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ADVANCED REVIEW

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Climate change and migration: A review and new framework for analysis

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Abstract

This article presents a new interpretive framework for understanding the implications of climate change for migration, and reviews and reflects on existing evidence and research gaps in light of this framework. Most existing climate-migration research is heavily environment-centric, even when acknowledging the importance of contextual or intervening factors. In contrast, the framework proposed here considers five different pathways through which climate change is affecting, or might affect, migration: short-term shocks, long-term climatic and related changes, environmental "pull" factors, climate adaptation and mitigation measures, and perceptions and narratives. In reviewing the existing evidence relating to each of these pathways, the paper finds among other things that short-term shocks may simultaneously increase and reduce migration; that the evidence on long-term trends provides a weak basis for understanding future dynamics; and that more attention needs to be paid to the other three pathways, by researchers and policymakers alike. Overall, the proposed framework and associated evidence review suggest a different and broader understanding of the migration implications of climate change from that outlined in the IPCC's most recent assessment, or in many existing reviews.

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climate change, immobility, migration and displacement

1 | INTRODUCTION

Researchers, policymakers, and mass media have paid a great deal of attention to how climate change may affect migration in recent years, and this will likely be of increasing concern in the coming decades. Yet most existing academic, policy, and media discourse on the subject is heavily environment-centric, even when acknowledging the importance of contextual or intervening factors. The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), for example, devotes a significant part of a 130-page chapter to migration and yet, despite this, and despite a

generally nuanced analysis, focuses almost entirely on migration associated with the environmental impacts of climate change (Intergovernmental Panel on Climate Change (IPCC), 2022, pp. 1041–1170). Most existing reviews of climate-migration linkages, while recognizing the multicausal nature of mobility and the indirect, contextual effects of climate change, likewise focus primarily on environmental impacts of climate-related shocks and changes (Berlemann & Steinhardt, 2017; Hoffmann et al., 2020; Kaczan & Orgill-Meyer, 2020; Maretti et al., 2019; Šedová et al., 2021), as do most critical interrogations of mainstream climate migration discourse, even when they are explicitly critical of its prevailing environment-centrism and eco-determinism (e.g., Bettini, 2017; Boas et al., 2019; Wiegel et al., 2019).

In this article, we adopt a broader and less environment-centric understanding of how climate change might affect migration. We suggest that climate change may affect migration patterns along any of five pathways: (1) through impacts on short-term weather shocks (rapid-onset shocks such as storms and floods, and slow-onset shocks such as droughts); (2) through the impact of greenhouse gas emissions on long-term climatic and/or environmental changes (e.g., increasing average temperatures, changing precipitation and river flows, sea level rise); (3) by contributing to environmental "pull factors" for migration (e.g., to places where agricultural productivity and economic opportunities may increase due to climate change); (4) through impacts of adaptation and mitigation measures and policies in (or partly in) response to climate change (e.g., land acquisitions, dam-building); and (5) through perceptions of and narratives about current and future climate change impacts. We adopt this broader framework on the basis that climate change is a global socio-ecological and not just environmental problem (Selby et al., 2022; Sultana, 2021) and in light of the well-established fact that migration patterns cannot be explained by "push factors" alone, and certainly not just environmental push factors (Black, Adger, et al., 2011; Flahaux & De Haas, 2016; Obokata et al., 2014), alongside the recognition that climate-related migration, as well as discourses about and responses to it, are embedded in global, historical and deeply racialized political and economic systems and associated forms of environmental change (Baldwin, 2016; Bettini, 2013; Gonzalez, 2021; Hartmann, 2010; Perry, 2021). Our findings align with other recent reviews that highlight the effects of climate change impacts on both migration pressures and constraints, the nonlinear impacts of climate factors on mobility, and differences in effects of rapid- versus slow-onset shocks (Hoffmann et al., 2020; Kaczan & Orgill-Meyer, 2020), as well as complex dynamics of vulnerability, resilience, and adaptation (Kaczan & Orgill-Meyer, 2020; Maretti et al., 2019; Nabong et al., 2023). However, while some have noted the role of perceptions and emotions (Hoffmann et al., 2020; Nabong et al., 2023) and of "green"' infrastructure development (Miller & Vu, 2021), existing reviews have paid little attention to the implications of "pull" factors, adaptation and mitigation interventions, and perceptions and narratives in analyzing climate change's broader implications for migration.

We use this framework to review, evaluate, and identify strengths, weaknesses, and gaps in existing expert literature on climate change and migration, considering each hypothetical pathway in turn. We draw upon a wide range of evidence, including quantitative, qualitative, and mixed methods research, and evidence on past, present, and projected future impacts of climate change on migration and the size, consistency, and strength of the body of evidence for each set of findings. We also examine and provide qualitative evaluations of widely used global estimates and projections of climate-related migration. We do this partly to provide an accessible summary of evidence for readers, but also to identify evidence gaps and misrepresentations, and to suggest priorities for future research. Our analysis builds upon a fuller evidence assessment produced in 2021 for the UK Foreign Commonwealth and Development Office (Selby & Daoust, 2021). That assessment identified approximately 650 studies relating to climate change and migration, of which over 270 were subsequently coded and analyzed using the above framework (not all of which are cited in this article). This review focused on English-language academic journal articles and expert studies by research, development, and non-governmental organizations published since 2005. Literature was identified through searches of electronic academic and open-source databases, including academic databases covering natural and social sciences disciplines (e.g., ScienceDirect, Web of Science), migration- and development-focused databases (e.g., 3ie, Climig), and web repositories of climate change, migration, and development organizations (e.g., development banks, UN agencies, research institutes). Searches were conducted first using the keywords "migration" and "climate change" and synonyms thereof and subsequently using the keywords "migration" (and synonyms) and specific climate change-related environmental, economic, and political developments (e.g., "drought", "adaptation"). Here, we summarize key thematic findings from this review and update findings to incorporate some recently published work. Information about our review methodology (including search strategies, inclusion/exclusion criteria, and limitations) and other key findings (on specific regions and on the social profile of and barriers to climate-related migration) are available in the full assessment report.

Before proceeding, three important qualifications about our framework are required. First, our five climate change-migration pathways are associated with very different types and volumes of evidence, which results in some unevenness in our discussion below. However, this unevenness is in our view an unavoidable function of both the nature of the

pathways themselves and the existing evidence thereon, and helps to draw attention to current research gaps—and hence we have intentionally opted not to try to smooth this unevenness away. Second, while we use the language of "push" and "pull" factors in this review, we acknowledge the critiques of "push–pull" accounts of migration for their tendency to portray migrants are being passively "pushed" and "pulled" by external forces while paying insufficient attention to the influence of people's aspirations and capabilities on mobility (De Haas, 2021; Flahaux & De Haas, 2016). And third, given space constraints, we do not discuss in the below complex ways in which social structures and associated inequalities—along lines of gender, age, income/wealth, household structure, educational levels, occupation type, and more—shape vulnerabilities to climate-related changes and patterns of mobility and migration. Evidence on these crucial issues is reviewed in Selby and Daoust (2021) and elsewhere (Kaczan & Orgill-Meyer, 2020).

2 | SHORT-TERM SHOCKS

Most existing research on climate-migration linkages focuses on short-term shock events, especially storms, floods, droughts, and short-term fluctuations in temperature and precipitation. Across these different types, findings are mixed and in some cases contradictory, with evidence indicating that shocks may be associated with increased migration in some contexts (or for some social groups) but decreased migration in (or for) others. Thus, flooding (Beine & Parsons, 2015; Kakinuma et al., 2020; Robalino et al., 2015; Wesselbaum, 2019), storms (Berlemann & Tran, 2021; Pajaron & Vasquez, 2020; Spencer & Urquhart, 2018), droughts (Baez et al., 2017; Defrance et al., 2022; Fishman & Li, 2022; Murray-Tortarolo & Salgado, 2021), positive and/or negative temperature fluctuations and extremes (Baronchelli & Ricciuti, 2022; Bohra-Mishra et al., 2017; Cai et al., 2016; Call et al., 2017; Call & Gray, 2020; Falco et al., 2019; Mueller et al., 2014; Thiede et al., 2016; Wesselbaum, 2019), and precipitation fluctuations (Coniglio & Pesce, 2015; Cottier & Salehyan, 2021; Leyk et al., 2017; Nawrotzki & Bakhtsiyarava, 2017; Nguyen, 2021) have each been associated in multiple studies with increased migration and displacement. Climate-related shocks may have a delayed impact on migration decisions, with studies showing that the effects of storms (Pajaron & Vasquez, 2020; Spencer & Urquhart, 2018) and rainfall fluctuations (Hunter et al., 2013; Thiede et al., 2016) on migration is lagged (e.g., increasing one or two years later). Yet flooding (Call et al., 2017; Chen et al., 2017; Chen & Mueller, 2019; Ocello et al., 2015), droughts (Cottier & Salehyan, 2021; Ocello et al., 2015; Quiñones et al., 2021) and temperature (Beine & Parsons, 2017; Mueller et al., 2020; Nawrotzki & Bakhtsiyarava, 2017; Nguyen, 2021) and precipitation fluctuations (Beine & Parsons, 2015; Call et al., 2017; Call & Gray, 2020; Thiede et al., 2016) have also each been found to be associated with decreased migration. Other studies have found no, insignificant, or inconsistent migration effects from flooding (Bohra-Mishra et al., 2014; Gray & Mueller, 2012; Mueller et al., 2014), storms (Loebach, 2016; Wesselbaum, 2019), droughts (Owain & Maslin, 2018; Selby, 2019), and precipitation fluctuations (Bohra-Mishra et al., 2017; De Longueville et al., 2019; Grace et al., 2018; Gray & Wise, 2016; Mueller et al., 2020). The evidence here supports the IPCC's "high confidence" observation that "climate-related migration outcomes are diverse ... and may be manifest as decreases or increases in migration flows" (IPCC, 2022, p. 1079).

Several contradictory processes are evidently at work. On the one hand, climatic shocks can contribute to displacement and migration pressures through the destruction and losses they inflict on property, livelihoods, income, food security, and infrastructures and services. This has been demonstrated in relation to flooding and storms (Bohra-Mishra et al., 2017; Pajaron & Vasquez, 2020; Spencer & Urquhart, 2018; Trinh et al., 2021) and short-term temperature and precipitation fluctuations (Baronchelli & Ricciuti, 2022; Bohra-Mishra et al., 2017; Call & Gray, 2020; De Longueville et al., 2019; Leyk et al., 2017; Mueller et al., 2014; Nawrotzki & Bakhtsiyarava, 2017; Nguyen, 2021). Yet in different contexts, or simultaneously, shocks may reduce migration capacities by depleting household resources, leaving people unable to move and "trapped" in circumstances of extreme environmental vulnerability (Black et al., 2013; Zickgraf, 2019). This phenomenon has been documented extensively, including in relation to flooding (Chen et al., 2017; Chen & Mueller, 2019; Ocello et al., 2015), storms (Pajaron & Vasquez, 2020; Robalino et al., 2015), drought (Quiñones et al., 2021), and temperature and precipitation fluctuations (Beine & Parsons, 2017; Nawrotzki & Bakhtsiyarava, 2017; Nguyen, 2021). In addition, in some cases, excess rainfall may beneficially affect agricultural production and related labor needs, employment, and income, thus reducing migration pressures (Call & Gray, 2020; Mueller et al., 2020; Nguyen, 2021), while in other contexts higher rainfall has been found to increase household income and thus provide resources to support migration (Abel et al., 2022; Cottier & Salehyan, 2021).

Whether shocks increase or decrease migration is affected by a range of shock- and context-specific factors. Shock intensity is one, albeit with mixed findings: studies have found, for instance, that high-intensity floods and storms are

associated with decreased migration, but lower-intensity ones with increased migration (Pajaron & Vasquez, 2020; Robalino et al., 2015), although others find that effects on migration are strongest for more severe storms (Berlemann & Tran, 2021). Shock duration is another: there is evidence, for instance, that hot spells may be associated with reduced migration initially, but increased migration as above-average temperatures continue (Nawrotzki et al., 2017; Nawrotzki & DeWaard, 2016), while other evidence suggests that droughts, as slow-onset shocks, are more associated with increased migration than rapid-onset shocks such as storms or floods (Baez et al., 2017; Kaczan & Orgill-Meyer, 2020). The precise timing of weather anomalies matters too: rainfall shocks before or during planting and growing seasons appear to have the strongest impacts on migration (Baronchelli & Ricciuti, 2022; Fishman & Li, 2022; Nawrotzki et al., 2013; Nawrotzki & Bakhtsiyarava, 2017). Shock frequency is also a factor, albeit a contradictory one: evidence suggests, for instance, that repeat shocks can variously increase migration pressures (Dun, 2011), reduce migration capacities (Pajaron & Vasquez, 2020), or be adapted to, as households stop perceiving them as shocks (Chen et al., 2017). In some contexts, shocks may bring benefits: for instance, flooding may be associated with improved soil quality and cultivation, and in turn with reduced migration given the advantages of staying in place (Chen et al., 2017; Chen & Mueller, 2019; Lewin et al., 2012). In addition, shock impacts are significantly shaped by socio-economic factors. Most notably, there is strong evidence that shocks are most clearly associated with migration in countries, regions, and communities with higher reliance on agricultural production and incomes (Beine & Parsons, 2015; Cai et al., 2016; Coniglio & Pesce, 2015; Hoffmann et al., 2020; Nawrotzki & Bakhtsiyarava, 2017; Wesselbaum, 2019); and in rural as against urban areas (Murray-Tortarolo & Salgado, 2021; Nawrotzki, Hunter, et al., 2015). In contrast, evidence on the impact of income is contradictory: some studies find a stronger shock-migration relationship in low-income countries and regions (Choksi et al., 2021; Defrance et al., 2022; Falco et al., 2019; Kakinuma et al., 2020), while others find effects to be stronger in middle-income areas, where economic constraints do not affect migration capacities to the same degree (Beine & Parsons, 2017; Delazeri et al., 2022; Hoffmann et al., 2020). The impacts of shocks on migration are also mediated by the presence of infrastructures and services such as irrigation (Benonnier et al., 2022). Finally, migrant or diaspora networks influence shock-related migration decisions and destinations through the provision of information and material support (Dallmann & Millock, 2017; Loebach, 2016), while also reducing migration pressures by supporting in-place adaptation (Afifi et al., 2016; Nawrotzki, Riosmena, et al., 2015).

Adaptation measures and shock responses clearly matter. A large and consistent body of evidence demonstrates that adaptation measures, such as adjustments in crop varieties used and in planting and harvesting dates, increased irrigation, and diversification away from sole reliance on agricultural income as well as embankment or dyke construction can reduce shock-related migration pressures (Biswas & Mallick, 2021; de Longueville et al., 2019; Etzold et al., 2014; Haeffner et al., 2018; Hermans & Garbe, 2019; Williams et al., 2020). At the same time, the implementation of smallholder adaptations (e.g., use of drought-resistant crops or irrigation) can also enable access to the resources needed to migrate (Burnham & Ma, 2018). Evidence also suggests that wealthier households more commonly have alternative sources of income and can thus engage in adaptations in response to, or in anticipation of, shocks (Biswas & Mallick, 2021; Etzold et al., 2014; Haeffner et al., 2018). The presence and quality of shock response systems, most notably emergency shelters and humanitarian relief, may also affect migration impacts (Ingham et al., 2019; Kartiki, 2011).

There is very strong evidence that flooding (Beine & Parsons, 2015; Dun, 2011; Gray & Mueller, 2012), storms (Kartiki, 2011), droughts (Baez et al., 2017; Hermans & Garbe, 2019; Kaczan & Orgill-Meyer, 2020), and short-term weather fluctuations (De Longueville et al., 2019; Gray & Wise, 2016; Hoffmann et al., 2020) matter primarily for internal as against international migration. This internal migration is usually identified as rural-to-urban (Call et al., 2017; Delazeri et al., 2022; Nawrotzki et al., 2017; Sedova & Kalkuhl, 2020; Thiede et al., 2016), though there is some evidence of climatic shocks leading to increased movement between rural areas (Etzold et al., 2014; Maia & Schons, 2020; Nawrotzki et al., 2017). By contrast, the effect of climatic shocks on international migration is either limited (Hoffmann et al., 2020; Kaczan & Orgill-Meyer, 2020) or possibly even negative (Sedova & Kalkuhl, 2020). Most shock-related migration is over short distances (De Longueville et al., 2019; Hermans & Garbe, 2019; Hoffmann et al., 2020) and most shock-related cross-border migration is towards neighboring countries (Beine & Parsons, 2017; Defrance et al., 2022; Radel et al., 2018). Evidence on the duration of shock-related migration is mixed and inconclusive. While multiple studies suggest that it is mainly temporary or short-term (Hoffmann et al., 2020; also Dun, 2011; Kartiki, 2011; Penning-Rowsell et al., 2013), in other studies weather extremes and fluctuations are linked to permanent or long-term migration (Bohra-Mishra et al., 2014; Call & Gray, 2020; Mueller et al., 2014). Part of the problem here is that most literature on shock-related migration does not examine migration duration. It seems likely that these analyses conflate or combine two phenomena: emergency evacuation or displacement (generally local and temporary), and migration in response to shock-related economic impacts (more likely to be extra-local and long-term or permanent).

Despite all this evidence on climate shock-migration, the number of estimates of its scale is relatively small. At a global level, the Internal Displacement Monitoring Centre (IDMC) provides the only known estimates of climate shock-induced migration and displacement. Its most recent report, for example, finds that 31.8 million people were displaced by weather-related disasters in 2022, including 19.2 m by floods, 10 m by storms, 2.2 m by droughts, and 12,000 by extreme temperatures (IDMC, 2023). While these findings are plausible, we wish to stress three things. First, the IDMC's figures are based on compiled governmental, international organization, and media sources characterized by inconsistent (and uncodified) reporting practices. These numbers should thus be treated with extreme caution. Second, as the IDMC periodically acknowledges, much (and even most) of these displacements occur via state-led pre-emptive evacuations and are therefore likely in large measure temporary (IDMC, 2020). And third, IDMC data shows no clear upward trend in displacement due to weather disasters over time. More broadly, a select number of academic studies have used more consistent datasets and rigorous quantitative methods, and on this basis identified associations between climatic shocks and increased migration within specific regions (Dallmann & Millock, 2017; Marchiori et al., 2012; Sedova & Kalkuhl, 2020; Spencer & Urquhart, 2018). However, a recurring limitation of these studies is that there is no way of knowing whether the patterns identified relate to the occurrence of migration or rather to its timing, that is, whether the shocks analyzed were the main causes of migration or whether they were the "straws which broke the camel's back" (Selby, 2014). Overall, neither these studies nor the IDMC's findings clearly substantiate the IPCC's summary claim that "[c]limate hazards are a growing driver of involuntary migration and displacement" (IPCC, 2022, p. 1044).

Paralleling this, there exist few projections of future shock-related migration numbers. Select IDMC reports (Anzellini et al., 2021; Ginnetti & Milano, 2019) and academic studies (Iqbal & Roy, 2015; Kam et al., 2021; Marchiori et al., 2012; Smirnov et al., 2022) do make projections, all projecting increased shock-related migration or displacement—a possibility which is far from implausible. Nonetheless, there are multiple reasons for caution: that the increased migration and displacement projections in these studies are at odds with the lack of clear evidence of equivalent current trends; that judging by current patterns, future shock-related displacement may mostly be in the form of temporary evacuations rather than permanent migration; that a large proportion of increases in displacement projected in such studies are functions of assumed population growth rather than climate change; that there are significant disagreements over attributing shocks to climate change (Hulme, 2014), plus uncertainties over how climate change will affect the incidence and severity of future climatic shocks (IPCC, 2018; Seneviratne et al., 2012); and that such studies typically give no consideration to possible future adaptations. As the authors of one of the above studies observe, their lack of allowance for possible long-term adaptation means that such projections "likely exaggerate the effects of future weather changes" on agricultural returns and in turn migration (Iqbal & Roy, 2015, p. 20).

3 | LONG-TERM CLIMATIC AND RELATED CHANGES

In contrast to short-term shocks, evidence on the effects of long-term climatic and related changes on migration is very limited. A small number of studies suggest that long-term warming (Cattaneo & Peri, 2016) and precipitation declines (Barrios et al., 2006; Beine & Parsons, 2015; Weinreb et al., 2020) can be linked to increased internal and international migration, though there is also evidence of warming having a negative effect on migration levels in some contexts (Cattaneo & Peri, 2016). Beyond this, however, there is no clear evidence. Research on links between glacier retreat and migration has reported no significant effects (Kaenzig, 2015). There is not yet evidence of the impacts of climate change-related sea level rise on migration levels. In addition, we are aware of no estimates of existing migration or displacement levels associated with these or other long-term climatic changes.

To be sure, there is extensive evidence of how coastal hazards, including flooding, erosion, and salinization, might influence internal migration pressures through impacts on infrastructure, property, agricultural production, income, and health (Chen & Mueller, 2018, 2019; Codjoe et al., 2017; Rakib et al., 2019; van der Geest et al., 2020). However, most such studies tend not to show whether such hazards are associated with changes (increases or decreases) in overall migration. It is clear that migration pressures arising from coastal hazards can be allayed by in-place adaptations such as coastal protection (e.g., seawalls, vegetation) and flood protection measures (e.g., floodgates, dykes), improvements to housing and public infrastructures, and changes to agricultural practices (Buchori et al., 2018; Buchori et al., 2021; Farbotko, 2022; Jamero et al., 2017; McMichael et al., 2021; Williams et al., 2020). Moreover, coastal hazards are typically not solely or clearly attributable to warming-induced sea level rise. In Bangladesh, for example, though increased soil salinity has been linked to higher internal migration (as well as lower migration in circumstances of

extreme salinization), increased soil salinity may itself be linked to land use changes, land subsidence, changes in river flow, deforestation, and groundwater depletion, among other factors, as well as sea level rise (Chen & Mueller, 2018, 2019). The question of how long-term climate and related changes might affect migration is thus fraught with methodological difficulties, with any evidence of impacts (such as they exist) typically obscured by contextual factors and short-term fluctuations and mediated by socio-economic differences and adaptation practices.

Contrasting this small body of evidence on existing impacts, numerous studies make projections about future long-term climatic and related pressures on migration, with most finding that tens or hundreds of millions may be displaced. Studies of exposure to climate change-induced sea level rise typically project exposure of between 150 and 400 million people globally this century or earlier (Hinkel et al., 2013; Kulp & Strauss, 2019; Neumann et al., 2015), although other studies suggest lower figures (Dasgupta et al., 2007). Building on such findings, others offer projections of sea level rise-induced migration on global (Burzyński et al., 2021; Lincke & Hinkel, 2021; Nicholls et al., 2011) and regional (Bell et al., 2021; Davis et al., 2018; Milan et al., 2016; Oakes et al., 2016) scales. High-end global estimates ranging from 70 million (Lincke & Hinkel, 2021) to as many as 187 million by 2100 (Nicholls et al., 2011). Still other studies present global (Chen & Caldeira, 2020; Missirian & Schlenker, 2017; Xu et al., 2020) and country-level (Barbieri et al., 2010; Oliveira & Pereda, 2020) projections of the migration impacts of long-term warming, finding in the extreme that 4.9 billion (Chen & Caldeira, 2020) and 3.5 billion (Xu et al., 2020) people globally may face migration pressures related to warming by the end of the 21st century. And most prominently, the World Bank's *Groundswell* report offers projections for internal migration arising from the combination of three slow-onset climate impacts (water stress, crop yield declines, sea level rise) in Sub-Saharan Africa, Latin America, and South Asia, finding that up to 143 million people may be displaced within these three regions alone by 2050, accelerating thereafter (Rigaud et al., 2018). The subsequent *Groundswell 2* report offers projections for these same three regions plus East Asia and the Pacific, North Africa, and Eastern Europe and Central Asia, suggesting that up to 216 million people could be displaced across the six regions by 2050 (Clement et al., 2021).

Yet there are numerous problems with such findings, and in our assessment, none can inform a sound understanding of the future scale or dynamics of climate-related migration. Such projections are mostly undertaken by earth scientists, modeling future exposure to the impacts of climate change without considering the social or economic dynamics of migration. Such studies also reduce environmental impacts to those arising from climate change. Findings are highly dependent upon the choice of climate scenarios, with different scenarios leading to huge differences in projections. Many of the projected increases in displacement are functions more of assumed population growth than of climate change impacts. Many use questionable data proxies for their projections, for instance basing projected impacts of warming on comparisons of asylum applications from source countries with hotter- or cooler-than-normal average growing season temperatures (Missirian & Schlenker, 2017). Projections also typically rely upon arbitrary and naturalistic assumptions about "the optimal temperature range for agriculture" (Missirian & Schlenker, 2017) or climatic limits to human habitation (Xu et al., 2020), which are held to drive migration. They typically fail to consider or allow for future adaptations to long-term climate change-induced changes ("there is a striking lack of realized adaptation in most regions", claims one study: Xu et al., 2020), despite the extensive evidence of in-place adaptations to short-term shocks, as discussed above, and although approximately 100 million people already live below the high-tide line (Kulp & Strauss, 2019). Illustrative of the significance of this, and as a partial exception, is a study by Nicholls et al. (2011), which suggests that while 72–187 million people may be displaced by sea level rise this century, the integration of two adaptation measures (dyke construction and beach replenishment) into their model causes these numbers drop to between 41,000 and 305,000: even under the most pessimistic climate scenario "the problem of environmental refugees almost disappears" with these two adaptations (p. 173). Future technological and economic changes are typically excluded from climate migration projections too. Projection studies also typically make no allowance for the impacts of environmental shocks and changes on migration capacities, despite the extensive evidence to this effect, as detailed above (one recent exception projects decreased migration among the world's lowest-income populations due to resource constraints caused by global warming: Benveniste et al., 2022). The standard findings of such studies are also at variance with the absence of clear evidence of equivalent present-day trends.

As others have also concluded, climate science and earth systems models and projections have dominated existing analyses of the implications of long-term climatic and related changes for migration (Gemenne, 2011; Jakobeit & Methmann, 2012; McMichael et al., 2020). And, due to their failure to integrate technological and economic developments, adaptation processes, other nonclimate change-induced environmental changes, or the more sociological dimensions of migration, and their overall climate-centrism (Hulme, 2011), they do not provide sound insights into the likely future scale or mechanisms of climate-related migration.

4 | ENVIRONMENTAL PULL FACTORS

Research on (primarily internal) migration has long pointed to the role of environmental preferences in informing migration decisions and destinations, including preferences for more "pleasant" climates and favorable environmental conditions that function as "pull" factors (Piguet, 2013; Svart, 1976). However, among our five hypothesized pathways, environmental pull factors have received the least attention in research on climate change and migration. Although a small body of evidence suggests that environmental variables may function as migration-related "pull" factors and that people may move to places with more stable and favorable climatic conditions, these studies do not examine environmental "in-migration" incentives associated with climate change specifically. For example, high-temperature shocks may be associated with movement toward countries with colder temperatures, which may be viewed as more "environmentally safe" (Bakaki, 2021), and when experiencing fluctuations in precipitation and temperature, people may move to areas with lower rainfall variability and lower likelihood of drought (Lewin et al., 2012) or with higher precipitation (Nguyen, 2021), which may present more favorable agricultural production and employment conditions. Some research suggests that in the context of climate-related changes, environmental pull factors, notably more attractive rainfall patterns and fertile land, may be more commonly identified than push factors as reasons for migration (van der Geest, 2011). However, migration and visa policies in destination countries can enable or restrict international migration intentions and decisions (Constable, 2017; Milan et al., 2016; Oakes et al., 2016), including those linked to environmental "pull" factors.

Nonmigration-focused research does support the hypothesis that environmental incentives may be associated with in-migration to areas potentially "benefiting" from climate change (such as increased agricultural productivity associated with projected precipitation increases in arid and semi-arid regions or projected temperature rises in relatively cold and northern regions). For example, concerns about climate change have been motivations for state and corporate purchases of land in regions of relative resource abundance (Fairhead et al., 2012; Scheidel & Work, 2018). There is also some evidence on "lifestyle migration" by people from higher-income countries and the expansion of related labor (e.g., construction, care, and hospitality) demands motivated in part by climatic considerations (Bahar et al., 2009; Maddison et al., 2013). Such trends could have significant migration implications and point to the need for additional research (though their potential scale is highly uncertain), and we have not identified any specific projections relating to environmental pull factors.

5 | ADAPTATION AND MITIGATION MEASURES

A large body of evidence focusing mainly on relocation and agricultural development projects consistently shows that climate change adaptation initiatives can themselves affect migration. Relocation initiatives introduced as part of climate adaptation programs have been found to involve forced displacement, linked to flood protection (Henrique & Tschakert, 2019; Krishnan, 2022; See & Wilmsen, 2020; Shinn, 2018), coastal defense (Owusu-Daaku, 2018; Warner & Wiegel, 2021) and dam construction (Arnall, 2014; Warner & Wiegel, 2021). Moreover, relocation initiatives may result in further, secondary migration pressures, for instance, linked to conflicts between "relocated" and "host" communities, tensions over land access and ownership, and unequal distributions of relocation benefits and support (Connell & Lutkehaus, 2017; Johnson et al., 2022; Lindegaard, 2020; Mortreux et al., 2018; Nichols, 2019; See & Wilmsen, 2020).

Climate adaptation initiatives involving agricultural development and expansion have been found to lead to displacement and migration via impacts on land, water, and livelihoods. The expansion of irrigated agriculture can undermine local adaptive capacities in dryland areas and intensify migration when grazing land is converted into private farmland (Magnan et al., 2016), and can contribute to migration pressures via overexploitation of water resources and exacerbation of land access inequalities (Adam et al., 2018). Corporate agricultural adaptation interventions have also been found to transfer market and climate risks to small producers, by limiting livelihood diversification and mobility options (Kennedy, 2022). Climate change adaptation initiatives (and narratives) have also been shown to contribute to justifications for land grabbing (or "green grabbing") which in turn lead to pressures for migration (Vigil, 2022). Moreover, in some contexts, climate adaptation initiatives may have more direct impacts on mobility. In Bangladesh, for example, commercial aquaculture projects implemented as a climate adaptation initiative have involved intentional flooding and salinization—or what Paprocki terms "anticipatory ruination"—and a resultant loss of work opportunities, in turn leading to out-migration (Paprocki, 2018, 2019, 2022).

Beyond this direct evidence, there is extensive broader evidence from literature which, while not focused directly on climate-migration linkages, have significant implications for understanding them. A growing literature on "maladaptation" documents negative environmental and social consequences (e.g., intensification of vulnerabilities, undermining of local adaptation mechanisms) resulting from locally and internationally funded adaptation measures such as agricultural expansion, forest protection, flood protection, and hydroelectric dams (Atteridge & Remling, 2018; Eriksen et al., 2021; Magnan et al., 2016). While not on migration specifically, this literature is relevant since the dynamics it describes are often associated with displacement and migration pressures. Studies of large-scale land acquisitions undertaken partly for climate adaptation reasons have parallel implications (Davis et al., 2015; Mazzocchi et al., 2021). In addition, there exists copious historical evidence of displacement arising from the sort of development projects that today are often framed as "climate change adaptation" initiatives: by one estimate, there were some 30–60 million "development refugees" (Scudder, 1993) from dam-building alone over the twentieth century (McCully, 2001). Such evidence suggests that the implications of climate adaptation measures for migration exceed that provided by existing direct evidence.

While there is not yet evidence of any direct impacts from climate change mitigation policies, projects, or investments on migration, paralleling the evidence discussed in the previous paragraph there are good reasons to think that climate mitigation may also have significant migration implications. "Green energy" developments (e.g., wind and solar farms; Achiba, 2019; Dunlap & Arce, 2022; Yenneti et al., 2016) and new forms of extractivism associated with "green" technologies such as lithium mining (Jerez et al., 2021; Liu & Agusdinata, 2020) have both been linked to conflict and negative socio-economic outcomes—and may conceivably, in turn, contribute to migration. Moreover, migration flows have historically been strongly linked to both economic opportunity and economic decline, which by extension suggests that the decarbonization of the global economy may have significant migration consequences. Studies of oil and gas producer regions and states, for example, have documented how increased production and prices have been associated with in-migration, and negative price shocks with out-migration (John, 2018; Snudden, 2018). Though further research is required on this issue, the implications of climate mitigation measures for migration may occur via land purchases associated with renewable power generation, new economic opportunities linked to "green" industrial developments, and in regions supplying minerals for "green" technologies, and reduced economic opportunities in regions and states producing fossil fuels (particularly those heavily reliant on fossil fuel exports and revenues).

6 | PERCEPTIONS AND NARRATIVES

Evidence regarding the relationship between perceptions of weather-related shocks, short-term climatic variations, and longer-term climate-related changes and migration is somewhat mixed. Numerous studies show that perceived (self-reported) impacts of climate-related changes (such as more frequent weather shocks and short- or longer-term changes in temperature or precipitation) can contribute to pressures, decisions, and intentions for migration (Afifi et al., 2016; Alam et al., 2017; Kabir et al., 2017; Koubi, Spilker, et al., 2016; Parsons & Nielsen, 2021; Steimanis et al., 2021; Warner & Afifi, 2014). There is some evidence that perceived climatic shocks (e.g., rainfall fluctuations) influence migration decisions even when *not* aligned with existing climatic data (de Longueville et al., 2020), indicating that perceptions alone can affect migration. And perceptions of future impacts of climate change, notably coastal threats associated with future sea level rise, have also been shown to influence migration intentions (Milan et al., 2016; Oakes et al., 2016; Stojanov et al., 2017). Other studies, however, report that perceived climate-related changes and impacts (Etzold et al., 2014; Goldbach, 2017; Shi et al., 2019) and future sea level changes (Birk & Rasmussen, 2014; Kelman et al., 2017) do not significantly affect migration decisions, or that perceived environmental risks (e.g., changes in drought or flooding severity) negatively affect migration intentions (Adger et al., 2021; Koubi, Stoll, & Spilker, 2016). Context-specific and socio-economic factors affect the extent to which perceptions of climate change influence migration: perceptions of climate impacts and associated migration responses may be more likely among those whose livelihoods are dependent on temperature and rainfall (Koubi, Spilker, et al., 2016; Warner & Afifi, 2014), those with more limited access to water resources and technologies (Parsons & Chann, 2019), and those with access to meteorological and climate-related information (Jha et al., 2018).

There is strong and consistent evidence showing that cultural, ancestral and emotional ties or attachments to place, community connections, and concerns about loss of identity, culture and livelihood often take precedence over perceived climate change impacts and concerns about future climate change (Adams, 2016; Amin et al., 2021; Bhusal et al., 2021; Farbotko, 2022; Kelman et al., 2017; Khanian et al., 2019; McMichael et al., 2021; Piggott-McKellar &

McMichael, 2021; Rabbani et al., 2022). Moreover, there is consistent evidence that people may privilege direct observations and lived experiences over external (e.g., policy, media) information and narratives about climate change effects and "crisis", and may consider migration a last resort, instead prioritizing in-place adaptation (Arnall & Kothari, 2015; Farbotko, 2022; Farbotko & Lazrus, 2012; Kelman et al., 2017; Perumal, 2018; Piggott-McKellar & McMichael, 2021). This evidence suggests that overall, perceptions may negatively affect climate-related migration. This illustrates, as others have suggested, the need for greater attention to voluntary *and* involuntary immobilities in the face of climate change (Boas et al., 2022; Wiegel et al., 2019; Zickgraf, 2021b). Migration *can* be a form of adaptation to climate change impacts, as discussed in literature on "migration as adaptation" (Black, Bennett, et al., 2011; Gemenne & Blocher, 2017), enabling people to diversify economic activities and income and to strengthen resilience to climate-related hazards and changes. However, our review shows extensive evidence that emphasizes economic and noneconomic costs and losses associated with migration, including livelihoods, property, and ties to community, culture, and place. Furthermore, while migration can be an effective adaptation for some, for others it may lead to intensified vulnerabilities, as well as concealing a lack of government investment in climate change adaptation (Vinke et al., 2020).

There is a small body of evidence indicating that narratives about climate change impacts and "climate migration" articulated by local authorities and international actors might themselves contribute to migration pressures. Narratives of "inevitable" climate change impacts have in some cases been used by authorities to justify unpopular relocation initiatives and forced removal (Arnall, 2014; Bertana, 2020; Kothari, 2014; Lindegaard, 2020). Narratives of looming "uninhabitability" may also encourage people to relocate and intensify movements toward urban centers or peripheries, as in contemporary Bangladesh (Paprocki, 2018). Research shows that state-led adaptation initiatives in response to rising sea levels, such as large-scale land purchases intended for future relocation projects, shape public perceptions of future migration by "making migration imaginable" (Hermann & Kempf, 2017). Although the body of evidence on these dynamics is as yet small, they may become significant contributors to migration, especially as evidence—and narratives—relating to climate change impacts and the need for "emergency" adaptation measures deepen.

7 | CONCLUSION

This article summarizes a range of evidence on the migration implications of climate change across five distinct pathways, thus providing a new interpretive framework to inform understanding of the implications of climate change for migration. The largest and strongest body of evidence on climate-migration linkages relates to short-term shocks; however, the evidence on this pathway is mixed, showing that weather-related shocks may contribute to migration pressures and increased migration, while reducing migration capacities in other contexts or conditions. In contrast, the most startling findings are suggested by research on long-term climatic and related changes; this pathway potentially has the most significant consequences for migration, though there is little evidence of its impacts so far, and research is beset by methodological shortcomings and dubious projections. In contrast again, only a small body of evidence examines climatic variables operating as "pull factors" to migration, though the possibility that climate change may result in such dynamics is plausible and certainly cannot be discounted. On climate change adaptation measures the evidence is stronger but again mixed: while adaptations in response to climate-related shocks and changes may mitigate migration pressures associated with short-term shocks, and will almost certainly do so in relation to long-term climatic changes, adaptation measures can themselves contribute to displacement and migration, and may well do so in increasing ways as more adaptation measures are taken (and the same potentially applies to climate mitigation measures). Finally, while evidence on perceptions and narratives is again mixed, it clearly suggests that attachments to place and local experiences often take precedence over "objective" vulnerabilities, and that narratives of "climate crises" and "climate refugees" may themselves enhance migration pressures.

There are clearly large uncertainties here. Among other issues, the volume and strength of evidence on each pathway may not accurately reflect how significant each will become. The amount of evidence on short-term shocks, for instance, reflects in part the amount of existing data on them, enabling analysis of links to migration, whereas the limited social scientific evidence on the impacts of long-term climatic change for migration—a change without clear historical precedent—reflects the lack of clear study methods, frameworks, or "data analogues". Indeed, we consider it an open question which of the five pathways above will prove to be most important in the decades ahead. We also recognize the limitations of this "pathways" framework, which was developed to guide this review. While the five pathways have been "siloed" and examined separately for analytical purposes, they do not operate in isolation from one another, and in both existing studies and our review, there is limited analysis of the linkages and interactions between them.

Despite these limitations, the findings outlined above illustrate the importance of, simultaneously, increased caution by climate and migration policymakers, and earth scientists, on "climate migration" numbers and projections (following Durand-Delacre et al., 2021; Gemenne, 2011; Jakobeit & Methmann, 2012), and for a conceptual widening and reimagining of discourse on climate-related migration, to consider climate change's migration implications in the round, rather than environmental push factors alone.

This analysis points to several important directions for both further research and policy discussion. First, more attention needs to be paid not only to the implications of long-term climatic and related changes for migration, on which little evidence currently exists, but also to the implications and impacts of climate-related "pull" factors, of climate change adaptation and mitigation initiatives, and of narratives about climate change impacts (including how narratives about "climate migration" may themselves influence migration). Second, further research and policy attention is needed, as noted elsewhere (Zickgraf, 2021a), to the multiple, complex patterns of mobility related to climate change pathways, with particular attention to migration duration, return, and immobility. And finally, there is a need for attention to the current and likely effects of other aspects of environmental change and crisis, in addition to climate change, on migration patterns. Although they are intensified by climate change, most socio-ecological changes and hazards have other, much more central causes. Furthermore, some hazards (such as groundwater crises due mainly to over-abstraction for irrigation, or industrial and agricultural pollution) are hardly caused by climate change at all—and may be exacerbated by climate adaptation and mitigation initiatives. The importance of other environmental changes and hazards and their impacts on migration, the implications of responses to these, and their interactions with climate change are likely to be obscured by a narrow focus on "climate-related migration".

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Gabrielle Daoust: Writing – original draft (equal); writing – review and editing (equal). **Jan Selby:** Writing – original draft (equal); writing – review and editing (equal).

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DATA AVAILABILITY STATEMENT

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FURTHER READING

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