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Bridging the Gap Between Climate Mobility Modeling and Policy Action

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Sustainability, Climate, and Geopolitics Program

The Sustainability, Climate, and Geopolitics Program explores how climate change and the responses to it are changing international politics, global governance, and world security. Our work covers topics from the geopolitical implications of decarbonization and environmental breakdown to the challenge of building out clean energy supply chains, alternative protein options, and other challenges of a warming planet.

Introduction

Climate mobility, or the movement of people in the face of a rapidly changing climate, is not some future abstraction but rather a reality that governments are grappling with today. Governments are already deciding where to invest in adaptation and where to concede that it will not be enough, whether to plan relocation for exposed communities or wait for people to leave on their own, and how cities can absorb arrivals they did not anticipate. These choices are expensive, consequential, and, in some cases, irreversible. And yet policymakers are making many of these decisions without drawing from climate mobility–specific evidence. That needs to change.

Policymakers are not using this evidence partly because it is often generated by academics for academics. Moreover, for nearly three decades, much research on climate change and human mobility has revolved around a singular question, "How many people will move?," which has produced starkly divergent answers—from tens of millions to more than a billion. The most widely circulated estimates have been borne from thin methodology, stripped of their assumptions in transit, and used in political arguments in ways the analysts did not intend.

Such critiques of these estimates have been well documented. But while projecting numbers of migrants is important, the debate over accuracy has largely obscured an equally valuable question: "How do these numbers actually help policymakers make climate mobility policy?"

In key stakeholder consultations with nineteen participants across four policymaking groups—bilateral and philanthropic donors, national governments, urban and local planners, and activists and civil society—we asked how they had encountered climate mobility projections, what decisions those projections informed, and what they need from modeling that they do not currently get. We found consistent demand for things that current models are largely not built to deliver.

This mismatch is not evidence of bad faith or bad science. Modelers face binding constraints: climate inputs are projected at decadal resolution, migration data are patchy or absent in the most climate-vulnerable places, and the methods that capture individual decisionmaking most convincingly are the least portable across geographies. And policymakers face constraints of their own: budget cycles, political headwinds, and the need to justify spending against competing priorities.[1] Both sets of incentives and challenges are rational.

Therefore, meeting the demand for upgraded, more frequent modeling requires movement from both directions—in other words, a better understanding of both what modelers can provide and what policymakers require.

Building on the literature review undertaken by Kerilyn Schewel et al. (2024), we assess thirty-seven modeling approaches to future climate mobility, including white papers and institutional reports that, while not peer reviewed, include the projections policymakers are most likely to encounter.[2] This paper defines climate mobility modeling as models with longer time horizons—excluding short-term forecasting and early warnings of mobility on scales of days to months, such as cyclone or drought warnings[3]—and those that project movement, rather than the risk of displacement (see the "Basics" section below).

We first mapped the literature to understand what types of migration, geographies, hazards, and time frames the models cover and where there are gaps. This review revealed some imbalances in coverage. For instance, we found that eleven of the thirty-seven models (29 percent) focus on only two countries (Bangladesh and the United States). And nearly half (seventeen of thirty-seven) address internal migration only. Twenty-seven percent treat sea-level rise as the primary or sole hazard. Almost all of the models make projections to 2050 or later.

We then mapped how closely these models align with what policymakers need to know. In a resource-constrained world, policymakers may not need better numbers so much as they need to know which existing tool answers which question—and which questions are not yet answerable with existing models. In this paper, we assess the four dominant modeling approaches—gravity, computable general equilibrium, agent-based, and econometric—and map the models against the four primary use cases identified during our stakeholder consultations: (1) political buy-in and advocacy, (2) long-term strategic planning, (3) project and program design, and (4) local and community planning. Some of these use cases are well served by what already exists, but some are not.

Next, we set out what would have to change for models to serve policymakers better. The first is bridging a basic information gap—as the most academic models were the least likely to be on policymakers' radars. Our consultations bore this out: The projections stakeholders knew best came from the World Bank, ProPublica, and First Street, not from scientific journals. In conclusion, we lay out seven priorities to help make modeling considerably more usable for policymakers and practitioners.

The Basics of Climate Mobility Modeling

Before diving into existing models and how policymakers can use them for their objectives, a brief overview of the field is useful. While there are still few climate mobility models, there are emerging trends in the questions they seek to answer and the tools they bring to bear.

Why You Can't "Count" Climate Migrants

Climate change is almost never the sole or primary driver of migration. Individual and household migration decisions are also the product of other overlapping pressures: economic opportunity, social networks, conflict, governance, and household circumstances.[4] Because climate is entangled with these other drivers, producing a single count of climate-driven migrants requires making modeling choices about how to isolate climate's contribution—and different choices produce different numbers.[5]

Models of climate mobility must deal with this complexity of drivers and cannot be conflated with estimates of risk exposure. Astronomical, widely cited figures, such as "1 billion by 2050," typically come from overlaying population maps with hazard maps or assuming all people in highly climate-exposed areas will move. However, displacement risk is more complicated and is a function of not just exposure, but vulnerability and capacity as well.[6] Some modelers have added proxies of vulnerability and capacity, such as education and poverty, to varying degrees of success.[7] Yet calculations of climate exposure and displacement risk are still different types of estimates than climate mobility estimates of future movement—the latter is the focus of this paper.

Box 1. The Human Mobility Spectrum

Human mobility is an umbrella term for the diverse ways people move. It is meant to capture a holistic range of movement: voluntary, involuntary, or somewhere in between. And the movement may be short or long term, cover short or long distances, and occur within or across borders. It may involve a single individual, a household, or an entire community. The reasons behind it are similarly varied.

This paper focuses primarily on migration, which typically refers to longer-term movement away from one's place of origin, usually across an administrative boundary. Conventionally, migration is distinguished from displacement by the degree of choice involved, but in the climate context that line gets blurry. Movement in response to a slow-onset stressor such as declining yields or salinizing soil is rarely either freely chosen or straightforwardly forced.

In addition, each model assessed here varies in its approach to defining and measuring migration. While many models like the Global Centre for Climate Mobility's (GCCM) Caribbean Shifts Model (2025) deliberately exclude temporary or nonpermanent migration from their future projections, in other cases, such as for the Small-Island Developing States, where nonpermanent or seafaring labor migration is essential to a country's economy or forms part of historic traditions, such movements necessarily form an important part of mobility projections.[8]

Climate mobility models are inherently complex and uncertain and need to be understood more as hypotheses than facts. Each model is the product of stacked assumptions, including emissions pathways, economic development, and policy choices, over a long time horizon. Uncertainty compounds at each step, so the headline number is always a simplification, not a fact.[9] Thus, models may have one well-known number (for example, 216 million, cited in the World Bank's Groundswell report), but they should always be understood in the context of a range, stated time frame, and scenario—in other words, 216 million by 2050, in a pessimistic scenario—instead of a single point estimate that implies more precision than the underlying methodology can support.[10]

Stripped of context, as often happens in media coverage, a projection can become a scare statistic rather than a meaningful policy input. Inflated, decontextualized numbers can feed securitized "climate refugee wave" narratives, be weaponized in anti-migration politics, and—when a predicted crisis does not materialize on schedule—erode credibility for the field and for legitimate adaptation and mobility policy arguments.[11]

None of this is an argument for dismissing climate mobility models outright but is instead an argument for better understanding where they come from. The variation in headline numbers reflects real differences in how researchers model human behavior, translate climate hazards into economic or social pressure, and define what counts as a climate-related move in the first place (or in some cases, common misunderstandings from policymakers about what the modelers actually find). Below is an overview of the four most common modeling approaches behind these estimates, so that any number encountered later in this paper—or elsewhere in the literature—can be read with a clearer sense of what it does and does not represent.

Understanding Current Approaches

Researchers rely on several distinct modeling approaches to project or explain climate-related mobility. Each embeds different assumptions about human behavior and requires different data, which is a large part of why the same climate scenario can produce different mobility estimates depending on which approach is used. Table 1 lays out in detail the four most common approaches, explains how they work, and analyzes their pros and cons.

Traditional modeling approaches commonly fall into four categories:[12]

Gravity models: There is rarely a singular reason as to why people move and why they choose, among myriad possible destinations, one place as their new home. Modeling all the reasons, especially at the individual level, is often impossible. However, in observations where there are thousands or perhaps millions of people choosing whether to move, certain aggregate patterns regularly materialize. Often, the population size of a destination and its geographic distance are the most important and useful factors for modeling a process like migration.[13] Thus, size and distance are the starting point of the gravity approach, and through the incorporation of climate stressors (like drought, sea-level rise, and crop failure)

as factors that adjust the *attractiveness* between places, gravity models represent a signature approach in the current climate mobility modeling field. But while they are especially useful in anticipating destination pressures for infrastructure and housing planning, they are largely silent on *who* is moving or *why*.

Computable general equilibrium (CGE) models: Climate shocks rarely affect migration directly; instead, they can alter agricultural productivity, wages, prices, and the availability of work, which in turn can change people's incentives and ability to move. CGE models are designed to capture these economy-wide interactions by representing how households, firms, and markets respond to a shock and how changes in one part of the economy ripple through others.[14] In climate mobility research, this makes it possible to translate specific climate-related effects (such as drought, heat, or flooding) into economic effects (such as low productivity, poor industry health, or unemployment) that may affect migration. Because these models can represent interactions across sectors and regions, they are particularly useful for testing "what-if" scenarios (for example, how adaptation investments or labor market policies might alter the effects of a climate shock). This model's reliance on detailed economic and demographic data, however, can limit its application in regions most vulnerable to climate change, where the data needed to calibrate the model are scarce.

Agent-based models (ABMs): Many models describe migration by looking for patterns across populations, geographies, or markets. ABMs, however, start from the constituent units of a system (individuals, households, or communities) and ask how their decisions and interactions might produce or reproduce those larger-scale patterns. It is therefore easier to understand an ABM as a framework, rather than a technology—one that describes a system from the perspective of its constituent units (agents).[15] These units can differ in their circumstances, information, preferences, and responses to climate hazards. In climate mobility research, this makes it possible to examine not only how many people move, but also who moves, who stays, or who becomes trapped, making ABMs particularly useful for targeted, equity-focused policy design.[16] Their bottom-up approach, however, means that findings are often closely tied to the assumptions, behavioral rules, and context of the particular population and place being modeled, making results difficult to generalize beyond the modeled setting.[17]

Econometric models: Migration responds to many overlapping economic, social, and environmental factors, making climate change's contribution to migration hard to isolate. Econometric models address this by utilizing the observed variation in climate conditions and migration to estimate the relationship between them. For climate mobility researchers, this provides an empirical basis from which the relationship between migration and hazards such as extreme heat, changing rainfall, and drought can be modeled. Because these models are grounded in historical relationships, they offer the strongest evidence base—as they are based on demonstrated (not just projected) impact—but their findings may be less informative where future climate conditions or socioeconomic circumstances differ substantially from those observed in the data. Moreover, because the focus of these models is on the observed relationship between climate change and migration, they often fail to account for populations that are unable to move.

Table 1. Trade-Offs Among Common Modeling Approaches

Modeling Approach	Pros	Cons	Example Model Literature
Gravity Models	Do not require assumptions about individual behavior; useful when the goal is a general resource allocation picture. Can directly capture climate-driven shifts in mobility barriers and in place attractiveness. Good for identifying likely *destination* pressures; helpful for infrastructure, housing, and services planning in receiving areas.	Do not tell you *who* is moving or *why*. Limited use for designing programs aimed at specific populations like low-income households and those with specific livelihoods (for example, farmers, coastal fishers, pastoralists, and outdoor manual laborers).	Jones (2024) Reimann et al. (2023) Riguad et al. (2018) Clement et al. (2021)
Computable General Equilibrium (CGE) Models	Capture ripple effects across the whole economy; useful for understanding how a climate shock in one sector or region could affect jobs, wages, and migration elsewhere. Can test "what if" policy scenarios (for example, adaptation investment and labor market interventions) and estimate economy-wide effects on mobility; useful for cost-benefit analysis of policy options.	Require detailed economic data that are often least available in climate-vulnerable regions—limiting use in lower-resource settings. Assume people and markets respond more predictably and "rationally" than they do in practice; potentially understate barriers, inequality, or nonlinear responses.	Rosengaertner et al. (2025) Burzynski et al. (2023, 2026) Oliviera and Pereda (2020) Barbieri et al. (2010)
Agent-Based Models (ABMs)	Capture differences across the population, including who is likely to move, who may be unable to ("trapped populations"), and who may choose to stay despite exposure; useful for designing targeted, equity-focused interventions. Can generate detailed, localized estimates of mobility and test how specific policy levers (for example, cash transfers, insurance, and remittances) might change outcomes; useful for piloting and evaluating local programs.	Findings are typically specific to the modeled location and do not reliably transfer to other regions, making them less useful for regional planning without separate modeling per area. High data and technical costs to build and validate; may require significant investment or technical partnership to use at all.	Bell et al. (2023) Best et al. (2022) Choquette-Levy et al. (2021, 2026) Oakes et al. (2016)

Modeling Approach	Pros	Cons	Example Model Literature
Econometric Models	Grounded in real-world, observed migration behavior; useful for building an evidence base that isolates climate's role from other drivers (for example, conflict, poor economic conditions). Well suited for answering the question: "Has climate change already driven migration, and how much?"; useful for justifying policy attention and funding based on *demonstrated,* not just projected, impact. Transparent, replicable, methods that can be applied across multiple datasets; useful for comparison of findings and building a shared evidence base among stakeholders.	Backward-looking, relying on the assumption that past relationships will hold under future climate scenarios; may understate risk under most severe warming scenarios. Struggle to capture people who are unable to move ("trapped populations") since samples are built from movers—a policy-relevant blind spot if the goal is protecting the most vulnerable. Struggle to capture sudden threshold/nonlinear effects (for example, a tipping point drought) and have difficulty separating climate effects from other bundled factors. Migration and climate data are often patchy or rely on poor hazard proxies.	Hirsch et al. (2026) Cattaneo and Massetti (2019) Chen and Mueller (2018) Cai et al. (2016)

Source: See appendix for full model references.

Box 2. The Role of Scenario Planning in Climate Mobility Modeling

Quantitative modeling and scenario planning serve different purposes but are best treated as complementary, not incompatible.

Modeling—using gravity, computable general equilibrium, agent-based, or econometric approaches—produces quantitative estimates grounded in data and statistical or simulated relationships. Even if these estimates are ranges, the models are rigorous, comparable across studies, and testable through sensitivity analysis and thus give more robust, testable, and specific estimates. But modeling has weaknesses, including false precision, heavy data requirements, overly complex findings, and difficulty capturing deep uncertainty or genuinely novel futures.

Scenario planning builds multiple internally consistent narratives about how the future could unfold, based on different potential situations and policy responses—not just physical climate variables—as an axis of difference. The process embraces deep uncertainty rather than hiding it, focuses on how different assumptions and policy choices lead to different results, and thus is well suited to stress-testing plans and helping stakeholders understand their roles. However, scenario planning is not quantitative, so it is less suited for budgeting or evidencing specific, detailed policy choices (where modeling may provide more granular, albeit imperfect, evidence). Also, its quality depends heavily on who is in the room defining the scenarios, and its findings are harder to communicate to audiences who expect a single number.

Key Findings at a Glance

With this grounding in modeling approaches and complexity, the next step is to take stock of the climate mobility modeling landscape itself. Academic meta-analyses already exist, but the field is also young and moving quickly, with 62 percent of models published after 2020.[18] Therefore, this paper distills the six most salient findings to orient readers new to the field. The full list of models assessed is included in the appendix.

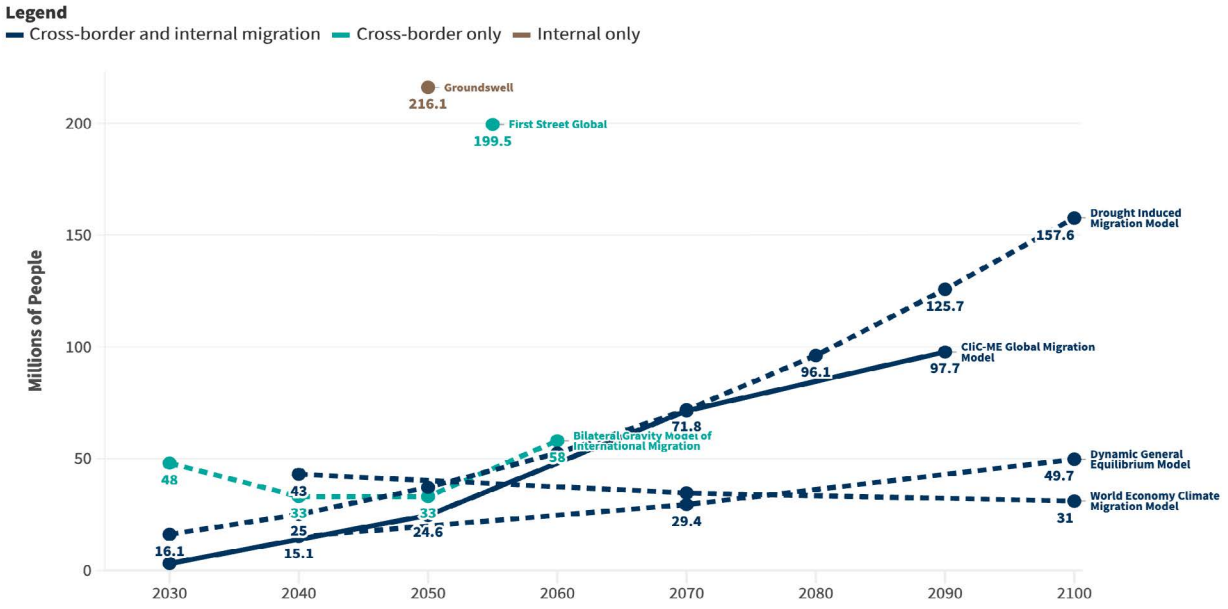
Key Finding 1: There is No "Best" Global Headline Number

There are currently seven different global climate migration projections, with four providing internal *and* cross-border migration estimates (see figure 1).

These global projections tell different stories partly because of their methodologies and how they present findings. First, gravity models typically produce estimates of internal or international migration in a specific scenario, but some models like Groundswell aggregate

Figure 1. Headline Numbers from Global Climate Migration Projections

Climate migrant projections from 2030–2100 under pessimistic scenarios



Sources: Burzyński et al. (2020), Burzyński et al. (2021), Cattaneo et al. (2024), Clement et al. (2021), Hirsch et al. (2026), Smirnov et al. (2023), and Szymanska et al. (2024). See appendix for full model references.

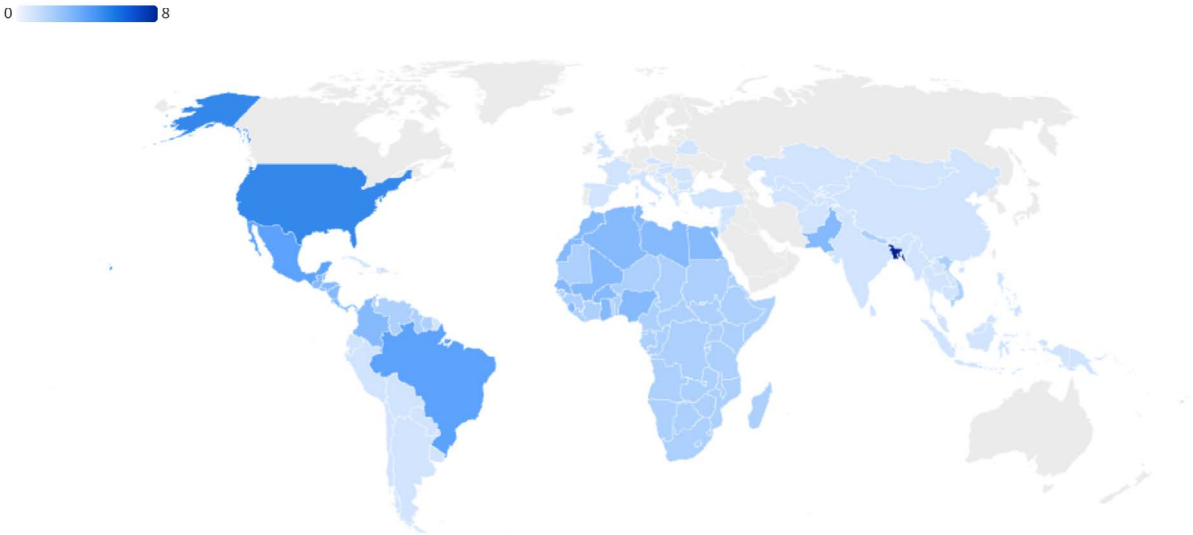
Note: Groundswell's headline numbers are derived from the sum of its regional projection models. Dashed lines indicate interpolated trajectories between decadal data points, as the underlying datasets provide values only for the years represented by the dots. The solid line for the CLiC:ME model represents a continuous projection.

the total number of people who will have moved by 2050, while other models like the Bilateral Gravity and World Economy report numbers moving within a given period, not a running sum, and so appear smaller. Second, CGE models, such as the Dynamic General Equilibrium Model, treat mobility as one output of a broader economic reallocation. This makes their estimates more conditional and often narrower in scope, typically capturing south-to-north movement among working-age populations. Finally, econometric models like First Street Global estimate the historical sensitivity of migration to climate variables, then apply that relationship to future climate projections. This is often why exposure-based models, especially those reporting cumulative headline figures, can appear to dwarf estimates from other approaches.

Key Finding 2: Models Cover Bangladesh and the United States More Than Anywhere Else in the World

Of the thirty-seven models assessed, six focus on Bangladesh and five on the United States (in other words, 29 percent of all models reviewed cover just these two countries) (see figure 2). Six models operate at the global level; six take regional approaches, with two covering the South American and African continents; and four provide coverage of nine subregions, including the Caribbean, Central America, Central Asia, East Asia and the Pacific, Eastern Europe, the Mediterranean, North Africa, and sub-Saharan Africa. Other regions, notably Western Europe and Australia, have less or no similar modeling.

Figure 2. Density of Climate Mobility Model Coverage



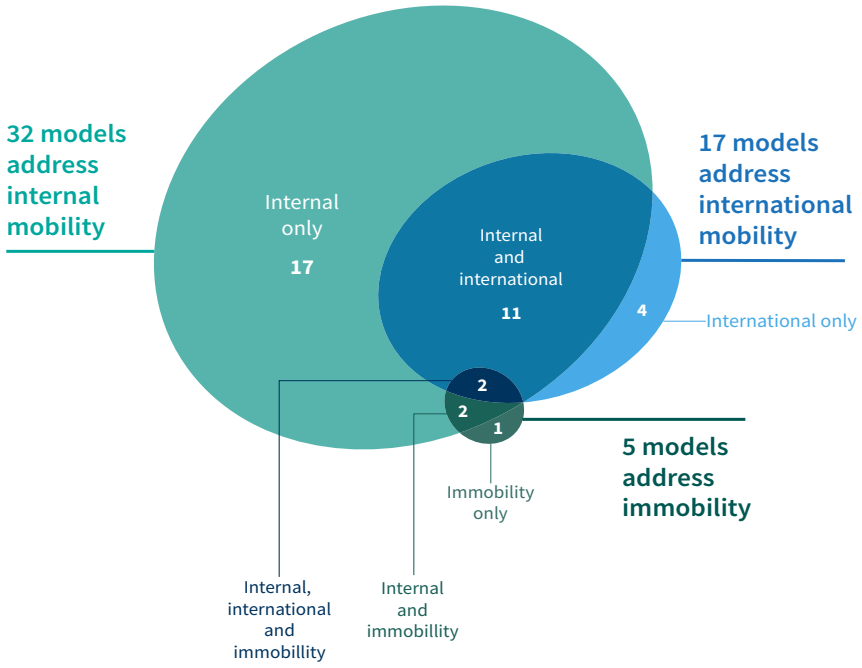
Source: Authors' calculations. See the Appendix for full model list.

Note: Totals include regional, national, and subnational models. Maps are illustrative; boundaries, names, and designations used do not represent or imply any opinion on the part of Carnegie or the authors.

Key Finding 3: Most Models Cover Internal Migration, with Nearly Half Only Focusing on It

Internal migration data are more widely available in most countries, as international movement can be harder to model if trying to include ever-changing and unpredictable policy choices about border, asylum, and visa policies (see figure 3). Simultaneously, most evidence points to climate mobility being primarily within countries, particularly rural-to-urban, so these models also cover a key part of the phenomenon. Some of these models, or 19 percent, model rural-urban flows specifically, and an additional 43 percent likely account for it when looking at the projection of internal migration. Thirteen models, or 35 percent, cover both internal and international (cross-border) migration.

Figure 3. What Types of Mobility Do Models Cover?



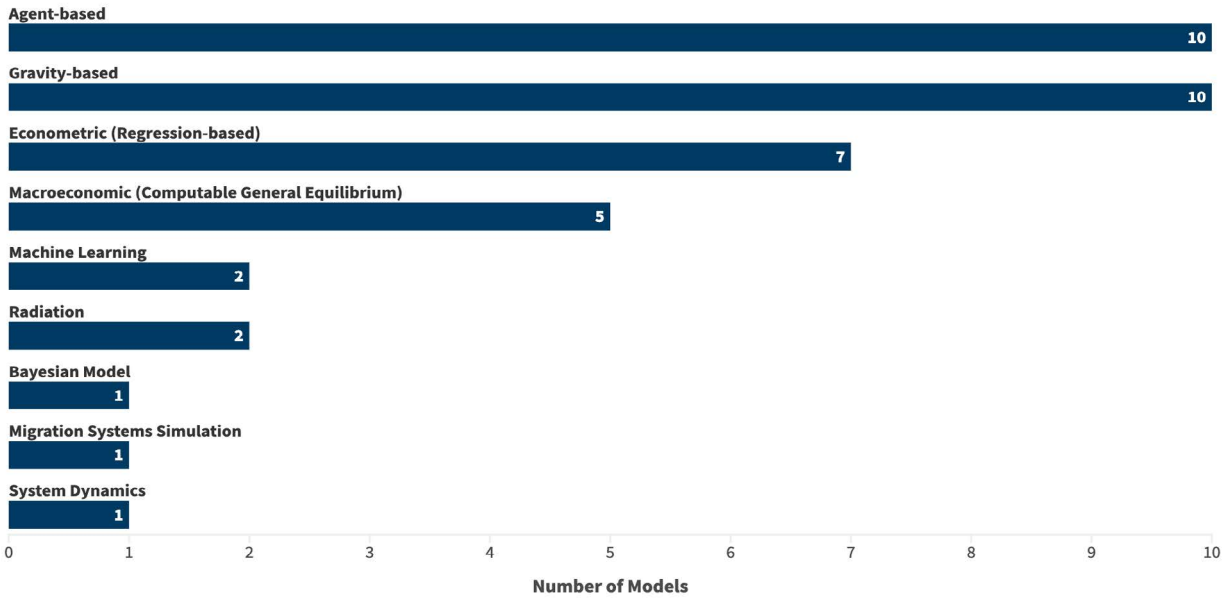
Source: Authors' calculations. See the Appendix for full model list.

Key Finding 4: More Than Half of Models Use Gravity or Agent-Based Modeling Approaches

Ten of the models reviewed are gravity models, which predict aggregate movement between places based on their size, wealth, and the distance between them (a proxy for "attractiveness"), with climate variables layered in (see figure 4). Notably, most of these gravity models were developed and refined by the same group of researchers, including Bryan Jones and colleagues at the Center for Integrated Earth System Information. These models include Groundswell I (2018), Groundswell II (2021), GCCM's Africa Shifts (2023), and the C40 Cities Future Urban Landscapes (2024).[19] Each model uses different inputs and assumptions, and recent iterations have made small tweaks for context or accuracy.

Another ten models are ABMs, of which three cover Bangladesh. Other models cover Burkina Faso, Kiribati, Maldives, Mali, Nepal, Senegal, and Tuvalu. ABMs can provide more granular, policy-relevant findings (see "Uses Cases" below), but they are assumption-heavy, context-specific, and require heavy data and technical lifts to create, limiting their transferability across regions.

Figure 4. Modeling Approaches in Climate Mobility Projections

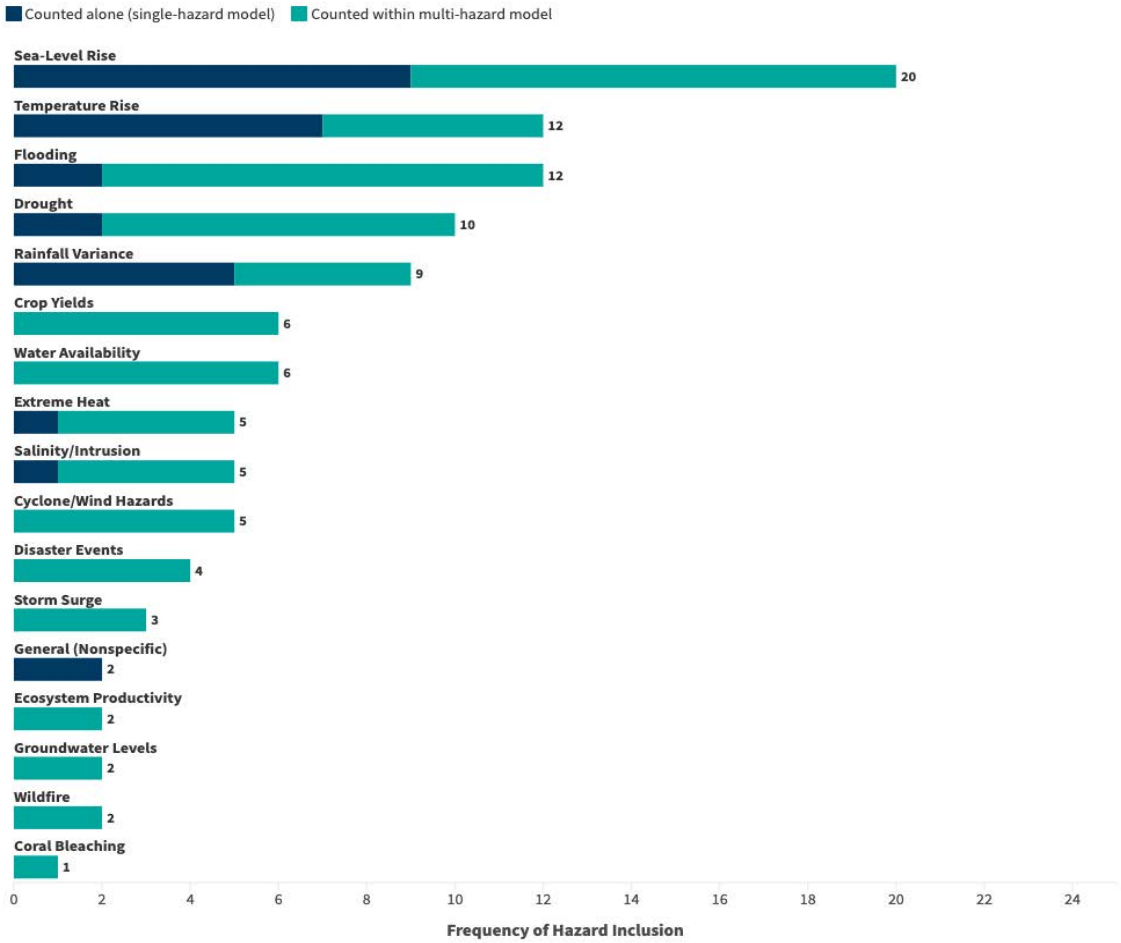


Source: Authors' calculations. See the Appendix for full model list.

Key Finding 5: Sea-Level Rise Is the Most Covered Climate-Related Hazard

Thirty-eight percent of all models incorporate sea-level rise as the primary or stand-alone hazard driving migration (see figure 5). Sea-level rise is a popular hazard to model because it is directional and cumulative rather than episodic, so it can be projected as a steadily rising surface, intersected with elevation and population data, and translated into the unambiguous outcome of uninhabitable land. Meanwhile, more than half of the models reviewed include sea-level rise alongside other hazards, such as flooding, temperature rise, and rainfall variability. Two models capture more unique impacts, such as coral bleaching and wildfires.[20] But a host of other climate hazards and related impacts, such as glacial melt, ocean acidification, and agricultural pests, have not been modeled, likely because of lack of data, limited relevance, and less policy attention.

Figure 5. What Hazards Do Models Account For?

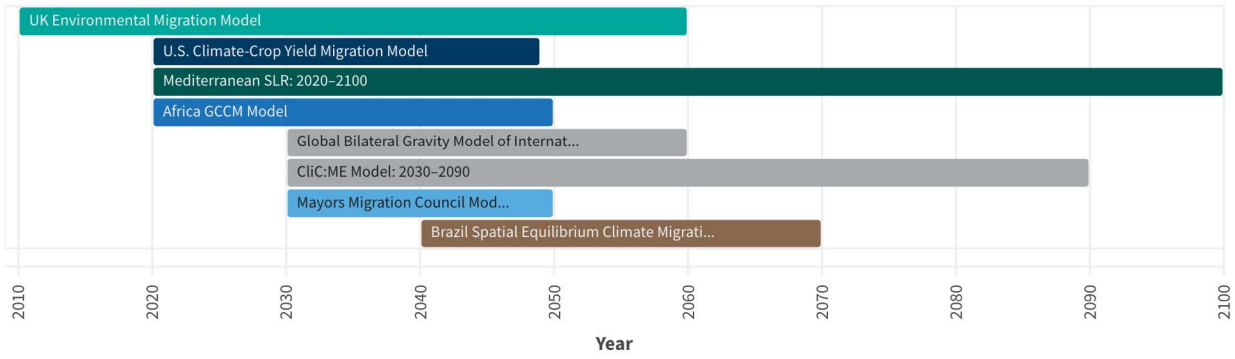


Source: Authors' calculations. See the appendix for full model list.

Key Finding 6: Most Models Focus on Long-Term Time Horizons (2050, 2100)

A majority of models focus on 2050- and 2100-time horizons for two principal reasons: First, scientists argue that the effects of climate change only become clear over longer time horizons. Second, the climate data the models rely on are produced on those same timescales. The standard emissions scenarios are designed to show how the climate diverges under different futures, and they barely separate from one another before about 2040, so a projection to 2030 captures mostly ordinary year-to-year variability rather than a climate signal. The models that do project the nearer term often work around this in one of two ways: by filling in the decades between the standard scenario dates or by focusing on a hazard whose near-term path is already well established, such as sea-level rise.[21] A handful of models produce 2030 and 2040 estimates that fit policy cycles better. The Global Center for Climate Mobility's Africa Shifts Model (Amakrane et al. 2023), Mediterranean Sea-Level Rise (SLR) Model (Reimann et al. 2023), the C40 Cities Model (2024), and the Climate Change: Migration and Economics (CliC:ME) Model (Burzynski et al. 2026) allow users to explore projections in ten-year increments (see figure 6).[22]

Figure 6. Climate Mobility Models with Near-Term Projections



Sources: Abel et al. (2013), Amakrane et al. (2023), Cattaneo et al. (2024), Feng et al. (2012), C40 Cities Model (2024), Oliveira and Pereda (2020), Reimann et al. (2023), and Szymanska et al. (2024). See Appendix for full model references.

Note: The Global Bilateral Gravity Model of International Migration, Mediterranean SLR, Mayors Migration Council Model, and GCCM Africa Model provide decadal projections.

Thinking Through Use Cases for Policymakers

Many of the models we assessed were not designed primarily with policymaking in mind, and some are better suited to certain types of policymakers than others. Policy stakeholders consulted across sectors referred to four primary use cases for climate mobility modeling:

increasing political buy-in and advocacy around climate mobility policies, supporting long-term policy and strategic planning, guiding project and program design, and strengthening local and community planning. This section demystifies which models serve which use case, and why.

Use Case 1: Political Buy-In and Advocacy

Most stakeholders use modeling to generate a sense of urgency around climate and mobility and to make the case within their own organization for why the issue deserves attention and resources. This is especially true among governments and funders, where senior leaderships face competing demands and need clear evidence on why climate mobility should be a priority. For example, one department within the United Kingdom's Foreign, Commonwealth, and Development Office explored a pilot climate mobility model to generate data on climate-related migration from key source countries to Europe and the United Kingdom to generate internal interest in the matter.[23] The Climate Displaced Persons Act introduced by U.S. Senator Edward Markey cites the 2020 Ecological Threat Register's projection of 2.1 billion people at risk of displacement to induce action.[24]

Activists also have long used estimates of climate migration modeling to call for stronger climate action and migration policies. For example, ActionAid released a report using a refined version of Groundswell's gravity modeling approach in South Asia to make the case that the region was "set to treble by 2050 due to climate inaction on global warming."[25]

Modeling plays an important role in raising awareness and advocacy. However, as argued above, modeling efforts are strengthened when their underlying figures, geographic scope, and scenarios travel alongside the headline claim. Doing so guards against both inaccuracy and the tendency for a striking number to displace the policy argument it was meant to support.

Use Case 2: Long-Term Policy and Strategic Planning

Many policy stakeholders engage regularly in long-term policy and strategic planning, and climate mobility models that project out to 2050 or 2100 can align well with those planning horizons. Bangladesh is a clear example of a country incorporating such modeling into its long-term planning. Its 2022 National Adaptation Plan references the future projections in the World Bank's Groundswell report to highlight the unique risks and vulnerabilities of the country.[26]

Other long-horizon planning processes run on similar timelines. In the Global North, examples include processes such as the U.S. State Department's Quadrennial Diplomacy and Development Review, which includes long-term blueprints for diplomatic and development efforts abroad, and the U.S. National Intelligence Council Global Trends reports, which

focus on fifteen-year future trends relevant to national security.[27] In the Global South, some countries think through fifty-year development time horizons, including for the African Union (Agenda 2063) and in places such as Bangladesh (Vision 2050 and Delta Plan 2100), Rwanda (Vision 2050), and Ethiopia (Vision 2050).[28] These plans are all possible candidates for incorporating global or regional models to flag long-range risks and identify hot spots worth planning around.

Where more complex, cross-sectoral planning is being conducted, CGE models may offer more value, since they capture how climate-driven migration interacts with labor markets, trade, and economic output, rather than treating migration as an isolated variable. How a planner uses a CGE model depends on what the plan is trying to achieve. In the Global North, CGEs can help anticipate demographic decline and identify where attracting migrant labor and skills will be necessary to sustain economic output. In the Global South, CGEs can help planners understand how their economies may need to be systematically reoriented—for instance, away from climate-exposed agriculture—as mobility patterns shift over decades.

Use Case 3: Project and Program Planning

Beyond long-term planning, climate mobility modeling can inform near-term decisions about how and where policymakers and practitioners should invest in climate mobility programs. Such programs range from interventions targeting hot spots of climate-driven out-migration to preparing communities where the modeling anticipates an increase in arrivals. The World Bank's Groundswell model has been used in the design and approval processes of a few bank operations (for instance, as part of the justification for a flood infrastructure investment in Niger).[29]

For many models, time frames may be a limiting factor. Most stakeholders work on projects and planning cycles that span one to five years. Models with long time frames may be less helpful in justifying and shaping immediate interventions when there are so many other pressing short- and medium-term needs and the models have so much uncertainty in their long-term estimates. In those cases, a handful of models with nearer-term projections can be helpful, such as the Caribbean Shifts Model (2025) and the Mediterranean SLR model, which make projections for mobility at the regional level available as early as 2030.[30]

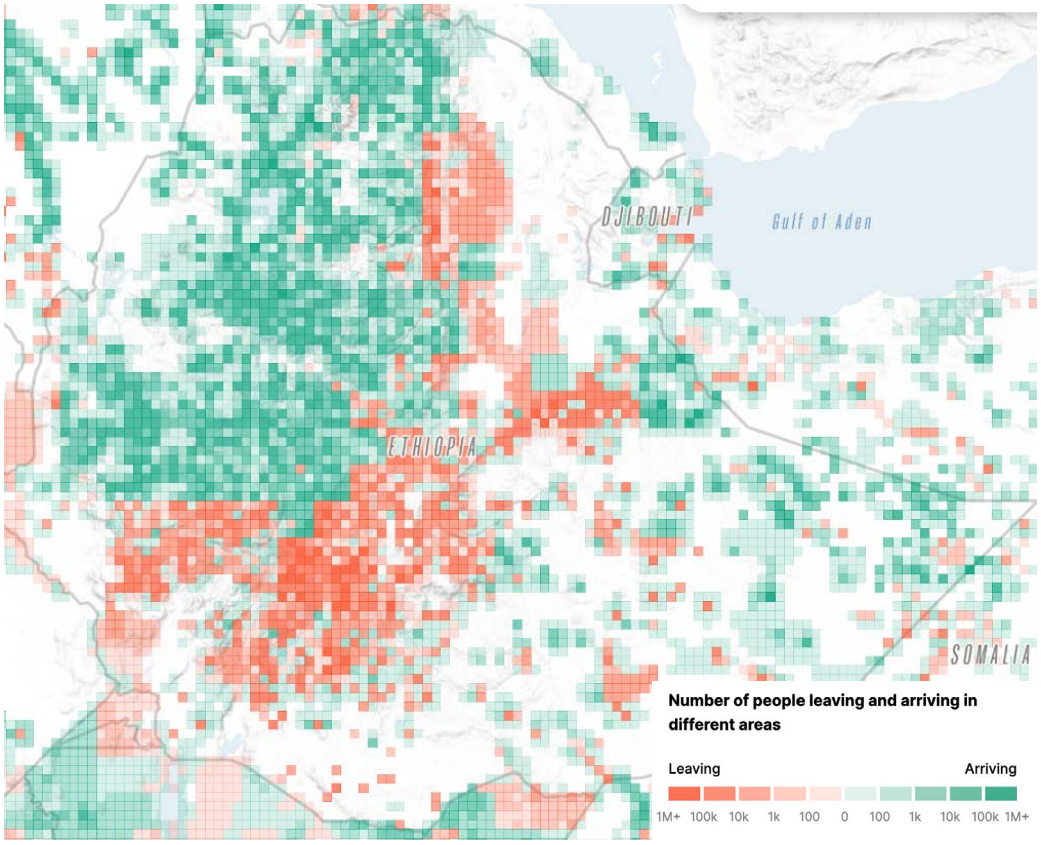
Prioritizing Place

Modeling can identify *where* interventions are most needed, particularly by identifying hot spots of in-migration and out-migration. In a context of scarce resources, national and international actors need to prioritize where they invest and thus need to know what places will see out-migration (and may need investments so people can stay if they wish) and where places will see in-migration (and may need investments to build out infrastructure and services for such growth).

Gravity and CGE models at national and regional scales, such as Groundswell I (Rigaud et al. 2108), Groundswell II (Clement et al. 2021), Africa Shifts (Amakrane et al. 2023), Caribbean Shifts (Rosengartner et al. 2025), CliC:ME (Burzynski et al. 2026)., can identify such hotspots.[31] There are slight differences, with some models more granular than others, but gravity models generally can give a broad understanding of movement in the country or region. At an even more granular level, CGEs may prove more useful. One illustrated case is a comparison of the in- and out-migration hotspots provided by the Africa Shifts Model versus the CliC:ME Model for Ethiopia.

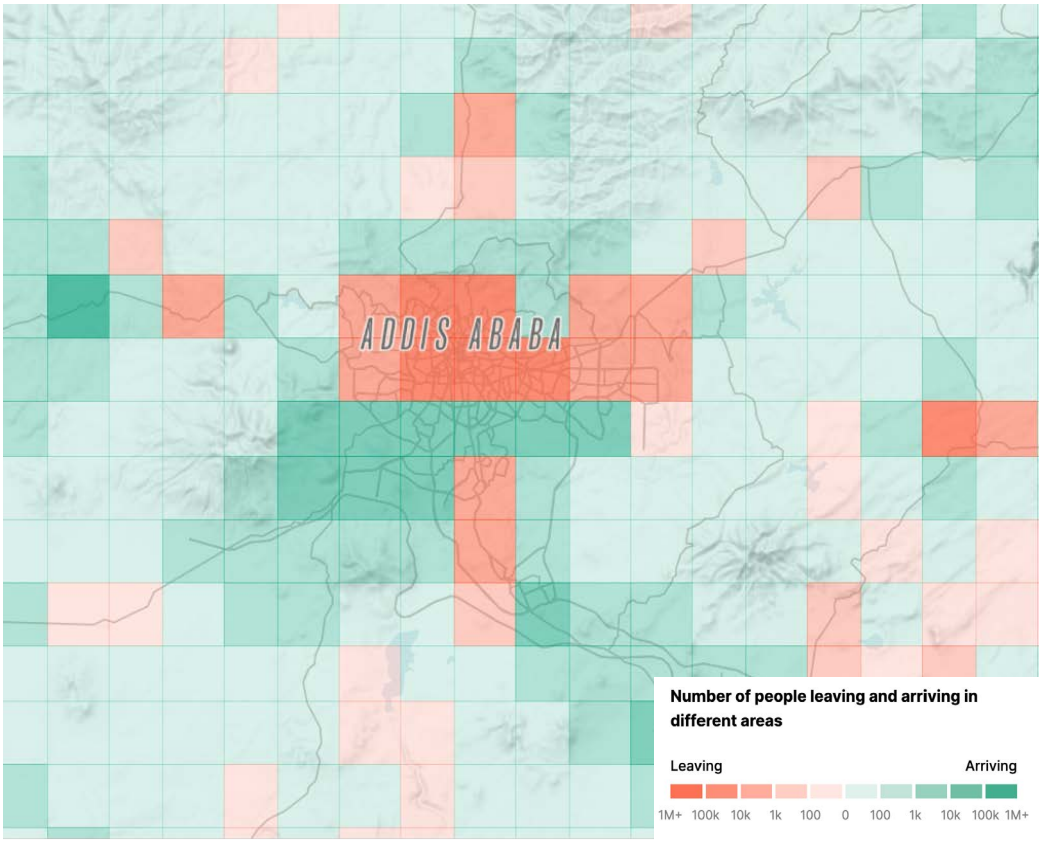
The GCCM's Africa Shifts Model shows broad strokes of movement, where green areas are in-migration hotspots and red areas are out-migration hotspots—the darker the color, the higher the level of movement (see figure 7).

Figure 7. GCCM Model Migration Hotspots of Ethiopia



Source: Center for International Earth Science Information Network (CIESIN), Columbia University, et al., Africa Climate Mobility Initiative (ACMI): Internal Migration Projections, NASA Socioeconomic Data and Applications Center (SEDAC), 2025, https://doi.org/10.7927/5TV3-FF20.

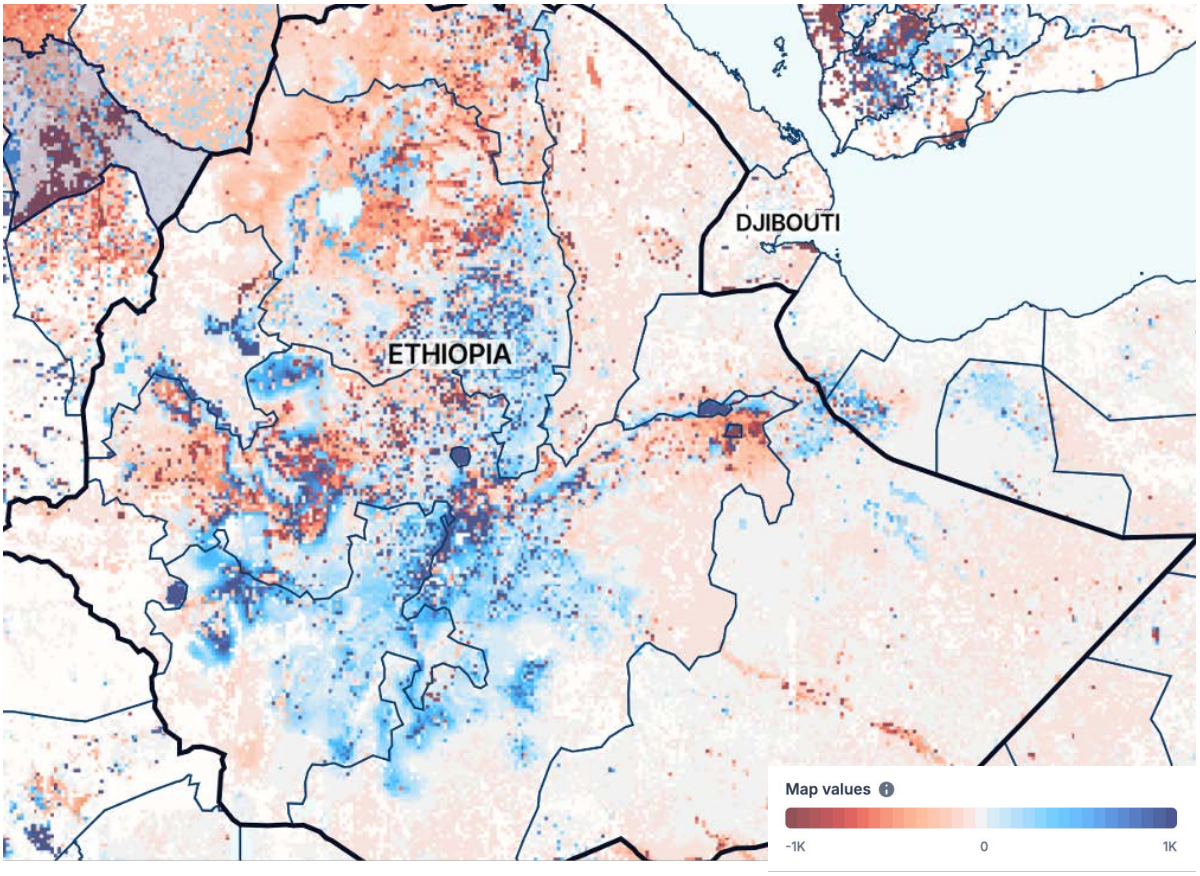
Figure 8. GCCM Model Migration Hotspots of Addis Ababa



Source: Center for International Earth Science Information Network (CIESIN), Columbia University, et al., Africa Climate Mobility Initiative (ACMI): Internal Migration Projections, NASA Socioeconomic Data and Applications Center (SEDAC), 2025, https://doi.org/10.7927/5TV3-FF20.

Addis Ababa is marked as a site of out-migration, with southern, peri-urban parts of the city experiencing in-migration (see figure 8). However, other nearby towns are obscured. The gravity model considers factors that influence place attractiveness, in this case, the impact of topography first on water access and agricultural productivity and then on population distribution.

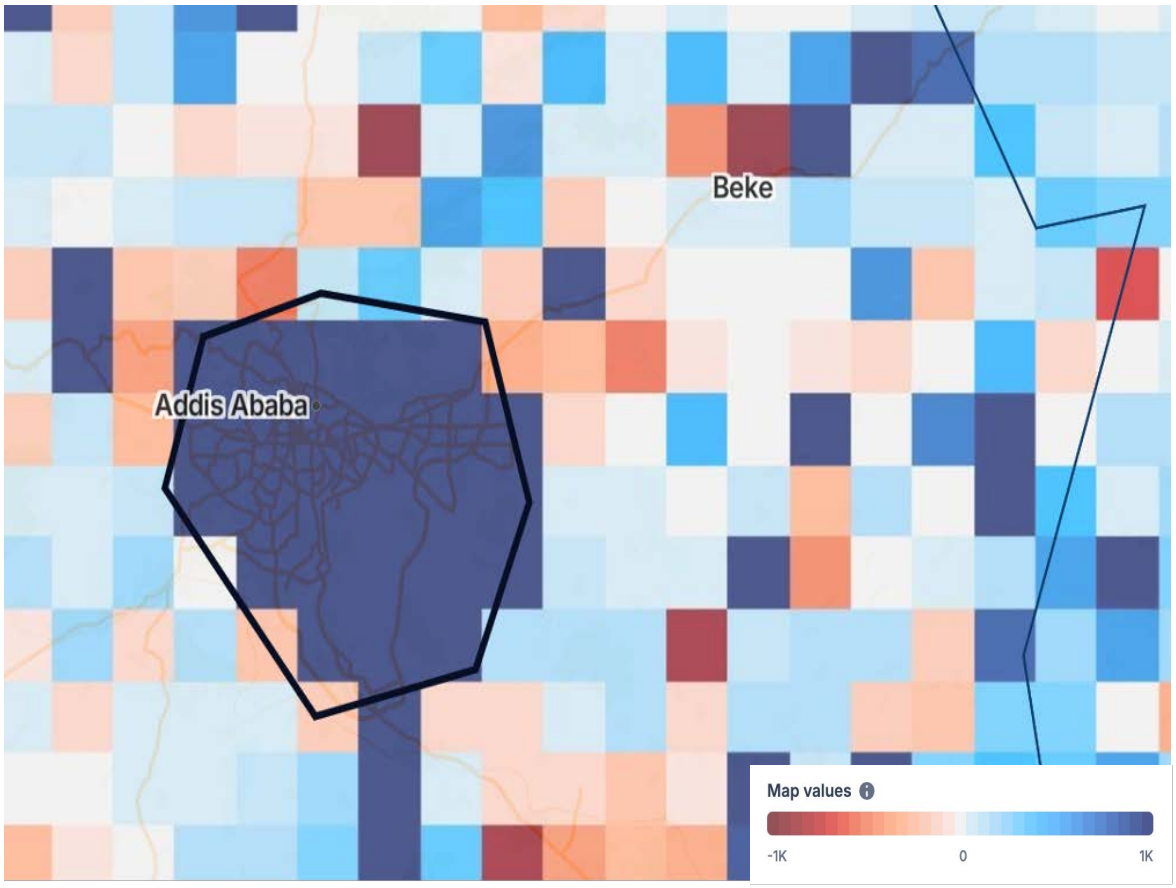
Figure 9. CliC:ME Model Migration Hotspots of Ethiopia



Source: Michal Burzyński, Frederic Docquier, and Aleksandra Szymańska, Climate Change: Migration Economics, CliC:ME, Version 0.1, LISER, https://liser.elsevierpure.com/en/publications/climate-change-migration-economics-clicme/.

The CliC:ME Model (2026) takes a similar color-coded approach, where blue means in-migration and red means out-migration (see figure 9).[32] However, the model provides more detailed in- and out-migration projections at a lower administrative level.

Figure 10. CliC:ME Model Migration Hotspots of Addis Ababa



Source: http://clicme.liser.lu/Michal Burzyński, Frederic Docquier, and Aleksandra Szymańska, Climate Change: Migration Economics, CliC:ME, Version 0.1, LISER, https://liser.elsevierpure.com/en/publications/climate-change-migration-economics-clicme/.

While both models show similar results, they are not identical. The CliC:ME Model projects that Addis Ababa will see substantial in-migration (see figure 10). This is likely because Addis Ababa is such an important economic hub for the country.

Even with these insights, understanding the mechanisms behind this pattern requires pairing gravity modeling with qualitative research (for instance, to explain diverging quantitative model estimates in Addis Ababa). The Groundswell reports, for example, used six case studies to add contextual depth that the numbers alone cannot provide. In their Uganda deep dive, consultations allowed the World Bank to identify additional contextual issues in in-migration hot spots Mbala, surrounding parts of Kampala, and Ntungamo, such as high poverty rates, informal settlements, and weak infrastructure.[33]

Investing for Impact

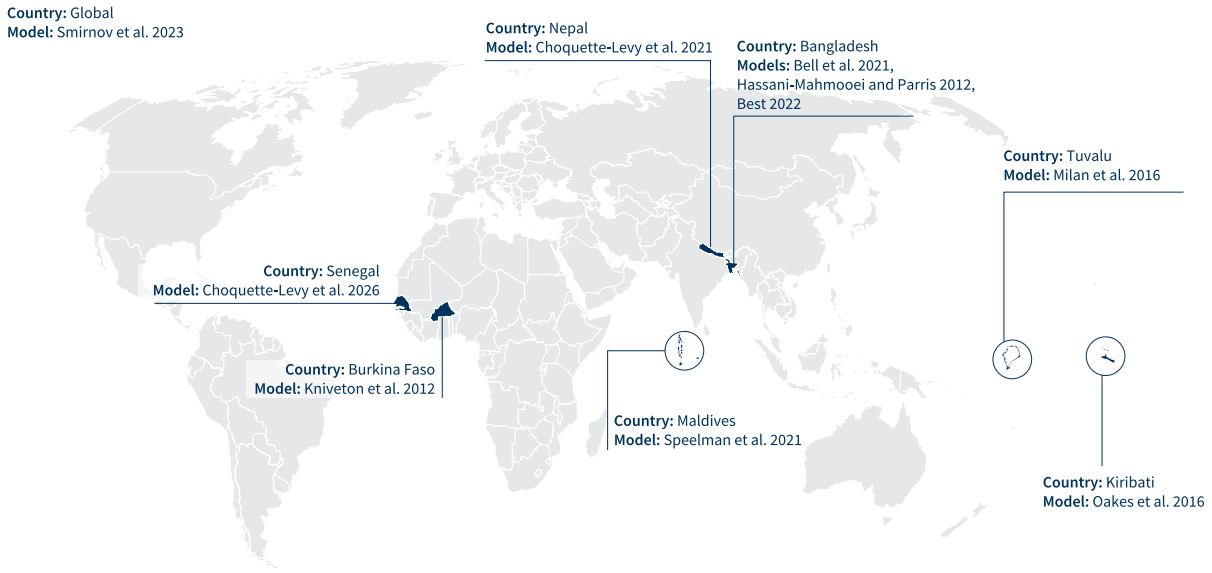
In addition, some climate mobility models estimate the *impact of different interventions*, including in-migration flows, and thus provide evidence for project design. For example, in their Mediterranean SLR Model, Lena Reimann and others explore how coastal adaptation policies, such as managed retreat, coastal wetland restoration, and coastline protection, are likely to influence both the quantity and spatial distribution of future migration patterns. This model found that while submergence due to sea-level rise could result in over 20 million internal migrations by the year 2100, highly engineered protective measures like dikes, sea walls, and barriers could bring that estimate down to as low as 2 million.

Other approaches cover a wider range of potential interventions. Nicolas Choquette-Levy and others assess how interventions like cash transfers, remittance banks, and index-based insurances affect the levels of migration and immobility experienced by an agricultural community in Nepal, including many families who lack the resources to move.[34] By allowing for direct engagement with household-level decisionmaking, the ABM in this study offers insights—amid worsening environmental conditions—into the uptake of varying adaptation strategies such as migration and cash-cropping under different intervention scenarios. It finds, for example, that a combination of all three interventions could facilitate migration for close to a third of households for which it would otherwise be out of reach.[35]

Ensuring Targeted Investments

During our stakeholder consultations, several participants stated that it is necessary to know both the number of people moving and the profiles of *who* is moving to ensure targeted investments. Most climate mobility models do not disaggregate to this level. ABMs are a notable exception, simulating individual- or household-level decisionmaking rather than aggregate flows—but usable ABMs currently exist for only a small subset of countries, which limits their near-term applicability (see figure 11).

Figure 11. Available Climate Mobility ABMs



Source: Author's compilations. See Appendix for full model list.

Note: Certain territories are not depicted in their entirety; owing to the scale of representation, not all islands and archipelagos are shown. Maps are illustrative; boundaries, names, and designations used do not represent or imply any opinion on the part of Carnegie or the authors.

For example, ABM work in Senegal has demonstrated the significantly increased resilience to both short- and medium-term climate shocks (drought and salt-water intrusion) among individuals with either vocational or university degrees.[36] In combination with the finding that climate shocks may foster increased population movements to an interior crescent or safety corridor comprised by the departments of Podor, Sedhiou, and Kolda (that have historically been *sending* regions), these modeling efforts provide concrete targets for economic development investments.[37] For instance, benefits could be seen in the trade and service sectors in the regions most likely to absorb these new workers, along with parallel local governance measures to secure adequate housing, land tenure, and access to social services.

Use Case 4: Local and Community Planning

Local and municipal planners can use climate mobility modeling to prepare infrastructure, housing, and service capacity. If a model predicts an influx of climate migrants, a city can plan housing stock, school enrollment, healthcare, and transit demand, all of which take years to adjust. For example, rapid urbanization across Africa, driven in part by significant rural-urban migration (including climate-related migration) has strained urban infrastructure and capacities. In response, Cities Alliances' urban expansion planning approach helps cities to forecast urban population growth in the next thirty years and to build out urban peripheries (where migrants tend to settle) and connect them to the core city before migrant settlements grow unsustainably in poorly serviced areas.[38] Such long-term planning, used by cities across both low- and high-income countries, could be better served with localized climate mobility modeling.

Understanding out-migration also matters, since it erodes the property and sales tax base a municipality depends on, so understanding that trajectory early lets local governments plan for revenue shortfalls.[39]

Modeling can also inform land use decisions—for example, whether it still makes sense to permit development in a flood-prone or fire-adjacent zone, or whether managed retreat is the more viable long-term path. That question ties directly into cost-benefit tradeoffs between adaptation (seawalls, cooling infrastructure) and retreat, and modeling gives planners the data to make that case credibly.

One model, made by C40 Cities, provides a more in-depth look at ten cities in the Global South: Accra, Amman, Bogotá, Curitiba, Dhaka, Freetown, Karachi, Rio de Janeiro, Salvador, and São Paulo.[40] A modification to the approach used in the Groundswell reports, the "INCLUDE" model is among the first to analyze internal climate migration at the local level. The results provide an in-depth profile for each city, which details not only the number of projected climate migrants (in ten-year time steps) but also a breakdown of their age, gender, the climate stressor most likely to have driven their movement, and, perhaps most importantly, a high-resolution mapping of the parts of the city where climate-affected populations are expected to move to and away from.

An Agenda for Making Climate Mobility Models More Usable

The section above demonstrates how policymakers can use climate mobility models, as well as the myriad ways existing models cannot answer policymakers' questions with enough accuracy, granularity, or at all. The models are constrained in scope, with many (1) covering

limited climate hazards and only a subset of types of movement such as migration but not forced displacement, or internal only, (2) using long, fifty-year time horizons unhelpful for program cycles, or (3) offering estimates of movement but not modeling the impact of different types of interventions.

Still, even though these models face a range of data and methodological limitations, which academic researchers continue to debate, they are proliferating and becoming more sophisticated. (For example, 62 percent have been published since 2020.)[41] As the field of climate mobility modeling grows, it will have to reckon with a structural methodological challenge. Current models are split between two families: gravity, econometric, and computable general equilibrium models, which are geographically portable but behaviorally shallow, and agent-based models, which are behaviorally rich but geographically rigid. Closing that gap—and making models genuinely useful to the policymakers who would fund and use them—will require not just methodological advancement, but also a distinct research agenda and new ways of working, organized around seven key priorities.

Modeling the Effects of Policy Interventions

This is perhaps the most significant priority in the field: very few existing models are built to test counterfactuals or simulate how interventions (for example, early warning systems, livelihood support, or managed retreat) change migration outcomes. This reflects a range of data challenges, as well as, in some cases, a normative reluctance to focus on what prevents people from moving. But these are the questions policymakers are asking, and building policy levers explicitly into model structures would turn these tools from passive projections into genuine decision-support instruments. This would be a significant methodological lift, but one with mature analogues in public health and economic policy modeling, where intervention modeling is already standard practice.[42]

Moving Toward a Modular, Fit-for-Purpose Ecosystem

The modeling field is likely better served by a suite of fit-for-purpose tools mapped to specific policy questions than by the search for a single "best" model. A practical next step would be for modelers, donors, and policymakers to build a shared taxonomy of policy questions and map future models onto it. Modelers have begun something along these lines with the Mobility and Migration Modeling Intercomparison Project, which uses coastal Bangladesh as a first case study.[43] But more needs to be done, both to get existing models into the hands of policymakers and to make the next generation fit for purpose. Bilateral donors and philanthropies are well placed to fund that coordination, since no single research group can build it alone.

Reorienting Toward the Policy Cycle

Current models are often built around scientific timescales—decadal projections, long-run climate scenarios—that do not align with how governments actually plan and budget, typically in cycles of one to five years. There are some exceptions (see the "Key Findings" section). Generally, however, modelers need to build shorter-horizon variants where feasible or, when models do play out until 2100, estimate findings on a decade-by-decade basis until then. Simultaneously, shorter time frames allow both researchers and practitioners to evaluate model findings (for instance, seeing how estimates through 2030 play out in reality, without waiting until 2050 or 2100).

Getting the timing right will likely require direct partnerships with government planning offices, since budget and policy cycles vary considerably across national and subnational contexts. It may require diverting research attention away from long-term modeling toward efforts to develop and evaluate medium-term estimates. It may also require a different set-up of funding and research processes—for instance, donors funding researchers to continuously update their models each year (or every three to five years), instead of funding them to produce one-off models.

Expanding Geographic Coverage

Existing models are heavily concentrated on a narrow set of Global South contexts and the United States. In some cases, big climate-related hazards such as heat, drought, and wildfires—which are already upending different regional contexts, including in Europe and Australia—remain entirely unmodeled. In other cases, country-wide future projections do not meet the needs and expectations of organizations and policymakers working in specific metro regions, such as Detroit or Chicago in the United States. In addition, modeling of immigration to the Global North is also limited.

Methodologically, gravity and CGE approaches are geographically portable enough to extend to these cases; the harder task is adapting agent-based behavioral assumptions—built on informal labor markets and weak safety nets—to contexts with formal insurance, asylum systems, and different migration infrastructures. But covering more countries will require modelers, funders, and policy partners to invest in countries that may be lower priorities, have less data availability, or host fewer research partners—all of which are challenges that will take time and continued effort to overcome.

Improving Spatial and Demographic Granularity

Some policymakers, particularly local planners and national governments, need to know where people are moving on a more granular level (for example, neighborhood flows, not just aggregate flows). Ideally, their movement would be disaggregated by age, gender, income, and/or occupation to best orient planning.

However, because this is as much a data availability and quality problem as a modeling one, modelers could get more granular when more granular administrative or survey data exists. Where possible, modelers should prioritize subnational resolution and should advocate for, and partner with, data collection efforts capable of feeding finer-grained inputs into their models. This may mean more donor and government investment in data collection and more research efforts to triangulate administrative data to get more granular. This work should default to open-source data as much as possible, even if initially limited.

Instead of waiting for national governments to collect and share more granular data, modelers may also need to work more directly with local authorities to either generate data in a specific city (for example, via surveys) or to find creative, local solutions to access that data (for example, via housing data that might be held by city authorities). While this would lead to less generalizable findings and methodologies, if done in close partnership with local stakeholders, these types of modeling approaches could be particularly impactful.

Moving From "How Many" to "Who, Why, and When"

While some policymakers care about headline numbers, effective policymaking requires going beyond volume and knowing more about the profile of movers and the drivers behind migrants' decisions. In addition, in order to target interventions in the most impactful and timely manner, some policymakers need to know not just the resulting numbers in 2030, but also the threshold or "trigger point" at which migration increases at a rate and scale above average.

Agent-based modeling approaches can answer many of these questions, but they are so locally specific and resource-intensive that they cannot be deployed everywhere. Researchers and practitioners should be more strategic in selecting where they invest in agent-based modeling: Evidence should be generated in places where the needs are greatest and where policymakers will use that data. And modelers may need to think through hybrid approaches that pair quantitative modeling with qualitative or survey-based methods, which are lighter-weight and more transferable than the current agent-based modeling method.

Integrating Emerging AI Methods

A layer of the field not addressed above is the growing use of machine learning. Humanitarian and academic actors have begun testing forecasting tools driven by artificial intelligence (AI). Such efforts include the Danish Refugee Council's Foresight model approach, developed with IBM, which projects displacement one to three years into the future, and hybrid approaches that pair machine-learning conflict forecasts with agent-based displacement models.[44] These efforts speak directly to the shorter-horizon planning gap described above. Evidence from the more mature field of AI-based weather and climate modeling, however, argues for caution rather than enthusiasm. Such models already outperform

physics-based counterparts on many near-term forecasts, but they have so far failed to reproduce slower-moving climate dynamics that unfold over months and years—precisely the kind of variability that matters most for migration decisions. Machine learning tools are also often the least transparent instruments available, contrasting with the field's need for outputs that policymakers can interpret and trust. Modelers exploring AI methods should treat them as approaches to test alongside, not automatically ahead of, the tools described above; and they should hold them to the same validation and interpretability standards proposed for the field as a whole.

Conclusion

The critique that has followed climate mobility modeling for three decades—that its numbers are too large, too confident, and too easily detached from their assumptions—has been productive. It has made the field more careful. But it has also set the terms of the conversation narrowly, treating the central problem as one of accuracy and prioritizing the fixing of methodologies over making modeling more usable. Evidenced by our interviews, accuracy is not what stands between these models and the decisions they might inform: Relevance is.

That distinction matters because the two problems have different solutions. A more accurate projection to 2050 does not help a municipal planner decide whether to permit development in a flood zone or a donor choose between livelihood support and early warning investment in the next funding round. What would help is a different set of outputs: shorter horizons; finer spatial resolution; disaggregation by age, income, and occupation; explicit representation of policy levers; and honest treatment of immobility as the more common outcome. And this points to a design, not accuracy, problem.

However, the task of bridging gaps does not belong to a single group. Modelers will need to not only innovate their methodologies but also listen more to policymakers' needs—even when those needs are not easily answerable or raise difficult normative questions. Policymakers will need to work within their governments both to make their own data publicly available to feed into such models and to be clearer about what precise questions they need modelers to focus on. And instead of an ad-hoc, siloed effort, this will require researchers, policymakers, data providers, and donors to get much more collaborative—and funders to invest in such collaboration. The field does not need a single best model. It needs a portfolio of models, made public and accessible, with their limitations marked and policy use cases as their guiding light.

Appendix

Supplemental Table S1. Climate Mobility Models Assessed

Each model (n = 37) was coded for modeling approach, geographic scope, spatial resolution, migration type (internal, cross-border, both, immobility), climate hazards represented, time horizon, treatment of policy interventions, data source, causal mechanism, functional form, scenario inputs, validation methods, assumptions, key findings, and publication venue and year. The following table is a subset of our model mapping and assessment work.

Model	Modeling Approach	Geographic Scope	Spatial Resolution	Migration Type	Climate Hazards Represented	Time Horizon	Treatment of Policy Interventions
Abel et al. (2013)[i]	Bayesian Model	National [United Kingdom]	Administrative	Cross-border	EXPERT ELICITATION	2010 - 2060	Not addressed
Amakrane et al. (2023)[ii]	Gravity Model with Econometric Component	Regional [Africa]	Rasterized View	Internal + Cross-border	MULTI HAZARD (Water Avail., Crop Yield, Flood Hazard, SLR)	Up to 2050	Not addressed
Bariberi et al. (2010)[iii]	Computable General Equilibrium (CGE) Model	Sub-national [North East Brazil]	Administrative	Internal	TEMPERATURE INCREASE	Up to 2050	Not addressed
Bell et al. (2021)[iv]	Agent-Based Model (ABM)	National [Bangladesh]	Administrative	Internal + Immobility	SEA-LEVEL RISE	Up to 2100	Modeled explicitly (Effects of increased access to credit on mobility outcomes.)
Benveniste et al. (2022)[v]	Gravity Model and Integrated Assessment Model	Global	Administrative	Internation-al-Immo-bility	General CLIMATE-ECON (Non-ag Specific)	Up to 2100	Not addressed
Best (2022)[vi]	Agent-Based Model (ABM)	National [Bangladesh]	N/A	Internal (general mechanism)	MULTI HAZARD (Temperature rise, flooding, salinity, cyclones, sea-level rise, and rainfall variability	Up to 2100	Not addressed
Burzyński et al. (2022)[vii]	Computable General Equilibrium (CGE) Model	Global	Rasterized View	Internal + Cross-border	MULTI HAZARD (SLR, Avg Surface Temp, Extreme Events)	Up to 2100	Modeled explicitly (Immigration law and policy scenarios)

Model	Modeling Approach	Geographic Scope	Spatial Resolution	Migration Type	Climate Hazards Represented	Time Horizon	Treatment of Policy Interventions
Burzyński et al. (2021)[viii]	Spatial General Equilibrium (SGE) Model + Gravity Model	Global	Rasterized View	Internal + Cross-border	TEMPERATURE VARIANCE & SEA-LEVEL RISE	2040, 2070, 2100	Modeled explicitly (Effects of changes to international migration restrictions on poverty at origin)
Cattaneo and Massetti (2019)[vix]	Econometric	National [Nigeria]	Administrative	Internal + Cross-border	TEMPERATURE & PERCIPITATION VARIANCE	2031 - 2060 & 2071 - 2100	Not addressed
Cattaneo et al. (2024)[x]	Gravity Model with Econometric Component	Global	Administrative	Cross-border	MULTI HAZARD (Temp, Precipitation, Droughts, Flood)	Up to 2060 (reported by decades)	Static Policy Assumption
Chen and Mueller (2018)[xi]	Source: Econometric	National [Bangladesh]	Administrative	Internal + Cross-border	SOIL SALINITY & FLOODING (Both)	N/A	Not addressed
Choquette-Levy et al. (2021)[xii]	Agent-Based Model (ABM)	Sub-national [Chitwan Valley, Nepal]	N/A	Internal + Immobility	TEMP INCREASE	Up to 2050	Modeled explicitly (Tests risk-transfer/ social-protection interventions (cash transfers, insurance, remittance banks).)
Choquette-Levy et al. (2026)[xiii]	Agent-Based Model (ABM)	National [Senegal]	Administrative	Internal	DROUGHT & SEA-LEVEL RISE (Separate Scenarios)	Up to 2050	Modeled explicitly (Models effects of aspiration-enabling resilience policies.)
Clement et al. (2021)[xiv]	Gravity Model with Econometric Component	Multi-Regional [East Asia & Pacific, North Africa, Eastern Europe & Central Asia]	Rasterized View (14-square kilometer grid)	Internal	MULTI HAZARD (Water Scarcity, Crop Productivity, SLR)	Up to 2050	Not addressed
Davis et al. (2018)[xv]	Radiation Model (Modified)	National [Bangladesh]	Administrative	Internal	SEA-LEVEL RISE	2050 & 2100	Not addressed
De Lellis et al. (2021)[xvi]	Radiation Model (Modified)	National [Bangladesh]	Administrative	Internal	SEA-LEVEL RISE	Up to 2050	Not addressed
Feng et al. (2010)[xvii]	Econometric	National [Mexico]	Administrative	Cross-border	TEMPERATURE, PERCIPITATION & SUMMER TEMP VARIANCE	Up to 2080	Held Constant
Feng et al. (2012)[xviii]	Econometric	National [USA, Corn Belt]	Administrative	Internal	HEAT/ TEMPERATURE & PRECIPIPATION (Both)	2020 - 2049 & 2077 - 2099	Held Constant

Model	Modeling Approach	Geographic Scope	Spatial Resolution	Migration Type	Climate Hazards Represented	Time Horizon	Treatment of Policy Interventions
First Street Foundation (2023)[xix]	Machine Learning + Econometric	National [USA]	Statistical entity (Spatially explicit modeling at census block group level across CONUS)	Internal	MULTI HAZARD (Flood, cyclone winds, wildfire smoke, drought, wildfires, and heatwaves)	Up to 2053	Not addressed
Hassani-Mahmooei and Parris (2012)[xx]	Agent-Based Model (ABM)	National [Bangladesh]	Administrative	Internal	MULTI HAZARD (SLR, Floods, Droughts)	2001 - 2050	Not addressed
Hauer (2017) [xxi]	Migration Systems Simulation Model	National [USA]	Statistical Entity (319 coastal origin counties and 3,113 destination counties across the US)	Internal	SEA-LEVEL RISE	Up to 2100	Not addressed
Hirsch et al. (2026)[xxii]	Econometric	Global	Rasterized View (12.5km Resolution)	Cross-border	MULTI HAZARD (Flood, Wind, Drought, Extreme Heat/Cold, Wildfires)	Up to 2100 (Examined at 2055 and 2100)	Not addressed
Jones (2020) [xxiii]	Gravity Model with Econometric Component	Regional [Central America & Mexico]	Rasterized View	Internal + Cross-border	MULTI HAZARD (Water Availability, Crop Yields, Ecosystem Prod., Flood, Groundwater, Extreme Heat Days, SLR)	Up to 2100	Not addressed
Jones (2024) [xxiv]	Gravity Model with Spatial Allocation	Multi-Subnational [Accra, Amman, Bogotá, Curitiba, Dhaka, Freetown, Karachi, Rio de Janeiro, Salvador, São Paulo]	Rasterized View	Internal	MULTI HAZARD (Crop Yields, Saltwater Intrusion, SLR, Flooding, Water Stress, Drought, Landslides)	Up to 2050 (10-year time steps)	Not addressed
Kniveton et al. (2012)[xxv]	Agent-Based Model (ABM)	National [Burkina Faso]	Administrative	Internal + Cross-border	RAINFALL VARIABILITY	Up to 2050	Not addressed
Martin et al. (2025)[xxvi]	Gravity Model and 'Hybrid Foresight Approach'	Multi-Subnational [Karachi & Ho Chi Minh City]	Administrative	Internal	MULTI HAZARD (Water Availability, Crop Yields, Ecosystem Prod., Flood Hazard, Groundwater, Heat Extreme, Drought, SLR)	2020 - 2050	Not addressed

Model	Modeling Approach	Geographic Scope	Spatial Resolution	Migration Type	Climate Hazards Represented	Time Horizon	Treatment of Policy Interventions
Milan et al. (2016)[xxvii]	Agent-Based Model (ABM)	National [Tuvalu]	Administrative	Internal + Cross-border	MULTI HAZARD (Cyclone, Drought, Rainfall Variability, Floods, SLR, Saltwater Intrusion, Storm Surge)	2015-2055	Not addressed
Naugle et al. (2018)[xxviii]	System Dynamics Migration Simulation Model	National [Mali]	Administrative	Internal + Cross-border	MULTI HAZARD (Temp., Extreme Events, Water availability)	1990 - 2060	Modeled explicitly (Compares governance/ urban-aid investment scenarios ("policy levers") as drivers of migration pressure)
Oakes et al. (2016)[xxix]	Agent-Based Model (ABM)	National [Kiribati]	Administrative	Internal + Cross-border	MULTI HAZARD (Cyclone, Drought, Rainfall Variability, Floods, SLR, Saltwater Intrusion, Storm Surge)	2015 - 2055	Not addressed
Oliviera and Pereda (2020)[xxx]	Spatial General Equilibrium (SGE) Model	National [Brazil]	Administrative	Internal	TEMPERATURE, RAINFALL & SUNSHINE HOUR VARIANCE	2040 - 2070	Not addressed
Reimann et al. (2023)[xxxi]	Gravity Model	Regional [Mediterra-nean]	Rasterized View	Internal	SEA-LEVEL RISE	2020 - 2100 (10 year time steps)	Modeled explicitly (Scenario-tests coastal adaptation and protection policies ("Shared Policy Assumptions") and their effect on migration)
Rigaud et al. (2018)[xxxii]	Gravity Model with Econometric Component	Multi-Regional [Sub-Saharan Africa, South Asia, Latin America]	Rasterized View (14-square kilometer grid)	Internal	MULTI HAZARD (Water Scarcity, Crop Productivity, SLR, Storm Surge)	Up to 2050	Not addressed
Robinson et al. (2020)[xxxiii]	Machine Learning [Artificial Neural Network]	National [USA]	Administrative	Internal	SEA-LEVEL RISE	Up to 2100	Not addressed
Rosengaert-ner et al. (2025)[xxxiv]	Computable General Equilibrium (CGE) Model	Regional [Greater Caribbean (Association of Caribbean States)]	Rasterized View	Internal + Cross-border + Immobility	MULTI HAZARD (Crop Yields, Temperature, SLR, Disasters, Coral Bleaching)	Up to 2050	Not addressed

Model	Modeling Approach	Geographic Scope	Spatial Resolution	Migration Type	Climate Hazards Represented	Time Horizon	Treatment of Policy Interventions
Shu et al. (2023)[xxxv]	Econometric with Spatial Allocation	National [USA]	Statistical Entity	Internal	FLOOD EXPOSURE	2023 - 2053	Not addressed
Smirnov et al. (2022)[xxxvi]	Agent-Based Model (ABM)	Global	Administrative & Rasterized View	Internal + Cross-border + Immobility	DROUGHT	Up to 2100	Not addressed
Speelman et al. (2022)[xxxvii]	Agent-Based Model (ABM)	National [Maldives]	Administrative	Internal + Cross-border	SEA-LEVEL RISE & MARINE HAZARDS (Captured Indirectly	Up to 2050	Modeled explicitly (Tests the effects in some narratives of environmental protection and resettlement policies)

Note: "Migration type" reflects the primary mobility outcome(s) modeled, with "Immobility" appended where a model explicitly represents trapped/immobile populations. "Treatment of policy interventions" indicates whether a model incorporates the effects of a specific policy variable or intervention (for example, adaptation investment, social protection, migration governance) as an explicit input or mechanism. Models that assume the effects of unspecified policy interventions through the use of SSP and/or RCP background conditions are not counted here as modeling policy interventions.

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