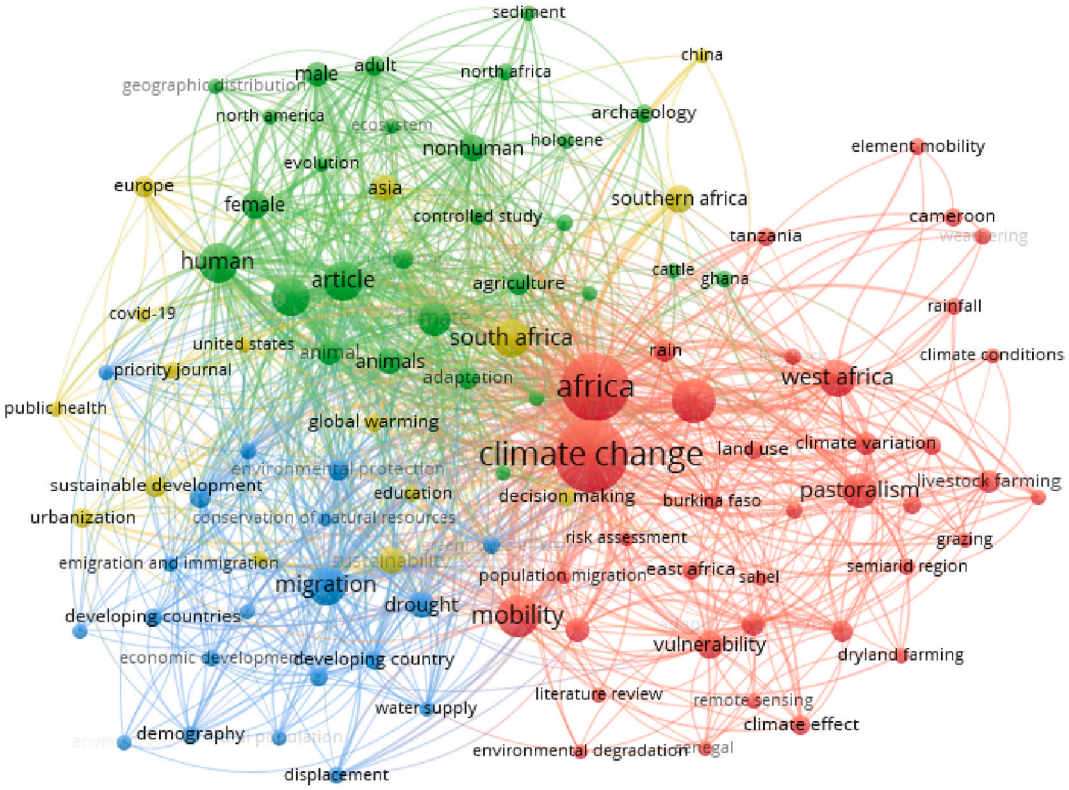

Fig. 3. Co-occurrence keywords.

4.1.2. Co-occurrence keywords

The type of analysis chosen for this study was co-occurrence keywords analysis, and the visual illustration of the results is shown in Fig. 3. The minimum number of occurrences of a keyword was set to a threshold of 5 occurrences of the 2689 words, and 102 met the threshold. Each keyword is represented by a circle, where the diameter of the circle and the size of its label represent the number of links between the keyword and the other. The bigger the circle, the more links the keywords have. The proximity of a circle to another indicates the degree of relatedness of the two keywords, and its colour represents the average publication year of keywords, shown in the colour bar. The more frequently the two keywords occur together, the thicker the line between them, and this represents the co-occurrence links between the two keywords. The keywords are subdivided into clusters, with red representing Cluster 1, cluster 2 representing blue, cluster 3 representing green and Cluster 4 representing yellow.

Climate change occurred in 99 and had a total link strength of 505; it had the most links with other keywords because it was the most common keyword. Africa followed it with a total link strength of 474; migration appeared at position 8 with a total strength of 205 and occurrence of 22. The analysis also showed that keywords such as 'climate change', 'mobility', 'Africa as a continent', 'Pastoralism' and 'global warming' are topical in the research network. Among all these keywords, climate change, Africa and mobility have the thickest lines and more prominent nodes, meaning that these words often appear together in the same publication and show that more researchers are researching the topic of climate-induced mobility in Africa. With these results, as climate change is increasing rapidly, especially in Africa, and thus leading to climate-induced migration, researchers are also increasingly focusing on the topic.

4.1.3. Citation and co-citation

The analysis of citations and co-citations is essential to assess the publication extent of the respective scientific papers and their contribution to research. Additionally, this analysis indicates the research's quality (Teplitskiy et al., 2022). The type of analysis used was co-citation, and the unit of analysis used was cited sources using the complete counting method. The minimum number of cited sources was 30; out of 8559 sources, and 27 met the threshold. This analysis calculated the total strength of the co-citation link with other sources and thus identified the sources with the greatest total link strength. It can be observed that the South Africa Journal of Science had the highest citations with 222 and a total link strength of 3146, followed by Nature with 176 and a total link strength of 2572 and the Journal of Human Evolution with a total link strength of 1708. Results are shown in Fig. 4.

4.1.4. Citation by source

Table 2 shows a summary of the ten most cited sources. The type of analysis used was citation, and the unit of analysis used was sourced using the entire counting method. The minimum number of cited sources was set at 2; out of 206 sources, and 29 met the threshold. This analysis aimed to calculate the total strength of the citation link with other sources and thus also identify the sources with the greatest total link strength. It can be observed that environmental management had the highest citation of 742, followed by the American Journal of Physical Anthropology with 485 and, lastly, the Journal of Global Environmental Change with 357.

4.1.5. Distribution by knowledge area

The distribution by knowledge area shows a concentration on climate-related issues, including migration. The results in Fig. 5 illustrate that the subject area of climate-induced migration is researched across most subject areas, with social sciences being the main subject area that publishes on climate-induced migration at 22.9%, followed by Environmental Science at 19.1%, Earth and Planetary Sciences at 14.1% and Agricultural and Biological Sciences at 8.8%.

4.2. Systematic review approach

The second section presents the results from the systematic review approach, including how some scholars define the concept of climate mobility, critical drivers of climate-induced migration, vulnerable communities and their coping strategies. Since the study was based on Africa, countries were grouped in their regions, and papers with climate-induced migration information were selected. The regions were broken down according to the African Union criteria, and the results are summarised in Table 3 in the

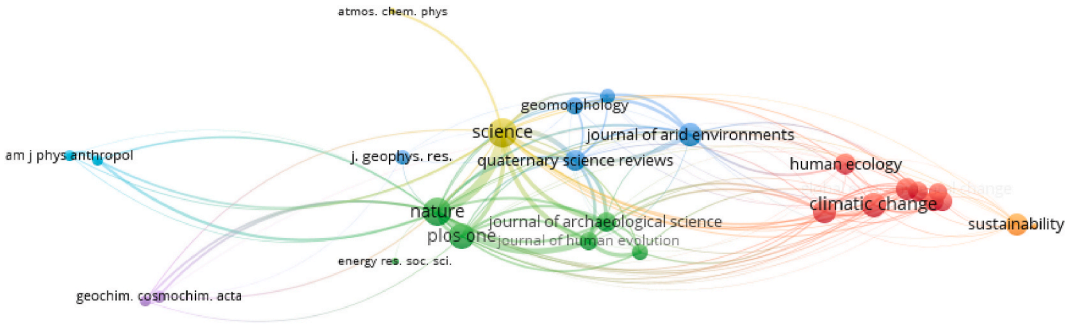

Fig. 4. Co-citation by source.

Table 2
Citation by source.

NUMBER	SOURCE	DOCUMENTS	CITATION
1.	Environmental management	2	742
2.	American Journal of Physical Anthropology	6	485
3.	Global Environmental change	4	357
4.	Nature	3	332
5.	Human Ecology	5	238
6.	Journal of Geophysical Research Atmosphere	5	174
7.	Geomorphology	2	129
8.	Earth Surface processes and landforms	2	110
9.	Journal of Environmental Management	3	99
10.	Sustainability (Switzerland)	6	65

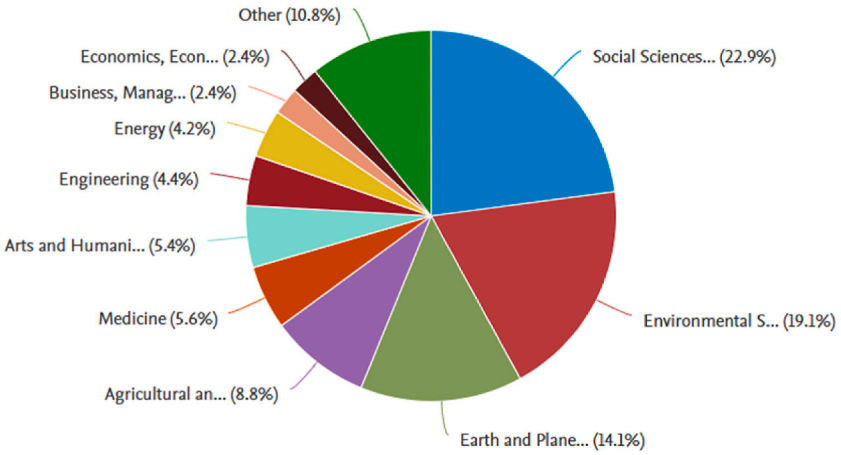

Fig. 5. Distribution by knowledge area source: SCOPUS.

Appendix section.

4.2.1. Concept of climate mobility

This study revealed that there are several concepts which scholars use to define climate-induced migration. Scholars such as Blocher et al. (2024) and Twinomuhangi et al. (2023) conceptualized climate-induced migration as mobility induced by shocks and stress resulting from changes in environmental conditions. In contrast, Scheffran et al. (2012) conceptualized it as a climate adaptation method. Azumah and Ahmed (2023) added that climate-induced migration is a method adopted by farmers to deal with declining agricultural production and, thus, to relocate to areas where production is higher, which is defined as a livelihood strategy. Osei-Amponsah et al. (2023) defined vulnerable groups as trapped populations and stated that this group uses climate-induced migration as an adaptative strategy. Ahmed (2018) conceptualized climate-induced migration by using the term 'climate refugees', referring to the affected communities that move from one area to another in search of better livelihood.

4.2.2. Key drivers of climate-induced migration

According to empirical literature, the critical events of climate-induced migration are changes in temperature, drought, floods, decrease in rainfall, livestock pests and crop diseases. These events are common in most African Countries (Leal-Arcas, 2012). Extreme weather events and high temperatures have led to rangeland degradation, crop failures, reduced crop production, water shortages and food insecurity in Kenya, Ethiopia and Ghana (Azumah and Ahmed, 2023). Moreover, extreme temperatures led to livestock losses and crop damage in Tanzania (Blocher et al., 2024). In South Africa, drought, hot temperatures and strong winds led to a significant loss of crops and livestock (Samuel and Sylvia, 2019). These findings align with the literature findings, confirming that food security, water security and global environmental security are key drivers in migration (Chazalnoël and Randall, 2022). These drivers create events that influence migration and displacement in the region; and due to the damage, migrants leave the affected area to settle in areas that are less affected and productive.

Extreme temperatures have been associated with reduced work hours on farming, further reducing agricultural productivity and causing mobility to towns in anticipation of non-farm livelihood opportunities (Hansen et al., 2019). Zickgraf (2022) also stated that Senegal has been experiencing severe drought and, therefore, residents from affected areas opted to migrate. Other events such as conflicts, flooding, crop failure, shortage of pasture and chronic water scarcity were observed and are also linked to climate-induced migration. Conflict-borne migration also corroborates the influence of political drivers on mobility (de Sherbinin et al., 2022).

4.2.3. Vulnerable communities

The most vulnerable groups affected by climate change, which thus leads to climate-induced mobility, are the rural and agriculturally dependent households and poorer households (Blocher et al., 2024). Azumah and Ahmed (2023), in a study conducted in Ghana, indicated that the most vulnerable groups that are migrating are mostly youth who prefer to go to cities and other communities, whereas farmers, such as male farmers, opt to relocate to cities or to other areas where production is higher, leaving women and children staying in the same area with extreme climate conditions. However, some female maize farmers also opt to relocate to seek fertile areas. This migration to cities might be because migration decisions are related to economic factors (Horwood et al., 2022). The need to secure economic opportunities means that an individual would look for a city or area with better opportunities than where they are migrating from (Ekoh et al., 2023).

Moreover, once the men reach the destination sites and secure livelihood income, they are able to adapt faster than women; and women's experiences and perspectives on climate-induced migration differ from men's in Ethiopia and Kenya (Samuel and Sylvia, 2019). In Senegal, most men migrate to other cities, leaving women to partake in gender roles and be responsible for household management and care responsibilities (Zickgraf, 2022).

In Uganda, the most vulnerable group are agro-pastoralists, regardless of whether they are male or female, and they find it hard to find pasture for their livestock (Twinomuhangi et al., 2023). In West African countries, most rural households are vulnerable to climate change; thus, most males migrate to find new jobs in the cities. This migration has led to an increase in female-headed communities (Osei-Amponsah et al., 2023). Agro-pastoralism is common in Uganda, and due to climate change, male pastoralists travel longer distances in search of water and pastures for their livestock. At the same time, women tend to migrate closer to wetland corridors that can sustain crop growth during dry periods. Awinia (2020) also mentioned that in Tanzania, climate-induced migration is more common among pastoralists who migrate to other communities in search of water and forage resources.

4.2.4. Coping strategies and mitigation

Scholars highlighted different coping mechanisms that vulnerable groups adopt to cope with climate change, which include financial assets and social networks (Addaney et al., 2022). It is stated that some members in Tanzania opted to use their savings in case of emergencies or if they could not plant during the season due to climate change (Blocher et al., 2024). The author also indicated that they would seek help from relatives or friends, engage in spiritual efforts and change eating habits. Twinomuhangi et al. (2023), in a study in Uganda, added that the communities share the same strategies as those found in Tanzania; however, the study also shows that some communities chose to pray and opt for community fundraising to assist the affected areas. Some farmers in Ghana indicated that they also get help from NGOs that support their farm businesses, along with some microloans. Although they are still required to pay them back, the interest rate is lower than that offered by local banks (Azumah and Ahmed, 2023).

Access to extension services has also become a common coping strategy in some areas where they tap into the available human capital and are interested to being empowered (Addaney et al., 2022). Extension officers train farmers on how to use modern technologies (Azumah and Ahmed, 2023). Climate-smart agriculture (CSA) adapts to modern technologies that reduce the effect of climate change (Azumah and Ahmed, 2023). Scholars have identified government support programs, such as social protection, as a strategy the African governments have developed to ease financial barriers to migration in climate change contexts. Social protection has been identified as one of the coping strategies that can facilitate switch movement or support adaptation, support trapped populations, deter distress migration and facilitate agency in migration decision-making, including for women (Silchenko and Murray, 2023).

In Zambia, the migration of wealthy males was reduced during extreme heat (Mueller et al., 2020). In countries like Nigeria, the government has a support program for relocating communities affected by floods (Ekoh et al., 2023).

In a study by Ekoh et al. (2023), they showed that staying back or waiting indoors until flood waters subsided was one of their coping strategies. This practice indicates that since Africa has a robust cultural attachment climate, induced migration might interact with the cultural aspects and affect the livelihood of African dwellers (Osei-Amponsah et al., 2023). Some individuals refuse to migrate as they cannot leave their ancestral land, which is a strong belief in Africa, indicating their strong connection to nature.

5. Conclusion

The aim of the study was to conceptualize climate-induced migration in Africa using a bibliometric and systematic literature review. The Bibliometric analysis shows that researchers are interested in the topic of climate-induced migration, and the subject area of climate-induced migration is researched across most subject areas. In terms of co-occurrence of keywords, the results showed that keywords such as 'climate change', 'mobility' and 'Africa' are intricately linked, thus proving that climate-induced migration is becoming a common subject. This might also be due to an increase in carbon emissions which leads to an increase in climate change. In terms of co-authorship per country, the study showed that there are three African countries that are researching the subject, which are South Africa, Ghana and Kenya. It also revealed that there is a close collaboration between South Africa and Nigeria. This is between the Southern and Western Region of Africa.

The second stage of the paper was to conduct a systematic review analysis by looking at how scholars in different regions of Africa conceptualize climate mobility. It can be concluded that though most scholars defined climate-induced migration in their own way depending on the study area or country, the common concept was conceptualizing climate-induced migration as a climate adaptation strategy that vulnerable groups voluntarily or involuntarily adapted to. Some called climate-induced mobility a livelihood strategy to be adopted by affected groups. It can also be observed from the literature that different terminologies have been brought up by different scholars, although they are referring to the term 'climate-induced migration'. These include climate refugees, climate human mobility, climate migration and climate mobility, which refers to the movement of people from one place to another, forced by

unconducive climatic conditions which threaten human security.

It can also be concluded that the key drivers of climate-induced migration in Africa are extreme weather conditions, which lead to an increase or decrease in weather conditions. Frequent droughts have also become a common experience in most African countries, with droughts such as El Nino. A decrease in rainfall has also been observed and has become a severe cause of concern since Africa relies on agriculture and depends on rainfall to irrigate crops and provide water for livestock. All these factors have led to reduced agricultural production, livestock losses and crop damage which affected their livelihoods and security. Thus, when nature cannot support their quality of life, people in affected areas migrate to other places that are less affected.

It can also be observed that there are different patterns in which vulnerable communities migrate. Some opt to move from one community to the other, some move from one region to another, some move from rural areas to urban areas and some move from one continent to another. All these movements are caused by climate change, among other factors.

The most vulnerable communities affected by climate change, leading to climate-induced migration, are primarily pastoralists who are forced to move from one community to another to search for greener pastures for their livestock. These are rural and agriculturally dependent households, as well as poorer households. It is observed that most males immigrate to other places, unlike females and youth. Various groups have produced different coping strategies as they feel climate-induced migration is their last resort after trying. The common strategies they adopted are categorised under financial assistance, adoption of new technology, minimal government assistance programs and use of extension services.

Climate-induced migration, just like any other migration, has social and economic consequences such as increased unemployment in cities and increased pressure on facilities such as housing and health care; thus, the scrabble for limited resources continues. Social aspects include changes in eating patterns. In addition, climate-induced migration has also been seen as an issue that impacts the health of the migrants. For an example, mental health problems have been experienced due to forced migration and is commonly unidentified and untreated. Moreover, for women and girls, sexual and reproductive health severely deteriorated in insecure environments. There has also been an increase in female or child-headed families as males migrate to other areas. This then becomes a gender issue.

Recommendations

Fewer information researchers are writing about the subject matter in the central African and North African countries, which makes it challenging to give a conclusion about Africa if there is less information from the other regions. More information is needed on how African governments are helping the affected communities to prevent them from migrating or to facilitate a smooth migration. This could either be due to a lack of research on the topic or that there is not much being done by African governments; thus, this research recommends a further study on the role played by African governments in assisting. Finally, due to the conclusion that the most vulnerable group is affected by climate-induced migration, research on the impact of climate-induced migration on women can be recommended, as well as the coping strategies they have adopted.

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CRediT authorship contribution statement

Thandoluhle Kwanhi: Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Florah Sewela Modiba:** Writing – original draft, Visualization, Project administration, Methodology. **Stephen Mago:** Writing – original draft, Supervision, Resources, Project administration, Methodology. **Shadreck Matindike:** Writing – review & editing. **David Damiyano:** Writing – review & editing.

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During the preparation of this work the authors used ‘Grammarly’ tool for editing purposes. After using this tool/service, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix

Table 3
Data Table

Region	Conceptualizing climate mobility	Patterns and trends climate-induced migration	Key drivers of climate-induced migration	Vulnerable communities	Coping strategies and mitigation	Reference	Journal
Northern Africa							
Mauritania	Climate adaptation method	European countries Other areas in the country	Drought Low rainfall	Men Women and children	Migrant social networks, agricultural co-operatives for women's irrigation.	Scheffran et al. (2012)	*Applied Geography*
Eastern Africa							
Tanzania	Environmental shocks	Rural-urban migration	Livestock losses and crop damage.	Rural dwellers, agricultural dependent households, poor households.	Savings, help from relatives or friends, engagement in spiritual efforts, changes in eating patterns.	Blocher et al. (2024)	*Population and Environment*
Ethiopia, Malawi, Tanzania, And Uganda	Climate adaptation strategy	Urban-rural Rural-urban	Extreme temperature and rainfall shocks	Urban and rural dwellers	Not listed.	Mueller et al. (2020)	*World Development*
Tanzania	Adaptation mechanism		Livestock epidemics and deaths.	Pastorates	Adoption of science and innovation.		
Uganda	Livelihood strategy	Cities Other wetlands	Rising temperatures, drought, rainstorms, flooding and landslides.	Agro pastoralism (both men and women), Rural women, youth and children	Sharing of labour and income across households, borrowing funds from family or neighbours, community assistance in with food and shelter, and labour. Prayer and community fundraising	Twinomuhangi et al. (2023)	*Local Environment*
Senegal	Adaptive strategy	Not listed.	Desertification, water scarcity, drought, coastal erosion, sea-level rise, flooding, soil salinisation and storm surges.	Fishermen	Not listed	Zickgraf (2022)	*Journal of ethnic and migration studies*
Mali, Mauritania Senegal,	Climate adaptation method	Not listed.	Not listed	Not listed	Remittances and other resources.	Scheffran et al. (2012)	*Applied Geography*
Tanzania Kenya, Uganda.	Adaptive strategy	Not listed.	Frequent drought and flood disasters, livestock pests and crop disease, and rising sea levels.	Pastoralists	Temporary labour migration	Chetto et al. (2024)	*Environmental Science & Sustainable Development*
Ethiopia Tanzania	Livelihood strategy	Not listed.	Not listed.	Poor people, males	Irrigation and social protection	Silchenko and Murray (2023)	*Climate Risk Management*
Sudan		-Southern Part of Sudan to Northern Part of Sudan	Decrease in annual rainfall, delays of seasonal rains, increase in dry spells.	Adult men, agriculturalists	Travel south with their animals into the richer and more spacious Southern	Trummer et al. (2023)	*Journal of Migration and Health*

(*continued on next page*)

Table 3 (*continued*)

Region	Conceptualizing climate mobility	Patterns and trends climate-induced migration	Key drivers of climate-induced migration	Vulnerable communities	Coping strategies and mitigation	Reference	Journal
					farmlands and migrate back north with the onset of the rains.		
Kenya Ethiopia	Positive adaptation strategy	Cities and urban areas in foreign countries. Rural neighbouring countries.	Rising temperatures and extreme weather	Struggling farmers, pastoralists, Agro pastoralists.	National policies, supporting humanitarian action, migration schemes and supporting adaptation plans.	(Leal-Arcas, 2012)	*Environmental Science and Policy*
Southern Africa							
Zambia Malawi	Livelihood strategy	None	None	Poor people and males	Irrigation and social protection	Silchenko and Murray (2023)	*Climate Risk Management*
South Africa	None	None	Drought, hot temperatures and strong winds	Pastoralists	Livelihoods diversification, education, capacity building, healthier lifestyle, increased climate awareness, rangeland restoration.	(Samuel and Sylvia, 2019)	*Journal of Arid Environments*
Malawi	Climate adaptation strategy.	Urban-rural Rural-urban	Extreme temperature and rainfall shocks.	Not listed	Not listed	Mueller et al. (2020)	*Environment and Development economics*
Zimbabwe	Displacement and adaptive migration to safer areas.	Peri-urban areas to refugee camps.	Cyclone Idai-heavy rainfall.	Women and children.	Government and NGO migration programme.	Trummer et al. (2023)	*Journal of Migration and Health*
Western Africa	None	Not listed	Concurrent heat waves and droughts or droughts followed by extreme rainfall.	No listed	None	Birkmann et al. (2022)	*Science of the Total Environment*
Côte D'ivoire, Ghana, Nigeria, Senegal, The Gambia.	Migrant as an agent of adaptation.	Migration to cities and other coastal areas	Drier, more drought-prone and arid climate, floods, drought, erosion, rising temperatures and sea level rise.	Increase in female-headed families as adult males migrate	None	(Osei-Amponsah et al., 2023)	*Frontiers in sociology*
Ghana	Adaptive livelihood strategy.	Upper East and Upper West Regions of Ghana migrate to Southern Parts of Ghana.	Destruction of their land, homes and livelihoods	People in rural areas, rural farmers and livestock keepers.	State planned migration.	(Addaney et al., 2022)	*Chinese Journal of Population, Resources and Environment*
Ghana	Declining agricultural production.	Cities and other communities.	high temperatures, floods, heavy rains and lengthy droughts	Rural farmers, youth males and female maize farmers.	NGOs, microloans to support farm businesses. Access to extension services and training on CSA.	Azumah and Ahmed (2023)	*Environmental Development*
Nigeria	None.	Intra-city relocation	Flood	People in coastal areas	Government-supported relocation, staying indoors until flood waters subside, "temporary bridges" and drainage constructions.	Ekoh et al. (2023)	Global Environmental Change

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