Hot, wet, and deserted: Climate Change and Internal Displacement in India, Peru, and Tanzania

Insights from the EPICC Project

Julia M. Blocher, Jonas Bergmann, Himani Upadhyay, Kira Vinke

Potsdam Institute for Climate Impact Research (PIK)

INTRODUCTION

Despite notable contributions to the literature in recent years, significant gaps remain in our understanding of the interaction between slow- and rapid-onset hazards and resulting displacement in the context of climate change. Displacement, migration, and immobility are all highly context-specific with risk perceptions and adaptation options varying across individuals, households and communities.

This background paper summarizes insights from reports on climate risk and population movements in three diverse countries – Peru[1], India[2], and Tanzania.[3] These mappings of climate-related livelihoods risks were conducted for a multi-country project called 'East Africa Peru India Climate Capacities' (EPICC)[4], which is funded by the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The field research conducted was supported by different institutions in the three case study countries. We choose to explore these three vastly different country contexts and their institutional settings to foster a deeper understanding on how climate change shapes displacement patterns differently and which good practices already exist to foster effective adaptation through migration or in-situ measures.

In particular, we contribute to the emerging debate on critical thresholds by considering the multi-layered and interdependent nature of risks affecting populations in primarily agrarian communities. In many contexts, environmental impacts unfold in complex ways and only trigger population movements after reaching "critical thresholds" at which the pressures become too strong for the socio-environmental system to cope.[5] People who are unable to adapt in place are thus compelled to move - or risk experiencing life-threatening conditions if they remain. While all our study countries face challenges to research and data on climate impacts and on human

[1] Jonas Bergmann et al., "Assessing the Evidence: Climate Change and Migration in Peru." (The International Organization for Migration (IOM) and PIK, Potsdam and Geneva, 2021). https://publications.iom.int/books/assessing-evidence-climate-change-and-migration-peru

[2] Himani Upadhyay et al., "Locked Houses, Fallow Lands: Climate Change and Migration in Uttarakhand, India." (PIK and The Energy and Resources Institute (Teri), Potsdam and New Delhi, 2021). https://www.pik-potsdam.de/en/institute/departments/activities/epicc/activities/risk-reports-on-climate-change-and-migration-1/risk-reports-on-climate-change-and-migration

[3] Julia Blocher et al. "Assessing the Evidence: Climate Change and Migration in the United Republic of Tanzania." (IOM and PIK, Geneva and Potsdam, 2021). https://www.pik-potsdam.de/en/institute/departments/activities/epicc/activities/risk-reports-on-climate-change-and-migration-1/risk-reports-on-climate-change-and-migration

[4] The EPICC Project (https://www.pik-potsdam.de/epicc) is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag. The Potsdam Institute for Climate Impact Research (PIK) is leading the execution of the project together with its project partners The Energy and Resources Institute (TERI), based in New Delhi, and the Deutscher Wetterdienst (DWD; German Meteorological Service), based in Hamburg. The project runs within the period of 1st January 2018 till 31st of August 2021 and is also known under the name "Climate Capacity Building: Risk Anticipation and Minimization".

[5] Schlenker, Wolfram, and Michael J. Roberts. "Nonlinear temperature effects indicate severe damages to US crop yields under climate change." Proceedings of the National Academy of sciences 106, no. 37 (2009): 15594-15598.; and Burke, Marshall, Hsiang, Solomon M. & Miguel, Edward, "Climate and conflict". *Annu. Rev. Econ. 7* (2015): 577–617; cited in Hoffmann, Roman, et al, "A meta-analysis of country-level studies on environmental change and migration". *Nature Climate Change* (2020): 1-9.

mobility, we use existing datasets and literature to make our analysis. We aim to improve evidence for policymaking and programming through concrete examples of good practice as well as of barriers to effectively addressing risks related to displacement.

Our approach is sensitive to different geographic and temporal scales of movement, considering both gradually developing hazards (like persistent drought) and rapid-onset hazards (like extreme weather events) as well as the interactions between them. The key learnings from each of the countries represent different facets of the complex relationship between climate change and population movements under different warming scenarios.[6]

INSIGHTS FROM INDIA: DEPOPULATION IN AGRICULTURAL COMMUNITIES OF UTTARAKHAND

Varied impacts of climate change are acting on natural resource dependent communities of Uttarakhand, a northern state located in the Indian Himalayan Region. As of 2011, it has a population of 10.11 million[7]. The state of Uttarakhand is divided into two main geographical zones: hill districts in the Himalayas that are mostly rural, and plains districts which include large urban centres. The state is already experiencing climate change impacts such as changing temperatures, upward-moving snowlines, receding glaciers, erratic rainfall, reduction in winter snow, increased heat, advancing cropping seasons, and drying up of perennial streams.[8] These impacts are having severe consequences for ecological resilience, local coping strategies and agrarian livelihoods, as majority of the state's population lives in the rural hill areas and is dependent on rain-fed agriculture (see figure 1).[9] Disaster displacement in Uttarakhand has been due to heavy precipitation events[10] like the Kedarnath floods in 2013.[11] Climate change and co-stressors like deforestation, unplanned housing on hill slopes, lack of road connectivity, add to the pressures on households displaced by disasters or forced to migrate in the state, which this chapter elaborates.

Projected Climate Impacts: More heat and more rain

Observed temperature trends in Uttarakhand indicate a warming trend (data for 1911-2011) and projections show that it will get warmer in the future.[12] The annual maximum temperature is projected to increase for all seasons across all 13 districts. Under a warming scenario in which states fail to comply with the Paris agreement , RCP4.5, the average annual maximum temperature in Uttarakhand would increase by 1.6°C (2021-2050), 2.4°C (2051-2080) and 2.7°C in (2081-2099).[13] Under an extreme, business as usual global warming scenario RCP8.5, temperatures in

[6] Recent climate models have used four scenarios to cover possible future emissions, the so-called representative concentration pathways (RCPs). RCP8.5 assumes the highest emission concentration without serious policy interventions, leading to a likely mean global surface temperature increase of 2.6 to 4.8°C for the end of the 21st century relative to 1850–1900 (pre-industrial times). For RCPs 6.0 and 4.5, likely ranges are 1.4 to 3.1°C and 1.1 to 2.6°C. Only RCP2.6, which requires strong mitigation, shows global temperatures staying below the 2° C target in the Paris agreement (0.3 to 1.7°C). Local changes precipitated by these global averages can be even more severe. This paper considers RCP2.6 as the low or 'optimistic' scenario, RCP4.5 as the 'middle-of-the-road' scenario, and RCP 8.5 as a high or 'business-as-usual' emissions pathway.
[7] Government of India (GoI), "A-1 Number Of Villages, Towns, Households, Population And Area" (GoI, Office of The Registrar General & Census Commissioner, India, 2011), https://censusindia.gov.in/2011census/population_enumeration.html.
[8] Government of Uttarakhand (GoU), "Uttarakhand Action Plan on Climate Change: Transforming Crisis to Opportunity" (GoU, 2014); Raghavan Krishnan et al., "Unravelling Climate Change in the Hindu Kush Himalaya: Rapid Warming in the Mountains and Increasing Extremes," in *The Hindu Kush Himalaya Assessment: Mountains, Climate Change, Sustainability and People*, ed. Philippus Wester et al. (Cham: Springer International Publishing, 2019), 57–97, https://doi.org/10.1007/978-3-319-92288-1_3.
[9] GoU (2014), Op. cit. 8.
[10] National Institute of Disaster Management (NIDM), "India Disaster Report 2013" (NIDM, 2014), https://nidm.gov.in/PDF/pubs/India%20Disaster%20Report%202013.pdf.
[11] Asian Development Bank (ADB), "India: Uttarakhand Disaster 2013; Joint Rapid Damage and Needs Assessment Report" (Asian Development Bank, 2013).
[12] Ashutosh Mishra, "Changing Temperature and Rainfall Patterns of Uttarakhand," *International Journal of Environmental Sciences & Natural Resources* 7, no. 4 (December 15, 2017), https://doi.org/10.19080/IJESNR.2017.07.555716.
[13] Upadhyay et al. (2021), Op. cit. 2.

Uttarakhand could rise by 1.9°C, 3.8°C, and 5.3°C respectively for the same time periods. Warm and very warm days are projected to increase across all districts under both RCP4.5 and RCP8.5.[14]

Inter-annual variability in observed rainfall is expected to continue in the coming decades, while average annual rainfall is projected to increase continuously. Under RCP4.5, rainfall would increase by approximately 6 per cent by mid-century (2021-2050), 10 per cent by late mid-century (2051-2080), and 16 per cent by end-century (2081-2099). For RCP8.5, projected increase is that of 8 per cent, 20 per cent, and 32 per cent for the same time periods.[15] Though the average annual rainfall is increasing, projections show an increase in consecutive dry days, thereby indicating an increase in heavy rainfall events,[16] which are projected to increase between 7 and 17 per cent across Uttarakhand[17].

Moreover, loss of up to a third of the ice on the Himalayan glaciers by the end of the century would also lead to floods as well as reduced water availability and localized decline in agricultural yields.[18] Without targeted disaster risk reduction and management, it is plausible that sudden-onset hazards-related displacement of people will increase, especially as heavy rainfall events increase.

[14] Defined as days that exceed 32 degrees C.
[15] Upadhyay et al. (2021), Op. cit. 2.
[16] Integrated Natural Resource Management Consultants (INRM), "Climate Change Risks and Opportunities in Uttarakhand, India: Technical Report on Current Climate and Future Climate Change Projections," Deliverable#3 Report (INRM, New Delhi, 2016).
[17] Upadhyay et al. (2021), Op. cit. 2.
[18] Hamish D. Pritchard, "Asia's Shrinking Glaciers Protect Large Populations from Drought Stress," *Nature* 569, no. 7758 (May 1, 2019): 649–54, https://doi.org/10.1038/s41586-019-1240-1; Golam Rasul et al., "Food and Nutrition Security in the Hindu Kush Himalaya: Unique Challenges and Niche Opportunities," in *The Hindu Kush Himalaya Assessment: Mountains, Climate Change, Sustainability and People*, In: Wester et al. (2019) Op. Cit. 8.

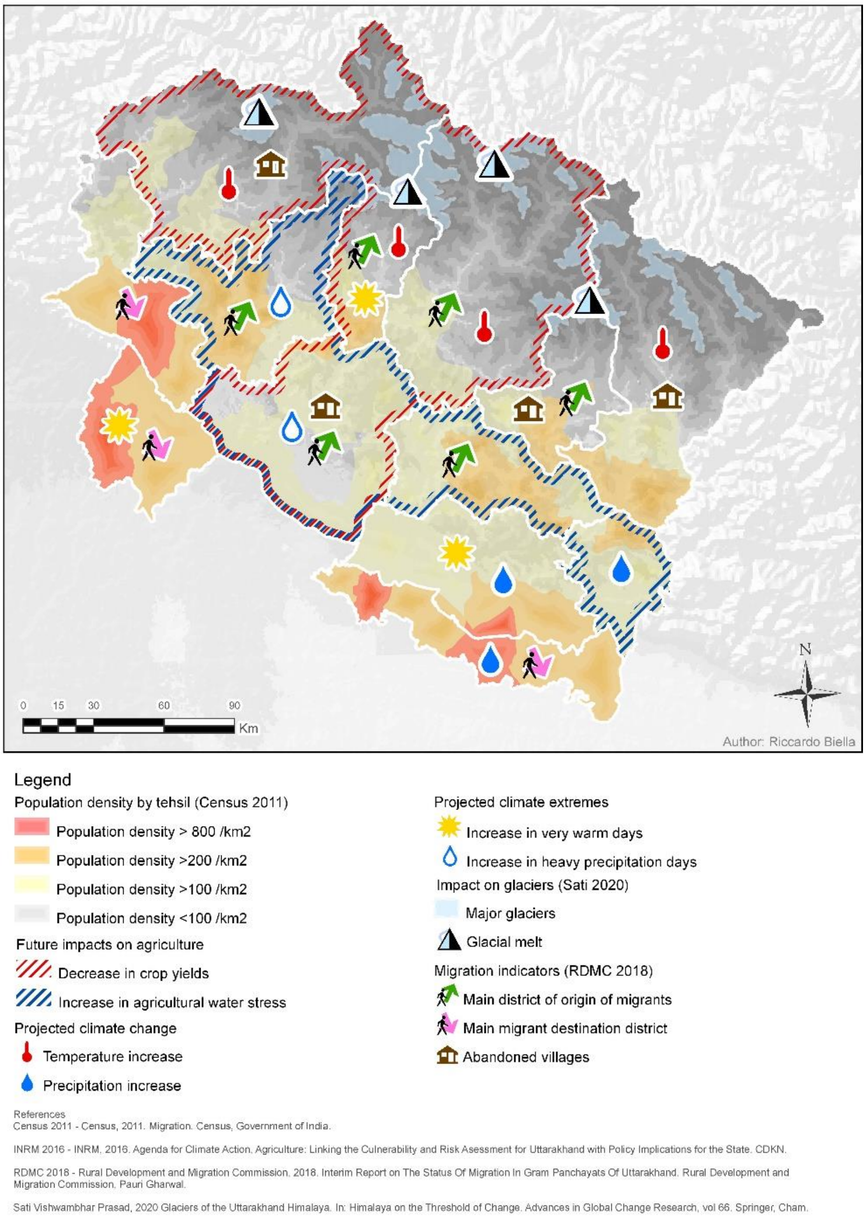

Figure 1: Livelihood Risk Map of Uttarakhand outlining projected climate change, projected climate extremes, impacts on agriculture, migration indicators and population density. Hill districts in the north, west and central part of the state are more impacted and are likely to face higher risk to livelihoods as majority of the population is dependent on subsistence-based agriculture- adding to out-migration from hill to plains districts. Figure © Upadhyay et al. 2021, Op. cit. 2.

Interactions of Climate Change and Displacement: Depopulation and Out-Migration

A number of studies attribute the unusual decline in population of Uttarakhand to out-migration.[19] A variety of reasons – among them, increasingly severe climate impacts – motivate people to migrate from hill to plains districts. A growing number of villages in Uttarakhand are uninhabited which has led to villages with abandoned fields and locked houses[20] (see figure 2). The state

[19] Bhagwati Joshi, "Recent Trends of Rural Out-Migration and Its Socio-Economic and Environmental Impacts in Uttarakhand Himalaya," *Journal of Urban and Regional Studies on Contemporary India* 4, no. 2 (2018): 1–14; Rural Development and Migration Commission (RDMC), "Interim Report on the Status of Migration in Gram Panchayats of Uttarakhand" (Pauri Gharwal: RDMC, April 2018); GoU, "Human Development Report of State of Uttarakhand" (Department of Planning, GoU, 2018); S Pathak, L Pant, and A Maharjan, "De-Population Trends, Patterns and Effects in Uttarakhand, India – A Gateway to Kailash Mansarovar" (Kathmandu: ICIMOD, 2017), http://lib.icimod.org/record/32787/files/icimodWP_22_017.pdf.
[20] RDMC, "Interim Report on the Status of Migration in Gram Panchayats of Uttarakhand."

government has identified both climate change and out-migration from hill districts as serious challenges.[21]

Figure 2: Locked and abandoned houses in Pauri Garhwal district (Uttarakhand, India). Photo © Himani Upadhyay, 2019.

Climate change acts as risk modifier by influencing existing population movements. Seventy per cent of the population is dependent on rain-fed agriculture, which is not highly productive.[22] In the last two decades, decline in agricultural productivity due to low rainfall, erratic rains, and drying mountain springs, has corresponded with out-migration (see figure 3).[23] Projections indicate a further increase in agricultural water stress and decrease in crop yields under the RCP4.5 and RCP8.5 scenarios.[24] Empirical research in Uttarakhand illuminates how some communities are already experiencing this:[25]

> *"Our mountain springs are dry; we don't have water to drink. I wanted to take my medicine but there was no drinking water in the house. I had to wait for my grandchildren to return from school, then they ran to the village common pool water area to fetch me some drinking water. Such is the situation here. If it doesn't rain, then we face problems. If there is water, there is life, and without water, there is nothing. I wonder how long we can live here, if it continues like this we too will be forced to migrate" (Woman, late 50s, Nainital district).*

Heavy precipitation events predispose agrarian communities to sudden onset displacement risk and to forced migration. For example, so-called "cloud bursts" – extreme heavy precipitation events – have increased in the Indian Himalayan region, with the maximum number been recorded for Uttarakhand.[26] In 2019 alone, there were 23 cloud bursts in the state.[27] They lead to flash floods, landslides, debris flows, rock fall, and soil erosion, all of which render locations on hill slopes vulnerable to human and economic losses, thereby increasing displacement risk.[28]

[21] GoU, (2014), Op. cit. 8.
[22] GoU, "Uttarakhand State Economic Survey 2016-17," (Planning Commission, GoU, 2017), http://des.uk.gov.in/files/Economic_Survey_2016-17.pdf.
[23] Rajendra Kumar Isaac and Monisha Isaac, "Vulnerability of Indian Agriculture to Climate Change: A Study of the Himalayan Region State" 11, no. 3 (2017): 7; Wester et al. (2019), Op. Cit. 8.
[24] State Climate Change Centre (SCCC), "Agenda for Climate Action: Agriculture Linking the Vulnerability and Risk Assessment for Uttarakhand with Policy Implications for the State" (SCCC, Uttarakhand Forest Department, Government of Uttarakhand, n.d.).
[25] Himani Upadhyay, "Why Some People Migrate and Some Stay in Response to Climate Change Impacts? Exploring the Climate Change-Migration-Adaptation Nexus in the Indian State of Uttarakhand" (Doctoral Thesis, Berlin, Humboldt University Berlin, Germany, In preparation).
[26] Amit Kumar et al., "Assessment and Review of Hydrometeorological Aspects for Cloudburst and Flash Flood Events in the Third Pole Region (Indian Himalaya)," *Polar Science* 18 (December 2018): 5–20, https://doi.org/10.1016/j.polar.2018.08.004.; Sushil Khanduri, "Cloudbursts Over Indian Sub-Continent of Uttarakhand Himalaya: A Traditional Habitation Input from Bansoli, District-Chamoli, India," 2020, 17.
[27] South Asia Network on Dams, Rivers and People (SANDRP), "Uttarakhand Cloud Bursts in Monsoon 2019: No Doppler Radars Six Years Since 2013 Disaster," November 12, 2019, https://sandrp.in/2019/12/11/uttarakhand-cloud-bursts-in-monsoon-2019-no-doppler-radars-six-years-since-2013-disaster/.
[28] Vishwambhar Prasad Sati, "Extreme Weather Related Disasters: A Case Study of Two Flash Floods Hit Areas of Badrinath and Kedarnath Valleys, Uttarakhand Himalaya, India," *Journal of Earth Science and Engineering 3* 3 (2013): 562–68.

Excessive rainfall destroys crops ready for harvest, damages fields, erodes assets and increases livelihood pressures. A farmer interviewed in Uttarakhand notes:

> *"Too much rain is not good, it causes damage. Because too much rain breaks the steps in our terrace farming. And they remain broken as people don't have money to repair them. We have to do step farming in the mountains, as we are on a slope, and if you want to do farming here, first you need to make a step. It stops the rainwater from flowing down, it holds the water. In my fields, all the steps have broken down, and we cannot afford to repair it. The government gives compensation packages but it basically gets lost somewhere by the time it reaches us (Man, early 60s, Almora district)".*

Figure 3: Dried naula (naturally-occurring water aquifer) in Pauri Garhwal district, Uttarakhand, India. Photo © Himani Upadhyay, October 2019.

As incomes become volatile, people migrate, leaving fewer people to do agriculture in the sending communities. This process can lead to a vicious cycle drawing down the adaptive capacities and social capital of the community, propelling more out-migration and ultimately reaching a critical threshold at which the settlement is abandoned[29]. In Uttarakhand, these are referred to as "ghost villages."[30]

Forced immobility in 'ghost' villages

While some people may be forced to migrate, others could be rendered immobile due to lack of resources, or feel committed to stay despite growing risks because of family obligations and other reasons.[31] In Uttarakhand, for example, women who stay back while men migrate are left with the twin responsibilities of managing both farm and household activities – while also coping with climate impacts.[32] Although the most vulnerable parts of society may be able to migrate in certain situations, they have far fewer options than those with resources. As climate change impacts become more discerning in the future, certain thresholds may be reached at which immobility

---

[29] Robert A. McLeman, "Settlement Abandonment in the Context of Global Environmental Change," *Global Environmental Change* 21 (2011): S108–20, https://doi.org/10.1016/j.gloenvcha.2011.08.004.

[30] A Dey, "Uttarakhand's Ghost Villages: Abandoned Farms, Empty Homes and Very Few People," *Scroll.In*, February 20, 2017, https://scroll.in/article/829726/dwindling-populations-barren-farm-land-abandoned-homes-haunt-uttarakhands-ghost-villages; Kavita Upadhyay, "Inside the Ghost Villages of Uttarakhand," *Indian Express*, June 24, 2018.

[31] Helen Adams, "Why Populations Persist: Mobility, Place Attachment and Climate Change," *Population and Environment* 37, no. 4 (2016): 429–48, https://doi.org/10.1007/s11111-015-0246-3; Richard Black et al., "The Effect of Environmental Change on Human Migration," *Global Environmental Change* 21 (2011): S3–11, https://doi.org/10.1016/j.gloenvcha.2011.10.001; Richard Black et al., "Migration, Immobility and Displacement Outcomes Following Extreme Events," *Environmental Science & Policy* 27 (2013): S32–43, https://doi.org/10.1016/j.envsci.2012.09.001.

[32] Surabhi Mittal, Gaurav Tripathi, and Deepti Sethi, "Development Strategy for the Hill Districts of Uttarakhand" (Indian Council for Research on International Economic Relations, 2008), http://www.icrier.org/pdf/Working_Paper_217.pdf; Fraser Sugden et al., "Agrarian Stress and Climate Change in the Eastern Gangetic Plains: Gendered Vulnerability in a Stratified Social Formation," *Global Environmental Change* 29 (2014): 258–69, https://doi.org/10.1016/j.gloenvcha.2014.10.008.

could be more pronounced for those socially and economically disadvantaged and they could become trapped in place.[33]

Instruments and Policies

Both for the medium and long-term, public institutions and government bodies need to prepare for demographic changes resulting from migration. In line with the principles of the Global Compact on Safe, Orderly and Regular Migration (GCM), to which India is a signatory, both national and sub-national governments need to ensure safe and orderly migration of those on the move.[34] From a climate adaptation perspective, research and policy need to focus on identification and prioritisation of strategies that can facilitate this, while also strengthening *in situ* adaptation options that allow people to adapt without leaving their areas of origin.

At the state level, the Uttarakhand Action Plan on Climate Change identifies the climate-migration nexus as an understudied topic and calls for more studies on the topic.[35] Uttarakhand's Vision for 2030 aims to reduce migration by "transforming agriculture", and by "providing livelihoods in hills."[36] Similarly, a plan document on Sustainable Development in the Indian Himalayan Region focuses on building skills and entrepreneurship to mitigate out-migration.[37]

INSIGHTS FROM PERU: "NO-ANALOG" THREATS AND DISPLACEMENT

Across Peru's arid coast, glaciated highlands, and tropical rainforest, people are exposed and vulnerable to many sudden- and slow-onset hazards,[38] which threaten livelihoods and drive displacement.[39] Between 2008 and 2019, the country with a population of 31 million has seen approximately 656,000 disaster displacements.[40] Beyond the projected increase in frequency and intensity of existing hazards like floods,[41] in a high-emissions scenario, several "no-analog threats"—that is, those with unprecedented, large impacts–could pose displacement risks without modern precedents towards 2100.[42] One of them is extensive glacier loss, which could drive large-scale displacement from Peru's largely rural highlands, home to 28 per cent of its population.[43]

---

[33] Clark L. Gray and Richard E. Bilsborrow, "Consequences of Out-Migration for Land Use in Rural Ecuador," *Land Use Policy* 36 (January 1, 2014): 182–91, https://doi.org/10.1016/j.landusepol.2013.07.006; Foresight, "Migration and Global Environmental Change" (The Government Office for Science, London, 2011); Jack DeWaard, Katherine J. Curtis, and Elizabeth Fussell, "Population Recovery in New Orleans after Hurricane Katrina: Exploring the Potential Role of Stage Migration in Migration Systems," *Population and Environment* 37, no. 4 (2016): 449–63, https://doi.org/10.1007/s11111-015-0250-7.

[34] GoI, "Intergovernmental Conference to Adopt Safe Orderly and Regular Migration: India Statement" (Intergovernmental Conference on the Global Compact for Migration, Marrakech: UN, 2018), https://www.un.org/en/conf/migration/assets/pdf/GCM-Statements/india.pdf.

[35] GoU, "Uttarakhand Action Plan on Climate Change: Transforming Crisis to Opportunity."

[36] GoU, "Uttarakhand Vision 2030," (Department of Planning, 2018).

[37] Niti Aayog, "Contributing to Sustainable Development in the Indian Himalayan Region," (GoI, 2018).

[38] SINAGERD et al., "Plan Nacional de Gestión del Riesgo de Desastres (PLANAGERD) 2014-2021" (Lima, 2014), https://www.preventionweb.net/files/37923_39462planagerd201420215b15d1.pdf.

[39] Bergmann et al. (2021), Op. cit. 1.

[40] IDMC, "Peru Country Information: As of 22 February 2021," Internal Displacement Monitoring Centre (IDMC), accessed February 22, 2021, http://www.internal-displacement.org/countries/peru.

[41] Jens H. Christensen et al., "Climate Phenomena and Their Relevance for Future Regional Climate Change," in *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. T. F. Stocker et al. (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2013); Filippo Giorgi et al., "Changes in Extremes and Hydroclimatic Regimes in the CREMA Ensemble Projections," *Climatic Change* 125, no. 1 (2014), https://doi.org/10.1007/s10584-014-1117-0.

[42] Bergmann et al. (2021), Op. cit. 1.

[43] INEI, "Péru: Perfil Sociodemográfico: Informe Nacional" (Censos Nacionales 2017: XII de Población, VII de Vivienday III de Comunidades Indígenas, Lima, 2018), https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1539/libro.pdf.

Projected climate impacts: Extensive glacier loss could escalate water stress and displacements

Accelerating glacier retreat threatens one of Peru's most essential sources of water supply.[44] Between 1962 and 2018, surface losses were at least 40 per cent for all glaciers[45], most drastic in recent years.[46] Peak river runoff is projected in 20–50 years in most areas.[47] In a high-emissions scenario, deglaciation in the Central Andes would be near complete by 2100.[48] Yet even in an optimistic low-emissions scenario, projected losses would range between 78 per cent and 94 per cent of glacier volume. Together with other climatic changes, such as rainfall changes[49] and related droughts[50], dry-season runoff will reduce from 2050s onwards[51] while water demand continues to grow[52].

The loss of glaciers harms downstream ecosystems and communities[53] and can affect displacements through various links. Deglaciation can threaten livelihoods by reducing water availability after runoff from glaciers peaks, as well as by exacerbating water quality issues, speeding up soil erosion, disrupting moorlands, and interfering with local hydrological cycles.[54] Peak river runoff is already crossed in various watersheds today.[55] Future glacier losses could significantly reduce dry season runoff and seasonal buffering capacities, especially as rainfall could become even more seasonal.[56]

---

[44] Pierre Chevallier et al., "Climate Change Threats to Environment in the Tropical Andes: Glaciers and Water Resources," *Regional Environmental Change* 11, S1 (2011), https://doi.org/10.1007/s10113-010-0177-6, http://link.springer.com/10.1007/s10113-010-0177-6; A. Rabatel et al., "Current State of Glaciers in the Tropical Andes: A Multi-Century Perspective on Glacier Evolution and Climate Change," *The Cryosphere* 7, no. 1 (2013), https://doi.org/10.5194/tc-7-81-2013, https://www.the-cryosphere.net/7/81/2013/; Bijeesh K. Veettil and Ulrich Kamp, "Global Disappearance of Tropical Mountain Glaciers: Observations, Causes, and Challenges," *Geosciences* 9, no. 5 (2019), https://doi.org/10.3390/geosciences9050196, https://www.mdpi.com/2076-3263/9/5/196; Mathias Vuille et al., "Rapid Decline of Snow and Ice in the Tropical Andes – Impacts, Uncertainties and Challenges Ahead," *Earth-Science Reviews* 176 (2018), https://doi.org/10.1016/J.EARSCIREV.2017.09.019, https://www.sciencedirect.com/science/article/pii/S0012825216304512

[45] Instituto Nacional de Investigación en Glaciares y Ecosistemas de Montaña (INAIGEM), "Inventario Nacional de Glaciares: Las Cordilleras del Perú" (Huaraz, 2018).

[46] Thorsten Seehaus et al., "Changes of the Tropical Glaciers Throughout Peru Between 2000 and 2016- Mass Balance and Area Fluctuations," *The Cryosphere Discussions*, 2019, https://doi.org/10.5194/tc-2018-289

[47] Sophie Adams et al., "Turn down the heat: confronting the new climate normal (Vol. 2): Main report (English)" (World Bank, Washington, D.C., 2014).

[48] Valentina Radić et al., "Regional and Global Projections of Twenty-First Century Glacier Mass Changes in Response to Climate Scenarios from Global Climate Models," *Climate Dynamics* 42, 1-2 (2014); Ben Marzeion, A. H. Jarosch, and Marlis Hofer, "Past and Future Sea-Level Change from the Surface Mass Balance of Glaciers," *The Cryosphere* 6, no. 6 (2012); Adams et al., "Turn down the heat: confronting the new climate normal (Vol. 2): Main report (English)"

[49] Christensen et al., "Climate phenomena and their relevance for future regional climate change"; Giorgi et al., "Changes in extremes and hydroclimatic regimes in the CREMA ensemble projections"

[50] El Servicio Nacional de Meteorología e Hidrología del Perú (SENAMHI), "Caracterización espacio temporal de la sequía en el Perú a escala de departamentos altoandinos (1981-2018)" (SENAMHI, Lima, 2019); SENAMHI, "Regionalización y caracterización de sequías en el Perú" (SENAMHI, Lima, 2015); SINAGERD et al., "Plan Nacional de Gestión del Riesgo de Desastres (PLANAGERD) 2014-2021"

[51] Norina Andres et al., "Water Resources and Climate Change Impact Modelling on a Daily Time Scale in the Peruvian Andes," *Hydrological Sciences Journal* 59, no. 11 (2014), https://doi.org/10.1080/02626667.2013.862336; Irmgard Juen, Georg Kaser, and Christian Georges, "Modelling Observed and Future Runoff from a Glacierized Tropical Catchment (Cordillera Blanca, Perú)," *Global and planetary change* 59, 1-4 (2007), https://doi.org/10.1016/J.GLOPLACHA.2006.11.038, https://www.sciencedirect.com/science/article/pii/S0921818106002967; Taru Olsson et al., "Downscaling Climate Projections for the Peruvian Coastal Chancay-Huaral Basin to Support River Discharge Modeling with WEAP," *Journal of Hydrology: Regional Studies* 13 (2017), https://doi.org/10.1016/J.EJRH.2017.05.011, https://www.sciencedirect.com/science/article/pii/S2214581816301008.

[52] Wouter Buytaert et al., "Glacial Melt Content of Water Use in the Tropical Andes," *Environmental Research Letters* 12, no. 11 (2017), https://doi.org/10.1088/1748-9326/aa926c; Wouter Buytaert and Bert de Bièvre, "Water for Cities: The Impact of Climate Change and Demographic Growth in the Tropical Andes," *Water Resources Research* 48, no. 8 (2012), https://doi.org/10.1029/2011WR011755.

[53] P. Tschakert et al., "One Thousand Ways to Experience Loss: A Systematic Analysis of Climate-Related Intangible Harm from Around the World," *Global Environmental Change* 55 (2019), https://doi.org/10.1016/j.gloenvcha.2018.11.006; Veettil and Kamp, "Global Disappearance of Tropical Mountain Glaciers: Observations, Causes, and Challenges"; Seehaus et al., "Changes of the tropical glaciers throughout Peru between 2000 and 2016- Mass balance and area fluctuations"; Mathias Vuille et al., "Climate Change and Tropical Andean Glaciers: Past, Present and Future," *Earth-Science Reviews* 89, 3-4 (2008), https://doi.org/10.1016/J.EARSCIREV.2008.04.002, https://www.sciencedirect.com/science/article/pii/S0012825208000408.

[54] Adams et al., "Turn down the heat: confronting the new climate normal (Vol. 2): Main report (English)"

[55] Michel Baraer et al., "Glacier Recession and Water Resources in Peru's Cordillera Blanca," *Journal of Glaciology* 58, no. 207 (2012), https://doi.org/10.3189/2012JoG11J186.

[56] Buytaert et al., "Glacial melt content of water use in the tropical Andes"

Interactions of climate change and displacement: resource depletion, non-economic losses, feedback mechanisms, and distribution conflicts

Present dynamics can inform our consideration of future patterns of displacement and migration. Both permanent and circular migration, driven by many factors, are part of the social fabric in Peru's highlands.[57] Migration is also a traditional diversification strategy to anticipate or react to hazards.[58] The line of "voluntariness" between migration and displacement is often unclear - and it may become increasingly blurred as impacts intensify. While local adaptation may reduce some of the risks highlighted above,[59] displacement can ensue when impacts overwhelm capacities. Across Peru's highlands, subsistence farmers are strongly dependent on meltwater for consumption and agriculture, especially during dry conditions.[60] While future glacier loss may first enlarge existing emigration dynamics from the Peruvian highlands, new flows could emerge eventually.[61]

Already today, farmers are leaving areas in later stages of glacier retreat as an attempt to generate new incomes and remit money,[62] especially as rainfall changes accentuate water stress and food insecurity.[63] Critical thresholds of water stress may be reached at which poorer households often have few choices but to leave.[64] Deteriorating pastures threaten herding for pastoralists, making displacement likely especially during the dry season.[65]

In recent fieldwork in the mountains of the Lima region (**Error! Reference source not found.**), an interviewed president of a peasant association observed:[66]

> *"The first thing that the global warming of the earth has eliminated was the mountain range, the snow-capped mountains... It dried up completely. [Before], the water just came from that hill, the one that is here... Well then,*

[57] Ronald Skeldon, "The Evolution of Migration Patterns During Urbanization in Peru," *Geographical Review* 67 (1977), https://doi.org/10.2307/213624; Ronald Skeldon, "Population Pressure, Mobility, and Socio-Economic Change in Mountainous Environments: Regions of Refuge in Comparative Perspective," *Mountain Research and Development*, 1985; Robin T. F. Cavagnoud, "Vulnerabilidades Medioambientales Y Migraciones Juveniles Desde Las Comunidades Altoandinas Cercanas Al Lago Titicaca (Perú)." *Revista Boliviana de Investigación / Bolivian Research Review* 13, no. 1 (2018).

[58] Frank Sperling et al., "Transitioning to climate resilient development: Perspectives from communities in Peru," Climate Change Series Environment Department Papers 115 (World Bank, Washington, D.C., 2008); Anna Heikkinen, "Climate Change in the Peruvian Andes: A Case Study on Small-Scale Farmers' Vulnerability in the Quillcay River Basin," *Iberoamericana – Nordic Journal of Latin American and Caribbean Studies* 46, no. 1 (2017), https://doi.org/10.16993/iberoamericana.211.

[59] Veettil and Kamp, "Global Disappearance of Tropical Mountain Glaciers: Observations, Causes, and Challenges"

[60] Buytaert et al., "Glacial melt content of water use in the tropical Andes"; Buytaert and Bièvre, "Water for cities: The impact of climate change and demographic growth in the tropical Andes"

[61] Helen Adams and W. N. Adger, "The Contribution of Ecosystem Services to Place Utility as a Determinant of Migration Decision-Making," *Environmental Research Letters* 8, no. 1 (2013), http://stacks.iop.org/1748-9326/8/i=1/a=015006; Jose M. Magallanes, "Climate Change and the Potential for Conflict and Extreme Migration in the Andes: A Computational Approach for Interdisciplinary Modeling and Anticipatory Policy-Making" (Doctoral Thesis, George Mason University, 2015), http://hdl.handle.net/1920/10159; Andrea Milan, "Rural livelihoods, location & vulnerable environments: Approaches to #migration in mountain areas of Latin America" (Doctoral thesis, Maastricht Graduate School of Governance, Maastricht University, 24 June 2016).

[62] Teófilo Altamirano Rua, *Refugiados Ambientales: Cambio Climatico Y Migracion Forzada* (Lima: Fondo editorial de la Pontificia Universidad Católica del Perú, 2014); Heikkinen, "Climate Change in the Peruvian Andes: A Case Study on Small-Scale Farmers' Vulnerability in the Quillcay River Basin"; Ben Orlove, "Glacier Retreat: Reviewing the Limits of Human Adaptation to Climate Change," *Environment: Science and Policy for Sustainable Development* 51, no. 3 (2009), https://doi.org/10.3200/ENVT.51.3.22-34; David J. Wrathall et al., "Migration Amidst Climate Rigidity Traps: Resource Politics and Social–Ecological Possibilism in Honduras and Peru," *Annals of the Association of American Geographers* 104, no. 2 (2014), https://doi.org/10.1080/00045608.2013.873326.

[63] Heikkinen, "Climate Change in the Peruvian Andes: A Case Study on Small-Scale Farmers' Vulnerability in the Quillcay River Basin"; Vally Koubi et al., "The Role of Environmental Perceptions in Migration Decision-Making: Evidence from Both Migrants and Non-Migrants in Five Developing Countries," *Population and Environment* 38, no. 2 (2016), https://doi.org/10.1007/s11111-016-0258-7; Andrea Milan and Raul Ho, "Livelihood and Migration Patterns at Different Altitudes in the Central Highlands of Peru," *Climate and Development* 6 (2014), https://doi.org/10.1080/17565529.2013.826127; Philine Oft, *Micro-Finance Instruments Can Contribute to Build Resilience*: *A Case Study of Coping and Adaptation Strategies to Climate-Related Shocks in Piura, Peru*, ed. Katharina Brach, Graduate research series Vol. 2 (Bonn: UNU-EHS, 2010); Philine Oft, "Can Resilience Be Built through Micro-Finance Tools? A Case Study of Coping and Adaptation Strategies to Climate-Related Shocks in Piura, Peru" (Doctoral Thesis, Geography, University of Bonn, 2009); Sperling et al., "Transitioning to climate resilient development: Perspectives from communities in Peru"

[64] Jonas Bergmann, "Migrating from areas with climate hazards: Assessing multilayered well-being consequences across Peru" (Doctoral thesis, Faculty of Humanities and Social Sciences, Humboldt-Universität zu Berlin, in preparation).

[65] B. Orlove, "The Past, the Present and Some Possible Futures of Adaptation," in *Adapting to Climate Change: Thresholds, Values, Governance*, ed. W. N. Adger, Irene Lorenzoni and Karen L. O'Brien (Cambridge and New York: Cambridge University Press, 2009).

[66] Bergmann (in preparation), Op. cit. 70.

> *it was nothing left … Little by little, with the heat it melted... The water was no longer advancing… The land has become dead and there is nowhere to put crops." (Man, early 50s, Lima region).*

Once limited local adaptation options were thwarted, water scarcity accelerated and increasingly forced out-migration. Feedback mechanisms such as the gradual loss of workforce, reduction of social networks, and closure of critical infrastructure have catalysed settlement abandonment. While often entire households left, in other cases, mostly older household members stayed behind with high vulnerabilities. A migrant in the regional capital explained:

> *"People left because the animals… had nothing to eat, they got thinner, and died… The village is depopulated, there are no more people, a few, no more. All are leaving because there is no more water. A lot of dryness, for this reason the youth have left… In some rooms are still the older adults, who are now dying." (Woman, late 70s, Lima region).*

Figure 4: Padlocked doors of migrants' homes in a Peruvian highland village after glacier loss. Photo © Jonas Bergmann, 2019.

Figure 5: Highlands of Peru. Photo (C) Jonas Bergmann, 2019).

Glacier loss could also jeopardize irrigation for the coastal agroindustry and water-intensive mining[67] during the dry season;[68] the ensuing threats to livelihoods and possible resource conflicts could drive displacement. Further displacement risks stem from glacial lake outburst floods.[69] Finally, for Peru's growing cities along the Pacific coast, the glacier losses could threaten the viability of buffering systems for water supply and result in usage conflicts.[70]

Glacier loss represents one of several "no-analog threats" without modern precedents for displacement.[71] In a high-emissions future, further threats could arise simultaneously and result in parallel disasters triggering both gradual, pre-emptive forms of migration and reactive displacements of unprecedented scale. First, climate change could also threaten the habitability of Peru's rainforest due to extreme heat stress,[72] which could occur in tandem with massive rainforest degradation or dieback.[73] Second, more frequent, extreme El Niño events[74] on top of higher sea levels[75] could periodically drive more displacement in Peru's densely populated coastal areas. Pre-existing displacement dynamics (for example, due to floods and wet mass movements) and migration, as illustrated in Figure 5, are also expected to increase as hazards intensify.

[67] Scott D. Odell, Anthony Bebbington, and Karen E. Frey, "Mining and Climate Change: A Review and Framework for Analysis," *The Extractive Industries and Society*, 2018, https://doi.org/10.1016/j.exis.2017.12.004.
[68] Buytaert et al., "Glacial melt content of water use in the tropical Andes"
[69] A. Emmer, V. Vilímek, and M. L. Zapata, "Hazard Mitigation of Glacial Lake Outburst Floods in the Cordillera Blanca (Peru): The Effectiveness of Remedial Works," *Journal of Flood Risk Management*, no. 11 (2016), https://doi.org/10.1111/jfr3.12241; Holger Frey et al., "A Robust Debris-Flow and GLOF Risk Management Strategy for a Data-Scarce Catchment in Santa Teresa, Peru," *Landslides* 13, no. 6 (2016), https://doi.org/10.1007/s10346-015-0669-z, https://doi.org/10.1007/s10346-015-0669-z; Mark Carey, Adam French, and Elliott O'Brien, "Unintended Effects of Technology on Climate Change Adaptation: An Historical Analysis of Water Conflicts Below Andean Glaciers," *Journal of Historical Geography* 38, no. 2 (2012), https://doi.org/10.1016/j.jhg.2011.12.002; Jonathan L. Carrivick and Fiona S. Tweed, "A Global Assessment of the Societal Impacts of Glacier Outburst Floods," *Global and planetary change* 144 (2016), https://doi.org/10.1016/j.gloplacha.2016.07.001; D. Schneider et al., "Mapping Hazards from Glacier Lake Outburst Floods Based on Modelling of Process Cascades at Lake 513, Carhuaz, Peru," *Advances in Geosciences* 35 (2014), https://doi.org/10.5194/adgeo-35-145-2014; Wilfried Haeberli et al., "New Lakes in Deglaciating High-Mountain Regions – Opportunities and Risks," *Climatic Change* 139 (2016), https://doi.org/10.1007/s10584-016-1771-5.
[70] Buytaert et al., "Glacial melt content of water use in the tropical Andes"
[71] Bergmann et al. (2021), Op. cit. 1.
[72] Oliver Andrews et al., "Implications for Workability and Survivability in Populations Exposed to Extreme Heat Under Climate Change: A Modelling Study," *The Lancet Planetary Health* 2, no. 12 (2018), https://doi.org/10.1016/S2542-5196(18)30240-7; Camilo Mora et al., "Global Risk of Deadly Heat," *Nature Climate Change* 7 (2017), https://doi.org/10.1038/nclimate3322, https://doi.org/10.1038/nclimate3322; John P. Dunne, Ronald J. Stouffer, and Jasmin G. John, "Reductions in Labour Capacity from Heat Stress Under Climate Warming," *Nature Climate Change* 3 (2013), https://doi.org/10.1038/nclimate1827.
[73] V. Masson-Delmotte et al., eds., *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty* (Geneva, 2018); Carlos A. Nobre et al., "Land-Use and Climate Change Risks in the Amazon and the Need of a Novel Sustainable Development Paradigm," *Proceedings of the National Academy of Sciences of the United States of America* 113, no. 39 (2016), https://doi.org/10.1073/pnas.1605516113.
[74] IPCC, "Summary for Policymakers," in *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, ed. H.-O. Pörtner et al. (Geneva, 2019).
[75] Borja G. Reguero et al., "Effects of Climate Change on Exposure to Coastal Flooding in Latin America and the Caribbean," *PloS one* 10, no. 7 (2015), https://doi.org/10.1371/journal.pone.0133409.

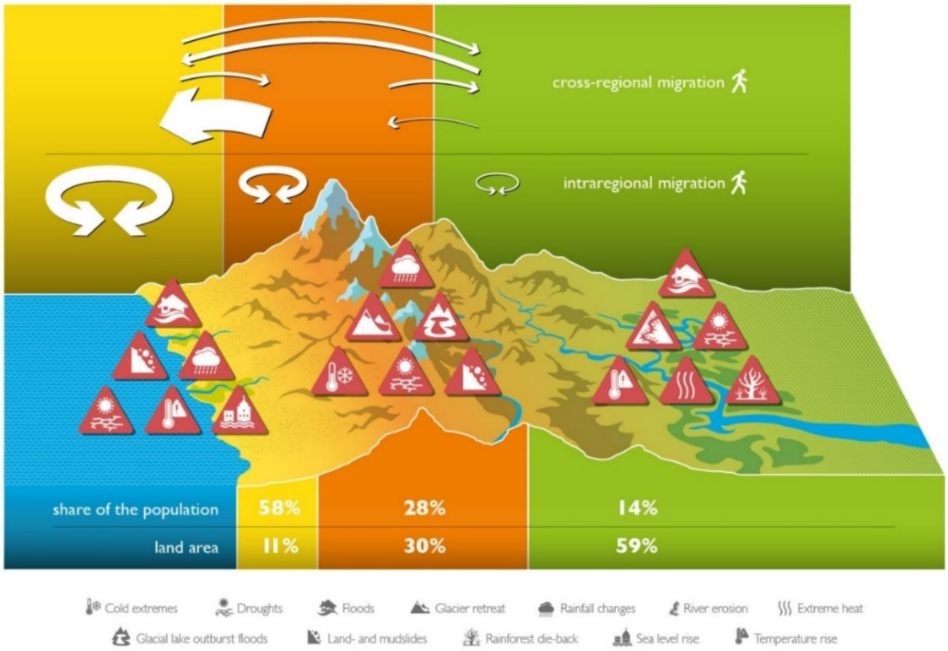

Figure 6: Net lifetime migration across Peru's three main topographical zones, with relevant hazards shown. Figure © Bergmann et al. 2021, Op. cit. 1.

Forced immobility

Simultaneously, many people may find themselves in increasingly dangerous areas and unable to leave, for example because they lack financial resources, social networks, or are bound by social obligations or emotional bonds.[76] Even when suffering from climate impacts, many people opt to stay, at least in the beginning of gradual changes.[77] Recent fieldwork found that in one Peruvian highland village, after glaciers had melted, only a few older adults stayed behind, resigned and exhausted:[78]

> *"What state have we come to? To a very sad life, a water crisis. Why do we lose both our youth and our children? Because there is nothing good here for how to survive. There is no work, there is no water! We, the older adults, are the only ones to stay in this village. There is no more youth, we cannot sow anymore given the lack of water. We only have one life but are in a time of crisis in [this village]" (woman in her late 60s).*

Some are in a state of *acquiescent* immobility:[79] they stay because they fear criminality, insecurity, and violence associated with city life. Others can be conceived of as living in *forced* immobility; despite their aspirations to leave, they lack required physical conditions, resources, or social networks. State support or remittances[80] may provide a critical buffer for some in immobility, while others will require facilitated migration or planned relocation.

Instruments and Policies

Peru disposes of laws to govern migration, internal displacement, and planned relocation. Integrated frameworks for disaster risk management and reduction cover emergencies and humanitarian responses. Moreover, many of the country's laws are grounded in human rights norms which could support a rights-based approach to address displacement risks.[81] Regional frameworks such as MERCOSUR as well as the Cartagena and Brazil Declarations are promising

[76] Helen Adams, "Why Populations Persist: Mobility, Place Attachment and Climate Change," *Population and Environment* 37, no. 4 (2016), https://doi.org/10.1007/s11111-015-0246-3, https://doi.org/10.1007/s11111-015-0246-3.
[77] Koubi et al. (2016), Op. cit. 69.
[78] Bergmann (in preparation), Op. cit. 70.
[79] Hein de Haas, "Migration theory — Quo Vadis?," November, International Migration Institute Working Papers 100 (Oxford, 2014).
[80] Aníbal Sánchez Aguilar, "Migraciones internas en el Perú," Primera edición (International Organization for Migration (IOM), Lima, 2015).
[81] For more detailed analysis, see Bergmann et al. (2021), Op. Cit. 1.

entry points for protection. The recent Peruvian Climate Change Framework Law and its Regulation are another step forward with their call for an "Action Plan to Avert and Address Forced Migration caused by the Effects of Climate Change".[82] Peru has signalled interest in addressing the topic not only through this Action Plan, but also to integrate it in its National Adaptation Plan (NAP).

INSIGHTS FROM TANZANIA: MULTIPLE SHOCKS AND FORCED IMMOBILITY

There is strong evidence that climate change has an impact on livelihoods in the United Republic of Tanzania, including through migration and displacement patterns. Average temperatures have been rising continuously between 0.1 to 0.5°C per decade since 1981 while warming sea surface temperatures in the Indian Ocean contribute to El Niño–like conditions that have led to flooding, cholera epidemics, destruction of crops and infrastructure, and loss of life.[83] Severe droughts in recent decades have undermined rain-fed agriculture, affected rangelands and forest systems, heightened flood risks, and lead to an extreme reduction in water levels in major lakes and rivers.[84] Due to the high population density on Tanzania's islands and along its coasts, the country is among African coastal countries with the highest number of people affected by floods annually.[85]

Projected climate change impacts: Extreme Heat, Droughts, and Flooding

Temperatures are projected to rise as much as 2.3-5.2°C nationwide over the coming decades. Under the most optimistic emissions scenario, RCP2.6, we can expect over 1°C average rise by the middle of the century (2030-2050), and 2.3°C by end-century (2079-2099).[86] Under RCP8.5, temperatures may rise 2.5°C by mid-century and 5.2°C by end-century.

The mean number of very hot days are likely to increase across the country.[87] The semi-arid central regions will be the worst affected, facing 40 more very hot days by the middle of the century and over 100 more by the end-century under RCP2.6, on top of a baseline of roughly 50 to 70 days per year (1985-2005 average).[88] Under RCP8.5, very hot days may increase by 70-90 by mid-century, and over 250 more by end- century.[89] In some coastal areas, heat and humidity outdoors would under this scenario supersede the human body's ability to thermoregulate.[90] This is dire considering two-thirds of workers are in the agricultural sector and work primarily outdoors.[91]

---

[82] Framework Law on Climate Change ("Ley marco sobre cambio climático. Ley Nº 30754 (2018)); Supreme Decree that approves the Regulation of Law Nº 30754, Framework Law on Climate Change ("Decreto Supremo que aprueba el Reglamento de la Ley Nº 30754, Ley Marco sobre Cambio Climático. Decreto Supremo N° 013-2019-MINAM).

[83] Blocher et al. (2021), Op. cit. 3.

[84] The World Bank Group. "Country Profile: Tanzania." Data Catalog. (2019): https://data.worldbank.org/indicator/SP.POP.TOTL?locations=TZ. Accessed 12 January 2021.

[85] Hinkel, Jochen, Sally Brown, Lars Exner, Robert J. Nicholls, Athanasios T. Vafeidis, and Abiy S. Kebede. 2012. "Sea-Level Rise Impacts on Africa and the Effects of Mitigation and Adaptation: An Application of DIVA." Regional Environmental Change 12 (1): 207–24. https://doi.org/10.1007/s10113-011-0249-2.

[86] See footnote 6; Collins, Matthew, Reto Knutti, Julie Arblaster, Jean-Louis Dufresne, Thierry Fichefet, Xuejie Gao, William J Gutowski Jr, et al. "Long-Term Climate Change: Projections, Commitments and Irreversibility." In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 108. (Cambridge, UK and New York, NY, USA, 2013).

[87] Defined as days on which temperatures exceed 32 degrees C; see also footnote 17.

[88] Cavan, Gina, Sarah Lindley, Deusdedit Kibassa, Riziki Shemdoe, Paolo Capuano, Francesco De Paola, Florian Renner, and Stephan Pauleit. "Urban morphological determinants of temperature regulating ecosystem services in African cities: the case of Dar es Salaam, Tanzania." EGUGA (2013): EGU2013-12086.

[89] Collins et al. (2013), Op. cit. 86.

[90] Mora, Camilo, Chih-Lin Wei, Audrey Rollo, Teresa Amaro, Amy R. Baco, David Billett, Laurent Bopp, et al. 2013. "Biotic and Human Vulnerability to Projected Changes in Ocean Biogeochemistry over the 21st Century." *PLOS Biology* 11 (10): e1001682. https://doi.org/10.1371/journal.pbio.1001682.

[91] URT. "National Five Year Development Plan 2016/17 – 2020/21" (Ministry of Finance and Planning, Dar es Salaam, 2016) https://mof.go.tz/mofdocs/msemaji/Five%202016_17_2020_21.pdf; Blocher et al. (2021), Op. cit. 3.

Hotter days will be accompanied by a continued decline in the long rains season as well as a shift and intensification of the short rains season.[92] Most climate models project more extreme precipitation events concentrated on fewer rainy days throughout the century. Shifts in the rain seasons affects food security in part because farmers have difficulty with timing of planting. Moreover, heavy rain can cause crop damage and spoil improperly stored crops. Without substantial improvement to climate services that allow agriculturalists to plan, they will continue to face challenges maintaining food stores for periods of drought (see figure 6).[93] Pastoralist livelihoods also rely on knowledge of seasonal patterns, and are particularly vulnerable to climatic stress.[94] Pastoralist livelihoods predominate in the drought-prone northern and central semi-arid areas.

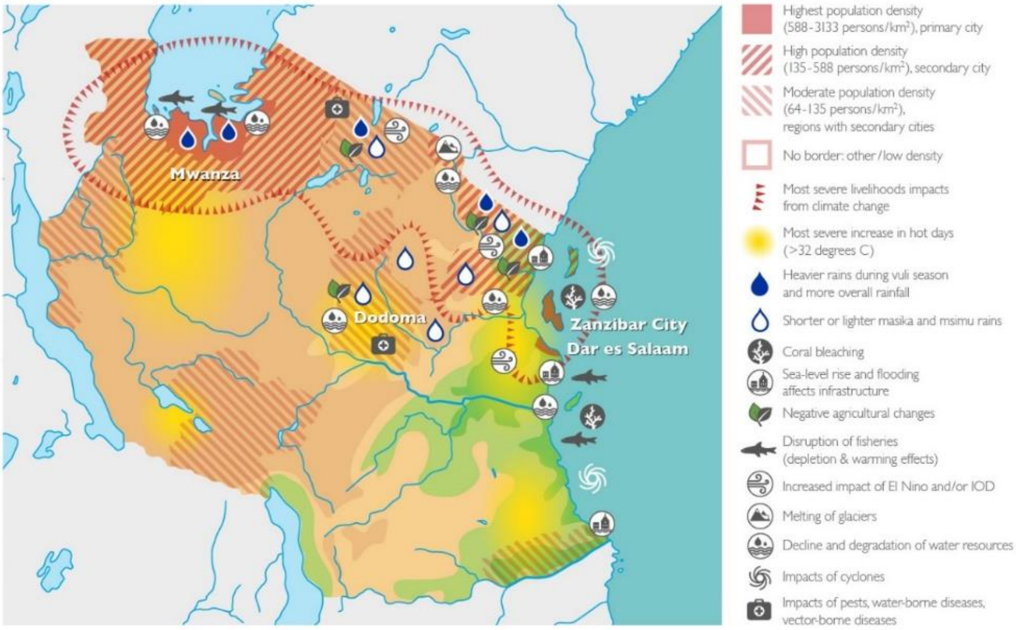

Figure 7: Known impacts of climate change on livelihoods in the United Republic of Tanzania. Coastal urban areas as well as northern regions are likely to face the highest displacement risks due to high population density. Pastoralists in northern and central semi-arid areas are particularly vulnerable to rainfall shortages. Figure © Blocher et al, 2021, Op. cit. 3.

Multi-causal mobility dynamics

Some 140,800 new internal displacements were recorded in Tanzania since 2008.[95] Disasters are primarily related to weather-related hazards (e.g. seasonal floods and storms), geophysical events (e.g. the 2009 earthquake in Rukwa Region), and epidemics (e.g. rift valley fever in 2006/7).[96] Official figures mask high turnover of rural-to-rural migrants that are likely to be the primary form of mobility in the country.[97] For example, while movements due to drought are difficult to

[92] Mapande, A. T., and C. J. C. Reason. "Links between Rainfall Variability on Intraseasonal and Interannual Scales over Western Tanzania and Regional Circulation and SST Patterns." Meteorology and Atmospheric Physics 89, No. 1–4 (2005): 215–34. https://doi.org/10.1007/s00703-005-0130-2.

[93] Afifi, Tamer, Emma Liwenga, and Lukas Kwezi. "Rainfall-induced crop failure, food insecurity and out-migration in Same-Kilimanjaro, Tanzania." *Climate and Development* 6, no. 1 (2014): 53-60.; Blocher et al. (2021), Op. cit. 3.

[94] Blocher et al. (2021), Op. cit. 3.

[95] IDMC, "Global database on internal displacement (GDID)," IDMC, accessed 22 February 2021, https://www.internal-displacement.org/database/displacement-data. Accessed 12 January 2021; IDMC, "Tanzania Country Information: As of 22 February 2021," IDMC, accessed February 22, 2021, http://www.internal-displacement.org/countries/tanzania.

[96] EM-DAT. The International Disaster Database. https://www.emdat.be. Accessed 12 January 2021.

[97] De Weerdt, John. and Hirvonen, Kalle. Risk sharing and internal migration. The World Bank. (2013)

estimate, evidence suggests it is common for pastoralists facing herd loss.[98] Climatic events add to other factors in the history of population shifts in the country: demographic changes and development; emigration restrictions and villagization schemes during the *Ujamaa* era (roughly 1961 to 1985); the so-called "decentralization by devolution" governance approach that focuses on developing rural, rather than central, hubs (introduced in the 1990s); and moving the capital from Dar es Salaam to Dodoma (officially completed in 2019).[99]

Interactions of Climate Change and Displacement: Critical thresholds after repeated or multiple shocks

Emerging research suggests that while families may not be forced to leave their homes in the case of one shock – a covariant man-made or natural shock, or idiosyncratic shock like a death in the family – the erosive nature of these events on household resources mean they can combine to induce displacement. A point may be reached at which either the individual determines that they, their family, and assets (including livestock) must move out of harm's way. Some migrants point to specific critical threshold events like droughts that precipitated their move.[100] Climate change accelerates both droughts and floods and the impacts of each often follows the other. One villager who moved from a low-lying area to higher ground after being frequently displaced by floods explained:

> *Among the natural disasters occurring frequently in the village are* ***floods and hunger****... Hunger also happens frequently because of the loss of food caused by floods… I moved here after being displaced in the low land of this village. My previous house was destroyed by floods in 2017. There were no deaths that occurred, but many houses and things inside the houses were destroyed by the floods. Also, diseases such diarrhoea happened in the area. (Woman, 30s, Morogoro Region)*

Limited government assistance means that people rely on neighbors, family, or inadequate strategies. Hazards may be so frequent that families cannot recover and whole villages disperse (see figure 7). As explained by another interviewee:

> *Floods occur in this area every year when the heavy rains take place in Dodoma. I was affected, as was the entire community, through* ***the loss of housing****. I moved to this village last year because the floods destroyed the village. When I came here, the river was more than four kilometers away, but* ***it keeps coming closer and closer every year. You can't build a permanent house here****… Moving from where I was before to come here, I didn't receive any assistance from the government. (Man, mid 40s, Morogoro Region)*

Figure 8: Abandoned structures in and Tindiga and Mambengwa Villages, Kilosa District, destroyed by severe flooding in 2017. All residents of Tindiga village where forced to relocate, some to the next village. Photo © Julia M. Blocher, 2019.

---

[98] May, Ann. "Unexpected Migrations : Urban Labor Migration of Rural Youth and Maasai Pastoralists in Tanzania." (2002); Munishi, Emmanuel J. "Rural-Urban Migration of the Maasai Nomadic Pastoralist Youth and Resilience in Tanzania : Case Studies in Ngorongoro District, Arusha Region and Dar Es Salaam City." (2013)

[99] Hansen, Peter. "Revisiting the remittance mantra: a study of migration–development policy formation in Tanzania." *International Migration* 50, no. 3 (2012): 77-91; Mollel, Henry Abraham, and Albertjan Tollenaar. "Decentralization in Tanzania: design and application in planning decisions." *International Journal of Public Administration* 36, no. 5 (2013): 344-353.; Robi, Anne. "Tanzania: Shift of Capital to Dodoma Is JPM's 'Dream Come True," AllAfrica.Com, November 8, 2018, accessed 10 August 2020, https://allafrica.com/stories/201811080741.html. A

[100] Tacoli, Cecilia. "Not Only Climate Change: Mobility, Vulnerability and Socio-Economic Transformations in Environmentally Fragile Areas in Bolivia, Senegal and Tanzania." (2011) https://pubs.iied.org/10590IIED/.

Forced Immobility & Displacement

Scholars warn that in the face of severe climate impacts, poorer families easily exhaust their available coping mechanisms and become involuntarily immobile.[101] Some research demonstrates that poor, rural Tanzanians are currently less likely to choose to migrate for employment, as compared to middle-wealth households who are better able to leverage previous earnings to invest in migration in anticipation of shocks.[102]

Other research suggests that, as compared to wealthy households, poor households are four times more likely to be displaced in response to hazards like floods and droughts.[103] This is likely because wealthier households have coping mechanisms that enable them to withstand the shock and/or bound back from the losses. Herd loss due to severe droughts is among the main reasons cited by working-age pastoralist men for moving to cities.[104] These moves are often temporary, as the men will return once they perceive they have earned enough to re-establish their livelihoods at home.[105] Under high-end climate-change scenarios, all rural areas will affected and displacement to urban areas may become tantamount to survival.

*Figure 9: Maasai elder builds a cow enclosure from brush for the household's dry season camp (*ronjo*), where the herders will stay for several weeks until conditions require further movement. "Is not a good thing to move during drought, but you must in order to save your cows," he says. "Nowadays I am moving them more often." Photo © Julia M. Blocher, 2019.*

Instruments and Policies

The country's 2012 National Climate Change Strategy and 2007 National Adaptation Plan of Action address the potential for climate change to disrupt livelihoods systems, induce migration,

---

101 Black, Richard, Nigel W. Arnell, W. Neil Adger, David Thomas, and Andrew Geddes. "Migration, immobility and displacement outcomes following extreme events." *Environmental Science & Policy* 27 (2013): S32-S43.

102 Beegle, Kathleen, Joachim De Weerdt, and Stefan Dercon. "Migration and economic mobility in Tanzania: Evidence from a tracking survey." *Review of Economics and Statistics* 93, no. 3 (2011): 1010-1033.

103 Ocello, Cristina, Alessandra Petrucci, Maria Rita Testa, and Daniele Vignoli. "Environmental aspects of internal migration in Tanzania." Population and Environment 37, no. 1 (2015): 99-108.Ocello, Cristina, Alessandra Petrucci, Maria Rita Testa, and Daniele Vignoli. 2015. "Environmental Aspects of Internal Migration in Tanzania." *Population and Environment* 37 (1): 99–108. https://doi.org/10.1007/s11111-014-0229-9.

104 Heaney, Alexandra K., and Sandra J. Winter. "Climate-Driven Migration: An Exploratory Case Study of Maasai Health Perceptions and Help-Seeking Behaviors." *International Journal of Public Health* 61, no. 6 (2016): 641–49. https://doi.org/10.1007/s00038-015-0759-7.; Afifi et al. (2014), Op. cit. 104.

105 Julia M. Blocher. "Migration Probabilities in the Context of Climate Change in Tanzania" (Doctoral thesis, Faculty of Humanities and Social Sciences, Humboldt-Universität zu Berlin, in preparation).

and incite resource-based conflicts.[106] The government supported the processes towards a Global Compact on Refugees and voted in favor of the Global Compact for Safe, Orderly and Regular Migration (2018). The country has signed, but not ratified, the Kampala Convention.[107]

The governance framework for human mobility in general could be improved by filling knowledge and data gaps as well as developing concrete policies on the subject. Approaches to pre-emptive planned relocations are nascent the country's National Adaptation Plan of Action (NAPA).

Primarily driven by population growth rather than by migration, the proportion of Tanzanians living in cities increased from 18.8 per cent in 1990 to 33 per cent in 2016 and will represent a majority of the population by the middle of the century.[108] The country's national five year development plan (2016/17 – 2020/21) nevertheless suggests that decentralized development in rural areas can build local resilience and "reduce push factors of rural-urban migration and thus relieve pressure on provision of urban social amenities and infrastructure."[109]

CONCLUSION

In India, Peru, and Tanzania different climate impacts are harming people's livelihoods. All three study sites show that various mechanisms determine displacement outcomes and highlight possibilities for intervention. In general, climate impacts are depleting key resources necessary for agricultural production and basic living standards in places with few alternative livelihood options. This in turn can lead to critical thresholds at which people become displaced or forcibly immobile. Climate impacts as well as subsequent displacement can result in social fragmentation up to the dissolution of the socio-cultural fabric of communities.

Among the factors influencing climate-displacement dynamics, we identify a number of common challenges: the increasing severity of the hazards, undiversified livelihoods and dependence on natural resources, and the household's lack of local coping options. Nevertheless, we highlight specific key issues in each study site:

- In Uttarakhand, India, erratic rainfall causes a disturbance of traditional agriculture. It is possible that in some areas this disturbance could turn into a disruption, with the result that forced displacement could occur.
- In Peru, the melting of glaciers and related water scarcity is already causing water shortages, driving people from rural areas to the cities.
- In Tanzania, multiple shocks to people's livelihoods, including successive droughts and floods, have displaced people and rendered others immobile.

In all three case studies, governmental assistance or international aid – such as social security programs or insurance schemes – could help to stabilize livelihoods in a changing climate. Adequate coping mechanisms emerges as an important factor in the displacement histories. In particular, people gradually exhaust strategies in response to slow-onset changes and their displacement can occur over several years. This dynamic also makes climatic event-attribution and the allocation support to displaced people also more difficult.

---

[106] United Republic of Tanzania (URT). Tanzania: National climate change strategy. (2012); URT. National Adaptation Plan of Action. (2007)

[107] African Union (AU). "List of countries which have signed, ratified/acceded to the African Union Convention for the Protection and Assistance of Internally Displaced Persons in Africa (Kampala Convention)". AU, 2020, accessed 22 February 2021, https://bit.ly/3muUF2i.

[108] NBS (National Bureau of Statistics). 2015–16 Demographic and Health Survey and Malaria Indicator Survey: Key Findings. United Republic of Tanzania. (2016); URT. "National Five Year Development Plan 2016/17 – 2020/21" (Ministry of Finance and Planning, Dar es Salaam, 2016) https://mof.go.tz/mofdocs/msemaji/Five%202016_17_2020_21.pdf

[109] *Ibid.*

In the diverse contexts considered above, worsening environmental stress combined with structural inequalities have already led to situations in which either the individual or household determines that they must move for the survival of themselves, their family, and their assets. Worsening climate impacts will, without appropriate adaptation measures, increase the likelihood of such situations to occur. A critical mass of individuals and households deciding to move in turn can affect the larger group migration dynamics as social and community structures may break down.[110] Thresholds associated with forced migration are closely linked to the concept of un-inhabitability, both in terms of environmental carrying capacity of an area and its perceived habitability[111]. Understanding the limitations of adaptation is crucial. In the analysis of all three cases, a business-as-usual (RCP8.5) emissions scenario would lead to multiple humanitarian catastrophes, driving large population displacements from practically uninhabitable areas and rendering many more exposed to shocks and unable to move.

[110] McLeman, Robert. "Thresholds in climate migration." Population and Environment 39, no. 4 (2018): 319-338.; McAdam, Jane. "The concept of crisis migration." Forced migration review 45 (2014). Meze-Hausken, Elisabeth. "Migration caused by climate change: how vulnerable are people inn dryland areas?." Mitigation and Adaptation Strategies for Global Change 5, no. 4 (2000): 379-406.
[111] Vinke, K.; Bo, C.; Cabrejos, M.; Gardiner, S.; Gärtner, J, Gracias, O.; Hollerich, J.-C.; Thornton, F.; Williams, D.; Schellnhuber, H.J. (in prep.): The Freedom to Move in Response to Uninhabitability: Enabling Climate Migration by a Nansen-Type Passport.