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Perspective

Research priorities for climate mobility

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SUMMARY

The escalating impacts of climate change on the movement and immobility of people, coupled with false but influential narratives of mobility, highlight an urgent need for nuanced and synthetic research around climate mobility. Synthesis of evidence and gaps across the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report highlight a need to clarify the understanding of what conditions make human mobility an effective adaptation option and its nuanced outcomes, including simultaneous losses, damages, and benefits. Priorities include integration of adaptation and development planning; involuntary immobility and vulnerability; gender; data for cities; risk from responses and maladaptation; public understanding of climate risk; transboundary, compound, and cascading risks; nature-based approaches; and planned retreat, relocation, and heritage. Cutting across these priorities, research modalities need to better position climate mobility as type of mobility, as process, and as praxis. Policies and practices need to reflect the diverse needs, priorities, and experiences of climate mobility, emphasizing capability, choice, and freedom of movement.

INTRODUCTION

The Intergovernmental Panel on Climate Change Sixth Assessment Report (IPCC AR6) recognizes that migration is already occurring globally in response to climate change and is likely to occur at larger scales in the future as global warming levels and associated risks increase.[1] The importance of climate mobility is recognized by the IPCC AR6 through its inclusion of displacement and migration as a key risk across sectors and regions.[1,2] For example, it assesses that, with every additional 1°C of warming, the global risks of involuntary displacement due to flood events are projected to rise by approximately 50%.[1] A recent study shows that, without mobility, by 2080–2100, unprecedented heat from global warming could leave one-third of the global population outside the niche of thermal habitability for humans.[3] In general, climate change is expected to become an increasingly important driver of human mobility and immobility over time.[4,5]

Most studies on climate mobility have focused on how impacts from climate change drive flows of migration and displacement. Many of these studies have been over-deterministic and have not well reflected historical contexts,[4,6] yet they contribute to commonly held "myths" around climate mobility in both research and policy, including notions of "mass migration" that present climate mobility as a security risk or as justification for highly restrictive immigration and border control policies.[6–8]

Further discourses have adopted racialized and homogeneous framings of migrants; some present them in terms of deserving or undeserving of help, and others pathologize the issue; for example, asserting that climate mobility is a "problem to be solved."[6,7,9–11] The combination of the increasing importance of climate mobility and highly influential but uninformed research framings and policy responses demands urgent reflection, deeper empirical investigation, and revision.

While mobility is inevitably multicausal, we focus here on "climate mobility": the mobility and immobility of people linked either directly or indirectly to the adverse effects of sudden- or slow-onset climate impacts.[12] Climate mobility includes a diversity of movements across space and time —such as displacement, relocation, long-term migration, or immobility—that are not captured well by the term "migration" and represent a distinct and growing field of study.[13,14] Climate mobility may occur as a direct climate-related impact; for example, when land is inundated by sea level rise or lost due to catastrophic coastal erosion. Climate mobility may also be mediated indirectly through other factors, such as when a climate-exacerbated drought affects agricultural livelihoods and motivates mobility or prevents in-migration to a water-scarce region.[15] The term "climate mobility" encompasses a range of mobility types such as forced displacement or involuntary immobility as well as potentially positive types, including autonomous, high-agency migration and planned community-led relocation, which can be forms of adaptation to climate change.[16] Climate mobility occurs primarily within but also across national borders, which involves different levels of constraints, agency, and vulnerability. Climate mobility also occurs over different timescales and can be temporary, recurrent, or permanent.[17]

There is increasing need to understand how mobility can reduce risk from climate change and under what conditions it can be a potentially effective adaptation option.[18,19] We adopt the IPCC definition of adaptation: the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit opportunities.[2] In general, mobility can be a successful type of adaptation to climate change if it increases well-being, reduces inequality, and promotes sustainability.[16] We categorize mobility in the context of climate change as potentially adaptive, recognizing that mobility may simultaneously reduce harm, provide beneficial opportunities, and involve significant material, tangible, intangible, or non-economic losses.[20,21] For example, under certain conditions, migration can enable proactive livelihood diversification that contributes to rural households' capacity to reduce vulnerabilities and adapt to changing conditions.[22] Across multiple policy circles, the idea that migration can be an effective way to adapt to climate change has been welcomed (such as by the International Organization for Migration [IOM],[23–25] the World Bank,[26,27] the African Union,[28] and the Global Compact for Safe, Orderly, and Regular Migration[29]) but also contested.[30,31] However, "successful" adaptation may be contingent on the timescale of analysis and types of vulnerability considered.[16] What constitutes adaptation for some may manifest over time or space as maladaptation for others or in different parts of the system.[19,32]

We begin with an overview of how climate mobility has been understood in the IPCC AR6 and its implications for the field's understanding of adaptation. We subsequently establish criteria for selecting research priorities, focusing on progress made in the AR6, research gaps, and important policy and development trends. Five general themes that emerge as research challenges are then presented, centering on climate-resilient development planning, mobility both as response to climate change and within a system affected by climate change, harnessing nature's contribution for adaptation, and specific coastal challenges associated with sea level rise, including retreat, relocation, and heritage. These challenges are elaborated into nine research priorities, which include integrating adaptation and development planning; involuntary immobility and vulnerability; gender; data for cities; risk from responses and maladaptation; public understanding of climate risk; transboundary, compound, and cascading risks; nature-based approaches; and planned retreat, relocation, and heritage. Where relevant, reference is made to theoretical grounding, generalizability concerns, and potential scalability of adaptation. The discussion then highlights multiple cross-cutting issues, including security, rights-based approaches, conflict-sensitive adaptation, and peacebuilding; overcoming sedentary biases in human mobility research and the disproportionate emphasis on cross-border mobility; social protection; response risk; and the importance of understanding climate mobility as a type of mobility, as praxis, and as a process.

CLIMATE MOBILITY IN THE IPCC AR6

The IPCC AR6 advances the understanding of human mobility under a changing climate through assessment of observed and projected impacts of climate change on mobility and its distributional and sectoral consequences for migration and displacement, including changes in impacts, risks, exposure, and vulnerability (see Tables S1 and S2 for additional information on the AR6 assessment on dimensions of climate mobility for exposure, vulnerability, impacts, and risks). The IPCC AR6 also assesses how dimensions of climate mobility, including migration and planned relocation, are understood as responses to climate change, noting examples of coping, adaptation, and maladaptation (Box 1).[1,2,33–38]

Climate mobility is assessed by the IPCC as a potentially effective adaptation strategy under current global warming levels and specific feasibility conditions.[2] However, the report notes that the outcomes of climate mobility are highly context specific. There is currently limited evidence and low agreement in the literature as to whether and in what contexts migration of various types is an effective strategy to adapt to localized climate change impacts. Further, place-based constraints add limits to the feasibility of migration as a form of adaptation.[39,40] For example, climate mobility in Africa was assessed to have low feasibility due to economic, institutional, and technological constraints despite its relatively high potential for risk reduction.[35,40]

When migrants send home part of their earnings in the form of either cash or goods to support their families, these transfers are known as remittances. Remittances have been growing rapidly in the past few years and now exceed official development aid and represent the largest source of foreign income for many developing countries.[41] Remittances are considered an important channel of finance for adaptation as they directly reach households, including low-income households in remote and vulnerable areas.[42,43] But inadequate finance and banking

Box 1. Adaptation, adaptation limits, and maladaptation dimensions of climate mobility identified in the IPCC AR6

Adaptation: The process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities.[92]

(1) The more agency migrants have (that is, the degree of voluntarism and freedom of movement), the greater the potential benefits for sending and receiving areas.[2,33,35]
(2) Adaptive capacities minimize the negative impacts of climate-related displacement and involuntary migration for migrants and sending and receiving areas.[2]
(3) Rural households frequently accomplish the goal of livelihood diversification with an increasing reliance on migration, urban wage labor, and remittances.[34]
(4) A synthesis of 63 studies covering over 9,700 rural households in dryland sub-Saharan Africa shows that 23% of households employed migration (primarily temporary economic) to adapt to changes in rain-fed agriculture.[35]
(5) There is emerging evidence that inclusion of universal safety net provisions that embed adaptation planning can reduce vulnerabilities of migrants.[36,38]
(6) Migration, including planned resettlement, is increasingly occurring in small islands to intentionally respond to or prepare for climate change impacts.[36,97]

Adaptation limits: The point at which an actor's objectives (or system needs) cannot be secured from intolerable risks through adaptive actions.[92]

(1) Migration as adaptation is not available to everyone.[37]
(2) Limited migration opportunities for low-income households can result in forced immobility, while, on the other hand, high tides, sea level rise, and cyclone damage could result in relocation of significant groups of the population.[34,97]
(3) The vulnerability of communities in small islands, especially those relying on coral reef systems for livelihoods, may exceed adaptation limits well before 2100 even for a low-GHG emission pathway.[36]
(4) For people displaced by climate change impacts, policy interventions have a determining influence on migration outcomes, such as the numbers of migrants, the timing of migration, and destinations.[34]

Maladaptation: Actions that may lead to increased risk of adverse climate-related outcomes, including via increased GHG emissions, increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future. Most often, maladaptation is an unintended consequence.[92]

(1) Migration does not necessarily mean that people move out of risk; in fact, often they might be subjected to new risks.[36,38]
(2) Globally, maladaptation has been reported most frequently in the context of agriculture and migration in the Global South.[1]
(3) Migration to urban centers can represent a significant adaptation opportunity for the migrants themselves but can also increase the vulnerability of their community of origin or destination (e.g., through depletion of the workforce or additional pressure on environmental resources and infrastructure, respectively).[34]
(4) The process of displacement and forced migration can leave people more exposed to climate change-related extreme weather events, particularly in low-income countries, which often host the highest number of displaced people. This is due to loss of shelter, assets, and, in some cases, citizenship, which reduces access to social services that can buffer climate impacts.[34]
(5) Costs to the poor may also include the secondary impacts of first-order adaptation activities, including the livelihood consequences of people migrating due to climate change impacts.[34]
(6) Poorer households, who often live in highly exposed locations, are more likely to be forced into low-agency migration as a means of adapting to climate risks and, at the same time, are the most likely to be immobile or trapped in deteriorating circumstances where migration would be a preferred response.[33]
(7) The poorest households […] typically lack the resources that would allow them to migrate in ways that maintain an acceptable standard of living and may find themselves unable or unwilling to move in the face of climate change impacts.[34]
(8) When poorer households do migrate after an extreme climate event, it is often in reaction to lost income or livelihood and occurs with low voluntarism and may perpetuate or amplify migrants' socioeconomic precarity and/or their exposure to environmental hazards.[33]

infrastructure can limit the potential benefits from remittances.[35,40] In Asia, benefits from international remittances across the Asia-Pacific region were approximately 276 billion US dollars (USD) in 2017, but migration requires a minimum level of resources—and liquidity constraints can impede internal migration by the poorest households, often rendering them immobile.[33,34,38]

Some limits to adaptation that affect mobility can be overcome with sufficient motivation and resources, either to reduce the need for mobility or to support voluntary immobility (called "soft limits"). Other adaptation limits are "hard," meaning they have reached system limits, such as the physiological thermal tolerance of people and nature to extreme heat,[44–47] and cannot be overcome without fundamentally altering the system.[1] The assessment also warns that mobility responses can be maladaptive; for example, if remittances are invested in unsustainable agricultural practices or if relocation increases the vulnerability of groups such as women, the elderly, and children.[17,48,49] The assessment also identifies that better outcomes can be facilitated by supportive policies and programs, specifically policies

that build adaptive capacity, providing greater agency to people on the move and enabling communities to support both outgoing and incoming residents; policies that reduce transit times and bureaucratic hurdles, reducing barriers to mobility; and policies that support livelihoods, community cohesion, and sense of identity and efforts to alter the narratives on migration.[17]

CLIMATE MOBILITY RESEARCH CHALLENGES AND KNOWLEDGE GAPS

A review of the IPCC AR6 and subsequent literature highlights five broad challenges and knowledge gaps. We need a better understanding of (1) how to integrate adaptation and development planning for better mobility outcomes, (2) mobility and immobility as responses to climate change and its effect on risk, (3) mobility within systems affected by climate change (such as urban and food systems), (4) nature's contribution to mobility, and (5) planned retreat, relocation, and heritage. This section elaborates these challenges as they are reflected in the literature.

Integrating adaptation and development planning

Broadly, it is increasingly recognized that climate change adaptation must be more fully integrated with socioeconomic development efforts to identify investment synergies between them, particularly for key dimensions of vulnerability and in resource-constrained contexts. For example, individuals and households that have reliable access to food and adequate food reserves, clean water, health care, and education will likely be better prepared to deal with the impacts of climate change.[50] While we have a growing understanding of how to integrate climate action with development planning,[35,51–53] development actors currently lack an understanding of the substantial synergies that can be achieved for well-being when integrating development planning together with both adaptation and greenhouse gas (GHG) mitigation.

Transforming development for climate mobility includes investing in locally anchored climate adaptation and pursuing community-led solutions for climate-resilient development.[12] This has implications for mainstreaming adaptation in broader developmental progress as well as for necessary adaptation finance commitments for climate mobility. However, we have a limited understanding of how climate mobility-related adaptation actions provide synergies, co-benefits, or trade-offs with broader development priorities, including health, energy, or gender equality, and progress toward the sustainable development goals (SDGs) more generally.[24,54] For example, refugees and other involuntary migrants can experience higher direct and indirect physical and mental health outcomes associated with exposure to disease, malnutrition, and changes in diet or activity.[24,33]

We urgently need bottom-up assessments of climate mobility-related adaptation costs, including the costs of inaction, the integration of costs in national adaptation planning processes, and access to finance by local implementing institutions and actors.[55] This is particularly evident for adaptation finance for cities that will be climate mobility hotspots.[12] An additional 950 million people are projected to join African cities by 2050, up from 537 million in 2015—even without accounting for climate mobility.[56] Despite this increase, up to 4.2 million people are projected to leave African cities due to climate mobility by 2050 under a future scenario of inequitable development and high emissions, which could slow the growth in some particularly impacted cities.[12] Underlying this trend, however, is increasing rural-to-urban migration, with urban settlements concentrating livelihood opportunities and adaptation and mitigation actions but also climate risks.[35,57,58] While mobility can improve material well-being through higher incomes, remittances, and investments in assets that allow upward social and economic mobility, migrants often enter precarious livelihoods,[59,60] suffer from weakened social networks and inadequate social safety nets, and are often exposed to different and greater climate risks while on the move or in their new location,[61] all of which impede adaptive capacities.[48,62,63]

There is a further need to ensure that climate finance is allocated to the local level and involves community participatory processes by mapping the baseline of climate finance that reaches the local level and using it to set goals for local climate finance, targeting the most climate-vulnerable areas and communities.[64] This would ensure that climate finance addresses needs and gaps and broadens equitable access to domestic finance. Importantly, these participatory processes will also better connect and mainstream adaptation with local-level development imperatives and contextual drivers of vulnerability.[65]

Mobility as response to climate change

Figure 1 shows how risk is affected by interactions among more severe climate hazards, changes in exposure, underlying socioeconomic vulnerabilities, and responses to climate change.[51,67] Synthesizing the literature on climate risk and mobility highlights the importance of understanding the lived experiences of moving or remaining in place and of receiving contexts, the complexity of climate change as one driver of mobility, and mobility and immobility outcomes that affect lives, livelihoods, and well-being.[10] Adaptation-related responses to climate risk can include *in situ* adaptation and/or movement, which can be voluntary or involuntary.[32,68] Focusing on mobility as one of these responses, Figure 1 shows that migration or displacement can increase or decrease overall risk. Voluntary migration can be used by households when adapting to climate hazards such as rainfall variability,[32,69] while less voluntary forms of migration and displacement emerge when available *in situ* adaptation options are inadequate. Groups and individuals who are involuntarily immobile may find that their exposure, vulnerability, and overall risk increase over time.[48,69] Migration outcomes are determined by changes in risks over time and space to the well-being of migrants, sending communities, in transit, and at destination communities. These outcomes are heavily influenced by the political, legal, cultural, environmental, and socioeconomic conditions under which migration occurs.[17,40,66]

The capabilities of individuals, households, and groups to make free and informed choices about whether, when, or where to move or not move are central to ensuring that mobility functions as an adaptation to climate change[14,20,68] (Figure 1). In areas with low adaptive capacity and high vulnerability, climate impacts also reduce agency to choose mobility or immobility by entrenching vulnerability. However, households and communities can also have strong reasons for remaining in place; for example, location-specific cultural or spiritual resources. Thus,

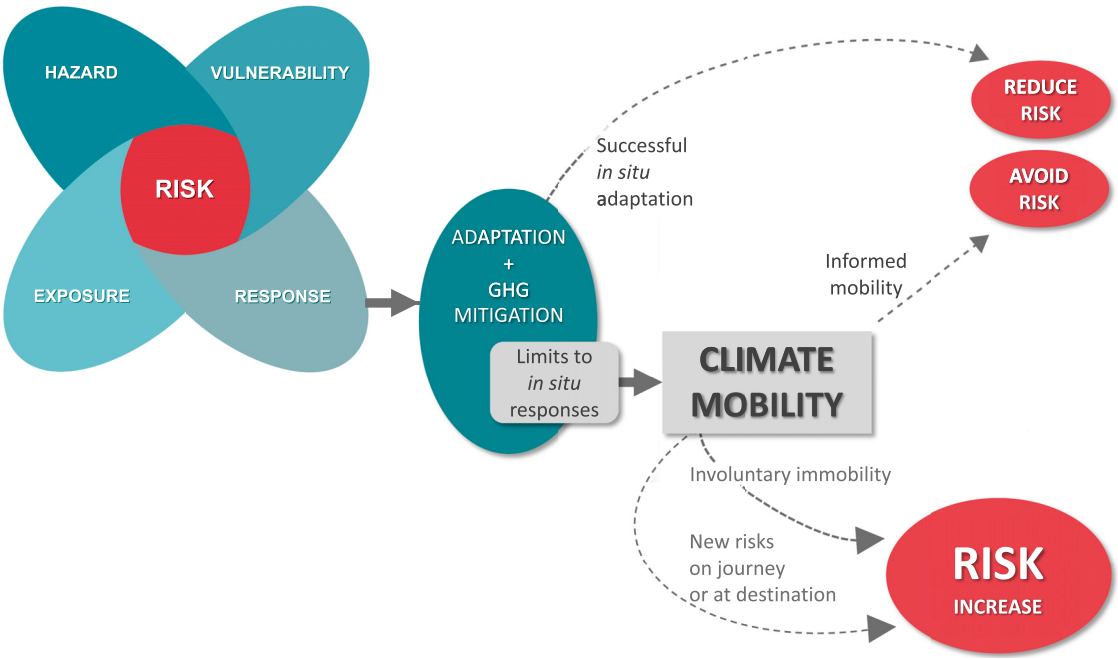

Figure 1. Adaptation and adaptation limits, climate mobility, and implications for future risk

This was elaborated by the authors from Figure MIGRATE.1 from the cross-chapter cox MIGRATE Climate-Related Migration in chapter 7: Health, Wellbeing, and the Changing Structure of Communities of the AR6 Working Group II to provide greater focus on characteristics of climate mobility described in the assessment and the literature.[17,66]

an understanding of a wider range of household preferences for immobility or mobility and different migration trajectories in a changing climate is also needed. We need to also better understand the relationship between the public understanding of climate risk and climate mobility.[70]

There is urgency to assess the implications of remaining immobile for the more vulnerable. The thresholds that render voluntary immobility into involuntary immobility and appropriate interventions that support mobility and relocation when the physical suitability and safety of a location degrades require attention.[59] This will help clarify the current understanding of voluntary and involuntary mobility along a continuum of agency.[68,71,72] It would also be useful to understand the linearity of this continuum and whether there are important tipping points or tolerances along such a continuum that could be managed and, therefore, what level of intervention might be sufficient. Such thresholds might include, but are not limited to, the exhaustion of a household's assets, inability to access sufficient food, or inadequate assistance from governments or authorities.[66] This could also help to better understand the timing of mobility to be adaptive; for example, before resources are exhausted.[73] As arbitrary risk thresholds have been used to legitimize the denial of refugee claims in New Zealand's immigration tribunal and elsewhere,[74,75] research on mobility thresholds could better inform legal support that prioritizes the needs of migrants and give greater application to the principle of non-refoulement[76] under climate change.

Mobility is inherently gendered and can exacerbate existing inequalities and inequities between women and men, expose them to new vulnerabilities, and intensify gendered experiences of poverty, discrimination, and socioeconomic inequality.[77] For example, women on the move in the context of displacement are often undernourished, malnourished, and easily susceptible to diseases.[78] The journey itself is fraught with physical demands, let alone exploitation, sexual abuse, and trafficking risks, especially for women and young girls.[78] Further, women and children are often "forgotten casualties" as the undocumented victims of the impacts of climate change.[78] Nevertheless, women play a critical role in sustaining households and communities, whether on the move or staying behind.[79,80] More evidence is particularly needed on the intersectional factors that make mobility an option for some but not for others, that shape the unequal distribution of mobility costs and benefits, and that influence adaptation outcomes in source and destination communities alike. Evidence of changing gender norms, gender equality, or empowerment outcomes and their effect on mobility as an adaptation strategy is deficient.[49,81,82]

Climate mobility responses at all levels are not without risks. While mobility-related activities may support short-term subsistence needs, there is also potential for longer-term trade-offs for vulnerability, GHG mitigation responses, and development.[53,83,84] Understanding the risks facing people engaging in climate mobility and avenues for reducing the risk of adverse outcomes from such mobility are important research priorities, particularly given the emerging understanding of how inappropriate responses to climate change can increase vulnerability or lead to maladaptation.[18,48,85]

Mobility within systems affected by climate change

Disruptions of the flows of essential goods and services, including water, food, health, and energy, have direct impacts on the climate response capacity of communities. Such impacts

can also affect their mobility or immobility. A diversity of scholarship is increasingly highlighting that adaptation to climate change requires conditions that enable the reliability of essential flows of goods and services and connectivity across space.[86–89] This is important because the impacts from climate change differ through space and time and often cascade across and within regions and systems,[85,90] potentially leading to simultaneous risks and hazards in co-dependent places and regions.[36] For example, migration to peri-urban settlements can reduce some risks (e.g., loss of crops and income due to climate extremes) but amplify others (e.g., heat stress and insecure land tenure).[72] This highlights the need to go beyond analysis of flows of people to understand flows of resources engendered by mobility and how they affect adaptation.

Harnessing nature's contribution to mobility

Environmental degradation influences mobility, and people adapt to environmental degradation by using mobility.[91] Nature-based approaches (NbAs) are actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.[92] Given that NbAs work directly with nature to address societal challenges, including reversing or halting environmental degradation, this means that they can play an important role in influencing the environmental conditions affecting mobility, including climate mobility.

Ample evidence shows that NbAs can reduce direct exposure to climate impacts, decrease sensitivities of human and livelihood systems, and build adaptive capacity.[2,51,93] For example, protecting and restoring coastal habitats (e.g., wetlands or mangroves) can reduce coastal erosion and flooding associated with storms and sea level rise by stabilizing slopes and shorelines, attenuating waves and increasing infiltration and storage of water,[2,94] and agroforestry can support long-term productivity and buffer temperature and rainfall extremes.[2,95]

However, studies have equally shown how inappropriately applied NbAs have resulted in injustices for local people or inequitable outcomes for certain social groups, including restricting access to natural resources and forced displacement as examples.[93] For example, community members can be prevented from accessing customary natural resources and/or forced to leave an area to make way for the NbAs.[96] This negatively impacts their lives and livelihoods. Typical NbAs, such as protected areas, community-based natural resource management projects, and sustainable forest management or forest carbon projects, including those focused on reducing emissions from deforestation and forest degradation, can have these effects when they are misguided or inappropriately applied.[2,35]

Retreat, relocation, and heritage

In coastal areas experiencing intensifying flooding and inundation among other climate hazards, retreat and relocation out of hazardous locations can reduce climate-related risks and increase the prospects of full portfolios of adaptive responses. Managed retreat and planned relocation simultaneously create both opportunities and losses, which are differentially experienced by those who are moving, those who remain, and in receiving areas.[97] Even where gradual international relocation is supported and planned through policy, as was the case with Kiribati's previous government's position on the "migration with dignity" strategy, strong cultural connections to land and uncertainty about life in receiving communities in Australia and New Zealand have contributed to growing opposition to indefinite or permanent migration.[36,74] Consequently, current President Taneti Maamau of Kiribati has affirmed the willingness of the people of Kiribati to stay put and adapt.[98] How to enable and manage retreat and relocation in a voluntary and inclusive way so that they proactively and effectively support social goals thus remains a major open question.[55]

Displacement and relocation highlight the need to assess how climate mobility affects heritage and what aspects of heritage associated with mobility can inform adaptation to climate change.[99] For example, climate change-related relocation of people from areas containing important archaeological resources places loss of territory and place attachment at the forefront of climate change impacts on cultural heritage.[99,100] Practicing intangible heritage, such as songs and rituals, can provide resilience benefits for displaced persons despite the loss of place-based tangible heritage of homes, neighborhoods, and landscapes.[101] Yet there is also growing evidence of the limits of adaptation options for types of heritage associated with climate-induced mobility changes.[102] For example, traditional mobility coping options of pastoralists across many African drylands are less viable in the face of accumulating climate impacts and other stressors.[53,84] For centuries, African pastoralists have drawn on intangible heritage in the form of Indigenous knowledge to build their resilience to climatic variability and to support adaptation practices.[103,104] In such contexts, out-migration or displacement may lead to the loss of Indigenous knowledge and local knowledge for adaptation.[37] By contrast, in China, the relocation or consolidation of villages that are depopulating due to out-migration risks severing ancestral links to land that are key components of rural identities.[60] Climate change threatens to make this traditional knowledge obsolete, undermining mobility-related adaptation and resilience more generally.[12]

ADAPTATION RESEARCH PRIORITIES FOR CLIMATE MOBILITY

For our purposes, the climate mobility research priorities identified here are scoped for their potential to open new frontiers of knowledge on adaptation that reflect current and projected impacts, vulnerability, and adaptation action relevant to climate mobility. The priorities draw on the five broad challenges identified through the IPCC AR6 and review of the literature above and clarify the conditions under which mobility can be a form of or contribute to adaptation, connect to the practicalities of locally led adaptation, clarify synergies and trade-offs with development, demonstrate policy relevance in the near term, respond to important and recognized knowledge gaps, clarify hard or soft adaptation limits for mobility, inform where responses might lead to maladaptation, and redress substantial gaps in climate change research funding and knowledge creation.[35,105]

Priority 1: Integrating adaptation and development planning

Climate-resilient development (CRD) holds potential as an integrating frame for climate mobility research as it makes explicit

and contextualizes priority development agendas. CRD is a process of implementing climate action, including GHG mitigation, risk reduction, and adaptation measures, to support sustainable development for all.[2] It also foregrounds the feasibility of adaptation across diverse development contexts while paying attention to synergies and trade-offs with climate mitigation.[35,39,40,53] Part of this process will require removing barriers to and expanding the alternatives that allow vulnerable people to adapt to climate change[33,34] and facilitating governance conditions—including rights-based approaches—for "safe, orderly and regular migration" aspired to by the Global Compact for Migration and by target 10.7 of SDG 10.[106–108] Further, CRD is assessed by the AR6 to have a strong potential to reduce risks of involuntary displacement and conflict.[33] For example, building inclusive and integrative approaches to climate-resilient peace would help prevent health risks related to migration and conflict.[33]

A second dimension includes recognition that mobility can be a form of adaptation when migrants are effectively integrated into receiving communities.[109] To do so, policymakers need actionable guidance on adaptation synergies between climate mobility and progress toward the SDGs, particularly no poverty (SDG 1); zero hunger (SDG 2); ensuring healthy lives and promoting well-being for all (SDG 3); clean water and sanitation (SDG 6); economic growth (SDG 8); industry and innovation (SDG 9); more resilient, sustainable cities (SDG 11); action on climate change (SDG 13); and stronger and more inclusive institutions (SDG 16).[54,107]

CRD must provide solutions for people to stay by supporting their choice to protect, and invest in, the places they call home. The IPCC AR6 assesses that actions that enhance *in situ* adaptive capacities can result in synergies for both adaptation and development.[33] For example, land management practices and policies that support the use of mulching improve soil fertility for better yields (SDG 2),[110] improve nutrition and adaptive capacity,[111] as well as reduce climate risks from rainfall variability and land degradation (SDG 13).[35] We further need clarity on what suites of adaptation options best serve to make remaining a viable option without maladaptation, increasing emissions, or curtailing people's mobility options. More research is also needed on how adaptation may increase migration and how such mobility creates connectivity between places through stronger rural-urban ties.[16,59] This could inform better integrated and coordinated policy responses, including in terms of spatial planning, flexible social service delivery and safety nets, and cooperation on food systems and food security in both rural and urban areas.[112,113] Research needs to extend current case studies to more generalizable principles for CRD at the local level, including to support urban planning for climate mobility; for example, through greater focus on equity and justice, inclusion, diverse knowledge, and ecosystem stewardship.[52]

Priority 2: Involuntary immobility and vulnerability

The concept of agency could provide an important framing for future research on involuntary immobility and vulnerability. When households have high agency, mobility responses are more likely to have positive outcomes.[33] However, interactions between the factors that promote agency of mobility—including household level determinants such as education, assets, and health as well as community resources and social networks—and immobility are less well understood. Preliminary modeling suggests that the number of involuntarily immobile households would increase due to the impacts of climate change on income. This could substantially increase vulnerability, especially for low-income households that would be deprived of mobility opportunities.[114] At the same time, voluntary immobility may represent an important adaptation. This has been noted for populations in Pacific Islands, where immobility can enhance resilience through cultural and spiritual links to the land.[115]

Figure 2 highlights the need to examine the multidimensionality of mobility within the context of complex and cascading climate change risk.[10] It is important for future research to identify biogeophysical as well as social tipping points, irreversibility, and other non-linear relationships of climate mobility in the face of compound and cascading climate risks, where erosion of assets and coping capacity leads to immobility (Figure 2). Outmigration or rural-to-urban migration in response to food insecurity and agricultural livelihood depreciation in agricultural regions can weaken local subsistence production capacity, disrupt family structures, reduce labor available for agricultural work, and increase the burden of responsibilities on women, among other impacts.[1]

Many of the factors that promote *in situ* adaptive capacity are the same as those that provide assets for mobility, so we may expect that programming and funding for climate adaptation may also promote mobility rather than immobility, although the interactions with climate policies remain poorly evidenced. Identifying and characterizing these more complex interactions will be necessary to better understand how immobility needs to be considered beyond vulnerability.[117]

Priority 3: Climate mobility and gender

While gender cuts across the other priorities, it also demands special attention. Gendered inequalities in access to and control over different forms of capital can lead to a gender-differentiated capacity to adapt,[33,35,36] where men are often better able to adapt, and women experience increasing vulnerability; e.g., to drought.[37] The relations between intersectional differences and climate mobility remain poorly understood, but evidence suggests that the younger and educated are more mobile and that, in some contexts, migration is suppressed by marriage, particularly for women.[62,63,118] Special focus needs to be given to research and policy processes to better understand gender-specific, rights-based approaches that focus on capacity building, meaningful participation of the most vulnerable groups, and their access to key resources, including financing, for risk reduction and adaptation.[119] Research needs to establish localization of policy and practice of social safety nets that support climate change adaptation to have strong co-benefits with development goals, such as education, poverty alleviation, gender inclusion, and food security, resulting in reduced vulnerabilities and climate risks that often lead to migration.

Intersectional analysis cautions against an undifferentiated view of women as the most vulnerable group. There are situations where subsets of women react, adapt better, or are more resilient.[37] Grassroots women self-help groups can be active agents of change for their communities, designing and delivering gender-responsive adaptation solutions for communities affected by or building on climate mobility.[37] Research needs

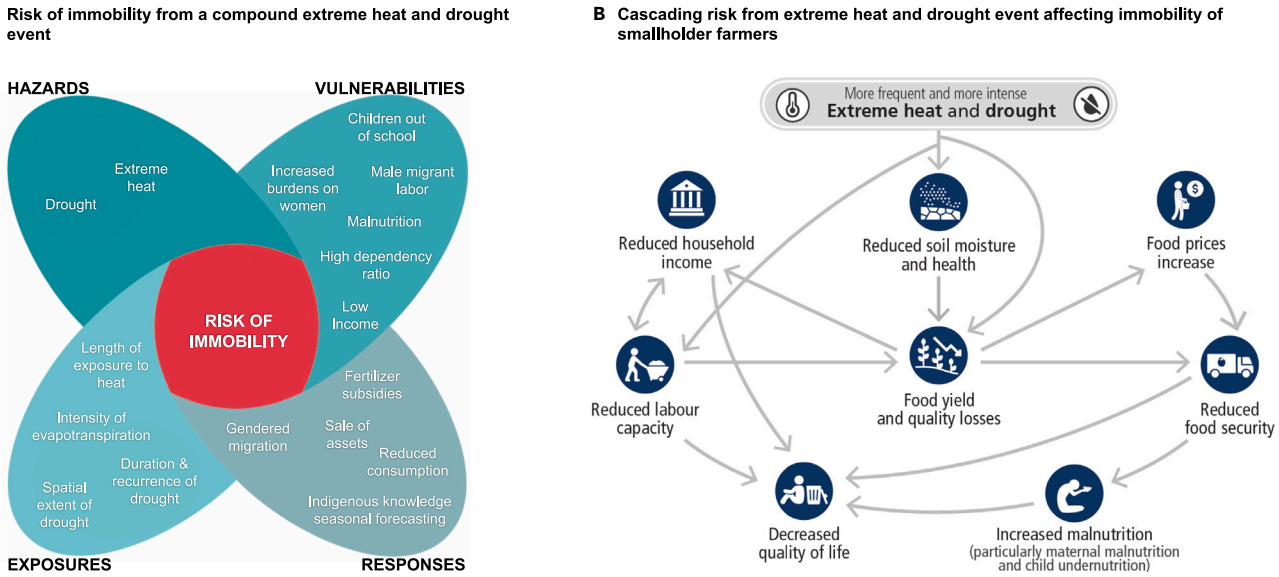

Figure 2. Risk of involuntary immobility from a compound drought and heat events

(A) Risk of immobility from a compound extreme heat and drought event. The figure elaborates the complex interactions of multiple drivers of risk to mobility (e.g., compounding vulnerabilities of malnutrition and low income interacting with a compound extreme heat and drought event).[36] As identified through the IPCC Representative Key Risk of Peace and Human Mobility, the role of impact cascades is prominent and could become severe for highly vulnerable populations with limited resources, even with moderate levels of warming[1] (elaborated by the authors from Figure 1.5c in Chapter 1: Point of Departure and Key Concepts of the AR6 Working Group II,[67] with detail on immobility described in the assessment and the literature).

(B) This example of a compound heat wave and a drought event striking an agricultural region shows how multiple risks are interconnected and lead to cascading biophysical, economic, and societal impacts that affect mobility and immobility, with vulnerable groups, such as smallholder farmers, children, and pregnant women, particularly impacted (reproduced from the IPCC AR6 SYR Longer Report, Figure 4.3c[116]).

to identify the enabling conditions that shape opportunities for substantive empowerment of women that boosts their adaptation capacity, whether on the move, residing in a new location, or staying.

Priority 4: Data for cities

Filling existing data gaps is essential for decision-makers, especially in rapidly urbanizing agglomerations that will experience, potentially, unprecedented movements of people from climate change—both inflows and outflows. Access to localized data in cities (especially spatial and demographic data), combined with financial and technical resources along with political agency, can facilitate planned, resilient, and inclusive urban growth, social inclusion, and social protection while building stronger ties across cities, between cities and rural areas, and among economies.[12] Recognizing the translocal nature of mobility and how it relates to urban systems is an important dimension for adaptation planning. Research on the role of migration networks that connect people between origins and destinations (for example, how they determine flows of remittances between rural and urban areas or between cities) will help with planning adaptation.[43,120]

Cities often lack information about the movement of people and the demographic profile of new arrivals.[121] They may also lack localized climate risk and vulnerability assessments. Climate mobility modeling and profiling exercises of otherwise "invisible" populations, such as informal dwellers and displaced people, can serve to fill some of these knowledge gaps and to facilitate dialog between local authorities and city residents.[122] However, to provide useful input for local and participatory planning, data must be translated to be user friendly, alongside interventions to enhance the literacy of local decision-makers and stakeholders.

Despite unprecedented access to open data, much of these data are raw and potentially time intensive and difficult to use for decision-makers without prior training. For example, the European Space Agency's World Cover Database[123] annually maps types of land cover globally (which can be used to calculate the availability of and proximity to green space), and the World 3D Buildings from the German Aerospace Agency[124] maps the heights of buildings globally on a 90 × 90 m grid. Researchers need to continue to provide and conduct secondary synthesis research using such types of data, and researchers globally need to make the data digestible and easy to understand for decision makers.

The Mapping Territorial Transformations in Africa platform provides aggregated indicators on compactness of urban forms and the availability of green spaces of close to 6,000 agglomerations on a regular basis to enable monitoring and evaluation of cities.[125,126] Green spaces may play a limited role in coping with heat waves in a city like Khartoum, where only 3% of the population lives close to a green space, but they could be a NbA to reduce risk from heat waves in a city like Abuja, where 55% of the population can benefit from their cooling effects.[127] Climate mobility is likely to contribute to increasingly dense settlements, leading to a loss of green spaces that makes settlements more vulnerable to urban heat island effects.[127,128] Cities urgently need information on settlement density to avoid the current high risk of locking in infrastructure that is vulnerable, as infrastructure can last for decades and be extremely costly to change.

Priority 5: Risk from responses and maladaptation

A better understanding of the nature of mobility will clarify current challenges to understanding maladaptation: whether it is proactive and planned or reactive in response to a particular climate hazard occurrence and what that means in relation to exposure to new risks and the potential for maladaptation at the destination. Focusing on the roles of social and human capital and other assets in shaping decisions to move or stay will be important for future research to elaborate the social dimensions of risk[73] as well as their potential role in determining the choice of destination and the level of resilience that ensues.[129,130] For example, the long-term development of social networks between migrants and non-migrants through trade and seasonal grazing migration enhances the adaptation of West African Fulbe herders responding to drought.[131] Doing so can highlight the differentiation of risks that are faced by newly arriving migrants, such as marginalization, compared with those faced by residents already living in destinations. The relation between conflict and mobility in the context of climate change requires further investigation and could deepen our understanding of how to avoid maladaptation, both for mobility as a result of conflict due to climate impacts as well as for conflict as a consequence of climate mobility.[61,132,133] Research on these issues will provide critical insights to inform efforts to prevent cascading vulnerabilities across different groups because of climate mobility.

Recent advancements in climate mobility modeling are seeking to better quantify how many people are likely to migrate in response to increasing exposure, including to flooding, extreme heat, and disease.[12,27,134] For example, as populations leave Africa's rain-fed lowlands and some highland areas may become relatively more attractive in the near term, it will be increasingly important to consider how a wider range of climate impacts will affect these areas, with consequences for climate mobility and human well-being.[12] For example, tens of millions more people are projected to be exposed to malaria in east and southern Africa as the *Anopheles* mosquito is projected to expand into higher altitudes with further climate change, which may overlap with rain-fed agriculture areas.[135,136] Extreme responses to climate change, such as solar radiation management (also known as solar geoengineering) could also redistribute malaria risk in developing countries, altering geographies of risk for mobility and immobility and highlighting how broader responses to climate change can increase mobility-related climate risk.[137,138] We need substantial cross- and interdisciplinary collaboration to understand these kinds of exposure and mobility-related risks at specific locations. Further, more actionable progress in this area requires the synthesis of currently disparate social, environmental, and climate data and research focus on dynamic movements of people beyond the number of people exposed to a climate hazard at a particular place.

Complementing large quantitative synthesis efforts, progress can also be made through a finer-grain understanding of whether and when mobility is most usefully viewed as an adaptation option as such and/or as the first of a series of adaptations that might be needed following arrival in a destination. This will help unravel whether mobility itself might be maladaptive or whether the maladaptation or enhanced exposure to new risks (climatic or non-climatic) may result from conditions in the destination or origin. Focusing on contexts of repeated or protracted displacement where livelihoods are constantly shifting[139] and where mobility can erode particular rights will also help to clarify current knowledge gaps on habitability[140–142] and hard and soft limits to adaptation.[18,85,143] This will also improve our understanding of the feasibility of certain livelihoods, such as pastoralism in the Sahel, at specific global warming levels, such as at 1.5°C or 2°C as per the Paris Agreement targets.[144]

Priority 6: Public understanding of climate risk

A focus on how people weigh harms and benefits when they make decisions about mobility and immobility can be one way to support agency and choice. Effective adaptation requires knowledge of current and future climate-related risks to be built into development planning at all levels of society.[52,145] For example, a recent study of migration intentions of urban populations in three Asian cities revealed that people were more likely to move because of heat stress.[146] Boosting general awareness of climate change and climate risks, together with access to localized climate information, holds the potential to help people make better decisions on how to cope and adapt, including by moving, either temporarily or permanently[12,35] (Figure 3).

In the context of climate change response, choices to move or stay are informed by many conditioning factors, including perception of climatic changes, climate literacy, and climate information. Figure 3 highlights the importance of future research targeting the relationship between informed choice, adaptation, and mobility outcomes. Reactive coping responses to climate change can be insufficient, unsustainable, or maladaptive.[32,48,85] The IPCC AR6 assesses that adaptation outcomes improve with the degree of choice and agency under which migration decisions are made.[2,33,35] Boosting climate literacy and increasing early warning systems and climate information can support adaptation through enhancing public understanding of risk,[35,70] but we know very little about the behavioral and psychological factors and capabilities necessary for this knowledge-to-action relationship in the context of climate mobility and adaptation more generally.

To translate recent progress in these areas of research into scalable policy, research needs to build empirical evidence and theoretical elaboration on the relationship between climate literacy and climate information on the one hand and mobility-related adaptation opportunities, choices, and feasibility on the other.[147–149] Complementing this progress, research needs to elaborate and clarify how climate literacy and climate information services can best work together across different groups and contexts, including integration of diverse knowledge systems, for hard-to-reach and vulnerable groups.

Priority 7: Transboundary, compound, and cascading risks

Adapting to transboundary, compound, and cascading risks requires capabilities that go beyond a single place or group of actors to include transboundary solutions to climate risk as well as the capability to manage cascading effects across multiple sectors.[85,90] To inform adaptation planning for transboundary, compound, and cascading risks at all levels, we need to explore the limits that are imposed on the potential of mobility for adaptation by overexposure at one or both sites of migrants' origin and destination and by disrupted mobilities of people, finances,

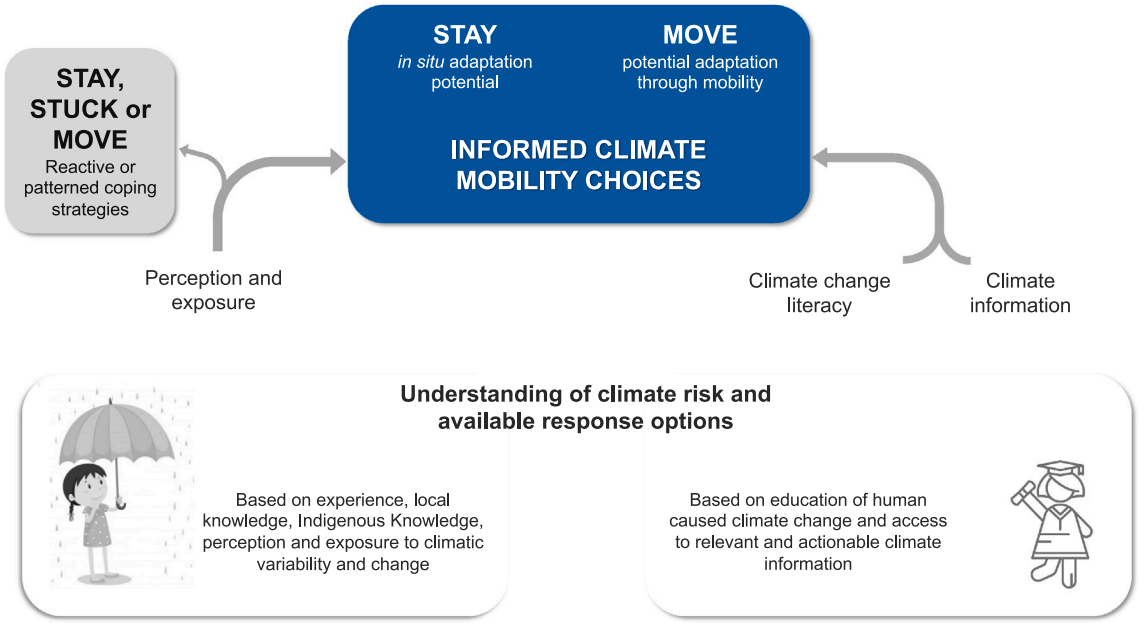

Figure 3. Public understanding of climate risk and its effect on adaptation through decisions to move or stay
This was elaborated by the authors from Figure 9.11a in Chapter 9: Africa of AR6 Working Group II, with detail on the relationship between climate mobility and public understanding of climate risk and response described in the assessment and the literature[35,70]).

and goods.[18] Collaborative and transboundary strategies can mitigate the risks and harness the benefits of increased mobility and connectivity.[35,150] To be protective, investments must be risk informed and anticipatory, considering how actions and impacts in one place might affect another place.[35,151] Shared resources, such as Africa's 60 international or shared river basins, open communities and countries up to transboundary climate risks but also offset risks or create potential for common benefits, such as hydroelectric power generation and regional food security.[35] The next generation of research on transboundary, compound, and cascading risks needs to conceptualize the governing of flows of people, water, income, technology, energy, food, vaccines, data, livestock, and other in relation to climate mobility and within broader adaptation thinking and policies.

Priority 8: Nature-based approaches

NbAs for climate change adaptation can reduce a range of climate risks to people, biodiversity, and ecosystem services with multiple co-benefits, including for mitigation and development in line with CRD.[152] By reducing exposure and vulnerability to climate change impacts, NbAs can influence climate mobility decisions and actions. This includes by changing ecosystem and livelihood conditions and through building adaptive capacity for those living in receiving and sending environments as well as for those on the move.[2,35] NbAs for agriculture, such as conservation agricultural practices introduced in farming systems, can reduce the degree to which people are affected by climate change impacts on agricultural yields.[2] Buffered climate change impacts on yields through NbAs could change how individuals make decisions to leave or stay in an area or even provide opportunities for those who are unable to leave. Thus, research needs to elaborate the role of NbAs in the push and pull factors for climate mobility.[91] A core research focus is to determine and understand the circumstances under which NbAs can support mobility as an adaptation strategy. This is especially important considering the potential interactions between the limits of mobility as adaptation[16,18] and, equally, the limits of NbAs.[93,153]

As with all adaptation options, there are constraints and limits to NbAs as an adaptation option.[1,2] Specifically, we need to know how NbAs and mobility could work together to support climate change adaptation to reduce climate risks for those most vulnerable. For example, NbAs are vulnerable to changes in the climate, and so there are hard physical limits that, when crossed, could make them unviable. For example, restoring coastal ecosystems to protect lives and livelihoods from storm surges and sea level rise has site-specific physical limits, but accelerating temperatures and sea-level rise could restrict NbAs in achieving adaptation benefits for coastal communities when storm surges exceed the moderating effects of ecological infrastructures of coastal ecosystems.[97] In these cases, NbAs as an adaptation option has reached a hard limit. However, to ensure safeguards are in place for those living in areas at high climate risk, research needs to clarify how NbAs and mobility can be mainstreamed together in ways that reduce risk and avoid maladaptation.[91]

We need greater understanding of the role of NbAs (such as conservation agriculture, wetland restoration, or sustainable grazing practices) in influencing immobility and mobility decisions in relation to the full range of rapid or extreme climate change events as well as slow-onset trends from climate change. An understanding of the role of NbAs in reducing climate risk considering the full translocal nature of these systems is needed to inform transformative approaches for implementation; i.e., how to use NbAs to reduce risk sustainably and equitably across these systems.

We also need special focus on the range of positive, negative, and unintended outcomes of NbAs, such as creating habitats for

disease vectors, loss of livelihoods through regulating resource use, or decreasing security for women. These outcomes influence how people make decisions to move or stay and could support mobility decisions as a form of adaptation. Equity and sustainability imperatives require that NbA research focuses on a more systematic understanding of the conditions that support successful justice in the processes and outcomes of NbAs, including associated nature-based value-added enterprises and employment.[34,64,154]

Anticipating the impacts of climate change on biodiversity and how this might interact with the impact of NbAs on human well-being and ecosystem services is crucial to improve the outcomes of NbAs for mobility. Likewise, anticipating how climate mobility and biodiversity are likely to interact in the future is critical for better understanding risks, improving decision-making, and informing NbAs that are both equitable and sustainable. However, despite the overwhelming consensus that biodiversity loss will likely decrease ecosystem functioning and nature's contributions to people, climate mobility forecasts often ignore how biodiversity will change in the future. Integration between climate mobility and biodiversity forecasts is a critical gap that requires urgent attention.

Urgent research priorities for harnessing NbAs to support positive mobility include (1) developing multioption adaptation strategies that consider the full distribution of limits of NbAs and mobility as adaptation for translocal livelihoods, (2) better integration of social science methods (including ethnographic approaches and Indigenous knowledge and languages) to understand the role of NbAs in translocal (e.g., rural-urban) networks of livelihoods, (3) understanding appropriate forms of finance and how these should be leveraged to support the successful interplay of NbAs and climate mobility to reduce risk, and (4) integrating climate mobility and biodiversity forecasts to understand how impacts of climate change on biodiversity will interact with climate mobility and potentially affect NbAs.

Priority 9: Planned retreat, relocation, and heritage

Understanding how planning and decisions surrounding retreat and relocation can best be made needs research to clarify how power dynamics inherent in land use should be navigated. This will need to bridge equity and justice in theory and in practice and connect near- and long-term actions in pathways of adaptive adjustments within regions of accelerating climate-related coastal risks.[97]

Many harms and benefits from retreat are more intangible and therefore difficult to quantify for decision making. For instance, people have multiple identities and roles, which can intersect to increase stressors and burdens for particular people and communities.[155] They may be more likely to be forced to move, whether through involuntary, mandatory resettlement or degrading livelihoods following disinvestment. Displacement and relocation may, in turn, result in exposure to climate hazards in a new location, insecure and unsafe livelihoods or housing conditions, or social exclusion and collectively increase vulnerability.[97,156,157] The psychosocial impacts of sudden events, such as extreme flooding, droughts, and/or hurricanes and cyclones, that can lead to a sense of lost identity and place and emotional distress are important but rarely assessed dimensions of impacts and risks.[34] Assessment of these intangible aspects, including through decolonized research modes, is critical to enable practice and governance and establish protection for the most vulnerable. When relocations reproduce structures that support current and historical marginalization, such as colonialism, relocation may increase vulnerability.[158]

Risk of displacement from coastal areas will continue to increase, as sea level rise will continue long after emissions of GHGs have stopped.[51,97] The associated increase in frequency of extreme sea level events and exposed population places limits on *in situ* adaptation options and the need for planned relocation or retreat to avoid displacement under stressed conditions.[97,116] Figure 4 highlights some of the multiple factors affecting community vulnerability and responses, such as limited access to institutional resources and finance, and low-income neighborhoods in exposed areas increase the complexity of climate change risk and challenges to mobility-related adaptation.

Research efforts should pay attention to questions of justice, considering improved inclusion in legal and governance processes for mobility support and resettlement, ethical evaluations, and an understanding of the losses and damages that resettlement may entail and how to compensate and assist populations in managing these transitions.[159,160] This is particularly important in the context of small island nations and low-lying countries, which face unprecedented adaptation challenges associated with the existential threat of sea level rise.[36,115,161] Small islands may no longer have access to their territory due to sea level rise, coastal erosion, salinization, and intensifying and repeated storms.[162] Approaches to adaptation and mobility for small island nations therefore cannot be constrained by outdated sovereignty norms, such as those encoded in the 1982 Law of the Sea Convention, which did not consider sea level rise.[163] Some Pacific governments have adopted national guidelines on internal displacement and planned relocations.[164] Beyond challenges of relocation, they face the need to preserve statehood, sovereignty, heritage, and territorial integrity amid challenges to the permanence of maritime limits and boundaries as well as protection of human rights.[161] This has become particularly evident since the world's first migration pact between Australia and the low-lying atoll county of Tuvalu, which could see 280 people per year given a "special mobility pathway" to "live, work and study" in Australia.[165] While the pact is ostensibly based on Tuvalu's climate change risk associated with sea level rise and the determination of Tuvalu to preserve their culture, heritage, and nationhood, in return, Australia will have effective veto power over Tuvalu's security arrangements with any other country. We currently have little understanding of how this can be done with dignity, avoiding maladaptation, or how it will play out at the household or island level, demanding urgent research attention. For island atoll countries and communities located in low-lying coastal areas, we also need to map absolute or shifting social baselines on the tolerability of loss, particularly for the intangible and place-specific experiences, such as Indigenous knowledge and languages,[102] and how policies and contested political narratives of "migration in dignity" or "stay and fight" affect related mobility outcomes over time.[10]

Improved social science approaches can help deliver more inclusive research agendas and deepen our currently limited understanding of how mobility-related adaptation affects and is affected by heritage.[10,102,166] Future research needs to show

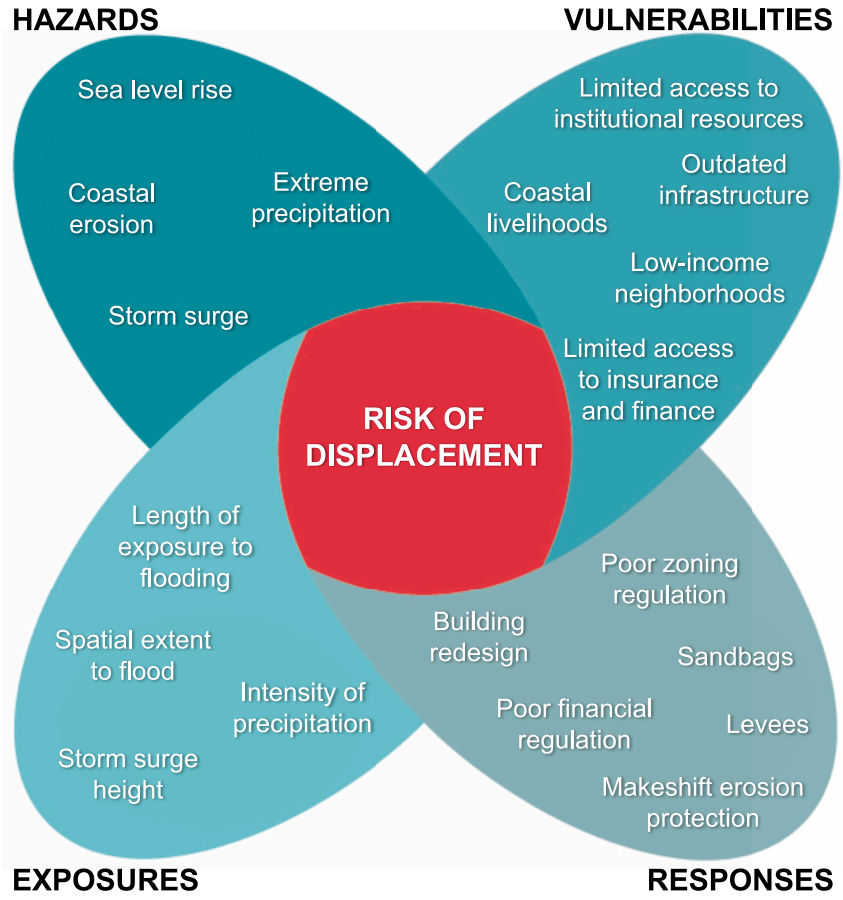

Figure 4. Risk of displacement from coastal compound storm surge, extreme precipitation, and riparian flooding

This was elaborated by the authors from Figure 1.5c in Chapter 1: Point of Departure and Key Concepts of the AR6 Working Group II, with detail on risk of displacement as an important dimension of climate mobility[67,97,116]).

how mobility can contribute to maintaining living heritage values. Current actions can undermine heritage value, such as existing conservation ethics and management that exclude local inhabitants from their social space, heritage, and policymaking through eviction, displacement, and gentrification, increasing the loss of their livelihoods and intangible values and decreasing their adaptive capacity to climate change.[167,168] Progress in understanding the heritage dimension of mobility will help address the need to deepen our understanding of the multifaceted, subjective, and affective aspects of movements.[10]

CONCLUSIONS

The topics and research questions above point to the breadth of issues that engage with climate mobility and the specific knowledge gaps for each. In the last decade, there has been a shift across research and policy toward recognizing mobility as an opportunity rather than a problem, but major gaps remain concerning the nine priorities established above. We now draw out more generalized and cross-cutting issues that underpin these questions and point to a way forward that should be foundational to all research on climate mobility.

Climate mobility has too often been portrayed as a one-dimensional story of "refugees" and "waves of migrants" forcibly displaced in the billions, with a disproportionate emphasis on cross-border mobility.[8,169,170] Greater attention is needed to understand the simultaneous losses and benefits that both mobility and *in situ* adaptation can create.[171] Future research needs to focus on how adaptation support for climate mobility can advance the objectives of SDG 16 "peaceful societies" to address the nexus with peacebuilding, building social cohesion and preventing conflict.[172,173] Perceptions of migrants and the framing of policy discussions in receiving communities and nations are important determinants of the future success of migration as an adaptive response to climate change.[174,175] Racialized framing and unjust logic around climate mobility may also generate spurious links between climate mobility and national security.[176–179] Focusing on the role of borders as an explicit object of inquiry in climate mobility research will be instructive in this area, particularly across diverse responses to mobility and climate change, including hardening of borders, loss of territory, and traditional patterns of cross-border mobility.[11] More progressive policy responses abound, which demand attention. Through natural resource sharing, conflict-sensitive adaptation, and climate-resilient peacebuilding, environmental peacebuilding can offer promising avenues for addressing conflict risk.[33,180,181] Future research needs to draw on these approaches and provide critical perspectives on the climate-mobility-conflict nexus, particularly for conflict-sensitive adaptation, sustainable and environmental peacebuilding, as well as economic and non-economic loss and damage. Rights-based approaches hold potential to reframe climate mobility. They prompt responsibility and obligation from the state toward those who are moving within or across borders, ensuring their human rights are met and bring an obligation to support mitigation and adaptation.[172,182] Fundamentally, research needs to prioritize the needs of migrants and their safety, including when mobility does not follow available legal routes.

Understanding how social protection can support migrants as they adapt to climate change and other shocks and stressors will be critical.[62] Social protection options are needed that support long-term adaptation and that build resilience to future shocks while also tackling the structural causes of vulnerability.[183] Research is needed on the types of social protections, such as unemployment and health insurance and financial transfers, that can support better outcomes for both migrants and those left behind. Such progress would align strongly with the need to integrate adaptation and development planning as well as

overcome individualization of responsibility to adapt to climate change under contexts of policy inaction on climate mobility.[22] A critical question, underscored by experiences during the coronavirus disease 2019 (COVID-19) pandemic, is how such protections can be extended to informal sectors.[184]

Most estimates of current and future climate-related mobility suggest that climate mobility will take place predominantly within countries.[12,27] However, we have almost no knowledge to what degree, and in what cases, increased internal migration might translate into international migration as well. Further, policies that influence or reduce the rate or concentration of mobility have been less explored in the climate context.

We need to develop effective and better ways to assess the outcomes of mobility. It would be misleading to conflate different dimensions and scales into one-dimensional statements on the success or failure of mobility. A realistic assessment of migration success requires the consideration of key dimensions, such as social, economic, ecological, and health,[69] at multiple spatial, temporal, and social scales.[16] With such a differentiation, serious conflation can be avoided; for example, generalizing migration outcomes without considering differences between economic and ecological dimensions or focusing too much on short-term benefits without considering long-term demographic or ecological trade-offs, which could increase vulnerability or lead to maladaptation.[16]

Understanding climate mobility in relation to climate change responses will be a particularly important advance in our understanding of how diverse responses to climate change affect mobility outcomes (Figure 1). It will be increasingly important to integrate ecological responses to climate change and socioeconomic processes with emerging understanding of climate mobility and risk; for example, how ecosystems might respond to an early spring event and its effect on provisioning of ecosystem goods and services for mobility.[185,186] While the literature to date has focused on adaptation-related dimensions of climate mobility, there is increasing evidence of mobility because of other responses to climate change, including GHG mitigation policies. For example, under rapid energy transitions, place attachment, resistance, and migration away from communities experiencing decline due to coal industry closure could be an increasingly important dimension of climate mobility that needs to be understood together with changes in climate hazards, exposure, vulnerability, and adaptation responses.[187,188]

It is also important to consider the often different outcomes of mobility on places of origin and destination; on a household level, they are frequently entangled through translocal connections between migrants and their families or household members at places of origin.[171,189,190] To do so, future research needs to emphasize freedom of movement and overcome sedentary biases that focuses on preventing migration.[191,192] As climate mobility can replace one form of precarity with another, greater nuance is needed to recognize mobility and *in situ* adaptation that can both create simultaneous harms and benefits.

Finally, as an interdisciplinary field, there is a risk that climate mobility research overlooks disciplinary expertise. Across the research priorities identified here, research, policy, and practice need to overcome disciplinary, ideological, and geographical research challenges that capture mobility research. A major research question for climate mobility is therefore to distinguish in what ways climate mobility is or is not distinct from other types of mobility and to what degree and in which cases climate change is influencing existing or creating new mobilities. Importantly, this includes developing a praxis of climate mobility through which meaningful changes that improve outcomes for migrants are brought to the forefront. Acknowledging the unequal power dynamics that underpin the relationships of researchers and migrants, especially as they relate to ongoing colonialism and Global South-Global North inequities,[105,166,193] as well as emphasizing the value of lived experiences, informed consent, and engagement of marginalized communities,[194] can help ensure that greater benefits accrue and facilitate actionable solutions for the most marginalized households and communities. Furthermore, theoretical development and empirical exploration can iteratively respond to emerging practices of climate mobility through developing policy-relevant science that informs interventions while emerging research questions are reflexively informed by practice.

EXPERIMENTAL PROCEDURES

Resource availability

Lead contact

Further information and requests for resources should be directed to and will be fulfilled by the corresponding author, Nicholas P. Simpson (nick.simpson@uct.ac.za).

Materials availability

This study did not generate new unique materials beyond those listed in the supplemental tables.

Data and code availability

This study did not generate or analyze datasets or code.

Methods

Analysis of the three working group reports[1,2,33–38,195] and synthesis report[51] of the IPCC AR6 text was done with NVivo12, exploring where and when reference was made to mobility, migration, and displacement of human populations. The key messages on climate mobility are reported in Box 1 (concerning adaptation, adaptation limits, and maladaptation) and in Table S1 (concerning impacts, projected risks, and vulnerability). After this, an exploratory review of climate mobility in the peer-reviewed literature since 2015, searched for by ["climat* change" AND "x"], explored each of the following descriptors of interaction linked with climate mobility associated with climate change: "mobility," "migrat*," "relocation," "immobility," "retreat," and "displacement." The search began with the first five pages of Google Scholar and then took a snowball approach, exploring the citing articles identified. The search aimed to gain a view on the breadth of the literature and framing of climate mobility rather than a systematic review of all published material. Supplementary literature identified by the authors were also included where remaining gaps or emerging scholarships were identified. The gathered literature was then explored for common themes, disciplinary approaches, diversity of methods, common challenges, and emerging and promising directions to inform synthesis with the IPCC assessment and identify research priorities for climate mobility.

SUPPLEMENTAL INFORMATION

Supplemental information can be found online at https://doi.org/10.1016/j.oneear.2024.02.002.

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AUTHOR CONTRIBUTIONS

N.P.S. conceptualized the paper and led writing. K.J.M., M.G.L.T., E.A.G., A.R.S., B.A., P.H., C.S., and L.C.S. helped conceptualize the paper and revise it for initial submission. S.S., H.S., P.A.W., A.L.S.M., G.C., A.N., K.A., S.R., and C.H.T. contributed specific content relevant to their expertise. N.P.S., K.J.M., M.G.L.T., E.A.G., A.R.S., B.A., P.H., C.S., G.C., and L.C.S. helped revise the paper. All authors reviewed and approved the final manuscript.

DECLARATION OF INTERESTS

The authors declare no competing interests.

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