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Climate-induced migration in the Global South: an in depth analysis



Abdulaziz I. Almulhim¹✉, Gabriela Nagle Alverio², Ayyoob Sharifi³, Rajib Shaw⁴, Saleemul Huq⁵, Md Juel Mahmud⁵, Shakil Ahmad⁶ & Ismaila Rimi Abubakar⁷

Scientists predict ongoing global climate change to trigger adverse events affecting about 143 million people in the Global South by 2050, leading to various forms of migration and mobility. While existing literature extensively examines climate-induced migration, there is a lack of studies considering the compounding impacts of multiple climate hazards on migration, mobility, and immobility. To address this gap, we conducted a systematic literature review to explore how climate-induced stressors, specifically rising temperatures, water stress and droughts, and floods and sea-level rise, have affected populations in the Global South, leading to voluntary and/or forced migration. Our findings show that these stressors have displaced and profoundly impacted millions of people, resulting in both internal and transboundary migration. Climate-induced stressors often trigger migration through indirect pathways influenced by multiple intervening institutional, political, and socio-economic factors and programmatic and policy gaps. Effectively addressing challenges related to climate-induced migration necessitates adaptation strategies that adequately consider the impacts of these intervening factors while recognizing their differential effects on various socio-demographic groups. We argue that support from Global North countries, including compensation for loss and damage, along with continued institutional and financial support from international non-governmental organizations, is crucial for managing climate-induced migration in the Global South. Without proper planning and adequate resources, migration may escalate and significantly impact human security. The findings of this study can inform climate migration policies and assist adaptation and migration experts in identifying intervention mechanisms and opportunities for people-centered climate solutions.

Climate change poses significant threats to human well-being, security, and livelihoods. According to the World Meteorological Organization¹, global temperatures have risen since the 1980s, with the period from 2015–2023 identified as the warmest on record. Prior to 2023, the highest global temperature recorded occurred in 2016 due to an exceptionally strong El Niño event². However, in 2023, this record was surpassed, with the global average temperature reaching 17.18 degrees Celsius³. Alongside rising temperatures, climate change is also causing an increase in extreme and adverse weather

events such as sea-level rise, floods, hurricanes, heatwaves, and droughts, which are becoming more frequent and widespread^{4,5}.

As a result of these increasing threats, there is a noticeable shift in patterns of human mobility, and it is predicted that the number of affected individuals will grow exponentially in the coming decades⁶. In the year 2020 alone, over 40.5 million people were forced to relocate, with 30.7 million of them being directly impacted by natural hazards⁷. Floods and storms were responsible for the displacement of 14 million individuals each, with Asia

¹Department of Urban and Regional Planning, College of Architecture and Planning, Imam Abdulrahman Bin Faisal University, P.O. Box 1982 Dammam 31451, Saudi Arabia. ²Sanford School of Public Policy, Nicholas School of the Environment, School of Law, Duke University, Durham, NC, USA. ³The IDEC Institute & Network for Education and Research on Peace and Sustainability (NERPS), Hiroshima University, 1-5-1, Higashi-Hiroshima 739-8529, Japan. ⁴Graduate School of Media and Governance, Keio University, Keio, Japan. ⁵International Centre for Climate Change and Development (ICCCAD), Independent University, (IUB), Dhaka, Bangladesh. ⁶Directorate of Library Affairs, Imam Abdulrahman Bin Faisal University, P.O. Box 1982 Dammam 31451, Saudi Arabia. ⁷College of Architecture and Planning, Imam Abdulrahman Bin Faisal University, P.O. Box 1982 Dammam 31441, Saudi Arabia. ✉e-mail: aialmulhim@iau.edu.sa

and the Pacific being severely affected regions, experiencing substantial human displacement and damage to buildings and infrastructure⁸.

Sustainable development goal (SDG) 10, which focuses on reducing inequalities within and among countries, emphasizes the importance of safe, orderly, and accountable mobility and migration (Target 7). However, climate-related extreme weather events, such as water scarcity and food shortages, hinder the achievement of this goal⁹. By 2050, it is projected that about 143 million individuals in the Global South will be displaced due to climate change impacts¹⁰. To address this SDG target, it is crucial to critically assess the consequences of climate change on migration, particularly in vulnerable regions like Africa, Latin America and the Caribbean (LAC), Southeast Asia, and the wider Pacific region^{11–13}.

While a few studies have explored the relationship between migration and climate change in the Global South, there is a dearth of comprehensive synthesis studies that systematically review the current state of knowledge about the connection between major climate hazards and migration outcomes in the region. Hence, the primary aim of this study is to examine the influence of increasing temperatures, water stress and drought, floods, and sea-level rise—tripartite environmental factors driven by climate change—on migration patterns in the Global South. Through a systematic review, the study aims to answer the following questions: Which climate-induced hazards and stressors have been extensively studied in the literature on the Global South? How do these hazards and stressors affect migration in Global South countries? What are the mediating factors that either impede or promote climate change-induced migration?

This study makes a significant contribution by synthesizing the findings of a comprehensive review of the intricate and multi-faceted interactions between climate change stressors and migration in the Global South. By providing policymakers and planners with valuable insights, this study aids in formulating targeted interventions and strategies to address the specific needs and vulnerabilities of different regions affected by climate-induced migration. The subsequent section of the paper includes a literature background on the nexus between climate and migration, as well as climate impacts in different regions of the Global South. The next section describes the materials and methods employed for systematically gathering and analyzing the literature. It is followed by the presentation of the findings. The subsequent section discusses the results in the context of the existing body of knowledge and explores their implications. The paper concludes with key lessons, limitations, and suggestions for future research directions.

Literature background and context

The climate and migration nexus

There is a lack of consensus regarding the terminology for individuals who migrate due to climate or environmental factors, as climate change interacts with other drivers of migration in complex ways^{14,15}. Climate change impacts, such as water scarcity, soil infertility, soil erosion, land degradation, and floods, often combine with other socioeconomic factors like poverty and inequality to drive migration^{16,17}. Additionally, determining the role of the environment and climate change in migration decisions is challenging^{18–20}. To address these challenges, the term, “environmental migrants” was introduced to highlight the relationship between the environment and migration. Environmental migrants are individuals who “*for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad*”²¹ (p. 3–4). However, the discourse has evolved, and the term “climate migrant” is now commonly used to emphasize how climate change exacerbates environmental issues and the associated migration^{22,23}. Thus, it is important to note that discussions on climate migration encompass both migration/displacement and immobility, both voluntary and involuntary²⁴.

Migration can be seen as a crucial coping strategy for individuals and households, allowing them to adapt and navigate changes in resource

availability across different environments²⁵, particularly to minimize their susceptibility to environmental shocks²⁶. In some cases, moving from vulnerable climate hotspots is not merely an ‘adaptation strategy’ but an essential survival mechanism in the face of ‘adaptation failure’²⁷. The decision to migrate due to climate change is influenced by changing environmental conditions, migrants’ characteristics, and other migration drivers such as economic, political, social, demographic, individual, and household factors^{28–30}.

There is substantial evidence indicating that the environmental impacts of climate change will lead to large-scale human mobility and displacement in the future. Estimates suggest that between 50 million³¹ and 250 million³² people could be affected by 2050, rising to 630 million by 2100²⁰. The World Bank projects that by 2050, 216 million across different regions, including North Africa (19 million), Sub-Saharan Africa (86 million), South Asia (40 million), LAC (17 million), Eastern Europe and Central Asia (5 million), and East Asia and the Pacific (49 million), will be impacted by climate change³³.

While there are limitations in modeling the flow of climate migrants and incorporating tipping points and emerging stressors that influence migration decisions³⁴, most climate migration models agree that climate-driven migration will increase in the coming decades²⁴. Migration can occur voluntarily or involuntarily to escape imminent risks. While internal migration within a country (mainly to urban areas) is more common³⁵, international migration is also increasing, especially in regions where climate change coincides with violent conflicts, such as Africa and the Middle East and North Africa (MENA)³⁶.

Global South context

Many countries in the Global South are grappling with rapid population growth, which strains the environment and diverts resources, posing challenges to local and regional sustainability^{37,38}. When combined with climate change impacts, these challenges contribute to increased migration. In response, international agreements like the UN Global Compact for Migration and the Global Compact on Refugees aim to ensure the orderly movement of refugees³⁹. It is crucial to consider migration as an integral part of environmental systems and incorporate discussions on the correlation between climate change mechanisms and patterns of human mobility^{30,32}. Climate change affects various aspects of human life, including livelihoods, public health, land use, infrastructure, water, and air quality, and socio-cultural activities^{40,41}.

Given that many Global South countries heavily rely on agriculture and natural resources, rising temperatures, floods, and water scarcity are placing strain on livelihoods and driving rural-to-urban migration²². This predominant form of climate migration contributes to urban sustainability challenges, including unplanned urbanization and the development of informal settlements in peri-urban areas⁴². In these settlements, residents typically engage in small-scale entrepreneurship, self-employment, casual work, and petty trading, constituting an informal economy¹². Unfortunately, these settlements often lack basic infrastructure and are poorly constructed, making them highly vulnerable to climate change-related hazards like floods and storm surges⁴². Water pollution and inadequate sanitation further pose health risks for residents in these areas⁴³. In cities where risks and dangers persist, people may be compelled to cross borders, further complicating, and expanding the dynamics of climate-related migration⁴⁴.

Climate impacts in the Global South by region

In 2022, global greenhouse gas (GHG) emissions reached a record high of approximately 36.6 Gt⁴⁵. The top contributors to these emissions were China, the United States, and the European Union, accounting for 19.3 Gt, which is about 53% of the global total (China: 11.4 Gt, USA: 5.1 Gt, EU: 2.8 Gt). In contrast, LAC accounted for only about 7% of total GHG emissions⁴⁶. Even though Africa produces the least GHG emissions, it faces the most severe consequences of climate change⁴⁷. On the other hand, Southeast Asia experienced the highest increase in GHG emissions between

1990 and 2010 compared to any other region in the world⁴⁸. Despite the relatively low contributions of most Global South countries to GHG emissions, they are more vulnerable to climate change impacts, including sea-level rise, floods, and rising temperatures⁴⁹. Moreover, these countries generally have lower adaptive capacities compared to their counterparts in the Global North.

Climate impacts in South Asia

South Asia is highly vulnerable to extreme weather events, including river flooding, sea-level rise, and extreme temperatures, which exacerbate both internal and cross-border migration^{50,51}. These impacts pose significant threats to food supplies, livestock, land, and crops, resulting in severe food crises that can trigger migration⁵². In India, farms are being destroyed annually by severe heatwaves and snowstorms caused by climate change^{53,54}. Likewise, torrential floods are displacing thousands and causing widespread property damage in Pakistan^{55,56}. In 2022, the world's deadliest flood in Pakistan affected 33 million people, with 2.1 million losing their homes⁵⁷. Similarly, the Haor areas of Bangladesh were severely impacted by flash floods, affecting approximately 4.2 million people^{58,59}.

The region's increasing urbanization and economic growth further contribute to migration, placing additional strain on urban sustainability by exacerbating congestion and diverting already scarce resources to support migrants⁶⁰. By 2040, the demand for energy in South Asia is projected to increase by 66%⁶¹. However, since most urban areas in South Asia are in low-lying coastal areas already affected by sea-level rise due to climate change, meeting the energy needs of these areas becomes increasingly challenging⁶⁰. Consequently, South Asian economies, including India, Sri Lanka, Bangladesh, and the Maldives, could experience a 1.8% reduction in their gross

domestic product by 2050, which could rise to 8.8% by 2100⁶². Among these countries, Nepal (2.2%), Bangladesh (2%), and India (1.8%) would be the most affected. Consequently, nearly 800 million people may experience deteriorating living conditions, potentially leading to large-scale migration¹⁴.

Climate impacts in the MENA region

In the MENA region, climate change has already led to water scarcity, desertification, sea-level rise, and loss of biodiversity, resulting in soil degradation, food insecurity, and salt intrusion into aquifers, which have triggered the displacement of people⁶³. The Gulf Cooperation Council region currently hosts around 30 million cross-country migrants who have primarily moved due to economic hardships and work opportunities in the energy and infrastructure sectors⁶⁴. However, as climate change intensifies due to the increasing use of fossil fuels, it is anticipated that migration into the oil-rich Gulf region will increase. It is important to note that projections indicate the region could become nearly uninhabitable by 2050 due to the severe impacts of rising temperatures⁶⁵. Saudi desert areas, for instance, are expected to face the most severe effects of global warming, including prolonged heatwaves lasting for months⁶⁶. Moreover, temperatures in the Middle East are projected to rise to 50 °C by 2100, posing significant health and livelihood challenges and putting 400 million individuals at risk of heatwave exposure⁶⁵. These compounding challenges are likely to lead to political and social strains.

Climate impacts in Sub-Saharan Africa

In Sub-Saharan Africa, densely populated coastal cities in countries like Nigeria, Tanzania, and Mozambique are witnessing seasonal sea level rises, resulting in floods that affect many people^{32,67}. In West Africa, countries such as Burkina Faso, Niger, Gambia, Mali, Sudan, and Senegal are experiencing droughts caused by rising temperatures⁶⁸. Severe droughts in Madagascar have also forced many people to leave their homes in search of more habitable lands^{69,70}. Despite contributing the least to GHG emissions, Africa remains the most climate-vulnerable region globally⁶⁸. This vulnerability is particularly heightened because a significant portion of the population relies on rainfed agricultural systems for their livelihoods⁵. As these agricultural systems become increasingly unsustainable, people will be compelled to migrate⁷¹. Models predict that by 2050, between 28.3 and 71.1 million people will be forced to migrate within the continent (Table 1 and Fig. 1). Many of these migrants will gravitate towards urban informal settlements, where the associated safety and health risks are growing¹². While the link between climate change and conflict is complex, the potential for resource competition to escalate into violence and conflict is high in Africa⁷².

Table 1 | Projected numbers and shares of internal climate migrants (in millions) by 2050 for the Global South

Region	Pessimistic reference	More inclusive development	More climate-friendly
Southern Africa	71.1	53.3	28.3
South Asia and the Pacific	35.7	21.1	16.9
Latin America and the Caribbean	10.6	10.5	5.8

Note: The scenarios are based on combinations of Shared Socioeconomic Pathways (SSP2—moderate development; SSP4—unequal development) and Representative Concentration Pathways (RCP 2.6—low emissions; RCP 8.5—high emissions) that drive climate impacts on crop productivity and water availability as well as sea level rise and storm surge. Source: (World Bank, 2018).

Fig. 1 | Climate Migrants in the Global South by 2050. Note: According to the World Bank Groundswell Report, around 143 million people will be displaced by 2050: 86 million from Sub-Saharan Africa, 40 million from South Asia and the Pacific, and 17 million from LAC.

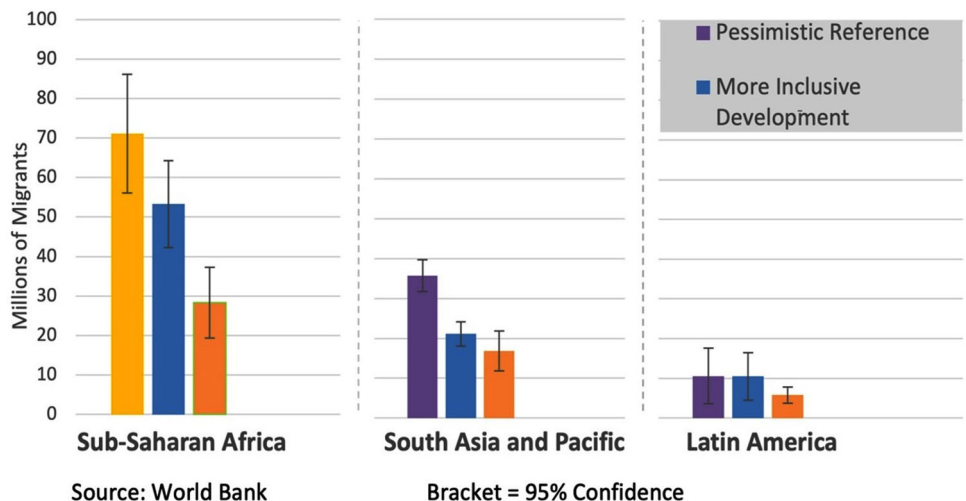


Table 2 | Reported environmental hazards per region in the Global South in 2021^a

Environmental hazard	Region	Number of occurrences	Total
Increasing temperatures	Africa	21	96
	Latin America & the Caribbean	33	
	Southeast Asia & the Pacific	42	
Drought	Africa	8	45
	Latin America & the Caribbean	12	
	Southeast Asia & the Pacific	25	
Water stress	Africa	15	68
	Latin America & the Caribbean	17	
	Southeast Asia & the Pacific	36	
Floods	Africa	8	97
	Latin America & the Caribbean	35	
	Southeast Asia & the Pacific	54	
Sea-level rise	Africa	12	126
	Latin America & the Caribbean	43	
	Southeast Asia & the Pacific	71	

^aSource: Centre for Research on the Epidemiology of Disasters (CREED, 2022). 2021 Disasters in Numbers. https://cred.be/sites/default/files/2021_EMDAT_report.pdf (Accessed: 25 April 2023).

Furthermore, water scarcity can exacerbate ongoing conflicts and increase the vulnerability of people displaced by conflict in the region⁷³.

Climate impacts on the Pacific Islands

The Pacific Island region is often considered the frontline of climate change due to the severity of its predicted impacts⁷⁴. Despite being referred to as “small” island nations, the Pacific Islands, spanning 25,000 islands, encompass approximately fifteen percent of the Earth’s surface⁷⁵. This region faces compounding challenges from rising sea levels, coastal flooding, erosion, and water scarcity⁷⁶. In Kiribati, for example, 94% of households reported being affected by natural hazards in the past decade⁷⁷. While migration from many Pacific Islands is inevitable in the event of complete inundation due to sea level rise, there are people living in the region who are unable to migrate due to financial constraints, raising concerns about those who may be trapped in unsafe situations⁷⁸. Pacific Island leaders have advocated for international agreements that promote safe migration for those affected by climate change, emphasizing the importance of “Migration with Dignity”⁷⁹. Planned relocation is often discussed as a potential solution to the loss of habitable land in the Pacific Islands. However, vulnerable populations are likely to face compounded risks rather than alleviation through such processes⁸⁰. While international migration schemes may offer a safer future for Pacific Islanders, the spiritual connection and sense of place they will lose by leaving their land cannot be regained⁸¹.

Climate impacts in Latin America and the Caribbean

Latin American and the Caribbean states are highly vulnerable to climate impacts, including mega-droughts, heatwaves, melting glaciers, and torrential rains and floods^{13,82}. Glaciers in the Andes region have lost between thirty and fifty percent of their area in just forty years, leading to water scarcity⁸³. Approximately 27% of the population in the region lives along coastlines, where sea levels rise faster than the global average⁸³. Continued deforestation of the Amazon rainforest threatens local and global climate adaptation and mitigation efforts⁸⁴. Prolonged droughts have resulted in severe food insecurity and migration in several countries, such as Mexico, Ecuador, Guatemala, El Salvador, Honduras, and Nicaragua^{85,86}. Models predict that between 5.8 and 10.6 million people will be internally displaced within the region by 2050 (Table 1 and Fig. 1). Already, documented cases of out-migration from Central America to the USA due to escalating agricultural stress indicate that regional migration patterns are likely to intensify further as the impacts of climate change worsen⁸⁷.

Impacts of climate-induced stressors on migration in the Global South

The results of the systematic review are presented in the following three subsections, which synthesize the findings on the impacts of increasing temperatures, water stress and droughts, as well as floods and sea level rise, on migration.

Increasing temperatures

Increasing temperatures, which feature 96 times in the Global South in 2021 (Table 2), are positively associated with migration. For example, a 1 °C temperature increase leads to a 1.9% increase in global migration¹⁰. Over the past 15 years, the Caribbean and Latin America have experienced average temperature increases ranging from 0.5 to 1 °C, resulting in glacial melting in the tropical region of the Andes Mountains⁸⁸. The combination of elevated temperatures and increased floods has significantly impacted many cities in the Global South due to global warming⁹. Mountainous countries, such as Bolivia, Peru, Ecuador, and Colombia, face significant challenges as their drinking water, agricultural production, and hydroelectric power depend on glaciers^{88,89}. It is projected that further temperature increases between 1°C and 6°C will exacerbate these issues, leading to increased transboundary migration⁹⁰.

In the Sahel region of Africa, rising temperatures caused by climate change have resulted in the shrinking of Lake Chad over the past five decades, compelling people in Nigeria, Niger, Chad, and Cameroon who rely on its water to move to urban areas⁹¹. In Southeast Asia, migration due to increasing temperatures is mainly observed in Vietnam, Myanmar, Thailand, and the Philippines^{51,92}. The decision to migrate to these areas is influenced by factors such as social cohesion, government support to communities, level of economic development, migration barriers, and political stability⁹³. The Arabian Gulf experiences continuous temperature increases at a faster rate than the global average, negatively impacting health, labor, and agricultural production⁹⁴. Consequently, people migrate to nearby urban areas in search of livelihood opportunities⁹⁵.

Water stress and drought

Water stress occurs when the demand for water exceeds the available quantity within a given period or when its poor quality restricts its use⁷³. Historically, water has played a crucial role in determining the location of human settlements. In the contemporary world, as climate change continues to accelerate, global water crises are increasing⁹⁶, with 103 water

scarcity and drought events occurring in the Global South in 2021 (Table 2). Consequently, migration from affected regions, particularly the Global South, is becoming more frequent⁹⁷. Landlocked countries and those located in arid and semi-arid lands are the most impacted by water stress. For example, Mongolia, Tajikistan, Uzbekistan, Kazakhstan, and Kyrgyzstan are situated within the Gobi Desert zone; Zambia, Zimbabwe, and parts of Botswana are affected by the Kalahari Desert; Mali, Niger, Chad, and Burkina Faso are located within the Sahel region; and Chile and Peru are in proximity to the Atacama Desert. These countries experience internal and external migrations due to water stress⁹⁸. However, most of these migrations are internal, as people move to more habitable areas within their countries due to restrictions on external migration in some destination countries⁸⁹.

Migration driven by water stress tends to occur more gradually in rural areas than in urban areas¹⁸. Additionally, such migrations are a result of insufficient resources to cope with reduced agricultural productivity, income, and subsistence capacity^{44,99}. Some researchers agree that migration resulting from water scarcity, although often over short distances, can lead to conflicts⁷³. In high-risk areas such as coastal regions prone to sea-level rise, large populations in Asia face water scarcity and other challenges during disasters, prompting migration³⁸. Moreover, in South Asia, migration is driven by growing social and economic disparities fueled by climate change in water-stress areas^{50,60}.

An emblematic example of the impact of climate change on water stress and migration can be seen in the semi-arid regions of northeastern Brazil, where subsistence farmers rely mainly on agriculture¹⁰⁰. As water scarcity intensifies, resulting in nearly an 80% loss in agricultural production, many people migrate to the south, where more favorable conditions exist⁷⁵. Similarly, in Potosi, Bolivia, households with farmlands over 3,500 m² resort to seasonal migration, while those with between 1,650 and 3,000 m² tend to move permanently when faced with water stress challenges³⁰. Many people from Guatemala, El Salvador, and Honduras, who have been affected by changes in precipitation due to climate change, have moved to the United States in search of employment and other opportunities¹³. The Tonga people of Southern Zambia and the Maasai people of Kenya also engage in annual migration due to water stress, seeking water and pasture for their livestock¹⁰.

Similarly, drought is common in most African nations, especially those within North Africa and the Sahel regions, affecting about one-third of the African population and leaving them with limited food and water for their families and livestock^{71,101}. For example, drought and insufficient rainfall in Western Sahara, Ghana, Senegal, and Burkina Faso have forced people to frequently migrate to urban areas⁶⁹. Additionally, sociodemographic dynamics, such as gender, sex, age, migration status, and household size, also influence migration decisions¹⁰². In Asia, for example, heads of households are more likely to move than other household members to provide for their families¹⁰³. Families in the Bolivian and Ecuadorian Andes, who are primarily unemployed and heavily dependent on agriculture, have been severely affected by drought, compelling them to move to other rural areas or neighboring cities⁸⁶.

Moreover, a 10% reduction in agricultural production due to droughts has resulted in a 2% growth in migration from LAC to the USA⁶⁷. Furthermore, recent droughts in the Middle East have further strained already scarce water resources, leading to low wheat production, which sustains most families in the region, and triggering migration to cities⁹⁴. Recurrent droughts caused by climate change also impact South Asia, posing threats to people's livelihoods and forcing them to decide whether to migrate as a family or adapt to changing environmental conditions⁹³.

Floods and sea-level rise

Floods and sea-level rise occurred 97 and 126 times, respectively, in the Global South in 2021 (Table 2). These events are primarily associated with increased precipitation and the melting of mountains and polar glaciers, including those in the Andes of South America¹⁰⁴, Papua in New Guinea, and Puncak Jaya in Indonesia¹⁰⁵, Africa's Kilimanjaro, Kenya, and Ruwenzori Mountains¹⁰⁶, and Himalayan Nepal, India, Bhutan, China, Afghanistan, and Pakistan¹⁰⁷. Flooding is a major consequence of climate

change, forcing people to flee flood-prone areas to avoid loss of life and property damage³⁸.

In Africa, Lagos and Accra are prone to recurrent flooding during heavy rains¹⁰⁸. Likewise, Nairobi is also susceptible to flooding in the rainy season, often leaving many people homeless, especially in vulnerable slum areas where water-borne diseases and malaria are prevalent¹⁰⁹. In South Asia, floods caused by climate change expose people to diseases like dengue fever, malaria, and cholera. These disasters are a result of climate change and inadequate urban planning, which lead to flooding after prolonged downpours¹⁰³. Those affected are often forced to endure recurrent floods as they lack alternative places to go, other than returning to their rural homes that lack jobs and basic infrastructure¹⁰⁸. In Saudi Arabia, for instance, floods in the past decade, particularly in Jeddah coastal city, caused by storm surges, have resulted in casualties, property damage, and significant displacements¹¹⁰. Torrential rains affecting cities in India, Pakistan, Nepal, and Bangladesh lead to flooding, affecting over 46 million individuals annually⁶⁰. Displacement is a common outcome in these countries, although many people have developed resilience due to the short-term nature of these floods¹⁰.

Rising sea levels, like floods, are a significant driver of migration for coastal populations. It is estimated that coastal risks will increase over the 21st century due to rising sea levels, disrupting people's lives, cultural and natural heritage, livelihoods, ecosystems, food security, and infrastructure^{57,60}. Even if global warming were to cease, these risks would escalate, compounded by extreme sea-level rise¹¹¹. Coastal wetlands are also at high risk of sea-level rise, resulting in significant losses before 2100⁹. However, in the case of rising sea levels, planned migration over a more extended period becomes possible⁹⁰.

Worldwide, about 450 million individuals are living at low elevations (below 20 m) and near coastlines (within 20 km)⁸⁰. Regions most vulnerable to the adverse consequences of sea-level rise include LAC, with a significant portion of the land being used for agriculture⁹⁹. A 1-meter rise in sea level would affect 5–7% of the populations in the Bahamas, Guyana, and Suriname¹¹². The Ganges-Brahmaputra-Meghna delta in Bangladesh is also one of the most affected areas, leading to great displacements of people¹¹³. In areas where agricultural lands have been submerged, people have been forced to relocate due to food scarcity, salinization, and reduced soil fertility^{10,52}. It is expected that by the end of this century, sea levels will rise by between 30 and 150 cm in the Southern Hemisphere, resulting in the submergence of most of the Maldives, as well as cities like Bangkok and Ho Chi Minh¹¹⁴.

Implications and recommendations

The results of this study detailed the tripartite environmental factors predisposing individuals in the Global South to migrate: increasing temperatures, water stress and draught, and floods and sea-level rise. The reviewed literature primarily focused on internal migration^{13,89,115}, given the complexity involved in assessing and predicting transboundary migration dynamics. The results demonstrated the dire impacts of climate change on the environment that require immediate addressing¹¹⁶. Despite having relatively lower contributions to global GHG emissions compared to Global North countries, the Global South experiences some of the most severe consequences of regional and global climatic changes^{41,83}.

Another study found that extreme temperatures significantly impact both internal and external migration and their patterns⁴, which aligns with prior research findings¹⁶. In the Philippines, for example, temperature rise increases outmigration rates⁹². Similarly, in Uganda, the expected temperature at the origin affects migration flows¹¹⁷, and higher temperatures lead to high migration rates in China¹¹⁰, Zambia⁷⁰, and the Arab world^{63,65}.

Water stress and drought are also significant push factors behind migration^{17,111}, corroborating previous studies. Basu and Shaw⁵⁴ reported a significant link between water scarcity and human migration in India. In Zambia, migration is influenced by water stress and food insecurity⁷⁰. Among riparian households in Bangladesh, drought, and saltwater intrusion influence decisions to migrate to the mainland or cities⁴¹. Water stress

also shapes climate-induced migration in Iran¹⁸, Kenya, Ethiopia¹⁰⁹, Israel, Jordan, and Syria⁹⁴, as well as several African countries^{102,118}.

Lastly, floods and rising sea levels increase the likelihood of internal migration due to displacements, loss of homes, and livelihoods^{4,97,111,112,119}, providing support to the existing literature. In Ghana, for instance, floods trigger migration due to disruptions in livelihoods and mobility, damage to housing, and lack of access to markets and services¹⁰⁸. Similar findings that floods do increase the likelihood and frequency of migration have also been reported in Nigeria¹¹⁵, Uganda¹¹⁷, Tanzania²³, Mali¹¹⁶, South Africa⁷², India^{54,103,113}, Indonesia¹⁰⁵, Vietnam¹²⁰, Thailand¹²¹, Bangladesh^{41,59}, Nepal, and Pakistan^{57,93}.

Adaptive measures to combat climate change as a major trigger of migration have been developed in various contexts. However, their comprehensive implementation in the Global South is hindered by socioeconomic factors¹¹⁴. For example, in regions where farmers rely on agriculture, the high cost of implementing relevant adaptation strategies is prohibitive due to the low socioeconomic status and income of the population⁸⁵. Migration becomes a personal adaptation strategy when adapting in place is no longer an option¹¹⁹. It is predicted that by 2050, migration as an adaptation to climate change will be implemented by 200 million people, either voluntarily or forcibly¹²². However, due to the expenses and resource requirements of migration, individuals and families with limited means may be unable to relocate, forcing them to face the challenges of climate change involuntarily¹²³. Some individuals will choose to face these challenges due to their cultural ties to the land and community¹²⁴, while others may seek opportunities in nearby cities as an alternative for livelihood generation^{90,111}. The lack of adaptive strategies, especially among individuals of low socioeconomic status, makes them particularly vulnerable to the impacts of climate change due to a lack of assets, knowledge, and networks¹²⁵. Therefore, as the risks of climate change intensify, there is a growing need to provide support for households that have made the decision to migrate, as well as to implement adaptation strategies for those who are unable or choose not to relocate¹³.

One intervention that governments can employ to assist communities in coping with climate migration is the relocation of affected people to better and more habitable locations^{41,44}. People living in areas affected by droughts, limited water resources, or frequent floods in low-lying areas should be relocated to areas with sufficient water or minimal flood risk¹²⁶. However, relocation requires resources and should be adequately planned with input from affected populations to avoid unanticipated challenges^{125,127}. Previous relocations have failed due to loss of livelihood, cultural heritage, and social networks, often resulting in abject poverty for the relocated people¹²³. Governments must strive to provide sources of livelihood for the relocated communities, although many developing countries struggle to implement such actions due to limited resources¹²².

Various initiatives have been launched to address international migration caused by climate change, such as the Task Force on Displacement, the Global Compact for Migration, the UN Network on Migration, the Kampala Convention, and the Cancun Adaptation Framework. While their direct focus on climate change varies, each has contributed to highlighting climate change as a fundamental driver of migration that must be promptly addressed¹²⁸. For instance, under the Nationally Determined Contributions (NDCs) of the Paris Agreement, mobility has been conceptualized as a strategy for adaptation. Most recently, the Nansen Initiative, which evolved into the Platform for Disaster Displacement, has specifically aimed to address the needs of cross-border migrants displaced by natural disasters¹²⁹. These initiatives encourage countries to commit to addressing the adverse effects of climate change on migrants and establish measures to acknowledge migration due to climate change, plan relocations, and promote collaboration to mitigate associated challenges^{120,130}.

Moreover, various approaches have been developed to help countries manage the challenges of climate migration¹³¹. For example, the International Organization for Migration maintains a twofold approach

that requires nations to appraise their climate change policies to distinguish between migration and climate migration policies effectively. It also involves reviewing existing tools for managing migration to understand how they can be restructured, and developing new tools to respond adequately to climate change-induced migration. Researchers have also advocated for social protection measures to manage climate migration, supporting people who choose to stay in their communities to maintain their livelihoods, and addressing the drivers of migration that force people to engage in maladaptive migration¹³². However, until recently, there has been limited cooperation between countries in the Global South concerning fostering safe migration or safeguarding the rights of climate migrants in receiving areas²⁵.

Therefore, it is essential to identify localities at risk of depopulation to effectively coordinate migration and relocation. Potential relocation areas for displaced individuals must be extensively assessed to ensure they can sustain increased populations without further hardships. Countries must share the responsibility of planning, identifying suitable relocation areas, and providing support to relocated individuals in host societies¹¹⁸. Additionally, collaboration between origin and destination countries is crucial for planning future climate change-induced migration in a way that benefits both nations¹⁰⁹. Conventions like the Organization of African Unity in 1963, the Bangkok Principles in 1966, the San Jose Declaration in 1994, the Kampala Convention in 2009, and the Kampala Ministerial Declaration on Migration, Environment, and Climate Change (KMD) in 2022 aimed to protect migrants and internally displaced individuals affected by climate change through humanitarian assistance, proper planning, remediation, community engagement, and proper documentation^{133,134}. The KMD, for instance, has enjoined East African countries to enhance cooperation, facilitate capacity building, and encourage multi-partner financing to prevent, minimize, and address the displacement of vulnerable communities caused by climate change¹³⁵. Similar measures can be implemented across the entire Global South to help address the challenges of climate migration^{9,62,136}.

Also, due to the limited capacity of Global South countries to address climate change impacts and the limited support from developed countries in assisting them in coping with these adverse effects³⁵, despite the obligations set forth by the Paris Agreement, public-private partnerships, philanthropic donors, and international organizations should establish and provide increased support to people living in areas prone to sea-level rise, flooding, and drought. This support should also extend to those who have limited financial and adaptive resources to avert prolonged displacement and migration¹⁹. However, developing countries must still take prompt actions and measures to combat climate change and its effects, and consider climate-induced migration a critical problem that must be addressed immediately within their countries and regions¹¹⁷.

Finally, the development and implementation of measures such as long-term planning, effective strategies for absorption of shocks and rapid recovery, and innovative adaptation solutions can contribute to enhancing the resilience of communities and avoiding the negative impacts of migration^{42,107}. Strengthening planning, absorption, recovery, and adaptation capacities requires concerted efforts across different sectors^{44,79}. These efforts should include upgrading infrastructure systems and increasing their resilience¹⁰⁸, improving household economic capacities^{29,88}, enhancing the efficiency of resource consumption and production^{25,99}, engaging local communities in planning and decision-making processes^{118,134}, utilizing modeling and scenario-making techniques for planning under different future scenarios, and employing smart solutions such as early warning systems to facilitate better response and absorption capacities^{136,137}. However, implementing these measures and strategies may present challenges, as Global South countries and communities may struggle to afford the adaptation costs, and have limited access to skilled human resources and necessary technologies^{7,11}. Therefore, cooperation with countries in the Global North is essential, including financial support and technology transfer. Such cooperation can strengthen partnerships and contribute to

achieving global goals (SDG 17). Furthermore, considering the potential implications of large-scale migration for security, it can promote peace and justice (SDG 16). In addition to support from Global North countries, the assistance of donors and international organizations will be crucial.

Conclusion

Interacting with high levels of vulnerability, climatic hazards have contributed to humanitarian emergencies, causing migrations and displacements. The impacts have been particularly severe in Global South countries where most of the world's population lives. As most of the future population growth will occur in the Global South and given the projected increase in the intensity and frequency of climate-induced hazards, these countries may experience even more severe impacts in the coming decades. Such impacts could result in massive internal and external migration flows, which would have significant implications for domestic and international security, economic development, human rights, and justice.

In this review, we have demonstrated how three types of climate-induced stressors—increasing temperatures, water stress and drought, and floods and sea-level rise—have resulted in internal and transboundary migration across different countries of the Global South. Further, we have discussed how projected climatic changes will further increase the severity and frequency of adverse weather events with serious consequences for internal and external migration flows.

Climate-induced stressors can lead to gradual or abrupt migration patterns and dynamics, depending on their nature. Increasing temperatures and water stress are more likely to drive gradual migration patterns by eroding livelihood options for communities. For instance, extended periods of water scarcity may leave communities that rely on agriculture with no choice but to migrate. On the other hand, abrupt migration may occur when rapid-onset adverse events, such as major floods become recurrent, rendering places uninhabitable. At the same time, adaptation becomes challenging when slow-onset stressors, such as temperature rise and prolonged drought, push the area beyond its tipping point and make it uninhabitable. Adopting strategies to enhance communities' coping and adaptive capacities can minimize the need for migration in the face of both gradual and abrupt changes.

This review has revealed that climate-induced stressors often result in migration through indirect pathways. Institutional, political, and socio-economic factors play significant roles in individuals' and households' decisions to move. It is crucial to note the differential impact of climate-induced stressors on vulnerable groups, such as women, minorities, and low-income groups. Therefore, adaptation plans and strategies to address migration issues should acknowledge and account for differences among various socio-demographic groups, avoiding generic solutions that may leave some groups behind.

Finally, it is essential to recognize that, depending on the scale of climatic changes and the response/coping capacity at the local level, adaptation strategies and measures may sometimes fail to work. Under such circumstances, voluntary or forced migration becomes inevitable. In these cases, migration can be considered an adaptation strategy to minimize exposure to risks and prevent the loss of human lives and properties. When migration is unavoidable, careful planning is necessary to ensure that migrating individuals and communities can access the necessary resources to sustain their livelihoods. Additionally, social and cultural issues must be considered to avoid potential conflicts with host communities that may also be facing difficulties due to climate change.

We hope that the insights reported in this study will inform actions toward better managing climate-induced migration patterns and dynamics in the Global South. One limitation of this study is the exclusion of gray literature, which often covers issues related to the Global South. Therefore, we recommend that future studies go beyond reviewing academic literature and include gray literature and news reports on climate change and migration patterns in the Global South. This would provide a more

comprehensive picture that better reflects the dynamics of climate-induced migration in the Global South.

Methods

This paper presents a comprehensive review and analysis of the existing academic literature on climate migration in the Global South. The data for this study were systematically gathered from peer-reviewed articles, selected based on their relevance to the research questions. The databases used for searching the articles were Scopus and Web of Science as the major global databases of peer-reviewed literature. The search focused on literature related to climate change and migration as influenced by tripartite environmental factors (increasing temperatures, water stress and droughts, and floods and sea-level rise). The search strings used in searching for literature in the "Title, Abstract, and Author Keywords" are provided in Supplementary Table 1. Global South countries comprise 134 nations in LAC, Africa, the Pacific, the Middle East, Southeast Asia, and the Caribbean¹³⁷.

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) technique was employed to guide the literature search and selection. Originally designed as a tool to address practical and conceptual issues in meta-analyses and systematic reviews^{138–140}, the PRISMA method is increasingly employed for high-quality reviews and to synthesize available empirical data^{95,141,142}. The quality of the research criteria identified for this study was assessed to ensure accurate conclusions¹⁴³.

Studies were considered relevant if they vividly described the research topic and contributed to achieving the research goal. To be included, a publication must meet the following criteria: (a) studied climate change impacts and their connection to migration in Global South countries, (b) provided approaches for addressing climate change-induced migration in the Global South. Publications were excluded if they (a) were not related to the research topic, (b) did not focus on the link between climate change/stressors and migration, and (c) were in languages other than English. The summaries and abstracts of the most relevant publications were screened based on the inclusion guidelines. Data from the articles were extracted and recorded on a spreadsheet, including the study objective, key findings, concept definitions, conclusions, and recommendations. Initially, 4974 publications were identified. Among them, 1627 records were duplicates. Additionally, two publications were detected and retracted by Zotero. Rayyan was used to perform the inclusion and exclusion process, while Zotero and Google Scholar were utilized to download the full text of the final selected papers. Out of the 3317 records screened based on title and abstract, 3,276 were found to be irrelevant. Further, 48 records were selected based on full-text retrieval, with one record not being available in full text. Finally, 47 publications were selected for data analysis and systemization (see Supplementary Table 2). Figure 2 provides an overview of the literature search and selection process.

For the analysis, climate change drivers (factors or themes) that influence migration in the Global South were categorized using content analysis. Evidence from various studies on coping strategies employed to adapt to climate change and migration, as influenced by the tripartite environmental and geographical factors, was collected using an information extraction sheet in Microsoft Excel. The inductive content analysis technique was used due to the lack of previous systematic reviews on this fragmented topic¹⁴⁴, making it the most suitable method for synthesizing information¹⁴⁵. This technique allows for a comprehensive extraction of insights from previous literature without preconceived bias. However, it is a time-consuming technique and involves a certain level of subjectivity in the analysis process¹⁴⁴. The inductive content analysis involved identifying and categorizing themes related to the intersection of climate and migration while reading the first paper. Similar themes that were identified are documented and synthesized with those found in the explored documents. New themes were established as new issues emerged from subsequent papers that did not align with the existing categories.

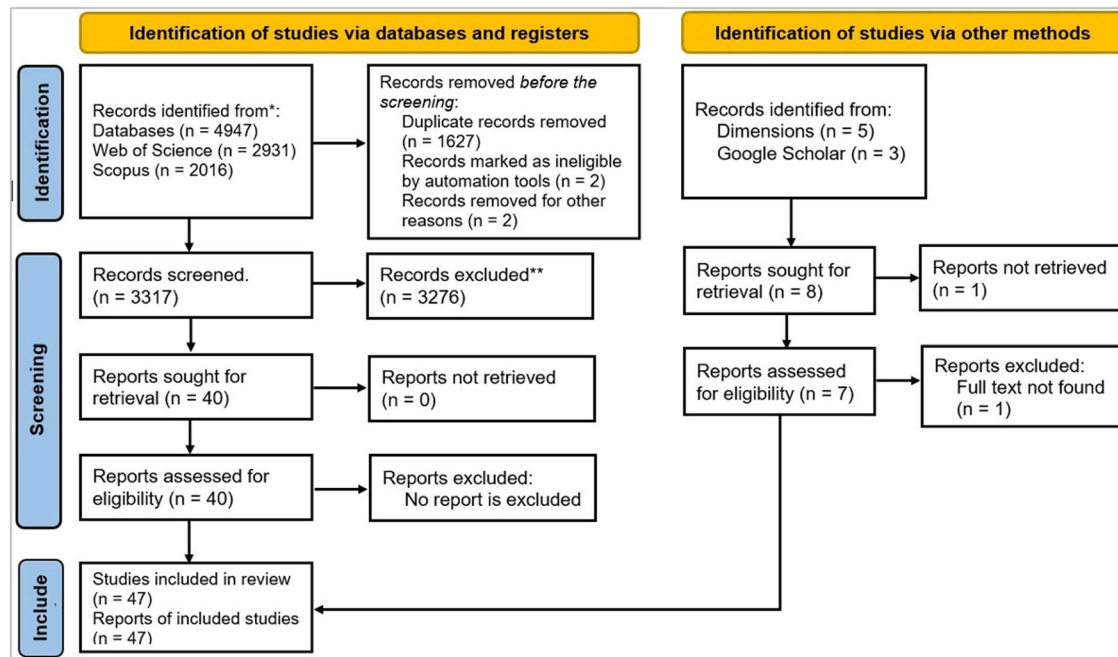


Fig. 2 | The PRISMA flow diagram. It shows articles' identification, screening, and exclusion/inclusion criteria.

Data availability

The data that support the findings of this study are available as supplementary information.

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Author contributions

A.I.A.: conceptualization, investigation, methodology, data curation, formal analysis, validation, and writing—original draft preparation, writing—review & editing, resources, project administration. G.N.A.: investigation, validation, writing—review & editing. A.S.: investigation, validation, original draft preparation. R.S.: validation, writing—review & editing. S.H.: investigation, validation, supervision, original draft preparation. M.J.M.: data curation, visualizing, writing—review & editing. S.A.: methodology, formal analysis. I.R.A.: investigation, validation, visualization, resources, writing—review & editing.

Competing interests

The authors declare no competing interests.

Additional information

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Correspondence and requests for materials should be addressed to Abdulaziz I. Almulhim.

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