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Mapping climate mobility hotspot risks: An approach for development organizations to assess risks and responses to climate mobility

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Summary

Concerns are growing across Latin America and the Caribbean that climate shocks and stresses are directly and indirectly connected to migration, displacement and relocation. But where are the climate mobility hot spots and which populations are most at risk? While statistical models that forecast climate mobility are rapidly improving, there are still uncertainties about the scope, scale and dimensions of climate mobility across the region. This report proposes a preliminary conceptual approach for development organizations such as UNDP to assess risks and responses to climate mobility. At its centre is a basic framework focusing on a shortlist of climate stresses and shocks, socioeconomic drivers and structural vulnerabilities correlated with out- and in-mobility.

The paper makes four recommendations on how development partners may assist countries facing increased climate mobility:

» Support national and subnational counterparts with timely and future -looking diagnostics tailored to local contexts.

» Invest in improved situational awareness of climate mobility with key government, private, and non-governmental partners.

» Support and strengthen policy, programmes and infrastructure to increase adaptation and resilience in areas of expulsion and reception.

» Help embed climate mobility priorities in development plans and planning from the national to the municipal levels.

1. Introduction

One way to better prepare for climate mobility is by anticipating where displacement, migration and relocation are likely to occur and who is most at risk.[2] Notwithstanding tremendous advances, most statistical estimates of climate mobility hotspots are fraught with uncertainties. First generation approaches emphasizing econometric methods are now complemented by second generation modelling using machine-learning methods.[3] This paper builds on ongoing initiatives and summarizes the literature on climate mobility forecasting. Drawing on empirical research, it proposes a basic conceptual framework for identifying possible climate mobility 'hotspots' in Latin America and the Caribbean. The intention is not to forecast future trajectories of climate-related migration and displacement. Rather, the aim is to rapidly identify spatial areas and demographics that are particularly vulnerable. By building foresight and shared understanding, UNDP can strengthen preparatory planning and enhance investment in adaptation and resilience strategies.

The paper highlights several geographies that are particularly at risk, namely the Gulf of Mexico, the dry corridor of Central America, the Amazon Basin region, north and north-eastern Colombia and parts of northern Brazil. These are hardly the only hot spots, with a wide range of geographies likely to experience increasingly precarious vulnerabilities owing to more frequent and intense climate shocks and stresses. The paper closes with opportunities for UNDP as well as several recommendations to support national counterparts. The aim of the report is not to compete with existing scientific studies or propose a new statistical model. Rather, the goal is to outline a practical conceptual and operational approach for UNDP country offices to organize descriptive assessments of indicative risks.

2 There are multiple definitional issues that should be noted in this paper. The focus is on climate mobility, which includes primarily displacement, migration and planned relocation (and considers 'trapped' populations). Other terms include 'environmental migration', 'climate or environmental refugee', 'environmentally displaced person' and 'disaster displacement'. See www.migrationdataportal.org/themes/environmental_migration_and_statistics.

3 See Byer, R., Schewe, J. and G. Abel (2023). Modeling climate migration: dead ends and new avenues, Frontiers (5).

2. Forecasting climate mobility – the state of the art

There is considerable interest in estimating current and future patterns of human mobility.[4] Applications range from forecasting international and internal migration[5] and estimating asylum applications[6] to predicting internal displacement flows due to conflict[7] and drought.[8] Approaches routinely apply statistical and econometric models[9] as well as case studies using a combination of quantitative and qualitative methods.[10] A common reflection across all assessments is that the factors driving human mobility are frequently complex, non-linear and compounding, and the underlying data are often of uneven quality and coverage. A rapid review of the peer-review published literature on climate migration in Latin America and the Caribbean also indicates that there are relatively few comparative quantitative assessments and an abundance of case studies using qualitative methods.[11]

Interest in predicting the scale of climate mobility steadily expanded over the past three decades. An early focus was on modelling the interaction of different types of climate stresses and shocks with different forms of migration and displacement.[12] These typically involved the application of econometric models drawing on historical data, though they have come under criticism for insufficiently accounting for nonlinearity of climate mobility and explaining only a small fraction of observed migration data.[13] More recently, advanced models applying machine learning are not just forecasting climate and human mobility, but also ranking the relative importance of specific drivers, including specific weather-related factors, socioeconomic variables and spatial heterogeneity.[14] Notwithstanding improvements in modelling techniques and enhanced computing power, some analysts claim that existing climate

4 Human mobility is a generic term that includes "all the different forms of movements of persons." It is used in the Cancun Agreement to refer to displacement, migration and planned relocation.

5 Migration forecasts include quantitative assessments of future migration trends since the 1990s, in particular. Approaches include argument-based forecasts, migration intention surveys, spatial interaction models, time-series extrapolation, Bayesian models and, increasingly, machine learning. See Valk, H et al. (2022). How to predict future migration: different methods explained and compared, Introduction to Migration Studies, link.springer.com/chapter/10.1007/978-3-030-92377-8_28. See also Welch, N. and Raftery, A. (2022). Probabilistic forecasts of international bilateral migration flows, PNAS 119 (35), pubmed.ncbi.nlm.nih.gov/35994637/ and Fuchs, J., Sohnlein, and P. Vanella (2021), Migration forecasting - significance and approaches, MDPI 1 (3), www.mdpi.com/2673-8392/1/3/54.

6 Such methods typically estimate migration drivers in countries of origin and destination using a combination of geolocated events and Internet searches, detections of illegal crossing at EU borders and asylum recognition rates. See Carammia, M., Incus, S. and T. Wilkin (2022). Forecasting asylum-related migration flows with machine learning and data at scale, Nature 12 (1457), www.nature.com/articles/s41598-022-05241-8.

7 See Rost, N. (2023). Can we predict conflict displacement?, IDMC, www.internal-displacement.org/expert-opinion/can-we-predict-conflict-displacement.

8 See Jabas, J., Maco, E. and M. Miranda (2022). Drought displacement modelling, IDMC, www.internal-displacement.org/sites/default/files/publications/documents/220906_IDMC_DroughtDisplacementModelling.pdf.

9 See, for example, the Global Displacement Forecast, which applies AI and machine learning (gradient-boosted trees) to 148 displacement-relevant indicators from 18 open sources. It focuses on 26 countries accounting for over 90 percent of all global displacement. Consult Danish Refugee Council at pro.drc.ngo/media/4c5hxa5c/230310_global_displacement_forecast_report_2023.pdf.

10 See, for example, IPCC reports.

11 These observations were confirmed during an interview with Pablo Escribano and Dalila Polack, 25 August 2023. One exception is the World Bank's Groundswell case study on Mexico and Central America. See World Bank (2019). Internal climate migration, Policy Note 3, Groundswell, documents1.worldbank.org/curated/en/983921522304806221/pdf/124724-BRI-PUBLIC-NEWSERIES-Groundswell-note-PN3.pdf.

12 See Beyer and Milan (2023).

13 See Beyer and MIlan (2023); Beyer, Schewe, and Abel (2023); Hoofman (2020); and Wesselbaum and Aburn (2019). Interview with Andrew Harper (UNHCR), 20 August 2023.

14 See Nival et al. (2021). and Beyer, Schewe and Abel (2023).

mobility models are not yet ready to inform policy-making about either in- or out-migration, at least not in relation to development, border, labour or migrant policy and practice.[15]

Newer climate mobility models are leveraging machine learning and spatial analytics. These move beyond econometric models that assume a linear function of environmental, economic, social, demographic, political and other factors. They build on qualitative studies that underline how mobility decisions and outcomes are frequently a result of complex interactions operating at multiple scales. More complex non-linear machine-learning approaches such as random forests and neural networks are offering promising new avenues that may overcome limitations of econometric models (see Table 1).[16] They can describe arbitrarily complex interactions and accommodate the high context-specificity of how migration responds to a wide range of variables.[17]

Table 1. Sample of climate mobility assessments

Approach	Geography	Author	Data sources
Machine-learning random forest and neural network model (2022)	Global	Global Migration Data Analysis Centre (IOM)	
Population gravity modelling and spatial pathways (2018, 2021)	Global	Groundswell (World Bank)	20 data sources including NASA, World Bank, Center for International Earth Science Information Network, and others
Foresight model using forecasting, scenario and Bayesian network analysis (2023)	Global	Danish Refugee Council (DRC) with partners	18 sources and 148 indicators including Armed Conflict Location and Event Data Project (ACLED), Uppsala Conflict Data Program, Food and Agricultural Organization (FAO), UNHCR, World Food Programme
Intersectoral impact model intercomparison project using GCM, GHM, GGCM, GVM, GBM, TRMM, VIEWS and other models (2022)	Sahel	Sahel Predictive Analytics Project – Research consortium facilitated by UNCHR	Same as above

The World Bank has issued several influential reports generating forecasts of climate mobility, including in Latin America and the Caribbean (see Table 1).[18] The Groundswell series applies both econometric models as well as spatial analysis. Drawing on several climate models,[19] it quantifies changes in

15 Interview with Rodney Martinez Guingla, 30 August 2023. See also Beyer and Milan (2023) and Beyer et al. (2023).
16 See for example, the IOM Global Migration Centre datasets, as well as a host of others identified by Beyer et al. (2023).
17 They may not be, however, the best approach to advancing a conceptual understanding of economic, social and other processes affecting migration due to their 'black box' nature.
18 See Clement, V., Rigaud, K., de Sherbinin, A., Jones, B. Adamo, S., Schewe, J., Sadiq, N., and E. Shabahat (2021). Groundswell I and II, Acting on Internal Climate Migration, openknowledge.worldbank.org/entities/publication/2c9150df-52c3-58ed-9075-d78ea56c3267 and Beyer and Milan (2023).
19 There are two sets of climactic and socioeconomic scenarios being used in forecasting models. There are the Shared Socioeconomic Pathways (SSPs) that cover five alternate future demographic, social and economic scenarios (SSP1 to SSP5) that represent different assumptions about growth, consumption, inequality and cooperation. There are also the Representative Concentration Pathways (RCPs) that explore greenhouse gas concentration and by implication, global warming: SSP1-RCP2.6 is a 1.9C increase by 2081–2100 and SPP3-RCP7.0 is a 3.9C increase. These scenarios do not capture inputs on future conflict, political and technological changes, or health crises.

climate-related,[20] socioeconomic and demographic variables and simulates internal migration from less to more attractive locations.[21] The Groundswell approach predicts internal migration arising from disasters and slow-onset hazards by 2050, with alternating ranges based on distinct scenarios.[22] However, the Groundswell assessments, like others before them, struggle to differentiate climate and environmental factors from other triggers in shaping migration. Moreover, they do not discriminate between mobile and trapped populations (people who need and want to move, but cannot), much less the duration of migration or displacement.[23] Likewise, they do not provide short-term assessments of human mobility. Nevertheless, the Groundswell reports, including the methodological annex, provide a potent advocacy tool, relevant methodology and useful baseline.

Another recent effort to measure risks and vulnerabilities associated with climate migration is the Sahel Predictive Analytics Project (see Table 1).[24] An underlying assumption of the many organizations involved in the assessment is that it is possible to anticipate short-, medium- and long-term change in climate,[25] food security,[26] conflict[27] and human mobility[28] to help identify current and future hotspots. Rather than focusing narrowly on the number of people on the move, it adopts a territorial approach. As with the Groundswell reports, the Sahel study applies a range of climate scenarios to its forecasting and finds out-migration clusters in areas where livelihood systems are increasingly compromised by climate impacts. It also considers climate in-migration, which concentrates, as expected, in areas with more attractive livelihood opportunities. The study finds that movements are most likely from less viable areas registering lower water availability and crop productivity and higher exposure to rising sea levels and storm surges. It also notes that people tend to migrate or be displaced into areas exhibiting better opportunities for agriculture and urban settings with more livelihood options.

Notwithstanding a proliferation of innovative approaches to measuring and predicting climate mobility, most studies suffer from a range of limitations. Very generally, qualitative studies focused on a single micro-location lack generalizability while quantitative assessments mapping a cross-section of countries often fail to account for the complex subnational heterogeneity of climate migration experiences. Another caveat is that in many parts of the world, including Latin America and the Caribbean, data availability, coverage and quality are highly uneven. These limitations are frequently openly acknowledged by researchers. Some of these challenges are being overcome. The increasing accessibility of a wide range of data, including remote sensing information, and the advent of machine-learning algorithms and AI-enabled computing are expanding opportunities to assess

20 Specifically, water stress, crop yields and seal level rise augmented by storm surges.

21 Amakrane et al. (2023) applies a modified version of Groundswell in Africa, and includes additional variables such as gradual ecosystem impacts, flood risks and conflict. He found contrary results despite replicating the methodology.

22 Importantly, the Groundswell model conducted simulations both with and without 'anthropogenic climate change'. The number of migrants attributed to climate change was the difference between both climate-change and counterfactual simulations. See Beyer and Milan (2023), p. 17.

23 See Migration Data Portal, https://www.migrationdataportal.org/themes/environmental_migration_and_statistics.

24 See Loeben, S. et al. (2022). Moving from reaction to action: anticipating vulnerability hotspots in the Sahel, UNHCR and OSCDS, www.unhcr.org/media/moving-reaction-action-anticipating-vulnerability-hotspots-sahel-0.

25 Specifically, global climate change data are from ISMIP and include temperature change, number of hot days above 35C, water availability (annual rainfall per person), water run-off (water discharged), exposure to droughts (crop area exposed to drought at least once a year) and crop yields (maize, rice, soy and wheat).

26 Food security indicators are drawn from WFP and FAO and include agricultural production (crop yields), small-holder production of crops and hunger.

27 Conflict indicators are informed by ACLED and VIEWS and include conflict history, the strength of political institutions and measures of democracy, socioeconomic conditions, food prices and food security, climate variability, societal vulnerability, natural and social geography, and social and political unrest.

28 The migration model is called INCLUDE and is based on UNHCR and OCHA data. It estimates 'population potential' that is a measure of influence that a population exerts spatially and is a proxy of attractiveness, assuming that agglomeration includes geographic, physical, political and socioeconomic conditions that make a place more desirable.

climate migration correlates. Even so, there continues to be a high level of uncertainty in findings and caution in their application.[29]

3. Proposed framework for climate mobility hotspots

The paper proposes a preliminary framework to assist in identifying climate mobility hotspots in Latin America and the Caribbean based upon three broad categories (see Table 2) and a mixed-methods approach. A first step involves assessing known **climate stresses and shocks** that are directly and indirectly correlated with mobility, including extreme weather events, changes in precipitation, temperature shifts, drought and sea level rise.[30] Step two includes mapping selected **socioeconomic drivers** including declining crop yields, increasing food insecurity and the extent of physical security. The third step entails a review of **structural vulnerabilities** ranging from political regime type to population income and education levels, which may shape the extent of mobility (or not). Likewise, a determination of plausible area of reception of climate-displaced migrants involves assessing geographic zones and urban agglomerations offering favourable livelihood options and/or attractive services and amenities. To estimate future scenarios, these metrics can then be correlated with different climate and development scenarios as well as historical patterns of migration and displacement. The proposed framework is intended to provide a generic overview of risks and vulnerabilities and does not account for temporal dynamics of climate mobility.

29 Indeed, there is a risk that the latest generation of analytics could contribute to overconfidence in the certitude of findings and lead to misleading recommendations.

30 Shocks are sudden-onset hazards and extreme weather events, many of which are expected to increase in frequency and severity. The onset of stresses is slower, including temperature rise, water stress, land degradation and sea level rise. Both phenomena generate stresses on social and economic conditions, increasing likelihood of migration. See Hoffmann R, Dimitrova A, Muttarak R, et al. (2020). A meta-analysis of country-level studies on environmental change and migration. Nature Climate Change. 10(10): pp.904–912 and Kaczan DJ and Orgill-Meyer J. (2020). The impact of climate change on migration: a synthesis of recent empirical insights. Climatic Change. 158(3): pp.281–300.

Table 2. Factors contributing to climate migration hotspots

	Variables	Possible datasets
Climate shocks and stresses	Floods, storms, cyclones, rising temperatures, droughts, intense precipitation, sea level rise	Disaster data (EM-DAT, NOOA, NASA), Flood data from (UNU), Rainfall data (FAO, Copernicus), Temperature change on land and water (FAOSTAT, Berkeley), Drought (GPCC, GDIS), Sea level rise (NASA, World Bank), UNEP[31] and WMO datasets[32]
Socio-economic drivers	Declining crop yields, increased water stress, food insecurity, physical insecurity	Food security (FAOSTAT, GIEWS), Crop yields (FAOSTAT, GEPIC and PEPIC) or maize, rice, soy and wheat and other yields from LPJmL, Land patterns (ISIMIP2b), Water stress (FAO Aquastat, WRI), Homicide data (Igarape Institute/UNODC)
Structural vulnerabilities	Political regime type, fragility index, population income, education levels	Political regime data (V-DEM), GDP per capita (CEPAL[33]), Subnational poverty rates (World Bank), School attendance (CEPAL) and other variables related to conflict and fragility (ACLED, UCDP, World Bank)
Climate scenarios	Temperature change, hydrological cycle, crop productivity, species distribution, temperature-related mortality, water availability, run-off, exposure to droughts	Global climate models (IPSL-CM5A-LR, GFDL-ESM2M, MIROC5, HadGEM2-ES), Hydrological models (CLM45, H08, LPJml, MPI-HM, PCR-GLOBWB, WaterGAP2),Gridded crop models (GEPIC, LPJmL, PEPIC, LPJ-GUESS), Temperature mortality model (TRM-Tsukuba), Overall vulnerability to climate change (ND-GAIN), Socioeconomic pathways (SSP) and Representative concentration pathways (RCP)[34]
Population data	Cross-border displacement, internal displacement, emigration, immigration, relocation	Refugee/asylum claimants (UNHCR), Internal displacement data (IDMC), International migration (IPUMS), Subnational population (NASA/CIESIN)

Source: Author

Several basic assumptions apply to the proposed methods and selected variables. First, worsening projected climate and development scenarios are likely to exacerbate climate mobility. Second, the accumulation of risks and vulnerabilities is more likely to increase the risk of climate mobility. Third, climate shocks are more likely to lead to direct (temporary) displacement while climate stresses are more likely to contribute to indirect (permanent) migration. Fourth, socioeconomic drivers increase the vulnerability of individuals, households and communities to shocks and stresses and mobility outcomes. Fifth, increased exposure to tropical storms and hurricanes, heavy rains and floods, sea level rise, reduced water availability, drought and declining crop productivity are strongly correlated to climate mobility.[35] Sixth, structural vulnerabilities such as political regime type, income levels and extent of education can both increase and decrease the incidence and duration of mobility. Finally,

31 See unepgrid.ch/en/platforms, and psl.noaa.gov/data/gridded/data.gpcc.html.
32 See library.wmo.int/doc_num.php?explnum_id=11270.
33 See statistics.cepal.org/portal/cepalstat/dashboard.html?lang=es.
34 See https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10 and tntcat.iiasa.ac.at/RcpDb/dsd?Action=htmlpage&page=welcome
35 See World Bank (2020) and Jones, B. (2020). Modelling climate change-induced migration in Central America and Mexico, Methodological Report, unpublished; and Chaves-Gonazels, D. (nd). Cambio climático y migración, UNDP; IOM (2021). La movilidad humana derivada de desastres y el cambio climático en Centroamérica, kmhub.iom.int/sites/default/files/publicaciones/la_movilidad_humana_derivada_de_desastres_y_el_cambio_climatico_en_centroamerica.pdf; Bleeker et al. (2020). Advancing gender equality in environmental migration and disaster displacement in the Caribbean, Studies and Perspectives 98, kmhub.iom.int/sites/default/files/publicaciones/advancing_gender_equality_in_environmental_migration_and_disaster_displacement_in_the_caribbean.pdf; CSM (2021). Mapeo sobre migración, medio ambiente, y cambio climático en América del Sur, environmentalmigration.iom.int/sites/g/files/tmzbdl1411/files/documents/mapeo-sobre-migracion-medio-ambiente-y-cambio-climatico-en-america-del-sur_csm.pdf; IOM (2022). Climate change and migration in Peru, publications.iom.int/system/files/pdf/assessing-the-evidence-peru.pdf; IOM (2023). Movilidad ambiental y climática en América del Sur: Fact Sheet Uruguay, June, robuenosaires.iom.int/sites/g/files/tmzbdl626/files/documents/2023-07/oim_mecc_factsheet_uruguay.pdf;

the legacy of mobility – particularly migration, displacement and planned relocation – can influence the likelihood (or not) of future mobility.

Any estimation of climate mobility hotspots is loaded with caveats and limitations. For one, the framework proposed here is intended to be descriptive. It provides the basis for correlation analysis rather than causal inferences that might be generated using regressions. Moreover, the shortlist of proposed metrics included in Table 2 is not exhaustive; rather they are included based on their empirically demonstrated association with mobility in reviewed quantitative and qualitative studies. It should be recalled that independent variables demonstrated as having a robust correlation with climate mobility in one setting may not necessarily generate similar outcomes in another.[36] Related, the risks and vulnerabilities proposed in Table 2 are not, and would need to be, weighted. Climate mobility hotspots can change. Indeed, the frequency and intensity of future climate shocks and stresses will be profoundly shaped by changes (or not) in greenhouse gas emissions. Likewise, the extent of socioeconomic risks and structural vulnerabilities will be conditioned by progress (or not) in sustainable development.

Finally, the location of hotspots will likely change over time depending on alternate climate and development scenarios as well as non-linear interaction effect. As such, there is a high degree of uncertainty when assessing dynamic climatic and non-climatic variables. While historical data are essential, it is important to consider projected shifts in climate as well as demographic and socioeconomic factors when considering mobility. It is also critical to continuously update assessments with new and improved data as they become available.[37]

4. Reviewing climate mobility factors

According to the Intergovernmental Panel on Climate Change (IPCC), **extreme weather events and shocks** provide the most direct pathway to displacement owing to loss of residence and economic disruption, though most people tend to return home as soon as it is practical to rebuild.[38] Areas particularly affected by major cyclones, hurricanes and storms include coastal communities – especially in small island States – where communities in low-lying areas are particularly vulnerable to both affected water supplies and storm surges. Likewise, populations living in areas prone to landslides and floods are similarly at risk.[39] Since decisions to move are costly and disruptive, displacement and migration are an adaptation strategy often deployed as a last resort.[40] Place attachment often

36 Ibid.
37 While this paper does not apply statistical modelling owing to time and resource constraints, this is recommended in future iterations.
38 According to the IPCC special report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, the increasing incidence and intensity of extreme weather events due to climate change will lead directly to the risk of increased levels of displacement.
39 Caribbean States are most exposed in this respect. Examples include Cuba, the Dominican Republic, Haiti and Puerto Rico, which have faced significant migration owing to extreme weather events. Also noted as a risk is Suriname, which has borne heavy rainfall resulting in the displacement of thousands of people. See WMO (2022).
40 There is also some evidence that climate changes, through impacts on productivity, can reduce mobility. For example, drought can limit long distance migration in some population groups. This is because pioneer migration to new areas as well as long-distance and international migration requires significant human and financial resources and is limited to wealthier populations.

dominates decisions about whether to relocate. Likewise, social differentiation in access to resources on the basis of ethnicity, wealth and gender are also key factors influencing migration decisions and outcomes.[41]

Meanwhile, **long-term environmental change and stresses** such as sea level rise and drought can also significantly affect human mobility patterns. This is often due to the pressures these stresses impose on income generation and livelihoods. Studies of Mexico–US and Brazilian internal mobility indicate that environmental changes related to drought and sea-level rise can also amplify existing patterns of rural-to-urban migration.[42] Declines in observed rainfall patterns, for example, can potentially influence differences in urbanization rates across countries, though more research is required to better understand the strength of the relationship. To be sure, sea level changes are an obvious driver of permanent displacement owing to coastal areas becoming uninhabitable – a particular concern for the Caribbean. Even so, in many areas under threat of long-term sea level rise, populations may elect not to move owing to reasons of culture and identity, preferring to adapt to the changing conditions.

There are significant non-climatic **socioeconomic drivers** that shape a decision or ability to move across borders or within a country. A host of social, economic and political factors influence the extent of voluntary migration, displacement and relocation. For one, underlying vulnerabilities and local adaptive capabilities will shape an individual, household or community's decision to leave or stay.[43] Adverse changes in agriculture, for example, may increase migration among middle- and lower-income groups but have limited impact on upper-income populations. Meanwhile, legal and institutional factors may deter people from crossing an international frontier or even mobility within existing borders.[44] Crucially, many people who are experiencing climate-related shocks, and to a greater extent stresses, may not cite climate factors as the reason for their move. For example, one survey of migrants to the US found that less than 6 percent of northern Central American respondents cited climate or environmental factors as reasons for their move despite severe drought and food insecurity.[45]

41 For example, many people affected by climate-related displacement and migration experience additional risks in their new destinations. The risks are particularly acute in cities where low-income and excluded migrants may cluster in high-density and risk-prone areas exposed to dangerous flooding and landslides. Many new migrants typically live in more hazardous areas than longer-residents. New migrants may also have less knowledge about climate risks and thus be more exposed to future climate risks.

42 Areas that are particularly susceptible include the Atlantic coast of South America and the subtropical North Atlantic and Gulf of Mexico. WMO (2022). State of the climate in Latin America and the Caribbean, July, reliefweb.int/report/world/state-climate-latin-america-and-caribbean-2021. See also Fent et al. (2009) and Oswald Spring et al. (2013).

43 Indeed, hazard-prone areas can actually see decreased levels of migration owing to investments to mitigate future shocks and stresses (e.g. flood barriers, water reservoirs, parkland, etc.). It is also possible that mobility can be decreased in poorer areas, precisely because local populations lack the means to move and are essentially 'trapped' in situ.

44 See Missirian A and Schlenker W. (2017). Asylum applications respond to temperature fluctuations. Science 358(6370): pp.1610–1614.

45 See the survey conducted by the Migration Policy Institute (MPI), World Food Programme (WFP) and Civic Data Design Lab (MIT) of 5,000 migrant-sending households in El Salvador, Guatemala and Honduras. It found that food-insecure people were three times more likely to make plans to migrate compared to those who were not. See Soto, A. (2021). Charting a new regional course of action: the complex motivations and costs of Central American migration, www.migrationpolicy.org/research/motivations-costs-central-american-migration.

Table 3. Selected climate shocks and stresses and socioeconomic drivers of climate mobility

	Generic description	Source examples
Extreme weather events	Climate-related hazards including above-average storms, heat waves, wildfires, floods, etc.	Black et al. (2013),[46] Bohra-Mishra et al. (2014),[47] Ghimire et al. (2015),[48] Guneralp et al. (2015),[49] Langet et al. (2020)[50]
Alterations in temperature	Increased intensity and frequency of heat waves	Cattaneo (2016),[51] Black et al. (2011),[52] Liu et al. (2017),[53] Peri and Sasahara (2019)[54]; Kephart, J. et al (2022)[55]
Changes in precipitation	Increased precipitation and flood risk increase in Latin America, particularly Colombia, Ecuador, Peru, southern Brazil and Uruguay, according to RCP2.6, RCP4.5 and RCP8.5	Beine and Parsons (2017),[56] Pörtner et al. (2022) [57]
Drought risk	Increased dryness and declines in rainfall in Latin America, particularly Argentina, northern Brazil, Central America and western Mexico according to RCP2.6, RCP4.5 and RCP8.5	Maes et al (2022)[58],), IPCC (2022)[59]; OECD (2023)[60]

46 Black R, Arnell NW, Adger WN, et al. (2013). Migration, immobility and displacement outcomes following extreme events.
47 Bohra-Mishra P, Oppenheimer M and Hsiang SM. (2014). Nonlinear permanent migration response to climatic variations but minimal response to disasters. Proceedings of the National Academy of Sciences. 111 (27): pp.9780–9785.
48 Ghimire R, Ferreira S and Dorfman JH. (2015). Flood-induced displacement and civil conflict. World Development. 66: pp.614–628.
49 Güneralp B, Güneralp İ and Liu Y. (2015). Changing global patterns of urban exposure to flood and drought hazards. Global environmental change. 31: pp.217–225.
50 Lange S, Volkholz J, Geiger T, et al. (2020). Projecting exposure to extreme climate impact events across six event categories and three spatial scales. Earth's Future. 8(12): pp.e2020EF001616
51 Cattaneo C and Peri G. (2016). The migration response to increasing temperatures. Journal of Development Economics. 122: pp.127–146.
52 Black R, Adger WN, Arnell NW, et al. (2011). The effect of environmental change on human migration. Global environmental change. 21: pp.S3–S11.
53 Liu Z, Anderson B, Yan K, et al. (2017). Global and regional changes in exposure to extreme heat and the relative contributions of climate and population change. Scientific Reports. 7(1): pp.43909.
54 Peri G and Sasahara A (2019). The impact of global warming on rural-urban migrations: Evidence from global big data. National Bureau of Economic Research.
55 Kephart, J. et al (2022) City-level impact of extreme temperatures and mortality in Latin America, Nature Medicine 28, pp. 1700-1705, www.nature.com/articles/s41591-022-01872-6.
56 Beine M and Parsons CR (2017). Climatic factors as determinants of international migration: Redux. CESifo Economic Studies. 63 (v4): pp.386–402
57 Pörtner H-O, Roberts DC, Adams H, et al. (2022). Climate change 2022: Impacts, adaptation and vulnerability. IPCC Geneva, Switzerland.
58 See Maes, M. et al (2022) Monitoring exposure to climate-related hazards: indicator methodology and key results, OECD Publishing, www.oecd-ilibrary.org/environment/oecd-environment-working-papers_19970900.
59 IPCC (2022) Climate change 2022: impacts, adaptation, and vulnerability, Intergovernmental Panel on Climate Change, report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_FinalDraft_FullReport.pdf.
60 OECD (2023) Environment at a glance in Latin America and the Caribbean: spotlight on climate change, www.oecd-ilibrary.org/docserver/2431bd6c-en.pdf?expires=1716234980&id=id&accname=guest&checksum=111986DE4AF7EC21AF56E7423A921DB3.

Sea level rise	Sea level rise estimates vary with low-elevation coastal zones and near coastal zones most at risk.	Haasnoot et al. (2021),[61] McMichael et al. (2020),[62] Neumann et al. (2015)[63]
Declining agricultural productivity	Potential impacts on maize (decreasing by 6–24%) and limited impacts on soy and rice by 2100, particularly in Mexico, Central America, the Caribbean, northern South America and central and south-eastern South America according to RCP8.5.	Falco et al. (2018) and Cai et al. (2016),[64] Jagermeyr et al. (2021)[65]
Changes in food security	Latin America and the Caribbean already has high food insecurity affecting 41% of the region (measured as proportion of income spent on food).	See Hernandez-Vasquez et al. (2022)[66]

Source: Author

Several recurring tendencies associated with climate stresses and shocks and socioeconomic drivers can be discerned from the literature on human mobility in Latin America and the Caribbean (see Table 3).[67] For example, adverse environmental factors appear to have stronger effects on internal (especially rural–urban) migration than international migration. Put another way, far fewer people appear to be moving across borders than within borders due to change in climate. A related point is that climate is one of several factors shaping decisions to move, along with socioeconomic deprivation and physical insecurity. Also, rising temperature and rainfall deficits in agricultural dependent countries tend to increase internal and international migration owing to depression of agricultural wages. Moreover, adverse climate changes in poorer settings tend to have weak effects on migration owing to resource constraints limiting mobility options. Finally, climate shocks can induce short-term internal displacement, though the impacts of extreme weather on longer-term migratory impacts are less clear.[68]

61 Haasnoot M, Winter G, Brown S, et al. (2021). Long-term sea-level rise necessitates a commitment to adaptation: A first order assessment. Climate Risk Management. 34: pp.1-15

62 McMichael C, Dasgupta S, Ayeb-Karlsson S, et al. (2020). A review of estimating population exposure to sea-level rise and the relevance for migration. Environmental Research Letters. 15(12): pp.123005.

63 Neumann B, Vafeidis AT, Zimmermann J, et al. (2015). Future coastal population growth and exposure to sea-level rise and exposure to global flooding, PLOS One, journals.plos.org/plosone/article?id=10.1371/journal.pone.0118571

64 Falco C, Galeotti M and Olper A. (2018). Climate change and migration: is agriculture the main channel? Working Paper 100, February, green.unibocconi.eu/sites/default/files/media/attach/WP_100.pdf and Cai R, Feng S, Oppenheimer M, et al. (2016). Climate variability and international migration: The importance of the agricultural linkage. Journal of Environmental Economics and Management. 79: pp.135–151

65 Jägermeyr J, Müller C, Ruane AC, et al. (2021). Climate impacts on global agriculture emerge earlier in new generation of climate and crop models. Nature Food. 2 (11): pp.873–885.

66 See Hernandez-Vasquez, A., Visconti-Lopez, F., Vargas-Fernandez, R. (2022). Factors associated with food insecurity in Latin America and the Caribbean: a cross-sectional analysis of 13 countries, Nutrients 14 (15), www.ncbi.nlm.nih.gov/pmc/articles/PMC9370137.

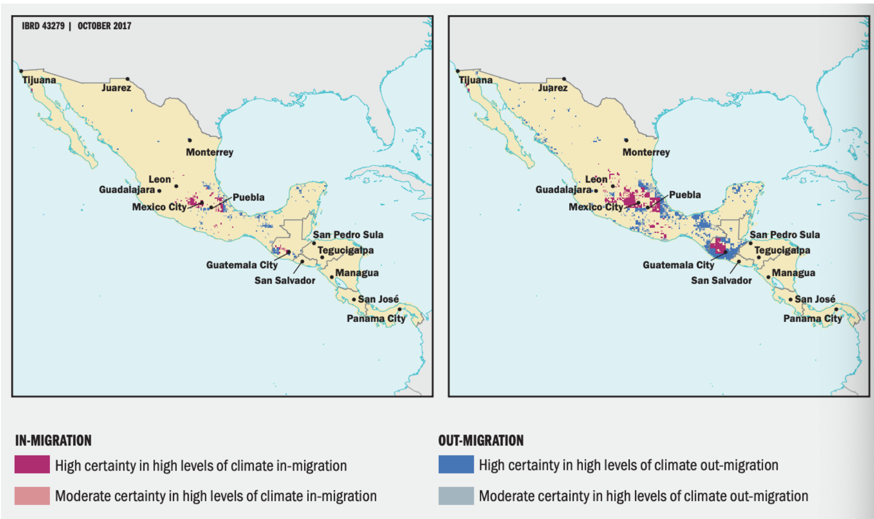
67 See Hoffmann et al. (2020).

68 See IOM, p. 11.

5. Generic climate mobility hotspots in Latin America and the Caribbean

Latin American and Caribbean countries will experience rising climate mobility, though of course the scale and dynamics vary from country to country and municipality to municipality.[69] One reason for the overall increase in risk is due to the increasing intensity and frequency of climate stresses and shocks affecting heavily populated areas. The region is one of the most highly urbanized regions in the world, with large- and medium-sized cities and significant coastal populations. Over 80 percent of Latin Americans live in cities with two-thirds of the population in cities of 20,000 people or more.[70] The most vulnerable populations typically live in peripheral and informal and marginal areas characterized by informality and concentrated disadvantage. Many also frequently register a high dependency on subsistence agriculture: households dependent on rain-fed agriculture and living on coasts are particularly sensitive to climate shocks and stresses.[71] Paradoxically, many people migrating and displaced to cities often relocate into precarious areas characterized by high exposure to climate-related hazards, physical insecurity, and marginal and informal livelihoods.

Map 1. Mapping hotspot cluster of out- and in-migration[72]



Source: World Bank (2018)[73]

69 See unfccc.int/news/new-report-details-dire-climate-impacts-in-latin-america-and-the-caribbean.
70 See CEPAL (2022). Comunicado Speaking to Territories and Cities is Critical for Rethinking the Development Model in Latin America and the Caribbean | Economic Commission for Latin America and the Caribbean (cepal.org)
71 Subsistence dependency on agriculture ranges from 10–30 percent across Latin America.
72 See World Bank (2019). Internal Climate Migration in Latin America. documents1.worldbank.org/curated/en/983921522304806221/pdf/124724-BRI-PUBLIC-NEWSERIES-Groundswell-note-PN3.pdf.
73 See World Bank (2018) Groundswell, Poly Note 3, documents1.worldbank.org/curated/en/983921522304806221/pdf/124724-BRI-PUBLIC-NEWSERIES-Groundswell-note-PN3.pdf. See updated information at www.worldbank.org/en/news/feature/2021/09/13/millions-on-the-move-in-their-own-countries-the-human-face-of-climate-change,

Climate in- and out-mobility hotspots are not just correlated with climate shocks and stresses, but also associated with latent vulnerabilities of both ecosystems and livelihoods (See Map 1).[74] As noted above, out-migration is more likely in areas where livelihood systems are compromised, and physical risks are acute. Meanwhile, the probability of in-mobility increases where livelihood options are better and where locations are considered safer and more secure. What this means is that many areas with deteriorating rainfall, declining water availability, declining crop productivity,[75] low lying coastal areas, and areas affected by insecurity are also potentially more at risk. Indeed, the number of coastal cities with more than 100,000 people expanded from 42 to 420 between 1945 and 2014, with many located close to fragile ecosystems. By contrast, densely populated settlements and pastoral or rangeland offering more appealing habitability and more economic opportunity are likely to see increased in-migration.

Several geographic areas are repeatedly identified when it comes to **climate shocks and stresses.** Among the climate factors are extreme weather events (hurricanes, cyclones, floods and fires) and stresses (droughts, changes in rainfall and sea level rise). The impacts of these are varied, including changes in planting season and crop production, especially among smallholders and key staples such as maize, and rising food insecurity. The IPCC, for example, highlights risks of freshwater scarcity in virtually all regions of Latin America and the Caribbean. Key geographic areas at risk include coastal ecosystems primarily in Central America as well as communities clustered on South America's Pacific and south-eastern Atlantic coasts. The so-called Dry Corridor of Central America, the Andean plateau including Chile, Peru and Argentina, heavily deforested areas of the Amazon Basin, and the north-eastern and northern states of Brazil are particularly at risk. In these areas, the combined intensity of climate shocks and stresses are contributing to declining harvests and food insecurity[76] and thus accelerating both migration and displacement.[77]

Several Latin American and Caribbean geographies are similarly impacted by deteriorating **socioeconomic drivers** linked to climate change. For example, the combination of temperature increases near the equator and associated with El Niño, glacial retreat and precipitation variability is not just increasing exposure to landslides and floods, it is also generating measurable shifts in land use and food production. The IPCC claims that while some areas could benefit, challenges to food production – both industrial agribusiness and smallholder harvesting – could grow across parts of South America, including the southern states of Argentina, Brazil, Chile and Paraguay[78] and the agricultural frontiers in the Amazon Basin. Similar risks to cash crops such as coffee and subsistence agriculture are also noted in El Salvador, Guatemala and Honduras.[79] The combination of extreme heat and drought is also contributing to wildfires in the interior of South America and impacting ocean and coastal ecosystems in South and Central America and Caribbean Island States and imposing risks to coastal communities and their fisheries. Another driver that both exacerbates and is exacerbated by

74 See World Bank (2018).

75 This is especially the case in agriculturally dependent areas, including among smallholder farmers. It is noteworthy that the IPCC reports that "there is limited evidence that these declines in crop yields [coffee production in Mesoamerica) may result in significant population displacement from the tropics to the sub-tropics." See Castellanos, E. et al. (2022), p. 1697.

76 See FEWS (2022). Central America and Caribbean food security outlook - October 2022 to May 2023, December 17, reliefweb.int/report/haiti/central-america-and-caribbean-food-security-outlook-october-2022-may-2023.

77 See Castellanos, E. et al. (2022), p. 1724.

78 The total South American cereal harvest declined in 2021 by 2.6 percent compared to the previous year. Combined with natural disasters, inflation and insecurity, food insecurity can rise dramatically. See Castellanos, E. et al. (2022). See also FAO (2023). The state of food security and nutrition in the world 2023, https://www.fao.org/documents/card/en/c/cc3017en.

79 Ibid.

climate and socioeconomic factors is crime and victimization. Real and perceived concerns with lethal and non-lethal violence also shape decisions on whether and where to move in the above-mentioned countries.[80]

Several **structural vulnerabilities**[81] also mediate the incidence, intensity and persistence of climate mobility. For example, countries that restrict cross-border and internal migration may impose restrictions on the ability of people to move voluntarily. They may also be more inclined to undertake aggressive planned relocation interventions, for example moving populations from areas prone to sea level rise. Likewise, States unwilling and unable to support populations facing climate stresses and shocks and facing pronounced socioeconomic pressures and fragility[82] may experience higher levels of mobility.[83] This is because poor State capacity and poor State–society relationships can worsen vulnerability. Likewise, the extent of mobility response (or 'traps') may vary in relation to local employment opportunities,[84] education levels, as well as the attractiveness of alternative options in urban centres or arable land.[85] Also, underlying demographic, social and economic factors connected to the extent of poverty, inequality, education and land tenure can all influence the extent of resilience to climate shocks and stresses and socioeconomic drivers. Finally, the dynamics of past migration, displacement and relocation experiences can also inform motivations to move. For example, populations benefiting from extensive diaspora and remittance networks may be more inclined to move than those with fewer networks of connection or reciprocity.

Some of the basic parameters of climate mobility in Latin America and the Caribbean can be traced out based on existing research (see Table 4).

Very generally, climate out-mobility tends to occur in areas where climate shocks and stresses and socioeconomic drivers are prevalent and where structural vulnerabilities – including basic incomes and livelihoods – are fundamentally compromised by climate impacts. Indeed, the decision to move is virtually always a 'last resort', even when relocation is mandated by a State authority. Thus, areas where there is deteriorating water availability, reduced crop productivity and low-lying coastal populations experiencing increased flooding are more predisposed to out-migration. Examples include lowland areas on the Gulf of Mexico and the Pacific coast of Guatemala as well as certain cities such as Monterrey and Guadalajara. Climate in-mobility will most likely occur where there are more promising income and livelihood opportunities. In some instances, densely populated settlements and rangeland areas may see more climate in-migration. Examples include the Central Plateau of Mexico (including the capital) and the highlands of Guatemala (the capital) as people leave hotter low-lying areas.

80 See IDMC (2020). The Americas, www.internal-displacement.org/global-report/grid2020/downloads/2020-IDMC-GRID-americas.pdf; Muggah, R. (2020). A humanitarian response to Central America's fragile cities, https://odihpn.org/publication/humanitarian-response-central-americas-fragile-cities; and Muggah, R. (2020). The shifting frontiers of displacement in Latin America, Oxford Handbook, www.elgaronline.com/display/edcoll/9781785360480/9781785360480.00030.xml.

81 Vulnerabilities can be physical, social and economic. A focus of the disaster risk community has traditionally concentrated on reducing physical risks, including to the built landscape.

82 See Moran, A., Busby, J. and C.. Raleigh (2018) Stretched thin: when fragile states face climate hazards, War on the Rocks, November 20, warontherocks.com/2018/11/stretched-thin-when-fragile-states-face-climate-hazards

83 See Moran, A., Busby, J. and C. Raleigh (2018). Stretched thin: when fragile States face climate hazards, War on the Rocks, November 20, warontherocks.com/2018/11/stretched-thin-when-fragile-states-face-climate-hazards

84 See Muller, V., Gray, C. and D. Hopping (2020). Climate-induced migration and unemployment in middle-income Africa, Global Environmental Change (65), www.ncbi.nlm.nih.gov/pmc/articles/PMC7737497

85 See Byrznski, M., Duester, C., Docquier, F. and J. de Melo (2022). Climate change, inequality, and human migration, Journal of the European Economic Association 20 (3), https://academic.oup.com/jeea/article/20/3/1145/6460489 and Warn, E. and Adamo, S. (2014). The impact of climate change: migration and cities in South America, Bulletin 63 (2), environmentalmigration.iom.int/resources/impact-climate-change-migration-and-cities-south-america

Table 4. Selected climate mobility hotspots in Latin America and the Caribbean[86]

	Examples of out-mobility	Examples of in-mobility
Argentina	Gran La Plata (floods),[87] Northeast (flood and contamination),[88] Catamarca, Mendoza and San Luis (desertification)	Buenos Aires (flooding and storm surges)[89]
Belize	Coastal areas (sea level rise [SLR])[90]	Belmopan
Bolivia	Central and southern highlands and eastern province (reduced rainfall loss of glaciers and flood risks)[91]	La Paz, El Alto
Brazil*	Northeast and north (drought and deforestation),[92] Atlantic coastal regions (storms and SLR), peri-urban Amazon (prone to drought and to flooding)[93]	Coastal cities (Natal, Recife, Salvador, Rio de Janeiro, Sao Paulo, Santos)[94] and interior cities (Belém, Manaus, Santarém)
Chile*	Santiago (droughts and floods),[95] Coquimbo (Monte Patria) (drought),[96] Petorca (water scarcity)[97]	Santiago (facing water stress)[98]
Colombia	Eje Cafetero including Caldas, Risaralda, Choco, Valle del Cauca, Tolima and Cundinamarca (floods, water scarcity and drought)[99]	Bogota, Cali, Medellin, Cartagena, Santa Marta and larger coastal cities
Costa Rica	Coastal areas (SLR),[100] Pueblo Nuevo Parrita (relocations)[101]	San Jose
Ecuador	Coastal Pacific area (droughts), central interior (extreme weather, intense rain and floods)[102]	Quito (facing water stress),[103] Guayaquil (facing storm surges)
El Salvador*	San Miguel, Usulután (extreme weather events, water stress)[104]	San Salvador as well as southern Mexico, US
Guatemala*	Pacific coast of Guatemala (reduced rainfall,[105] rising heat, storms, SLR), Quetzaltenango (Cabrican) (rising temperatures), Alta Verapaz and Altiplano (weather shocks, low harvests, food insecurity)[106]	Guatemala city and highland plateau (rangeland), Caballo Blanco (relocated) as well as southern Mexico, US (floods and food insecurity[107])
Guyana	Low coastal elevation populations (31% of national population exposed to SLR)[108]	Georgetown

86 These areas are based on a review of the literature, including IPCC, IOM and WMO reports, among others.
87 See Jensen and Birche (2017). See also devministerio.ecoclimasol.com
88 See Argentina MAyDS [Ministry of Environment and Sustainable Development] (2020). See also devministerio.ecoclimasol.com
89 See Castellanos, E. et al. (2022), p. 1766.
90 See IOM (2021), p. xi.
91 See IOM (2022), p. 54–56.
92 See Oliveira and Pereda (2020); Spinoni et al. (2015); Vieira et al. (2015); Mariano et al. (2018); Tomasella et al. (2018); Marengo et al. (2020); Confalonieri et al. (2014); Government of Brazil, (2020).
93 See Pinho et al. (2015); Mansur et al. (2016); Andrade and Szlafsztein (2018); Parry et al. (2018).
94 See IOM (2022), p. 65.
95 See IOM (2022), p. 74–75.
96 See IOM (2022), p. 75.
97 See IOM (2022), p. 75.
98 See Castellanos, E. et al. (2022), p. 1766.
99 See IOM (2022), p. 82–84.
100 See IOM (2021), p. xi.
101 See IOM (2021), p. 19.
102 See IOM (2022), p. 88.
103 See Castellanos, E. et al. (2022), p. 1766.
104 See Spencer and Urquhart (2018). See also IOM (2021), p 17.
105 See Warner and Afifi (2014).
106 See FEWS (2023). Irregular weather disrupts the harvest in Central America: June 2023 to January 2024, fews.net/latin-america-and-caribbean/food-security-outlook/june-2023.
107 See Aguilar et al. (2019).
108 Significant sectors of Georgetown, the capital, are below sea level. See Castellanos, E. et al. (2022), p. 1766. See also Nagy et al. (2019).

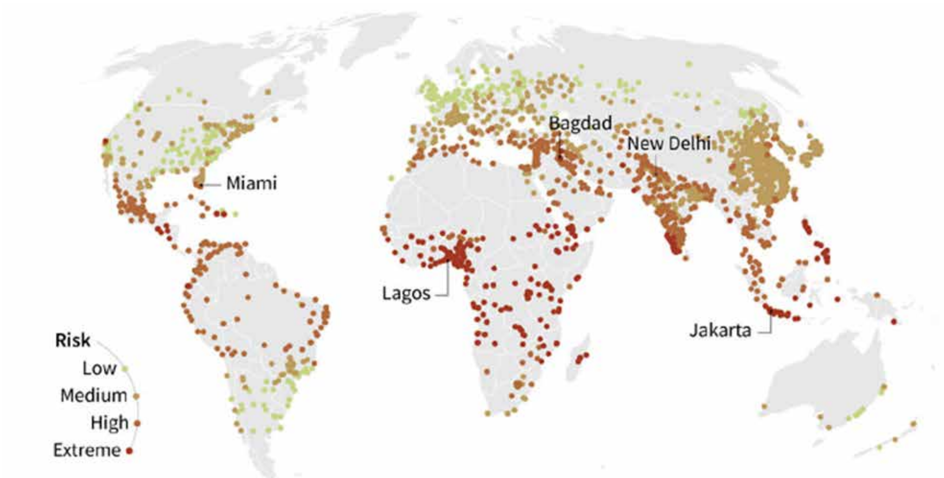
Honduras*	Low coastal elevation populations (SLR),[109] southeast border with Nicaragua, northern Honduras (floods)[110]	Tegucigalpa, Guatemala, southern Mexico, US
Mexico	Low-lying areas of Gulf of Mexico (reduced rainfall, rising heat, SLR)	Mexico City and highland plateau (rangeland), Monterrey, Guadalajara[111]
Panama	Coastal areas (SLR)	Panama
Paraguay	Areas near Paraguay and Parana rivers (floods),[112] border of Bolivia in Cerro Chovorca (fires)	Asuncion
Peru*	Coastal areas in northern area and Ica, Lambayeque and Tacna (drought and crop risk),[113] Huánuco, La Libertad and Pasco (flooding), Lima, Callao, Sechura and Chiclayo (SLR),[114] Highland areas of Piura, Loreto, Pasco, Mancora and Ancash, Puno, Junin, Cusco (glacial retreat, water scarcity and intense rains),[115] Huancavelica, Apurimac, Huánuco, Puno, Amazonas and Ayacucho (high food insecurity)	Lima (facing water stress),[116] Arequipa, Huaraz, Cusco, Amazon sites (income)[117] as well as external migration to Spain, Argentina, Italy and Chile
Suriname	Low coastal elevation populations (68% of national population exposed to SLR),[118] Paramaribo, Waniko, Sipaliwini, Commewijne and Paramaribo (floods)[119]	Paramaribo
Uruguay	Coastal region, Rio de Plata area (floods and coastal threats due to SLR)[120]	Montevideo and relocation to Canelones, Maldonado, Colonia, Florida, Soriano, Pay-sandú, Tacuarembó, Rivera and Artigas[121]
Venezuela	Low coastal elevation population (6% of population exposed to SLR)[122]	Caracas and selected coastal cities (as well as US, Colombia, Ecuador, Spain, Peru and Brazil)

Source: Author with inputs from IPCC (2022)[123] and IOM (2022, 2021)

*These countries are described as the most sensitive regions to climate migration and displacement by the IPCC (2022).[124]

109 See IOM (2021), p. ix.
110 See IOM (2021), p. 19.
111 See environmentalmigration.iom.int/resources/impact-climate-change-migration-and-cities-south-america.
112 See IOM (2022), p. 106.
113 Key areas of drought risk are Lambayeque, Tacna and Ica and medium risk for Ancash, Apurímac, Arequipa, Ayacucho, Cajamarca, Huancavelica, Junín, La Libertad Moquegua, Piura, Puno and Tumbes. The highest number of drought events have occurred in the Altiplano and the northern high jungle (SENAMHI, 2015).
114 See IOM (2022), p. 59, publications.iom.int/system/files/pdf/assessing-the-evidence-peru.pdf
115 Exposed basins include Mantaro, Ramis, Vilcanota, Majes, Santa, Mayo, Amazonas (Loreto), Marañón (Amazon) and Huallaga. See Reguero et al. (2015); Milan and Ho (2014); Zimmerer (2014); Bergmann et al. (2021); Warner and Afifi (2014); Wrathall et al. (2014). See also IOM (2022) publications.iom.int/system/files/pdf/assessing-the-evidence-peru.pdf.
116 Lima is the second driest capital city in the world and vulnerable to drought and heavy rain peak events. See Castellanos, E. et al. (2022), p. 1766.
117 See IOM (2022).
118 See Nagy et al. (2019).
119 See IOM (2022), 123.
120 See IOM (2023). robuenosaires.iom.int/sites/g/files/tmzbdl626/files/documents/2023-07/oim_mecc_factsheet_uruguay.pdf and IOM (2022), p. 129.
121 See IM (2022), p. 130.
122 See Nagy et al., 2019.
123 See Castellanos, E. et al. (2022), p.1751–1752.
124 “The Andes, northeastern Brazil and the northern countries in CA are among the more sensitive regions to climatic-related migrations and displacements, a phenomenon that has increased since AR5 (high confidence). Climatic drivers interact with social, political, geopolitical, and economic drivers; the most common climatic drivers for migration and displacements are droughts, tropical storms and hurricanes, heavy rains and floods (high confidence).” See Castellanos, E. et al. (2022), p. 1691–1692.

Map 2. Cities at risk from climate change. Estimates of the vulnerability of large cities.



Source: AFP - Reproduced using Verisk Maplecroft ranking of 576 cities (2019)

6. Conclusion and recommendations

A wide range of climate change impacts are already affecting Latin America and the Caribbean, and these are likely to intensify over the coming years and decades. These include hydrometeorological hazards such as extreme rainfall, land and marine heat waves, mega-droughts and glacier melt, all exacerbated by El Niño/La Niña.[125] Some of these shocks and stresses are reaching record-levels, including loss of forest cover and biodiversity in the Amazon, glacial melt in the Andes, protracted droughts affecting large swathes of South America and northern Central America and sea level rise affecting coastal regions of the Gulf of Mexico. Several hotspots are observable with wide-ranging impacts not just on ecosystems, but also on food and water security and ultimately migration. The future development prognosis of Latin America and the Caribbean is also far from clear, raising fundamental questions about social and economic stability and implications on mobility decisions.[126]

More positively, there is growing acknowledgement of the centrality of rethinking climate mobility and approaches to reinforcing adaptation and resilience. Notwithstanding the lack of consensus on basic definitions of climate mobility,[127] there is a noticeable shift in conceiving of migration as an adaptation strategy that seeks to promote safe mobility and reduces risks in vulnerable places. Indeed, moving from one place to another is a way that humans have always responded to challenging conditions.

125 See WMO (2022). State of the climate in Latin America and the Caribbean 2022, library.wmo.int/index.php?lvl=notice_display&id=22104.

126 See UN (2023). Halfway to 2030, caribbean.un.org/en/229018-halfway-2030-latin-america-and-caribbean-progress-and-recommendations-acceleration.

127 People moving as a result of climate change have many names, including environmental migrants, climate refugees, disaster displaced and climate displaced. There is currently no global formal recognition of climate migrants and displaced people, and these categories have no legal meaning. Nor is there a dedicated global instrument to protect and assist people moving due to climate change. Indeed, no government currently offers a legal migration pathway solely on the basis of an individual's exposure to climate change. See Schewel, K. (2023). Who counts as a climate migrant? Migration Policy Institute, July 20, www.migrationpolicy.org/article/who-is-a-climate-migrant.

To wit, migration does not just result in reducing physical vulnerability; it can be used to facilitate remittance flows. This represents a shift in perspective, away from a narrow focus on prevention of migration and protection or management of at-risk migrants towards one that understands migration as a more fundamental coping strategy in the face of adversity.

Quantitative climate mobility forecasting initiatives have surged in recent years, though the extent to which they are ready to inform decision-making varies considerably. In the immediate term, UNDP and development actors can support partners to anticipate and respond to climate mobility in high-risk locations, including in Latin America and the Caribbean. A focus can be on strengthening adaptation and resilience in both out- and in-migration areas and at-risk populations. Rather than investing in and reproducing sophisticated mapping tools, UNDP can provide simple tools to help organize data, expand shared awareness and shape priorities.

Recommendations

This assessment has identified several opportunities for UNDP to strengthen public awareness and engagement with climate mobility in Latin America and the Caribbean. It also features several entry points to improve diagnostics of potential hotspots and strengthen strategies for promoting adaptation and resilience. Several key opportunities stand out:

First, UNDP can support descriptive diagnostics by tailoring the conceptual framework and datasets to local contexts: UNDP can undertake rapid assessments, supplemented with robust forecasts, that focus on a selection of dominant climate shocks and stresses, socioeconomic drivers and structural vulnerabilities. These rapid assessments can draw on publicly available data and be developed with relevant local counterparts to help define shared understanding of climate mobility hotspots. They can also include a shortlist of priority recommendations for adaptation and resilience promotion in likely out- and in-migration areas and at-risk populations. Such diagnostics should be treated as dynamic planning tools and updated as appropriate.

Second, UNDP can invest in improved awareness of the multiple dimensions of climate migration from the national to the subnational levels. UNDP can strengthen communication and awareness of risks and opportunities in out- and in-mobility areas. At a minimum, UNDP can work with partners to advocate for greater investment in early warning and detection from networked observation satellites and field-based monitoring. UNDP can also advocate for improved climate, socioeconomic and vulnerability indicators of migrants and displaced people at the regional, national and subnational levels. In addition, UNDP can promote strategies that mitigate and build resilience to hazards and strengthen adaptation. As more data become available at a higher resolution, UNDP can also support research counterparts to develop more accurate modelling and scenarios as well as support countries to identify a basic repository of publicly available datasets to generate more rapid assessments of climate mobility.

Third, UNDP can support and strengthen policy, programmes and infrastructure at the national and subnational scale to increase adaptive responses and resilience in the hosting areas. Given existing demographic patterns, the share of rural–urban and urban–urban migration from all causes will be to large- and intermediate-sized cities. Ensuring strategies are in place for economic and social inclusion between migrants and non-migrants is essential. Building State capacity to address possible climate hazards and socioeconomic drivers can strengthen resilience and reduce impacts on agricultural yields and food insecurity while also building more positive perceptions of State legitimacy. Several countries and cities[128] are already adjusting domestic legislation to facilitate entry and residence. Further, UNDP can support vulnerability assessments that account for the ways climate shocks and stresses may interact with fragility, conflict and violence to shape mobility.

Fourth, UNDP can help embed climate mobility priorities in development plans and planning. Support for climate mobility requires anticipatory and preparatory development policies. This means identifying and bolstering economic sectors that can thrive in the wake of climate shocks and stresses. It also entails market assessments to assess opportunities for employment and productive alternatives for climate migrants. UNDP can work with local partners to develop strategies for adapting in place to help communities develop data-driven, viable and just policies. UNDP can also work with partners to advocate and enable mobility for those who must move to avoid extreme climate risks. Finally, UNDP can highlight the importance of providing support in receiving areas, including registration systems, preparedness plans for re-skilling, inclusive training and investment in critical infrastructure and services.

128 Brazil created a Municipal Coordination Office for Migrant Policies. Argentina also passed legislation in 2010 to provide provisional residential permits and in 2022 created a new ‘humanitarian visa’ for people displaced by climate disasters from Mexico, Central America and the Caribbean. Cities such as Bogota, Buenos Aires, Esmeraldas, Quito and Sao Paulo have all adopted metropolitan adaptation plans, which are increasingly accounting for migration.

Annex 1. Modelling climate mobility – a generic description

Modelling climate migration involves complex interdisciplinary approaches combining climate science, social science and economics. The aim is to assess how changes in climate – including extreme weather events, rising temperatures, changes in precipitation and sea level rises – may influence human migration patterns. There is a high degree of uncertainty in any estimate owing to the complex interactions of climate, society and economics. While multiple models have been developed,[129] they all essentially follow a similar process:

1. **Climate scenarios:** The first step is to project future changes in temperature, precipitation, sea levels and a selection of other variables such as water scarcity and crop yields under different emission scenarios such as those developed by the IPCC.

2. **Vulnerability assessments:** The second step involves focusing on regions that are particularly vulnerable to climate change based on geographic location, exposure to climate hazards, underlying socioeconomic conditions and adaptive capacities.

3. **Population dynamics:** The third step entails a review of basic demographic data, including population distribution, age structure and migration history, combined with climate projections. The intention is to better understand interaction effects of climate changes, population characteristics and migration.

4. **Socioeconomic factors:** The fourth step involves incorporating a range of socioeconomic variables such as income, education, employment, governance and infrastructure, which can influence people's ability to adapt to changing climate conditions and either encourage or discourage migration.

5. **Agent and gravity models:** Agent-based models simulate individual agents and their interactions with areas affected by change. Gravity models estimate the likelihood of migration between two locations based on factors such as distance, population size and economic opportunities.[130]

6. **Scenarios and statistical analysis:** Researchers then apply a range of statistical methods to analyse historical migration patterns and correlate them with past climate variability. It is then possible to simulate multiple scenarios under different climate projections and policy interventions.

129 See, for example, Jones, B. (2020). Modeling climate change-induced migration in Central America and Mexico: Methodological Report, assets-c3.propublica.org/Climate-Migration-Modeling-Methodology.pdf.

130 Gravity models are often used to assess likely migratory patterns. A recent study finds that while they may help capture spatial patterns of international migration, they often do not capture temporal dynamics and lack statistical support. See Beyer, R., Schewe, J. and H. Lotze-Campen (2022). Gravity models do not explain, and cannot predict, international migration dynamics, Humanities and Social Science Communications 9 (56), www.nature.com/articles/s41599-022-01067-x.

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José Antonio Ocampo

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Manuel Mera

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Sandra García Jaramillo

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Guillermo M. Cejudo, Cynthia L. Michel y Pablo de los Cobos

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Elena Sánchez-Montijano y Roberto Zedillo Ortega

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Natalie Dietrich Jones

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Pablo Sanguinetti

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Mauricio Cárdenas y Sebastián Orozco

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Análisis del sistema tributario y propuesta de reforma para financiar el sistema de seguridad social: el caso paraguayo
Agustina Carvallo, Carlos Charotti, Carlos Fernández y Felipe González

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Resumen por Santiago Rodríguez y Almudena Fernández

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Rodrigo Orair

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Mariana Viollaz

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José Hidalgo Pallares

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Manuel Mera y Federico Ortega

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Análisis del sistema tributario chileno
Ricardo Guerrero, Jorge Atria, Michel Jorratt e Iván Ramírez

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Emanuele Sapienza, Gloria Manzotti y Luqman Patel

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