METHODOLOGICAL PAPER

Assessing the impacts of climate change on flood displacement risk

DECEMBER 2019

INTRODUCTION

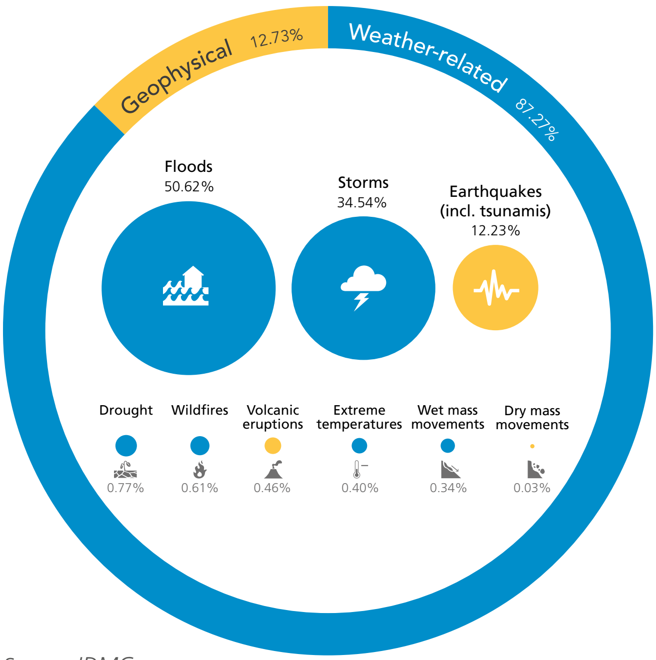
A number of attempts have been made to estimate the future scale of climate-related migration, but relatively few peer-reviewed studies examine the risk as it applies to displacement.[1] The latter lack of evidence is surprising for at least three reasons.

First, the impacts of unplanned or spontaneous mass displacement would inevitably be disruptive and may trigger humanitarian crises, something that is not expected in the case of planned or adaptive migration.[2]

Second, the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) calls for "recommendations for integrated approaches to avert, minimize and address displacement related to the adverse impacts of climate change".[3] If the risk of future displacement is to be addressed, it must first be measured and its drivers identified.

Third, displacement associated with disasters is already a significant global challenge. Climate and weather-related hazards force tens of millions of people to flee their homes every year.[4] Floods trigger just over half of these displacements, and storms more than a third (see figure 1).[5]

FIGURE 1: Disaster displacement by hazard type (2008 – 2018)



Source: IDMC

iDMC internal displacement monitoring centre

www.internal-displacement.org

By displacement, we mean: "Situations where people are forced or obliged to leave their homes or places of habitual residence as a result of a disaster or in order to avoid the impact of an immediate and foreseeable natural hazard. Such displacement results from the fact that affected persons are (i) exposed to (ii) a natural hazard in a situation where (iii) they are too vulnerable and lack the resilience to withstand the impacts of that hazard. It is the effects of natural hazards, including the adverse impacts of climate change, that may overwhelm the resilience or adaptive capacity of an affected community or society, thus leading to a disaster that potentially results in displacement. Disaster displacement may take the form of spontaneous flight, an evacuation ordered or enforced by authorities or an involuntary planned relocation process. Such displacement can occur within a country (internal displacement), or across international borders (cross-border disaster displacement)".[6]

With so many people already affected and extreme weather events predicted to become more frequent and/or severe in many parts of the world, it is imperative to establish the magnitude of future displacement risk, its drivers and what might be done about it. The Intergovernmental Panel on Climate Change (IPCC)'s sixth assessment report (AR6) may attempt to answer at least some of these questions, but it is unclear upon what evidence its findings will be based.[7]

This paper presents a first attempt to fill this information gap by estimating future flood displacement risk. It focuses on floods because they are responsible for most of the observed disaster displacement and estimated risk. By comparing future points in time with the present and across various climate change and development scenarios, it reveals the magnitude of risk, how it differs from the present, and what is driving the changes.

Internally displaced persons are among the most vulnerable and face a variety of risks to their lives, health and well-being.

ANTÓNIO GUTERRES, UN SECRETARY GENERAL

In order to increase the global visibility of internal displacement, the UN secretary general, António Guterres, announced the establishment of a high-level panel on the issue in October 2019. In his statement he highlighted the fact that it "undermines the efforts of affected countries to achieve the Sustainable Development Goals".[8] This means that understanding and reducing displacement risk should be a priority if the 2030 Agenda for Sustainable Development is to be implemented successfully.[9]

METHODOLOGICAL APPROACH

FLOOD SCENARIOS: COUPLING CLIMATE AND HYDROLOGICAL MODELS

The extent of future flooding was estimated by transforming future precipitation from global climate models into the estimated flood depth using hydrological models. Daily precipitation figures obtained from four global climate models were translated into runoff using six global hydrological models.[10] The CaMa-Flood global river model was then used to compute the river flow generated by this runoff.[11] The annual maximum of daily values was calculated for every year and every grid cell at a spatial resolution of 0.25 degrees, and its corresponding return period was determined based on a pre-industrial control simulation.

A flood was assumed to occur where and when the return level exceeded the current local flood protection standard contained in the FLOPROS database.[12] For each of these projected flood events, the fraction of the grid cell area inundated was estimated using a bias-correction and downscaling technique.[13] The annual maximum inundated area and maximum inundation depth were then obtained at a spatial resolution of 2.5′ (about five km at the equator) for two IPCC representative concentration pathways (RCPs), one with strong and the other with weak global greenhouse gas (GHG) mitigation efforts.

ESTIMATING DISPLACEMENT FROM EXPOSURE AND VULNERABILITY DATA

The number of people likely to be displaced by riverine flooding was assessed by combining the flood maps with modeled population distribution estimates. Two global one-kilometre resolution scenarios of population distribution that are consistent with IPCC's shared socioeconomic pathways (SSPs) were considered.[14] When a grid cell exceeded a flood depth of one metre, the number of people living in that cell multiplied by the fraction of area flooded was estimated as displaced. As such, this report defines displacement risk as the annual maximum number of people displaced by a single event in a given grid cell.

The CLIMADA framework was used to match the modelled hazard, exposure and vulnerability – in this case flooding, population and one-metre step function respectively – and then to calculate the resulting displacement risk.[15] The maps were projected using a common coordinate reference system of 2.5′ grid cells (about five km at the equator), and annual displacement was averaged to a 10-year interval during which the population is taken as constant.

The IPCC scenarios considered were the Sustainability and Inequality pathways SSP 1 and SSP 4, with the stabilizing/declining and increasing GHG concentration pathways RCP 2.6 and RCP 6.0, respectively.[16] These are described in more detail in the box below. We defined a base year as the average of annual maximum displacement from 1976 to 2005. To assess the impact of changing population and/or flood intensity on future displacement risk, we also computed the displacement risk using constant baseline population.

RCPs AND SSPs EXPLAINED

In order to explore different climate and demographic scenarios in a consistent and comparable way, IPCC has developed a catalogue of pathways.

RCPs describe 21st century pathways in terms of GHG emissions and atmospheric concentrations, other air pollutant emissions and land use changes.[17] We considered two RCPs for this report:

- RCP 2.6: A **strong mitigation** scenario under which the increase in global mean surface temperature by 2081-2100 is likely to be 0.3°C to 1.7°C, compared with 1986-2005
- RCP 6.0: A **low/no mitigation** scenario under which the global mean surface temperature increase is likely to be between 1.4°C to 3.1°C

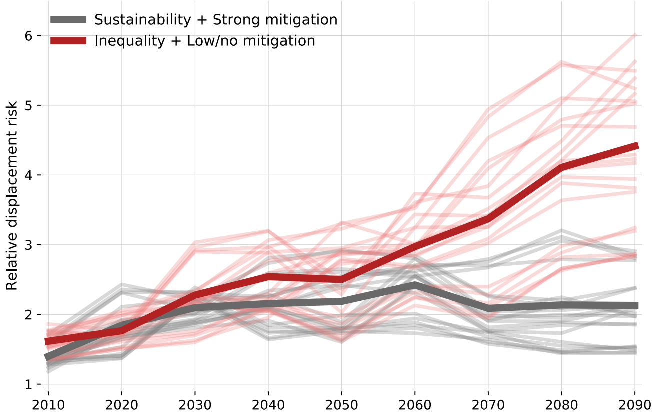
SSPs provide five pathways for global society's evolution in socioeconomic and demographic terms.[18] The two SSP scenarios considered are:

- SSP 1: **Sustainability** – Taking the Green Road (low mitigation and adaptation challenges), under which global population peaks at approximately 8.5 billion around 2050 and then declines to about seven billion by 2100
- SSP 4: **Inequality** – A Road Divided (low mitigation but high adaptation challenges), under which global population peaks around 9 billion in 2070 and remains fairly constant until 2100

FLOOD DISPLACEMENT RISK: FUTURE SCENARIOS

Figure 2 shows the relative change in global displacement risk compared with the 1976-2005 baseline according to two combinations of RCPs and SSPs. Even under RCP 2.6-SSP 1, the most optimistic of the four scenarios, displacement risk is predicted to double by the end of the century.

FIGURE 2: Relative change in global displacement risk compared with the 1976-2005 baseline.

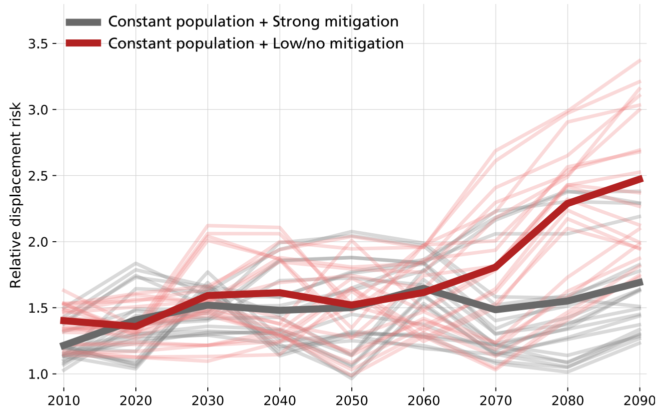


Short-term variations between decades are the result of natural climate variability. The light lines show the different combinations of climate and hydrological models. The darker lines show their average.

Under the least optimistic scenario, RCP 6.0-SSP 4, displacement risk rises steadily throughout the century to reach a near five-fold increase by 2090. In climate change terms this is a "business as usual" scenario in which substantial global GHG emissions continue as a result of unambitious mitigation policies. Current policies around the world are projected to lead to warming of about 3.2°C by 2100, close to that assumed by RCP 6.0.[19]

The increase in displacement risk is mainly the result of population growth and ever more frequent and intense riverine floods. To isolate the contribution of climate change, the population figure can be fixed to the baseline value. Figure 3 shows the expected increase in displacement risk caused only by more frequent and intense floods. The increase is roughly 1.7 times under RCP2.6 and 2.5 times under RCP6.0.

FIGURE 3: Relative change in global displacement risk compared with the 1976-2005 baseline when only climate change is considered



Short-term variations between decades are the result of natural climate variability. The light lines show the different combinations of climate and hydrological models. The darker lines show their average.

Above, we have presented the changes in displacement risk over time. Another way to think about this is to look at how flood displacement risk will change based on the degree of global warming. Under the Paris Agreement, for example, states committed to keep the global temperature rise in the 21st century well below 2°C above pre-industrial levels and to pursue efforts to limit it further to 1.5°C. In order to estimate what the impact on displacement risk would be, we looked at it only as a function of global warming. Displacement risk is projected to rise across both scenarios, as shown in figure 4. A temperature rise of between 1.5 and 2°C would lead to an increase of about 50 per cent in the intensity and frequency of hazards that cause displacement.

Figure 5 shows the expected increase in the frequency of riverine floods with the potential to trigger displacement, that is those in which water levels rise by more than a metre, in different parts of the world. It is calculated for 2046-2095 compared with 1996-2045 under RCP 6.0. To get a better sense of where the displacement risk is expected to increase the most, population distribution in 2070 under SSP 4 is shown in Figure 6.

Taken together, the two maps show that hazard frequency is likely to increase in many of the same parts of the world where population is expected to live by the end of the century. Low-income and developing countries in sub-Saharan Africa, south and south-east Asia, Oceania and Latin America are predicted to be disproportionately affected, having the highest concentration of people exposed to increasingly frequent floods. The same regions are also expected to have the highest rates of urbanisation.

FIGURE 4: Displacement risk attribution: relative change in displacement compared with the 1976-2005 baseline as a function of global warming only.

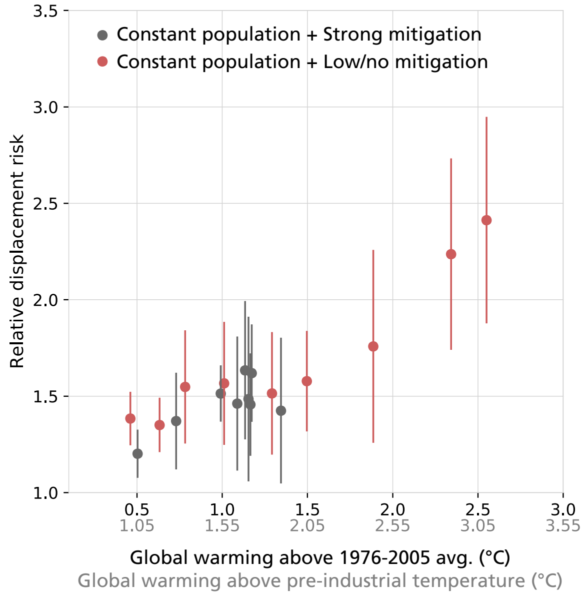


FIGURE 5: Change in frequency of flood displacement events in 2045-2095 compared with 1996-2045 under RCP 6.0

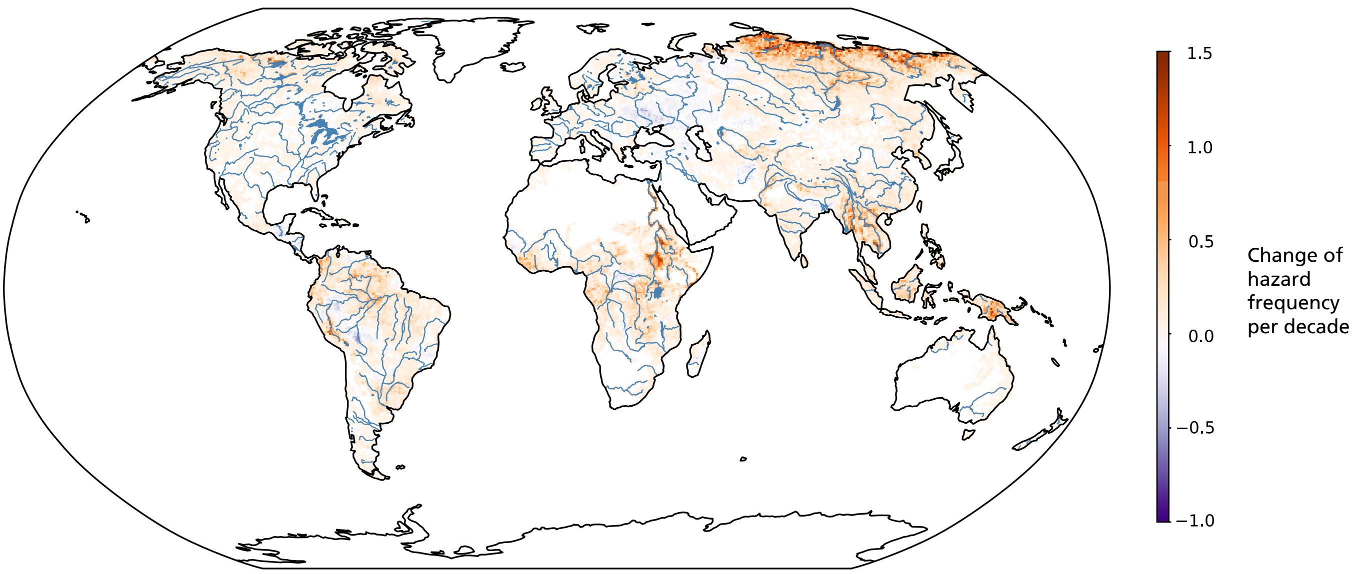
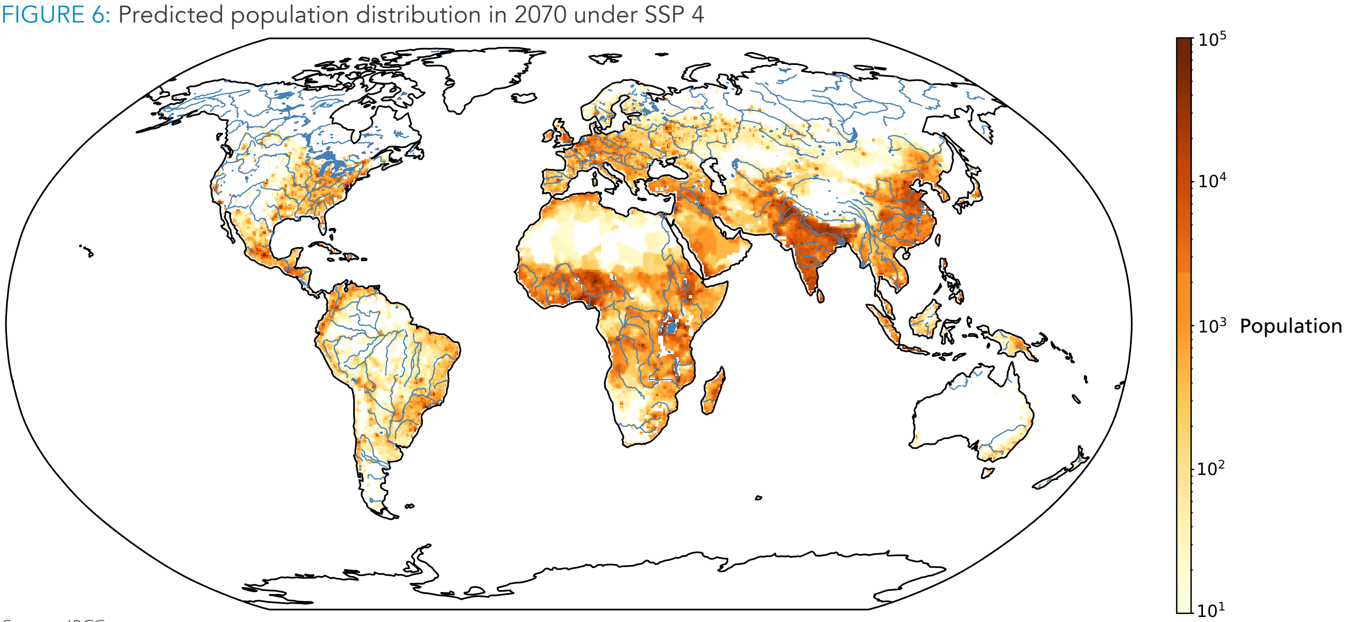


FIGURE 6: Predicted population distribution in 2070 under SSP 4



Source: IPCC

CONCLUSION AND IMPLICATIONS FOR POLICYMAKERS

Disaster displacement already impedes efforts to achieve the Sustainable Development Goals. Any further progress will be slower, more complicated and more likely to be undermined unless governments identify and commit to measures that reduce displacement risk.

This paper analyses only the increases in climate-related displacement risk associated with one hazard: riverine floods. It thus provides a partial picture of one type of climate-related displacement risk. As we set about similar analyses for storms and other hazards, we will learn how much the risk will increase above and beyond what has been presented here.

The results of the analysis for this report already suggest that implementing the Paris Agreement's mitigation provisions alone will not be enough to reduce flood displacement risk. On the contrary, it is likely to double by the end of the 21st century even under the most optimistic combination of scenarios.

It is clear that a combination of both mitigation and adaptation will be required, particularly in areas with the largest projected increases in risk. Urban development will play a significant role in shaping that risk, not only because of the ever growing number of people living in flood-prone areas, but also because it influences the impacts of floods by altering the absorptive capacity of the land and the way water flows through or accumulates in towns and cities.

Given that the current trajectory of GHG emissions is close to the IPCC's worst-case scenario, a vast amount of adaptation will be required to offset the impacts of climate change and projected population growth in flood-prone areas. Without such efforts, flood displacement risk may increase five-fold by the end of the 21st century.

The increase in flood risk also means that affected areas will have to improve their ability to undertake pre-emptive evacuations and other lifesaving early actions. This is particularly true for regions such as sub-Saharan Africa, where the increase in risk is predicted to be among the greatest but capacities to transform early warning into life-saving early action are relatively weak.

Torrential rain has caused devastating flooding in parts of Kenya, affecting tens of thousands of people, thousands have been forced to flee, homes and farmland are damaged or destroyed, livestock have been lost and roads and infrastructure have been washed away. Kenya Red Cross is working with the Government of Kenya to support those affected by floods, delivering emergency relief items and essential supplies like household items and water and sanitation in evacuation centres for people already displaced. Areas affected by flooding so far include Marsabit, Wajir, Mandera, Turkana, Elgeiyo Marakwet, Kitui, Meru, Kajiado, Nandi, Kwale, Muranga and Busia. Photo: Kenya Red Cross/John Bundi, October 2019

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ENDNOTES

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Cover photo: Flooding in Myanmar in August and September 2019 affected more than 76,000 people in Mon state – the worst hit state by numbers affected. Credit: IFRC, September 2019

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