POLICY FORUM

Addressing the human cost in a changing climate

Displacement costs remain largely invisible, hindering effective action

By **Bina Desai[1], David N. Bresch[2], Christelle Cazabat[1], Stefan Hochrainer-Stigler[3], Reinhard Mechler[3], Sylvain Ponserre[1], Jacob Schewe[4]**

Climate change is leading to systemic and existential impacts, and evidence is mounting that these can result in the displacement of human populations. There is a rapidly growing demand for comprehensive risk assessments that include displacement and its associated costs to inform humanitarian response and national planning and coordination. However, owing to complex causation, missing and incomplete data, and the political nature of the issue, the longer-term economic impacts of disaster- and climate-related displacement remain largely hidden. Current approaches are rarely ex ante and prospective and do not consider systemic risk management. Not surprisingly, response-based approaches have shown mixed results, repeatedly demanding substantial resources while not addressing the root causes of displacement.

Climate change is not only affecting the intensity, frequency, and duration of hazards that trigger displacement but is also eroding already fragile livelihoods and ecosystems, acting as an aggravator of existing vulnerability and contributing to chronic poverty and conflict in affected countries (*1*). Although disaster risk reduction as a cross-sectoral issue has gained considerable attention over the past two decades, disaster displacement risk is still not fully integrated in national policies and planning. Out of 46 countries included in the 2020 Internal Displacement Index, most acknowledge disaster displacement in principle and have climate policies or national adaptation plans in place. However, only 27 recognize the link between the gradual impacts of climate change and displacement (*2*).

With an evidence-based, longer-term vision and investments, climate-related displacement—the forced movement of people in response to a hazard—can be averted and replaced by a range of measures such as planned relocation that is voluntary (at least to a large degree) and financially supported, or by building the resilience of at-risk populations, reducing vulnerability to such an extent that moving is not required. What is missing is a risk-informed framework for country-led, forward-looking approaches to make the case for substantial investment in effective risk reduction, durable solutions for those displaced, and the prevention of new displacement.

Applied risk science, using probabilistic models and large empirical datasets compiled over the years, combined with insights from local empirical research and community assessments, now offers the opportunity for a step change in informed decision-making. For example, the shift from deterministic disaster risk assessments, based on historical data, to state-of-the-art probabilistic modeling used by the insurance industry, calibrated with historical data but including randomness to encompass all possible scenarios, presents a notable advance in risk science that is yet to be fully applied to displacement risk. New tools and risk modeling platforms, such as CLIMADA run by ETH Zürich or CAPRA of the World Bank, can now be adapted for displacement risk assessments. Further, assessing the social and economic cost of displacement can provide incentives for transformational action and change, from mere response to disaster displacement to proactively addressing vulnerability and exposure, thereby reducing displacement risk.

"Applied risk science… now offers the opportunity for a step change in informed decision-making."

DISASTER DISPLACEMENT AND CLIMATE CHANGE

Disaster displacement is a global reality and everyday occurrence. Millions of disaster displacements have been systematically recorded since 2008—on average, 24.5 million new movements every year (*3*). Weather-related hazards account for almost 90% of all these displacements (*2*), with climate change and the increasing concentration of populations in areas exposed to storms and floods, coupled with socioeconomic drivers of vulnerability, meaning that more people are at risk of being displaced. Demographic, historical, political, and socioeconomic factors determine whether people can withstand the impacts of a physical hazard or environmental stressor or have to leave their homes. Climate change interacts with all of these factors, particularly where resources and the capacities of humans and systems are already stretched (*4*). For example, sea level rise results in loss of land in coastal areas and low-lying atolls of island states, forcing communities to retreat or leave the land altogether. Salinization can reduce crop yields, undermine arable land and freshwater availability, and force people to move. Increasing temperatures affect soil moisture and degradation, which make the soil susceptible to nutrient loss and erosion, thereby destroying the livelihood basis for rural communities. Glacial retreat and melt, loss of biodiversity, and land and forest degradation mean decreased ecosystem services and provisioning services, pushing people to move. Because climate change can also alter the intensity, frequency, and duration of hazard events, climate anomalies and more devastating sudden-onset disasters may follow.

Most of the impacts of climate change only result in displacement for those vulnerable to them. This essential point is repeatedly forgotten, with important policy implications (*5*). A prosperous farmer with access to drip irrigation and fertilizers, reliable buyers, loans, and insurance will not be as affected by changes in rainfall patterns as a smallholder subsistence farmer relying on the regularity of seasonal rains or a pastoralist in search of pasture for his herd. An urban dweller with an office job and regular income will not need to leave his home because of the loss of mangroves, which are providing sustenance to millions in coastal communities. Nonetheless, although individual vulnerability leads to a risk of adverse displacement outcomes, disaster and climate risks are increasingly becoming systemic because high-level and widespread impacts may ripple through social and economic networks, incurring

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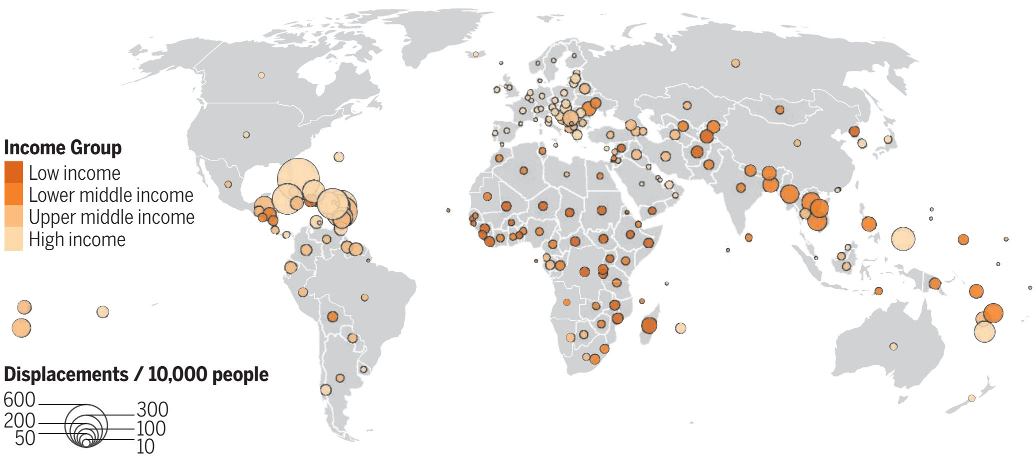
further adverse micro and macro impacts and disruptions (*6*).

Climate change is thus a displacement trigger in its own right (e.g., loss of coastlines through sea level rise and coastal erosion), a visible aggravator (e.g., when livelihoods are eroded because of soil degradation and loss of ecosystem services), and a hidden aggravator (e.g., increasing the intensity of cyclonic winds and shifting rainfall patterns that result in floods). But the impacts of climate change interact with broader changes in the physical and social environment, resulting in potentially rising costs associated with future displacement.

Global disaster displacement risk relative to population size

Average Annual Displacement (AAD) risk is a compact metric that represents the estimated effect, accumulated over a long time frame, of future small to medium and extreme events and estimates the likely displacement associated with them on a yearly basis for sudden-onset hazards such as tsunamis, cyclonic winds, storm surges, and riverine floods. See (*10*) for details. Each country's AAD risk relative to its population size is shown (expected annual displacements / 10,000 people). Country income group classification from the World Bank.



GRAPHIC: N. DESAI/*SCIENCE* BASED ON B. DESAI *ET AL.*

A HEAVY BURDEN...ON NOBODY'S BALANCE SHEET

Disaster displacement often undermines the welfare and well-being of affected individuals and communities and can also incur a substantial social and economic burden on countries. Although many countries have begun to plan for the risk of extreme events in one way or another, governments typically do not formally account for displacement risk and their associated costs in national development plans and annual budgets of line ministries. Even without taking into account the aggravating forces of climate change, there is growing evidence that displacement not only severely disrupts the lives of those forced to flee their homes but also has an economic impact on local communities and national economies (*7*). The direct cost of providing every internally displaced person (totaling more than 55 million in 2020) with support for housing, education, health, and security has been estimated at US$370 per person per year, accumulating to more than US$20.5 billion for 2020 (*2*).

These figures are mostly based on information available from protracted conflict-related displacement situations because the economic impacts of displacements linked with disasters and climate change usually go unrecorded. A key knowledge gap exists here because only limited event-based or nationally aggregated data is available on how long people remain displaced after a disaster, despite ample evidence that this type of displacement is often long-term and can become protracted (*2*). These impacts can add up to billions of dollars worldwide. Each time one person is displaced, even for a few days, costs arise for transportation, shelter, food and nonfood items, and the loss of income if the person cannot continue their usual work. Adding in long-term consequences, such as lack of schooling, training, and on-the-job experience, increases this economic impact. These costs should be on national balance sheets but are instead most often borne by communities themselves, by local governments that have to divert already limited development funds to response, and by humanitarian actors. In the face of increasingly severe disaster- and climate-related displacement, these costs are only set to rise.

The highest economic impacts usually stem from the loss of income and the need to provide displaced people with shelter and health care. Disaster-resilient housing and livelihoods, as well as strong primary health care systems, are also where investments are needed most ahead of disaster events to reduce displacement and enable lasting solutions. By nature of its mandate, humanitarian response is not set up to invest in resilient livelihoods or infrastructure and service development.

It is not only low-income nations that are at risk of economic impacts due to displacement. During the 2019–2020 bushfires in Australia, the loss of economic production as a result of people missing just one day of work during displacement was estimated to be about US$510 per person (*8*). These costs add up, particularly if a disaster causes considerable housing destruction, which may delay people from returning to their homes for months. The cost of covering housing needs resulting from Australia's Black Summer bushfires was estimated to be between US$44 million and US$52 million for a year, posing a substantial financial burden, given that previous recovery efforts indicate that it can take people between 1 and 4 years to rebuild their homes (*8*).

ASSESSING DISPLACEMENT RISK

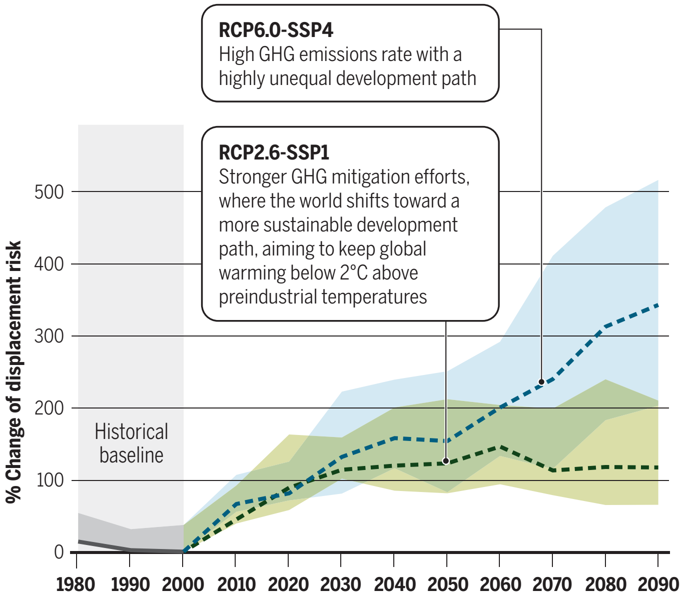
These numbers and examples from across the globe highlight that we need to get better at understanding and assessing the nature and scale of disaster displacement risk. The coverage and detail of relevant datasets have improved, and various models and approaches exist at regional and global scales, although their time frames, methods, and resulting estimates vary enormously. For example, the World Bank, using a gravity model and new data on climate change, water availability, and crop production, has estimated that slow-onset climate hazards such as water scarcity and declining crop yields could lead to more than 100 million additional internal migrants in Latin America, South Asia, and sub-Saharan Africa by 2050 should neither accelerating climate impacts nor unequal development be adequately addressed (*9*).

In many such assessments, there is a strong focus on environmental stressors and hazards, and on climate change's impacts on their intensity and frequency. This may have potentially resulted in inflated numbers and certainly in an inflated perception regarding the role of climate change in the dynamics of human mobility and forced movements today and in the coming decades. Estimates from a probabilistic model that takes housing rendered uninhabitable as a proxy for displacement in sudden-onset disasters, such as floods and cyclones, suggest that an average of around 14 million displacements can be expected each year (a conservative approach that is highly likely to be an underestimate) (*10*). This displacement risk is heavily concentrated in the Asia-Pacific region, where both exposure and vulnerability are high. Even in relative terms—that is, numbers of potential displacements in relation to population size—displacement risk is high not only for South and East Asia but also for Pacific and other small island states (see the first figure).

Climate change as well as changes in population size and composition and of key social and economic indicators all affect how this displacement risk may change in the future.

Change in flood displacement risk

Shaded areas show different scenarios of flood displacement risk based on a range of climate and hydrological models, relative to historical baseline. The width of the shading represents an estimate of the uncertainty induced by natural climate variability and limitations in current understanding of the climate system and hydrological systems. Dashed lines show the average values across models. Historical baseline is defined by the average flood hazard frequency and intensity from 1976 to 2005, combined with population data for 2000. RCPs reflect different trajectories of variation in atmospheric GHG concentrations. SSPs reflect different scenarios of global socioeconomic development. Modified from (*11*).



RCP, representative concentration pathway; GHG, greenhouse gas; SSP, shared socioeconomic pathway

a smaller magnitude but more frequent disaster with a return period of 10 years would incur more than US$1 billion. The estimated possible amount of funding that the country may be able to divert from existing development budgets and credit buffers adds up to just over US$1 billion of fiscal resilience, which means that Bangladesh is likely to be unable to cover the costs associated with internal displacement for events that occur every 10 years on average.

Further estimates of such costs can provide the basis for making the case for preventive action and for developing appropriate financial instruments such as national reserve funds, enhanced social protection schemes, and catastrophe bonds, as well as regional or global sovereign insurance pools (*14*). Beyond these first steps in developing basic estimates of the costs, further work is required to better understand who bears these and how benefits from improved policies would be distributed across different segments of society.

According to probabilistic, spatially explicit risk modeling that uses ensembles of climate models and hydrodynamic modeling to quantify flood hazard, is calibrated on past events, and incorporates commonly used climate change and development scenarios, rapidly increasing exposure due to population growth may be the largest driver of displacement risk in the future (*11*). Nevertheless, this strong role of population size should not overshadow the fact that the substantial increase related to climate change is not trivial (see the second figure). New assessments show that we can expect a 50% increase in displacement risk related to floods for each degree of temperature increase (*11*). Although, currently, various epistemic uncertainties need to be reckoned with, such projections serve to illustrate the future burden to consider in a rapidly warming and changing climate.

Beyond probabilistic and deterministic disaster displacement risk models, there are other modeling approaches that can increasingly be put to the task. Agent-based network models can assess individual-level impacts and costs through a bottom-up methodology that can reflect how shocks to one part of a system (community, economy, country, or region) can cascade through the whole system and also spill over into other systems (*12*). Further, a system dynamics approach can describe in a relatively comprehensive manner the relationships between a wide range of dimensions and indicators, although it requires granular datasets that are often unavailable and is highly cost- and labor-intensive to develop.

Finally, integrating risk estimates with analysis of public finance allows quantification of the relevance and "additionality" of internal displacement impacts on governments' (and often donors') budgets. First attempts at undertaking this analysis, adapting the International Institute for Applied Systems Analysis (IIASA) catastrophe simulation model (CatSim) in support of public financing strategies in pre- and postdisaster contexts, have shown that the cost of internal displacement can substantially increase national and global budget gaps (fiscal gaps) and the chance of budget crises (*13*). For example, in Bangladesh, a disaster with a return period of 50 years can be expected to incur costs related to internal displacement of nearly US$4.1 billion per year of subsequent displacement;

INVESTING IN THE FUTURE

Comprehensive risk assessments that account for displacement risk and estimate its economic costs signal a need to improve coordination on budget allocations and cooperation in program execution across ministries and public and private sectors. This would enable the explicit inclusion of these contingent risks into budget stress-testing procedures and other risk-management planning processes. It would also provide incentives for managing risk with an ex ante approach, because it anticipates the ex post consequences and trade-offs involved in responding to shocks (*13*).

Risk assessments should help communities and local and national governments grappling with immediate displacement risk or the prospect of intensifying natural hazards or loss of territory or habitats. More financing must be made available for localized, granular displacement risk assessments, which municipalities can use to inform urban development plans, zoning regulations, and local building codes and for forward-looking, long-term planning for relocation where necessary.

Recent attempts at providing a measure for displacement risk and its impacts are

GRAPHIC: KELLIE HOLOSKI/*SCIENCE* BASED ON KAM *ET AL.* (*11*) only the first step. In the coming years, further investment should build on the promises of longer-term risk modeling and couple its results with impact assessments so that countries can build displacement estimates into their multiyear development plans (*15*). Understanding needs and priorities in the decision-making processes of affected populations, institutional capacities, and socioeconomic dynamics, even if less systematically assessed, will be at least as important at indicating what the future holds. Given the scope and complexity of the problem, a pluralistic methodological setup is required to contribute to a better understanding of displacement risk and to inform effective policy and response under a broad range of circumstances. ■

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POLICY FORUM

Pathways to coastal retreat

The shrinking solution space for adaptation calls for long-term dynamic planning starting now

By **Marjolijn Haasnoot[1,2], Judy Lawrence[3], Alexandre K. Magnan[4,5]**

There is an urgent need to take coastal retreat more seriously as an option for adapting to sea level rise (SLR) and as a strategy capable of providing positive outcomes, if planned ahead. Early signs of such thinking are emerging. We demonstrate how exploring pathways to managed retreat adds value in the context of irreversible long-term SLR. Retreat is typically framed and understood as a single action, largely used after events rather than preemptively, and considered as a last resort. However, implementing managed retreat constitutes a multidecadal sequence of actions (i.e., across pathways) including community engagement, vulnerability assessment, land use planning, active retreat, compensation, and repurposing. This Policy Forum advances practical knowledge on what pathways to coastal retreat may look like and how they can pave the way for flexible and positive transformational adaptation, if started now.

SHRINKING SOLUTION SPACE

SLR globally accelerated from 1.4 mm/year (1901–1990) to 3.6 mm/year (2006–2015) and will continue to do so during this century (10 to 20 mm/year in 2100) (*1*). Sea levels could rise between 0.43 and 0.84 m globally by 2100, relative to 1986–2005, as a median estimate under low and high emission scenarios, respectively. However, a rise of 2 m by 2100 cannot be ruled out (*1*). There is also a clear commitment to SLR centuries into the future due to inertia in both the climate and ocean systems; for every degree of warming, sea levels will eventually rise ~2.3 m (*2*).

Inexorable SLR makes some degree of relocation of coastal residents, buildings, infrastructure, and activities inevitable, even if global warming is mitigated to 1.5° or 2°C. The necessity of paying more serious attention to pathways to managed retreat is becoming urgent (*3*). To begin with, observed coastal flooding is already reaching unacceptable levels for communities and infrastructure in many low-lying coastal settlements around the world (*1*), and unless adaptation starts now, in a few generations, more regions (e.g., small islands, parts of the US coast, major deltas) will be at risk of coastal flooding (*1*). Additionally, retreat requires decadal lead time to plan and implement equitably (*3*, *4*). Furthermore, many decisions taken today have a long legacy effect and create path dependencies, closing off some options in the future. For example, coastal defenses last for many decades and protected areas attract people and assets, which lead to expectations of further protection. On the other hand, creating space for wetlands to grow as sea levels rise provides a temporary buffer, keeping future options open for later development or a lower barrier to retreat.

Ongoing and accelerating SLR, compounded with other climate-related changes (e.g., intensification of extreme events such as storms, heavy rainfall, and river flows) and increasing population at the coast, is already progressively shrinking the solution space of available adaptation options. Accommodation options (e.g., elevated buildings, early warning, and shelter) will not be enough to reduce coastal risks to acceptable levels under SLR-induced flooding and erosion. As sea levels rise, groundwater salinization will render water supplies unusable and limit food production to saline-tolerant crops. Nor will nature-based solutions, such as offshore reefs or wetland restoration, be likely to keep pace with combined climate change impacts (*1*) and human pressures that have reduced space and sediment supply to the coast. Such responses are therefore expected to be only temporary adaptations in many places (*5*).

Hard protection, either through holding the line (protect) or advancing seaward (advance) using levees, barriers, or artificial islands, can be beneficial, for example, in resource-rich megacities but also has limitations, as sustained and rapid SLR would make it increasingly difficult to extend infrastructure within available time frames (*6*). Also, hard protection will not be an affordable long-term solution for

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