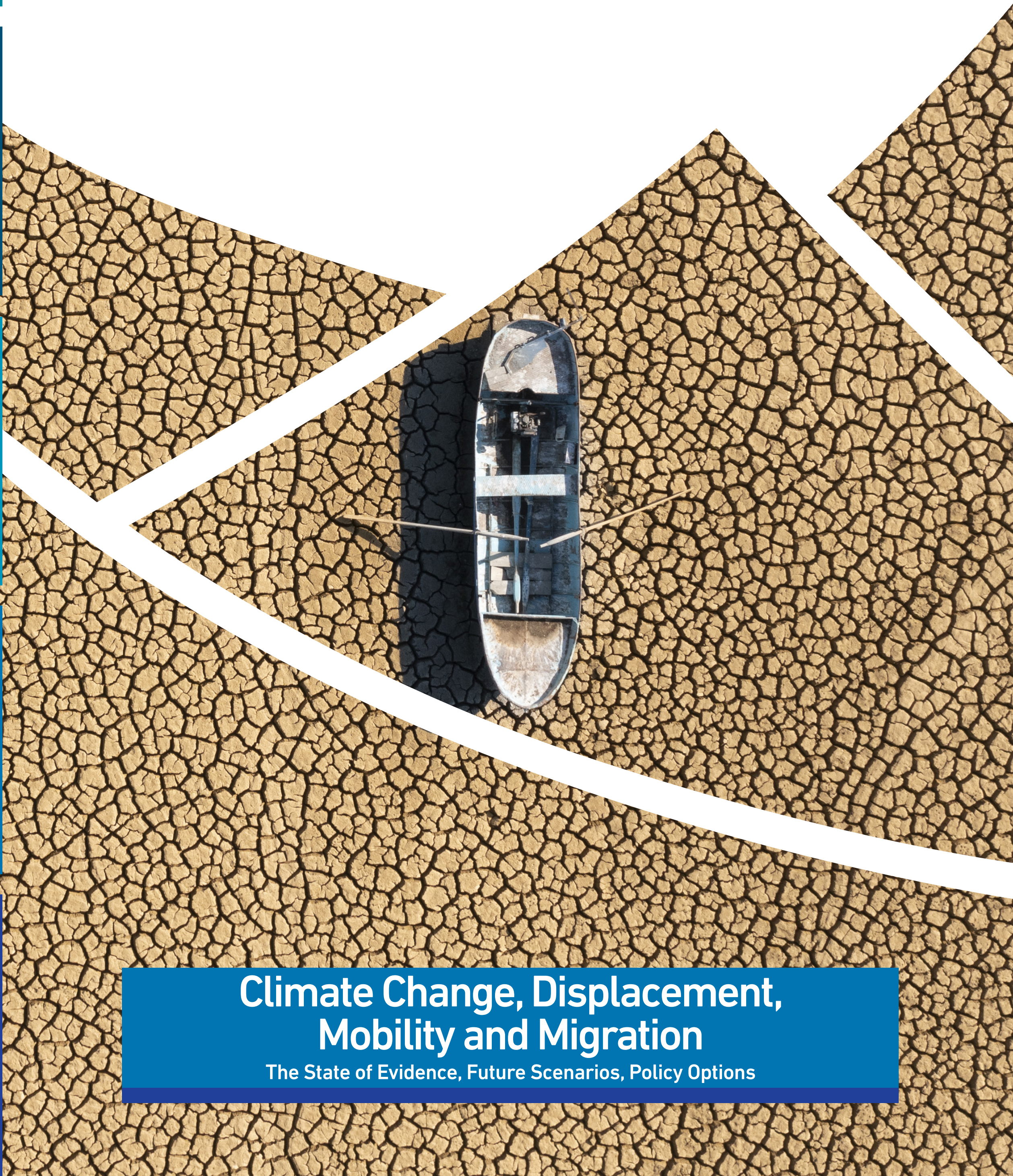
Delmi

Research overview

2022:9



Climate Change, Displacement, Mobility and Migration

The State of Evidence, Future Scenarios, Policy Options

Climate Change, Displacement, Mobility and Migration

The State of Evidence, Future Scenarios, Policy Options

Mathias Czaika, Rainer Münz

Research Overview 2022:9

Delmi

SWEDISH GOVERNMENT INQUIRIES
The Migration Studies Delegation
Ju 2013:17

Delmi Research Overview 2022:9
Order: www.delmi.se
E-mail: ju.delmi@regeringskansliet.se
Cover: Temizyurek, IStock
Stockholm 2022
ISBN: 978-91-89701-18-2

Preface

Climate change calls for concerted political action and a host of other efforts, not only to reach the goals set out by the global community to limit global warming but also to mitigate the effects it has on human conditions. One of these effects will inevitably be the short- and long-term displacements of the inhabitants of communities in affected areas and regions. However, to assess the magnitude of these effects is a very complex task and ponders the question of the state of the art of research in this field.

As shown in this research overview, past predictions of future migration that have guided decision- and policymakers have typically been incorrect, inflated and drawn up catastrophic scenarios of mass migration. Since migration, mobility, immobility, and displacement are connected to and influenced by a complex set of drivers, reality is more multifaceted. That the drivers also vary depending on the country/regional context implies that they demand different responses. To better meet the imperative of limiting, mitigating, and adapting to climate change and its effects, it is important to further investigate these complex drivers and factors that influence migration, mobility, immobility, and displacement, as well as their potential future impacts.

As we strive to meet the challenges of future climate related migration and mobility, one thing can be said for sure: any environmental determinism that draws a direct, causal, and often linear link from past, current, or projected future climate developments, to predictions about the exact scale of future human mobility and international migration, risks being misleading for decision- and policymakers. We find this is one of many import takeaways from this report.

The authors of this research overview are Mathias Czaika, University Professor in Migration and Integration at Danube University, and Rainer Münz, Visiting Professor at the Central European University (Department of Public Policy) and at the Diplomatic Academy in Vienna. The work on this report has been followed by Annika Sundén, Associate Professor in Economics, and member of Delmi's Board of Directors. At the secretariat of Delmi, Delegation Secretaries Daniel Silberstein, Anna Hammarstedt and Constanza Vera-Larrucea have contributed to the review process of the report.

As usual with Delmi-publications, the authors are fully responsible for the report's contents, including its conclusions and policy recommendations.

Stockholm October 2022

Joakim Palme Chair, Delmi	Henrik Malm Lindberg Acting Director, Delmi

Summary

This research overview presents what we know about the complex impact of climate and environmental change on the drivers and outcomes of mobility within countries, forced displacement, voluntary and involuntary immobility, as well as its implications for international migration. It is documented that natural disasters – most of them related to extreme weather conditions – may have caused the internal displacement of almost 350 million people between 2008 and 2021. Although most of this population returned relatively shortly after the immediate risks to their lives and livelihoods had been abated, a small fraction (possibly around 6 million) of those forced to move by disasters did not return to the sub-region or place from which they were initially displaced. An even smaller population crossed international boundaries following a natural disaster.

Despite a clear improvement in terms of available data, we can still identify severe knowledge and evidence gaps. Based on a review of the state of knowledge and existing data, we assess and discuss the multiple ways in which climate and environmental change can influence mobility and international migration of people at risk. Part of this impact is clearly direct, such as displacements as a consequence of the destruction of assets and livelihoods by natural disasters. Yet, we also emphasize that the most important implication is indirect, as climate change interacts with other potentially relevant drivers of internal mobility and international migration.

In contrast to the effects of sudden environmental shocks and disasters on migration, the implications of gradual (slow-onset) environmental degradation induced by climate change on internal mobility, displacement, and cross-border movement are more complex to assess, quantify, and predict. The gradual environmental degradation has a relatively indirect impact on human mobility and migration that is more challenging to directly measure, as degradation can, for example, reduce the ability for people to sustain themselves financially. Therefore, despite being part of a population that is negatively affected by climate change manifestations, many *people exposed to environmental degradation* (e.g., soil erosion, declining precipitation and freshwater supply, protracted heat waves) consider their patterns of mobility to be motivated by worsening economic conditions (lower harvests, declining livestock, etc.). Social surveys also show that a considerable number of people living in negatively affected areas have never heard of the phenomenon of climate change.

By moving from rural areas to larger cities and metropolitan areas, people seek to reduce their exposure to adverse effects of climate change including droughts, soil erosion, protracted heat waves, declining agricultural productivity. Many of them might, however, *exchange risks* associated with a slow onset degradation in rural areas, with, for example, an exposure to floods, rising sea levels, and coastal erosion. The (mainly) urban populations considered to be especially at risk as a result of rising sea levels include about 250 million people settled on land with an elevation of less than 1 meter, and over 700 million people settling between 1 and 10 meters above current upper tide levels.

We further highlight the often ignored yet increasingly relevant phenomenon of voluntary and involuntary immobility, including trapped populations who *despite* climate-induced stress remain in environmentally degrading locations. Therefore, even though we have little evidence on the exact scale of the phenomenon, it is suggested that hundreds of millions of people stay put, either voluntarily or involuntarily, in vulnerable and stressful situations that are (in)directly caused by environmentally induced deprivations.

The future of climate-induced internal mobility and international migration is uncertain for three reasons. First, the pace of future global warming is still unknown as it depends not least on the (collective) action of major greenhouse gas emitters (including the EU, US, China) in drastically reducing emissions during the 2020s and 2030s. Second, it is unclear as to what extent states are able and willing to engage in effective prevention, adaptation, and mitigation strategies protecting or empowering their citizens against the most severe effects and outcomes of climate change. And third, we are still lacking in the ability to assess and quantify environmentally- induced internal mobility and international migration.

Sammanfattning

Den här kunskapsöversikten går igenom vad befintlig forskning säger om hur klimat- och miljöförändringar påverkar migration inom länder, påtvingad migration, frivillig- och ofrivillig immobilitet samt hur det påverkar internationell migration. Det är konstaterat att naturkatastrofer – de flesta kopplade till extrema väderfenomen – kan ha bidragit till att mer än 300 miljoner människor behövt flytta inom sitt land, mellan 2008 och 2020. Även om de flesta av dessa återvänt relativt kort efter händelserna, har en del av dem (uppskattningsvis runt sju miljoner människor) som behövt flytta inte kunnat återvända. En mindre grupp migrerade till andra länder till följd av naturkatastrofer.

Baserat på en genomgång av befintlig kunskap och data gör vi en bedömning samt diskuterar de många sätt som klimat- och miljöförändringar kan påverka intern- och internationell migration för personer som är särskilt utsatta för klimat- och miljöförändringar. En del av påverkan är direkt, som när personer tvingas migrera på grund av att ens tillgångar eller försörjning förstörts till följd av naturkatastrofer. Vi understryker dock att den viktigaste påverkan är indirekt, eftersom klimatförändringar interagerar med andra faktorer som orsakar intern- och internationell migration.

Till skillnad från hur plötsliga naturkatastrofer påverkar migration, är effekten av klimatförändringar på olika typer av migration betydligt svårare och bedöma, kvantifiera och förutse. Klimatförändringar har en (relativt sett) indirekt påverkan på mobilitet och migration som är svårare att mäta, eftersom gradvisa klimatförändringar kan försämra personers möjligheter att försörja sig över tid. Många som är utsatta för klimatförändringar ser därför sin migration som ekonomiskt motiverad, snarare än ett resultat av klimatförändringar. Enkätundersökningar visar också att en betydande del av människor som lever i områden som påverkas negativt av klimatförändringar aldrig har hört om fenomenet ”klimatförändring”.

Ett sett för personer att minska sin sårbarhet för effekterna av klimatförändringar är att flytta från landsbygden till större urbana områden. Många som gör det byter dock risker kopplade till långsammare klimatförändringar på landsbygden, mot risker i form av översvämningar, höjda havsnivåer och kusterosion som i högre grad påverkar urbana områden. Omkring 250 miljoner människor bedöms vara särskilt utsatta för höjda havsvattennivåer, då de bor i områden som är mindre än en meter över havsytan (främst urbana områden). Ytterligare 700 miljoner människor bor i områden som är mellan 1–10 meter över havsytan.

Vidare belyser vi det ofta ignorerade (men alltmer relevanta) fenomenet kring frivillig- och ofrivillig immobilitet. Det vill säga, personer som klimatförändringar till trots stannar kvar i områden som tydligt påverkats negativt. Även om det fortfarande saknas forskning kring den exakta storleken på det här fenomenet, går det att konstatera att hundratals miljoner människor stannar, antingen frivilligt eller ofrivilligt, i sårbara och utsatta situationer skapade (in)direkt av klimatförändringar.

Hur klimatrelaterad migration kommer se ut framåt är osäkert och svårt att avgöra på grund av åtminstone tre anledningar. För det första är framtidens klimatförändringar avhängig de val som görs kommande decennier av de aktörer som släpper ut mest växthusgaser (främst EU, USA och Kina). För det andra är det osäkert hur långt stater är villiga (eller har möjlighet) att proaktivt arbeta med att förhindra, anpassa och mildra effekterna av klimatförändringar för sina medborgare. Slutligen, vi saknar fortfarande möjligheten att uppskatta och kvantifiera klimatrelaterad intern- och internationell migration.

Acknowledgements

This review of available literature and data on the relationship between Climate change, displacement, domestic mobility and international migration has been developed under the guidance of Daniel Silberstein (Delmi). He has given administrative as well as intellectual support and feed-back throughout the project. Additional helpful comments and suggestions were provided by Christopher Genillard (Genillard & Co), Henrik Malm Lindberg (Delmi) and Anna Hammarstedt (Delmi). Lisen Löwstedt (Delmi) carefully doublechecked all references. The authors would like to thank for this support, help and the feed-back.

Table of Contents

Figures and tables

Figures

Tables

1. Introduction

How many people are affected by extreme weather conditions and climate change? How many of them get displaced, relocate within their country of birth, or even leave for another country? And how many will do so in the future? These are the key questions that this research overview aims to answer. It assembles uncontested empirical evidence, hints at information and data gaps, and suggests what the EU and European countries can do to address issues of mobility and displacement related to climate change. Important in this context is to introduce a debate based on empirical rather than anecdotal evidence.

1.1 Environmental 'refugees': from 10 million to 250 million?

The term 'ecological refugee' was first coined in 1976 – almost half a century ago – by Lester Brown, the founder of the Worldwatch Institute, and his co-authors P. McGrath and B. Stokes (Brown et al. 1976). A decade later, Jodi Jacobson (1988) made a first assessment of the quantitative impact assuming that there were already up to 10 million 'environmental refugees' living on our planet in the mid-1980s. In her worst-case scenario, assuming a rapid rise of sea levels, she concluded that in the future, the number of 'environmental refugees' would be six times as numerous as the number of political refugees. A year later, Mustafa Tolba (1989), then Executive Director of the UN Environmental Program (UNEP), repeated that assessment by claiming that the global number of 'environmental refugees' may reach 50 million.

In the early 1990s, the Intergovernmental Panel on Climate Change (IPCC 1992), installed by the UN, declared migration and forced displacement as the single most important consequence of climate change, thereby hinting at shoreline erosion, coastal flooding, and severe drought as the main drivers. Building on that assessment, the British biodiversity expert Norman Myers (1997) assumed that, in the mid-1990s, there were approximately 25 million 'environmental refugees' worldwide. He projected this figure to quadruple to 100 million by 2010, and possibly reach 200 million by 2050. Myers' models assumed a few additional drivers with relevant impact on environmental displacement including desertification, lack of freshwater, salination of irrigated lands, and the depletion of biodiversity. A decade later, he revised the upper bound of his projection to 250 million 'environmentally displaced people,' a level that might be reached by 2050 (Myers 2007).

These figures and projections have often been quoted and requoted. The prediction of 150–200 million climate change 'refugees' by 2050 is a figure that is often widely circulated and projected in highly influential political publications such as the early reports of the International Panel on Climate Change (IPCC 1992) and the Stern Review on the Economics of Climate Change (Stern 2006). The same figure was also quoted in reports from inter-governmental organisations such as the Council of Europe (2006) and UNESCO (Piguet et al. 2011), as well as by NGOs such as Friends of the Earth (2007), Greenpeace (Jakobeit and Methmann 2007) and Christian Aid (Myers 2007). Another contributing factor as to why Myers' figures have been so widely circulated, may be due to the fact that they were used in a report by then UN Secretary General Ban Ki Moon, thereby adding further credibility to the forecast.[1]

Vikram Kolmannskog (2008) categorized estimates and projections such as the ones published by Myers (1997, 2007) as "impossible to check." In 2011, Stephen Castles, a senior migration scholar suggested that Myers' "*objective in putting forward these dramatic projections was to really scare public opinion and politicians into taking action on climate change*"[2]. This does, however, not mean that Myers' identification of at-risk regions and his assessment of the size of populations exposed to the consequences of climate change (cf. Figure 4.10, chapter 4) was incorrect.[3]

Francois Gemenne explained potentially inflated numbers of future environmental refugees by the fact that

> […] figures are usually based on the number of people living in regions at risk, and not on the number of people actually expected to migrate. Estimates do not account for adaptation strategies [or for] different levels of vulnerability
>
> Gemenne 2009: 159

Part of the problem is terminology, as speaking about 'environmental refugees' may suggest an analogy to political refugees. This implies that people negatively affected by climate change will attempt to seek 'protection' from environmental change in other countries. In that sense a forecast of 250 million 'climate refugees' by 2050 does not appear to be very likely given the current global number of 21 million political refugees under UNHCR's mandate

[1] Refworld | Climate change and its possible security implications: report of the Secretary-General

[2] Quoted in Barnes (2013).

[3] The population at risk is not identical with the (usually smaller) population that becomes mobile.

and 4.4 million asylum seekers (mid-year 2021).[4] If such forecasts would instead relate to voluntary and involuntary internal mobility within countries caused by climate change,[5] the projection would be more realistic and the discussion less controversial. However, it would simultaneously lack a 'sensational' and 'alarmistic' element drawing public attention.

Some estimates and predictions are based on polls that survey mobility and migration intentions as many people generally *think about* moving to improve their living conditions. Up to the point of deciding about moving, such people form part of a latent population of *potential* migrants who – some constantly, many just occasionally – reflect upon moving elsewhere. Based on a nearly global survey conducted in 2015-16, Gallup estimated that more than 750 million adults "*would like* to migrate to another country if they could" and more than 500 million people *think* they may need to move to another country because of environmental stress within the next five years (Esipova et al. 2018).[6]

At the same time, millions of people stay put, either voluntarily or involuntarily, in vulnerable and environmentally stressful situations directly or indirectly caused by the effects of environmental degradation inducing deprivations. In the short term, many if not most people exposed to slowly and rapidly deteriorating environmental conditions neither migrate across international borders nor move long-distance within their own country. Despite its numerical relevance, the phenomenon of (voluntary and involuntary) immobility, especially in the context of environmental stress, is often ignored. For this reason, we have little empirical evidence available on the factors explaining immobility that constrain (and sometimes motivate) people to stay put despite situations of perceived or actual environmental stress (Schewel 2020).

In closing, it is possible to identify the size and location of future populations at risk exposed to environmental degradation. However, in the absence of uncontested scientific evidence, it is difficult to predict which part of the people at risk might become mobile and who will stay put.

[4] https://www.unhcr.org/figures-at-a-glance.html

[5] See Table 4.2

[6] As the poll was conducted in 2015-16, we already know that this expected cross-border movement of several hundred million people (time horizon: 2016-2021) has not materialised.

1.2 What do we know?

As a matter of fact, there is robust evidence that global warming has been taking place for some decades now (Figure 1.1) and is likely to continue (IPCC 2022).

Furthermore, with regards to migratory patterns we observe an increase of spatial mobility when looking at the volume of people who migrate externally across international borders or internally within their country of residence. International migration at a global level is however better documented than domestic mobility.

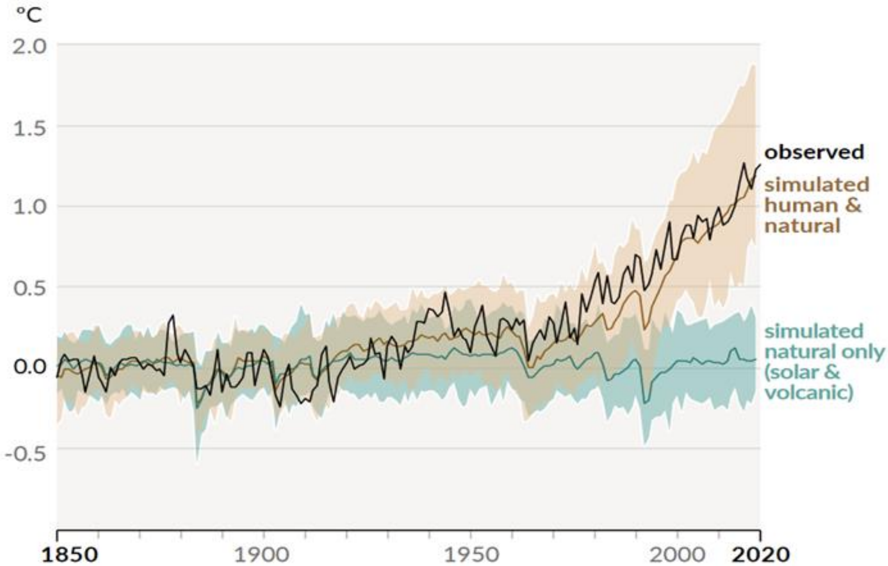
- The UN Population Division estimated that in 2020 about 280 million people resided permanently, or for a period of more than 12 months, outside of their country of birth – compared to 175 million in 2000 (UN DESA 2021). These people are defined as international migrants.[7]
- In contrast to international migration numbers, the global number of people who have moved (permanently or temporarily) internally within their country of birth is largely unknown and can only be roughly estimated. One estimate based on data for the early 2000s published by the UN Development Program put the number of internal migrants at 740 million (UNDP 2009).[8] Given that the world population has increased by about 30 percent between 2000 and 2022 while rural-to-urban mobility continued at a considerable pace, the current number of internal migrants may well be above 2 billion people.

It is, however, unclear how many people who have left their place of origin since the beginning of the 21st century *because of climate change* and environmental degradation. Hence, the exact number of people who have left their place of residence due to the direct or indirect influence of rapidly or slowly evolving environmental factors is so far unknown. Nonetheless, advancing conceptual and empirical research efforts provide the basis for well-informed estimates and assessments.

[7] The figure is slightly inflated by persons included in the UN DESA (2020) database who are not actually living outside of their country of birth. This includes, for example, 2.6 million Chinese citizens born in mainland China and living in Hong Kong and Macau and vice versa; 3.4 million Palestinians living in Jordan, Lebanon, and Syria under the mandate of UNRWA (mostly born in these countries); 1.5 million people who have moved as US citizens from Puerto Rico to mainland USA (data for 2020).

[8] The calculation for the early 2000s was based on data from 24 countries covering 57 percent of the world's population (UNDP 2009: 21-22).

Figure 1.1 Change in global surface temperature, 1850-2020, in °C



Note: The data shows annual averages and ranges for observed temperature (in black) and simulated temperatures differentiating between factors caused by human activity (mainly greenhouse gas emissions; in brown) and purely natural factors unrelated to human activity (volcano eruptions, solar activity; in green).
Source: IPCC 2021

1.3 What do we want to know?

This research overview is mainly guided by three research questions (for used terminology see Table 2.1):

- To which extent does environmental change, caused by global warming (Figure 1.1), affect the volume of internal/domestic mobility[9] and international migration?
- What can be said about future numerical estimates, in terms of people leaving their place of residence for environmental change and natural disasters linked to climate change?
- What are political measures that can address the actual or potential impact of climate change on mobility?

[9] Including voluntary mobility within countries and domestic displacement.

The answer to the first two questions is less straightforward than people often think.

- First and foremost, this is due to measurement problems. Available data on mobility within countries and on international migration tend to be incomplete and, thus, not always reliable.[10]
- Secondly, the extent and pace of future global warming is uncertain as this will not least depend on the political will and ability of UN Member States to implement the Paris Climate Accord of 2015[11] and reduce greenhouse gas emissions. To reach this goal, countries need the support of relevant domestic actors (citizens, trades, corporates) as well as global actors (transnational corporations).
- Finally, international migration and internal/domestic mobility are not the only behavioural strategies of people exposed to climate risks and environmental degradation. Adverse effects of climate change can also be mitigated and adapted to through other strategies.

This allows for a range of political options *in addition* to a significant reduction in the emission of greenhouse gases and leads to our third question:

- What are the main challenges and possible implications for Europe, European policy makers and other relevant actors? And how can state actors address, manage or prevent environmentally induced international migration and domestic mobility?

[10] For an overview of the merits and limits of the academic climate migration literature based on quantitative analysis see Hoffmann et al. (2021); and for the data situation see: Migration Policy Practice Vol 10 (1). http://www.eurasylum.org/wp-content/uploads/2020/04/MPP-January-March-2020-1.pdf

[11] Formally entering into force in 2016 https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

2. Climate-induced environmental stress as driver of mobility, and non-mobility

Chapter 2 discusses the nature, contexts, drivers, and processes of environmentally induced migration and non-migration. We describe decision-relevant factors of an 'environmentally stressful situation', which establishes the context for the formation of aspirations for migration, and potentially, contribute to facilitating and/or constraining its realization. In the context of climatic and environmental change, slowly and rapidly changing environmental stress factors may influence migration decisions and other behavioural responses in multiple ways. We refer to the complex linkages and interactions between various forms and manifestations of climatic and environmental change and the broader set of structural determinants of internal mobility, international migration and displacements.

It is largely uncontested that environmental change triggers mobility. The most obvious link is between exposure to sudden onset shocks and disaster and subsequent displacement. Between 2008 and 2021 some 344 million people were displaced by natural disasters. Beyond that, the effects of slow-onset changes are rather subtle, collateral, and gradual. We explore the most relevant transmission mechanisms by which environmental change may trigger migration processes but may also keep people in trapped situations of involuntary immobility.

2.1 Migration, mobility, and the climate

There are several ways in which environmental and climate change *can* lead to various forms of voluntary and involuntary migration, mobility, and displacement.[12] The most common forms and categories of climate-induced migration and mobility are (Table 2.1):

[12] We are exclusively looking at climate as independent and mobility as dependent variable: The reverse relation – the likely impact of international migration and domestic mobility on climate change and environmental degradation – is outside the scope of this report. We can, however, assume that people moving from rural to urban regions and

- Displacement or evacuation, and subsequent return or resettlement, caused by sudden 'natural' disasters[13] destroying livelihoods or severely disrupting food/water supply.
- Domestic mobility and international migration caused by slow onset changes causing degradation of livelihoods, loss of arable land, food insecurity, scarcity of freshwater, soil salination, etcetera.
- Self-organised mobility or relocation taking place in anticipation of slow or sudden onset changes destroying livelihoods in the future.

Terms used in this research overview relate different forms of mobility and migration. Table 2.1 specifies their precise meaning.

Table 2.1 Terminology of our analysis of climate-induced movements: definitions and description of key terms

Key term	Definition	Description
International migrants	Persons living outside of their country of birth for 12+ months	This category includes regular migrants, asylum seekers and refugees, as well as irregular migrants.
Internally/domestically mobile people	Persons living outside of their region/town of birth, but still in the same country	This category includes people who are mobile on a voluntary basis but also internally displaced persons who stay outside their region of origin for an extended period.
Internally/domestically displaced persons	Persons who are forced to leave their place of residence (temporarily or permanently) and find shelter or protection in the same country	This category includes people displaced by natural disasters, by purely man-made disasters, and by political violence or warfare.

from poorer to richer countries increase their ecological footprint. As a result, both mobility within countries and international migration potentially lead to higher greenhouse gas emissions.

[13] Most 'natural' disasters are related to extreme weather conditions and climate change (floods, storms, droughts, wildfires; see Figure 3.4).

Key term	Definition	Description
Internationally displaced persons	Persons who are forced to leave their country of residence as a result of natural disasters (temporarily or permanently) and find shelter or protection in another country	This category includes people displaced across international borders by natural disasters who have been granted some form of humanitarian protection.
Asylum seekers	People asking for refugee status or humanitarian protection in another country because of fear of political persecution by authorities of their home country/country of residence (as a result of political activity or orientation, religious orientation, ethnicity, gender, sexual orientation)	This category only includes people asking for asylum whose status has not yet been decided.
Refugees	Persons who flee political oppression or persecution based on political activity/conviction, religious orientation, ethnicity, gender, sexual orientation	This category includes people recognized as refugees or given humanitarian protection (individually or collectively) by the country of destination, but also people registered as refugees (for example by UNHCR). Legally this category does not include people who have left their country of origin because of climate change, environmental degradation, or natural disaster as this is neither covered by the Geneva Convention nor by European and national asylum laws.

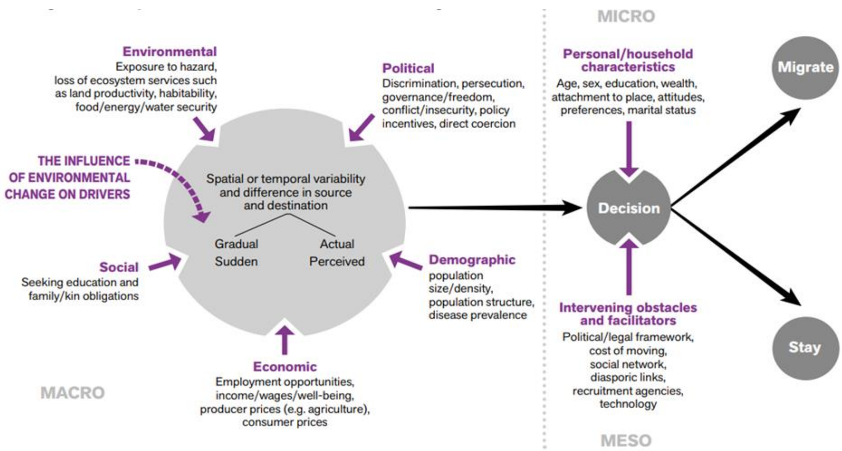
Key term	Definition	Description
Involuntary immobile people	Persons who would like to leave a place of residence with deteriorating living conditions, but lack the means to become mobile	This category only includes people 'trapped' in regions with severe ecological deterioration.
Sudden-onset event which displaces people	Natural disaster, purely man-made disaster Extreme weather conditions and geophysical events with environmental impact are only called 'disaster' when they negatively affect residential areas	Most natural disasters are related to extreme weather conditions or climate change: floods, droughts, wildfires. Geophysical events (earthquakes, tsunamis, volcano eruptions with no relation to climate change) are the exception. Purely man-made disasters include accidents in mines, factories, nuclear facilities, the collapse of hydroelectric dams, the poisoning of rivers, freshwater reserves and soil, etc.
Slow-onset change affecting people's livelihoods	Gradual change of climate and environmental conditions that negatively affect residential areas and livelihoods	Environmental changes causing degradation of livelihoods such as: loss of arable land, food insecurity, scarcity of freshwater, salination, disappearance of permafrost soil.

2.2 Migration as adaptation to gradual and sudden-onset environmental change

Climate change that manifests itself gradually through, for example, rising sea levels, coastal erosion, prolonged heat waves, droughts, salination and desertification is expected to make internal mobility (i.e., movements within countries) and international migration increasingly likely in the long term. At the same time, sudden onset extreme weather events such as more frequent hurricanes or flooding have the power and potential to trigger immediate large-scale displacements, which are either self-organised or assisted in form of evacuations (Black et al. 2011; Shen and Binns 2012; Martin et al. 2014; Veronis and McLeman 2014; Islam 2017; Rigaud et al. 2019; Clement et al. 2021).

Environmental change and degradation can manifest itself as shortages in the quantity and quality of natural resources such as fertile soil or freshwater. This can establish a fundamental risk in securing stable livelihoods and can therefore be a 'root cause' for people deciding to leave or escape an environmentally stressful region or situation. Detrimental effects of climate change as well as acute environmental shocks, such as protracted heat waves, droughts, or floods, can harm or even destroy livelihoods and can lead to food and water insecurity. It is, however, not necessarily the direct effects of climate and environmental change on people's perceptions of risks and vulnerability that make them decide to leave an affected region. It is often the rather indirect consequences for people's economic survival, sustainability, and overall vulnerability that play a decisive role (Abu et al. 2014; Beine and Parsons 2015; Khavarian-Garmsir et al. 2019; Martin et al. 2014; Mortreux and Barnett 2009). These studies suggest that the influence is indirect via economic factors such as declining or more volatile agricultural incomes, shrinking livelihood opportunities, and rising food insecurity.

Figure 2.1.Mobility decisions under environmental stress: complex configurations of drivers



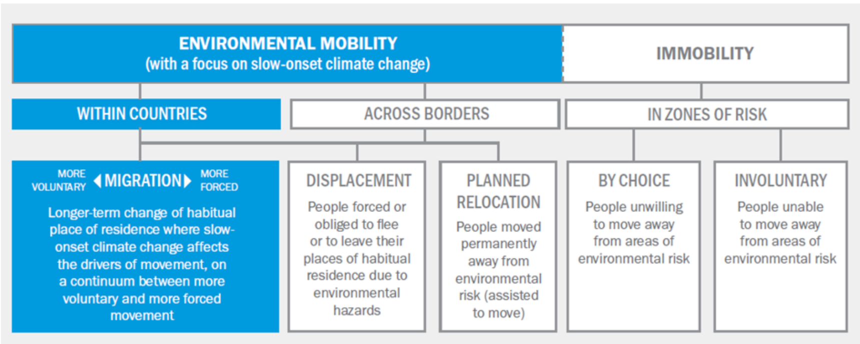
Source: Ionesco et al. 2017, p. 37

Migration and mobility decisions are complex, even though the decision outcome itself appears as if binary: leaving or staying (Figure 2.1). Yet the multitude of factors that are potentially relevant in a migration decision-making process, the search for and processing of information about potential and actual risks and opportunities, and perceptions thereof, contribute to a cognitive and emotional complexity. Hence, behavioural responses to gradual climate change are hard to predict.

Ultimately, the combination of economic, political, social, and environmental factors establishes a complex location-specific mix of incentives and constraints which influence people's aspirations to migrate and their capability to do so. In such contexts, however, people without access to sufficient economic, social, or informational resources often lack the freedom and agency to choose between moving or staying. Their only option is to adapt to the consequences of climate change at their place of residence (Figure 2.2).

The role of climate change as a potential driver of internal mobility and international migration is extensively studied, although predominantly for developing countries and the global South more generally (Clement et al. 2021; Rigaud et al. 2019; Migali et al. 2018; Migali and Natale 2021). Several studies find evidence that slow-onset changes in temperatures and rainfall are associated with domestic mobility and occasionally also international migration. Points of departure are mainly rural areas and regions dominated by agricultural production (Backhaus et al. 2015; Bohra-Mishra et al. 2014; Cai et al. 2016; Nawrotzki et al. 2016).

Figure 2.2 Mobility options in the context of environmental stress



Source: Rigaud et al. 2019, Clement et al. 2021

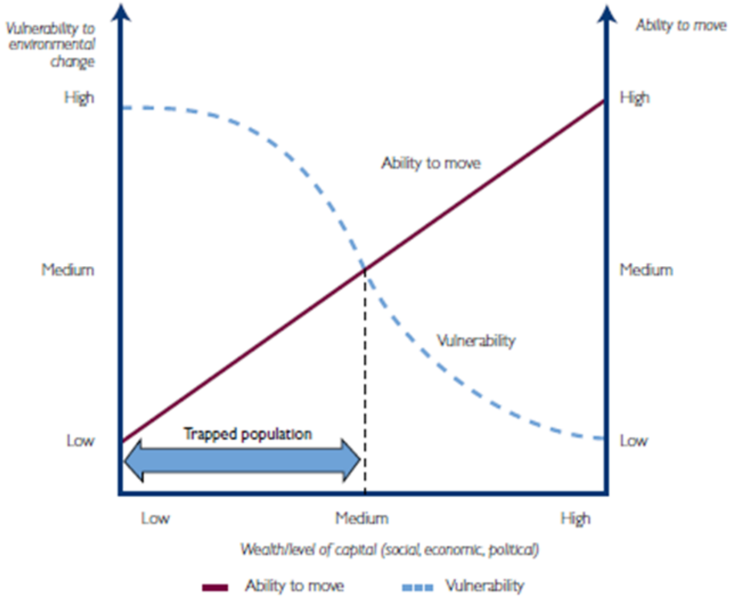
However, if climate change is evaluated alongside other factors such as the economic and political situation, the effects of these economic and political factors are often stronger since their impact on people's livelihoods is more direct (Joseph and Wodon 2013). Some studies even conclude that climate change as such does not directly influence domestic mobility and international migration intentions and actual decisions to move (Abu et al. 2014; Beine and Parsons 2015; Codjoe et al. 2017; Mortreux and Barnett 2009). These studies suggest that the influence is indirect via economic factors such as declining or more volatile agricultural incomes, shrinking livelihood opportunities, rising food insecurity (Martin et al. 2014; Khavarian-Garmsir et al. 2019). Domestic mobility and international migration are also influenced via growing health-related risks in a deteriorating environment (Marchiori et al. 2012) as well as resource-based political conflicts that are aggravated by climate change (Abel et al. 2019).

In any case, in environmentally stressful situations, which often coincide with several of these challenges, it is usually the most adversely affected and vulnerable people who are unable to move (Veronis and McLeman 2014). They often lack financial resources, relevant social networks, and political representation (Figures 2.3 and 2.4). Therefore, voluntary mobility within the country of residence and planned relocation as an adaptation strategy is generally not available to all people who are negatively affected by the multiple manifestations of gradual climate change (Cattaneo et al. 2019), but primarily to those who are relatively 'better off' (i.e., endowed with resources). This is even more true for international migration which requires legal access to another country, or at least the ability to reach the territory of another country dependent on the possession of travel documents, the availability of cash to pay for the travel and ideally also skills that can be deployed in the country of destination.

It is not only gradual processes of environmental degradation that can trigger the wish for temporary or even permanent relocation. The same can happen in response to sudden environmental shocks such as floods or heavy storms, but also recurrent water shortages and droughts within places that have historically been less exposed to such environmental risks. However, sudden-onset natural disasters predominantly lead to temporary internal, short-distance mobility, rather than protracted long-time displacement and/or international migration; at least not in the immediate aftermath of a disaster (Beine and Parsons 2015; Islam 2017; World Food Program 2017).

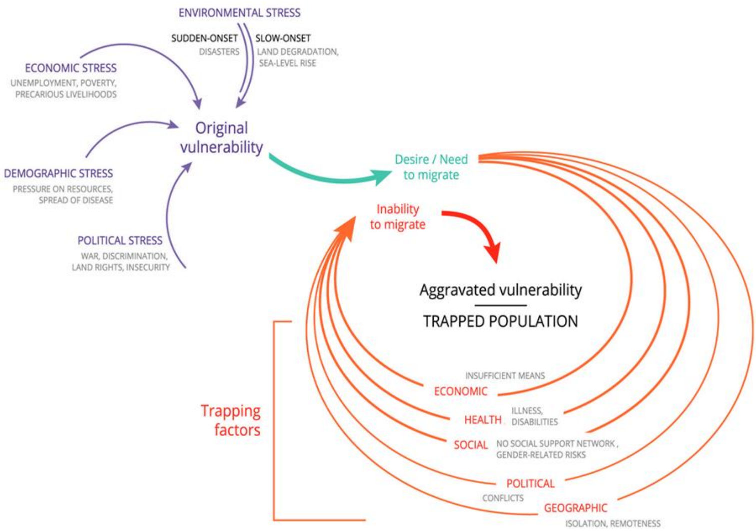
In addition, sudden-onset disasters can also indirectly increase the intention and resolve to leave a certain region if the massive deterioration of proximate economic drivers – like joblessness and loss of income, loss of assets and habitat – are not addressed by relief and reconstruction efforts (Warner et al. 2010; Wodon et al. 2014).

Figure 2.3 Environmental stress separates populations into trapped and mobilised groups



Source: Black et al. (2011)

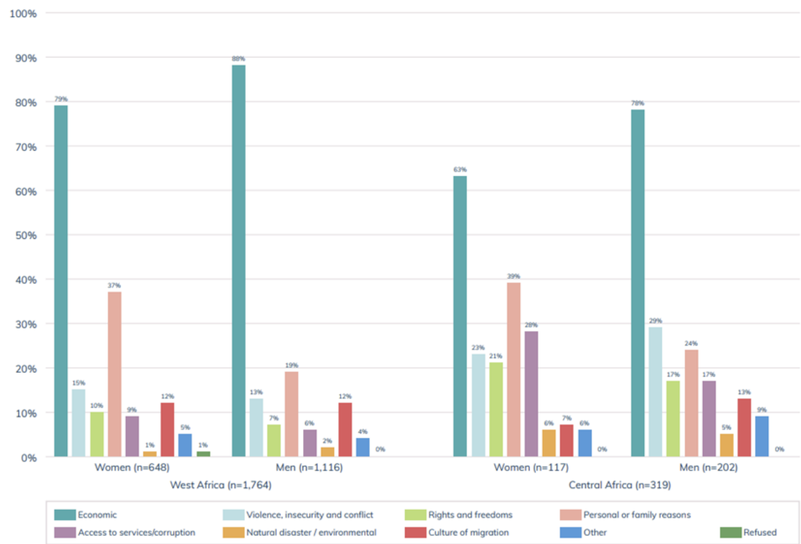
Figure 2.4 Drivers and circumstances leading to 'trapped' populations



Source: IOM. https://environmentalmigration.iom.int/environmental-migration-1

The analysis of climate-induced mobility and migration is confronted with a lack of information on the side of (potential) migrants. Despite some obvious manifestations, a significant share of people living in middle- and low-income countries are not fully aware of the implications of climate change and global warming on sustainable livelihoods (Helbling et al. 2021). A considerable number of individuals living in negatively affected regions have never heard of climate change and are not aware of its consequences; they are not 'climate literate'. In a sample of 37,000 people interviewed across 30 African countries, less than half of the respondents were climate literate (Helbling et al. 2021). This partly explains why – in face-to-face or online interviews – the majority of migrants (or potential migrants) do not mention environmental factors and climate change as main reasons for their decision to leave the region or the country of origin.

Figure 2.5 Main reason for migrating to another country, international migrants from West Africa and Central Africa compared, Survey 2020



Source: MMC Briefing Paper, June 2021 https://mixedmigration.org/resource-type/briefing-paper/

When asked, the majority refer to economic factors, such as lack of income, low wages, or lack of market access, as the main underlying reasons for migration. Political violence and social tensions are also often mentioned (Figure 2.5). It is, however, possible that the underlying cause affecting these more proximate reasons is environmental stress (Afifi 2011; Mora and Taylor

2006) even if people are not fully aware of this. In any case, empirical data suggests that intentions to migrate are stronger amongst those who are aware of climate change (Helbling et al. 2021).

Evidence also suggests that natural disasters and environmental degradation alike increase the likelihood for social tensions and, sometimes, violent conflicts (Abel et al. 2019, Mallick and Vogt 2012 Naudé 2010). There is, however, no supportive evidence that actual disasters or reasonable fear of such disasters leads to higher numbers of asylum seekers (Neumayer 2005). The main reason for this is that natural disasters rarely lead to displacement across international borders. Another reason is that people temporarily displaced by disasters from their place of residence rather fight for material compensation and reconstruction either covered by insurance or financed by the public coffer of their home countries and, wherever possible and necessary, seek external help from the international community.

Finally, climate change is often considered merely as a push factor at the place of origin. Nevertheless, a favourable climate in receiving countries or regions is also a relevant driver influencing migration decisions of professionals and retirees (Gottlieb and Joseph 2006; Poston et al. 2009; Rodriguez et al. 2004; Sunil et al. 2007; van der Geest 2011). Retired North American seniors moving to the 'sun belt' of the USA and retired North-western Europeans moving to the northern shores of the Mediterranean and adjacent Atlantic shores are most evident examples for this. Beyond that, favourable weather and climatic living conditions in places like Barcelona, Lisbon, Miami, and Los Angeles are considered an asset for companies trying to recruit foreign professionals and talent.[14] This also explains why such locations have been successful in attracting additional foreign direct investment and hosting start-ups.[15]

2.3 Interlinkages between environmental change and other drivers of migration

It is well established that fundamental drivers of migration or mobility do not work in isolation but interact in several ways (Czaika and Reinprecht 2020). Such interaction occurs as the effect of environmental and climate change on migration or mobility depends on various non-environmental drivers or facilitators. As a result, the environment-mobility-migration nexus is difficult to predict.

[14] See e.g. Czaika (2018), Ewers and Dicce (2018)

[15] See, for example: Butcher (2021), Kieckens (2021), Kuntara (2021).

Multiple interactions between or combined effects of environmental stress and economic drivers (Martin et al. 2014; Khavarian-Garmsir et al. 2019) are probably the most relevant combination of factors. Indirect effects – such as environmental stress causing resource-based conflicts (Abel et al. 2019) or exposing people to health-related risks (Marchiori et al. 2012) – have been identified as relevant for migration and mobility.

One study shows, for instance, that both a person's age and income – a combination of a demographic and an economic factor – influenced the capacity and decision of those who were displaced by Hurricane Katrina to return or not to return to New Orleans (Groen and Povlika 2010). At the same time, African Americans whose livelihoods had been destroyed returned less frequently than white Americans. Groen and Povlika (2010) linked this to people's fear of a similar event occurring again, as well as to new opportunities that had arisen at their new place of residence. In the end, the share of New Orleans' African American inhabitants dropped due to lower return rates.

There is, however, also another explanation for this: compensation for destroyed homes were disbursed based on the assumed property value, rather than the actual cost of reconstruction. Consequently, financial support to many people living in poorer neighbourhoods before displacement fell short of the amount needed to rebuild their homes as the location-specific market value of their real estate was low, and part of the reconstruction costs were not related to location (Green and Olshansky 2012).[16]

Under quite different circumstances evidence from Zimbabwe and Afghanistan suggests that a mix of political, economic, and environmental drivers have contributed to displacement within and emigration from these two countries (McGregor et al. 2011; Smith et al. 2011). At the same time, droughts in Zimbabwe disproportionately affected the rural population due to the underlying stress created by both political and economic insecurity.

Political conflict over natural resources such as availability of ground or river water, often in combination with loss of economic rents or insecurity of livelihoods, have contributed to domestic rural-to-urban mobility of larger numbers of people and occasionally also to international migration. Mobility and migration are often influenced indirectly by climate-induced land degradation or water scarcity as these factors create social, economic, and political consequences. For instance, dwindling fish stocks and decreased

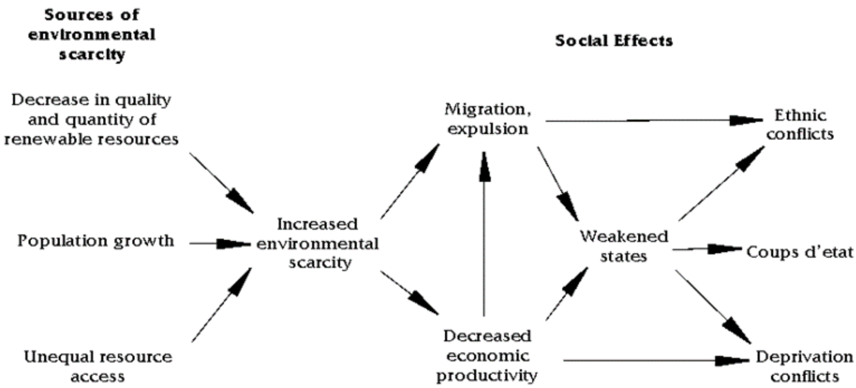
[16] See also https://www.newstatesman.com/uncategorized/2007/08/city-katrina-nagin-state

agricultural productivity reduce the reliability of household food supply or income if there are no viable adaptation measures initiated by local and national governments (Black et al. 2011). Consequently, migrants themselves may link their reasons for leaving to economic, rather than environmental factors, despite the fact that climate change may be the underlying cause.

Also, the direct and indirect links between environmental change, various forms and intensities of conflict, and mobility and migration dynamics of people at risk establish multiple causal factors and repercussions (discussed below) for processes of migration and displacement (Figure 2.6).

Environmental degradation leading to environmental stress and enhanced resource scarcity may not only trigger mobility and migration but also establish pre-conditions for various forms of social conflicts over resources. Such conflicts may turn violent and displace people as a result of those political and social consequences rather than the initial environmental causes for conflict. A pertinent example are conflicts between farmers and herders over declining freshwater resources triggering displacement (Brottem 2021).[17] At the same time, such large-scale displacements strain (environmental and other) resources at the new place of residence so that displacement itself becomes the self-perpetuating 'knock-on' effect for further mobility (King and Skeldon 2010).

Figure 2.6 The environment-migration-conflict nexus



Source: Homer-Dixon (1994)

[17] For a general overview see: https://climate-diplomacy.org/case-studies/pastoralist-and-farmer-herder-conflicts-sahel

In general, migration and mobility decisions are not just a reaction to environmental stress but are influenced by a broader set of drivers in which people making these decisions are embedded. The combination and interaction of economic, political, social, cultural, and demographic drivers shape the effect of environmental stressors on migration (Black et al. 2011). Multiple drivers often act simultaneously, and environmental stress might cause changes in economic, political, or social conditions, but these may also 'feedback' in terms of the misallocation or over-use of natural resources (Renaud et al. 2011).

Often, the interlinkages between climatic change and other mobility or migration drivers are context specific and tend to vary in accordance with the respective ecosystem (see Table 6 in appendix).

- In drylands, for instance, extreme heat events, droughts, and variability in the amount and timing of rainfall may interact with land degradation, water scarcity, and depletion of soil nutrients. Meanwhile, growing intensification and market-orientation of agriculture as well as increasing enclosures and land grabbing can be the main reason as to why people decide to leave.
- As herding and subsistence farming decline give way to more specialized livestock pasturing and mechanized farming, young (mostly male) adults leave rural areas for urban centres where they hope to find opportunities to earn cash income. Similarly, people leave tropical and sub-tropical forest regions in the Americas, Central Africa, and Southeast Asia where longer heat waves and occasional periods without rainfall increase the likelihood of fires. The impact of climate change in combination with commercial deforestation leads to loss of ecosystems which squeezes out indigenous and customary forest users.
- In a growing number of coastal zones and densely populated river deltas, the situation is characterized by rising ocean temperatures and sea levels. This increases the intensity of rainfall as well as the frequency and intensity of storms, causing floods, coastal erosion, soil and aquifer salinization. In part, this happens due to rapid urbanization and industrial development in river delta regions of South and South-East Asia, combined with the loss of protective features such as mangroves or marshes and declining offshore fish stocks.
- Consequently, economic opportunities for small-scale fishing are declining, and in some places, we can find an intensification of aquacultures. The effect is twofold. On the one hand, people are forced to move from smaller islands and seaward edges of deltas because of erosion and salinization. On the other hand, households which are

dependent on farming or fishing need to look for alternatives, which can also incentivize or force household members (often the young) to move temporarily or permanently depending on the availability of income opportunities elsewhere.

- In mountainous regions, increasing variability of rainfall and rising temperatures are, on the one hand, leading to growing seasonal and inter-annual water scarcity, but also to flash floods, as well as mud- and landslides of increasing magnitudes. Because of the heterogeneity of mountainous environments, effects are varying across regions, but common features are: poverty through deforestation, remoteness, and lack of physical and social infrastructure. Subsistence farmers often lack food and water security so that households can try to diversify their incomes. For many of them, seasonal and longer-term mobility, and even international migration, become an essential strategy in order to sustain livelihoods (see Table 6 in appendix).

The mentioned examples indicate that a growing number of people worldwide are exposed to stressful situations caused by environmental change. Internal mobility and – to a smaller degree – international migration is part of a wider range of strategies of adaption to changing environmental conditions, particularly for people living in regions with extreme weather and climate variability (Jónsson 2010; van der Geest 2011).

2.4 Voluntary and involuntary immobility

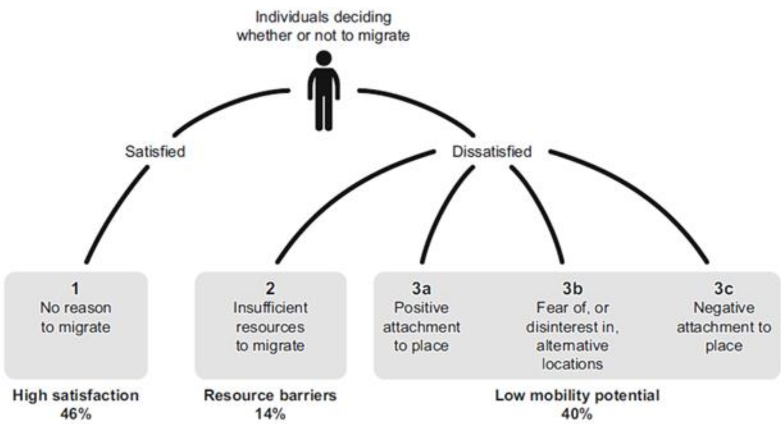
Available data suggest that over the past decades, hundreds of millions of people have moved within their country of birth, either temporarily or permanently, to find a more environmentally sustainable or attractive place to live. And many more have a desire to do so. However, many, if not most, people with aspirations to relocate to a 'better' place never actually move.

Conceptually, migration decision-making can be thought of as a cognitive process consisting of two steps (Brown and Moore 1970). Individuals first decide *whether* they want to migrate. Then they decide *where* they want to relocate. The first step involves developing the motivation, intention, and aspiration that goes beyond a vague desire to migrate (Carling and Schewel 2018). The second step involves the assessment of migratory options and the eventual decision to move.

Migration research shows, however, that many people with mobility aspirations cannot actualise them. Instead, they risk feeling trapped in situations of involuntary immobility (Carling 2002; Schewel 2020). At the same time, remaining in a difficult context can also be the outcome of a voluntary decision (Adams and Kay 2019; Nawrotzki and DeWaard 2018).

Behavioural sciences suggest some explanations for non-migration and 'on site' adaption (Czaika and Reinprecht 2022). That is, the decision not to migrate in the context of environmentally stressful situations despite exposure to severe risks for life and assets is not irrational per se and not necessarily the result of limited information, capacity, or material resources. Voluntary non-migration of a non-trapped population can also be the result of people's capacity to make self-determined decisions, to develop adaptation capacity or to be influenced by some simple biases and misconceptions (Czaika and Reinprecht 2022).

Figure 2.7 Why populations persist: mobility, place attachment and climate change



Source: Adams (2016)

Consequently, immobility despite objectively deteriorating situations may be subjectively perceived as voluntary and the preferred option, but also as involuntary, due to a low mobility potential and resource constraints (Figure 2.7).

Box 2.1 Migration and uncertainty

Any forecast of migration process needs to take uncertainty and volatility as well as data gaps into account. Domestic mobility and international migration processes are embedded in often complex, and sometimes rapidly changing environments. This coupled with a high degree of human agency owing to the different actors involved makes migration forecasting difficult and challenging – in particular for longer time horizons (Bijak and Czaika 2020b).

Migration uncertainty can be broadly categorized into two different sources:

1. Lack of data and information (epistemic uncertainty) and
2. The random distribution of relevant events and processes (aleatoric uncertainty).

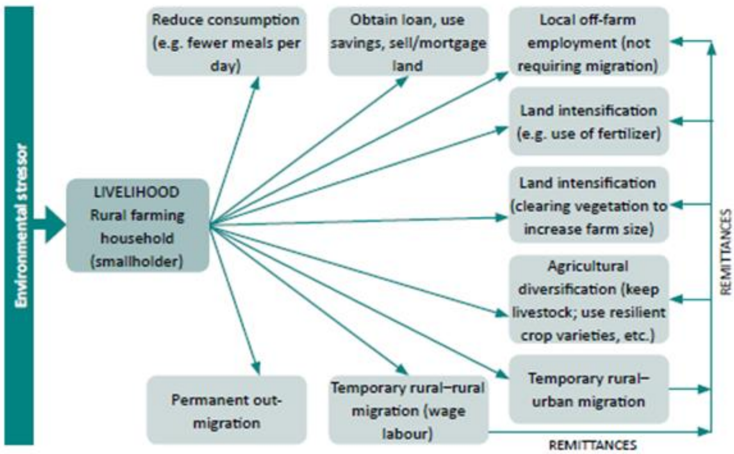
Imperfect knowledge and data include the deficits in the conceptualization, measurement, and description of mobility/migration and its drivers, along with an incomplete understanding of human decision making when confronted with the alternative to move or to stay. Aleatory uncertainty includes unpredictable shocks to migration and its migration-inducing environments as well as unpredictable aspects of human behaviour, human interactions, and human agency in the face of the unknown (Bijak and Czaika 2020a). Even unforeseen advancements in data or analytical methods can be of 'aleatoric' nature.*

To a certain degree lack of data and information (epistemic uncertainty) concerning gradual (slow-onset) environmental changes in combination with other slow-changing, gradual societal processes – such as declining fertility or urbanisation trends – may by manageable in migration modelling. Taking ad hoc events with low probability such as sudden-onset natural disasters that can have a high impact on human mobility and displacement into account is difficult.

**In the early 2000s, for example, no migration researcher would have anticipated that location data of cell phone users, Facebook data or data from Google Analytics would one day become relevant for their analysis (see: https://www.migrationdataportal.org/blog/measuring-migration-big-data-and-innovative-data-sources).*

Overall, the evidence pertaining to mechanisms and processes of environmentally induced migration and displacement suggests that in environmentally stressful situations, selection processes lead to situations where some people (can afford to) move outside the risk zone while the majority remains. This immobility despite environmentally stressful situations can indeed be voluntary and is often explained by factors such as place attachment (Adams and Kay 2019; Nawrotzki and DeWaard 2018) as well as social ties and family networks (Schewel and Fransen 2020). It may however also be involuntary due to a lack of economic or financial capabilities or other factors that limit the ability to move (Carling 2002; Schewel 2020). In general, though, adaptation 'on site' is often part of a wider family or household strategy combining migration and non-migration strategies. This is manly true for rural households affected by the consequences of gradual environmental change (Figure 2.8).

Figure 2.8 Possible responses to environmental stress on livelihoods in farming areas



Source: IOM (2017)

Remoteness and isolation are important factors that contribute to the vulnerability of populations in peripheral mountain, forest, and some dryland areas. Households and people living in such rural areas usually have the least migration opportunities and adaptation prospects. People living in areas with adequate access to roads, markets, and social infrastructure have a greater range of migratory options and access to internal mobility, and occasionally also international migration. Rural to urban migration rates are high, especially in Sub-Saharan Africa and South Asia and particularly in more developed and better-connected areas (Figures 3.13 and 3.14). Rural households that participate in resource sharing networks supported by emigrated family members have greater food and water security as they have access to cash. Such networks are likely to grow in importance as impacts of climate change on food production and water systems intensify.

At the same time, mobility and migration are critical for sustained livelihoods and part of an adaptation strategy of households exposed to environmental (and other external) stress. Internal mobility and, at a smaller scale, international migration, are two fundamental coping strategies by which households adapt to climatic and non-climatic shocks, risks, and uncertainty.

In countries with little fiscal capacity and/or political resolve to mitigate risks and effects of climate change through prevention and strengthening of resilience, mobility – of at least some family members – may be the only option for households to adapt. In any case, households that lack social networks and therefore migratory options are inherently more vulnerable and less able to adapt to the impacts of climatic shocks, weather variability, and environmental change.

The reliance of households on mobility and migration to meet rural livelihood needs seems to be growing, primarily across less developed countries (Rigaud et al. 2019). Seasonal mobility is already common in regions with a high seasonality of weather and climate conditions. Spells of longer periods of absence from 'home' are becoming increasingly common. Since moving within a shorter range is a rather low-cost option, most climate-related mobility takes place within provinces and countries or to nearby places across borders.

Temporary mobility and migration of family members seeking income and employment opportunities outside of their place of origin is part of an adaptation strategy of households in middle- and low-income countries. Especially households that receive remittances on a regular basis from family members living in other countries have greater long-term social and economic prospects. At the same time, remittances increase socio-economic inequality within sending communities (Adams et al. 2008, Kóczán and Loyola 2018).

In the aftermath of disasters and times of crisis, the ability to receive remittances from family members of compatriots associations can improve prospects for reconstruction and recovery and to some extent enhance preparedness and adaptation (Gemenne 2022). That is linked to the countercyclical volume of remittances sent back to relatives and local communities in countries of origin. In comparison to 'normal times,' migrants tend – on average – to send more money home when their place of origin is affected by a crisis (ADB 2012, Sirkeci et al. 2012). Thus, prior emigration can have a positive impact on the pace of recovery from extreme weather events such as floods and droughts.

2.5 Conclusion

Several studies have established that the fundamental drivers of migration or mobility do not work in isolation but interact in several ways. The effect of environmental and climate change on internal and international migration or mobility depends on multiple non-environmental factors including economic, social, political, and other facilitating or constraining factors. As a result, the environment-mobility-migration nexus is not always easy to identify and anticipate for a particular region.

Overall, evidence on the mechanisms and processes of environmentally induced migration and displacement suggest that in environmentally stressful situations, stratified selection processes lead to situations where some people (can afford to) move outside of environmental risk zones. The majority, however, stay put and (voluntarily or involuntarily) adapt 'on site'.

While the qualitative and quantitative assessment of environmentally induced displacement as a phenomenon raises a lot of interest in political and societal realms, the phenomenon of environmentally induced 'trappedness' in economically and socially stressful situations remains largely ignored and receives little political attention.

3. Environmentally induced mobility: assessing the evidence and identifying remaining uncertainties

Chapter 3 explores recent data and empirical evidence hinting at the nexus between environmental change and spatial mobility. It outlines the type, frequency, and impact of natural disasters (sudden-onset events) with a particular emphasis on short- and long-term displacement. It also discusses how slow onset ecological changes that deteriorate living conditions thereby contribute to mobility patterns from rural to urban regions; and how this impacts the risk exposure of people moving to urban agglomerations.

3.1 Natural disasters and displacements

The most obvious impact of climate factors on mobility comes from so-called natural disasters. While some of them are of geophysical nature[18] which are unrelated to environmental conditions, almost 90 percent of such disasters are caused by extreme weather conditions and their immediate consequences – such as floods, storms, droughts, and wildfires – leading to displacement or evacuation (Figure 3.1). Most of these events are monitored and well-documented.

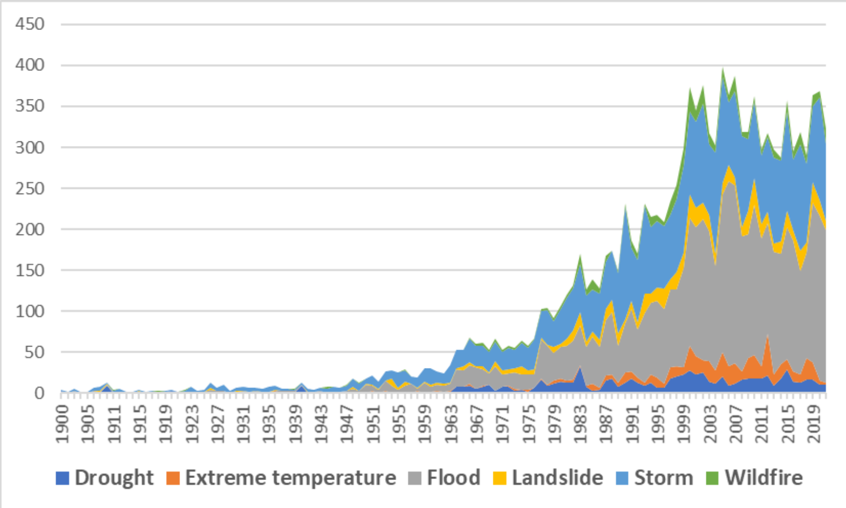
It is evident that global warming coincides with an increase of extreme weather conditions causing disasters. However, not every weather-related disaster is linked to climate change. For example, the absolute number of geophysical incidences such as earthquakes and volcanic eruptions are not influenced by greenhouse gas emissions and remain rather stable over time. It is hereby primarily the hydrological events (floods caused by rainfall), the climatological events (droughts, wildfires), and the meteorological events (storms, spring tides) that have significantly increased in frequency and volatility (Figure 3.1).

As analysed in Chapter 2, it remains unclear as to how, and to what extent, these trends translate into the displacement of human beings. Climate change

[18] Earthquakes, tsunamis, volcano eruptions.

has been proven to make certain hazards in some regions more frequent and intense, but by far not all weather-related disasters triggering displacement are directly related to climate change. While it is evident that climate is a driver of displacement, the full impact is still subject to analysis.[19]

Figure 3.1 Number of weather-related disasters by type of event, 1900-2020



Source: EM-DAT (2022)

Unfortunately, reliable global data on natural disaster-related displacements are only available since 2008 (IDMC 2021). At the same time, it should not be overlooked that purely man-made events (such as nuclear accidents, mining related poisoning of fresh water, etc.) can also trigger disasters and displacement.

During the 20th and early 21st centuries both the number of reported natural disasters (Figure 3.1) and the number of people negatively affected by weather-related natural disasters have been steadily increasing. At the same time, our capacity to cope with such events has also dramatically increased. This capacity is related to more precise weather forecasts, improved warning systems and disaster preparedness, as well as improved quality of housing, infrastructure, river management, and shoreline protection.

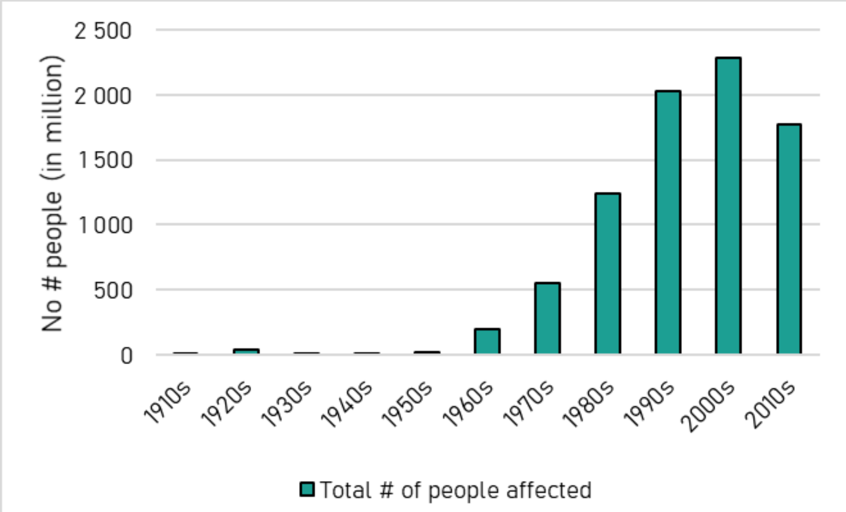
[19] "Of 131 extreme events in different parts of the world investigated in peer-reviewed studies by one scientific journal, 68% revealed an influence of climate change on altered exceedance probabilities. Many extreme events are therefore already being influenced by climate change" (Faust, Rauch 2020).

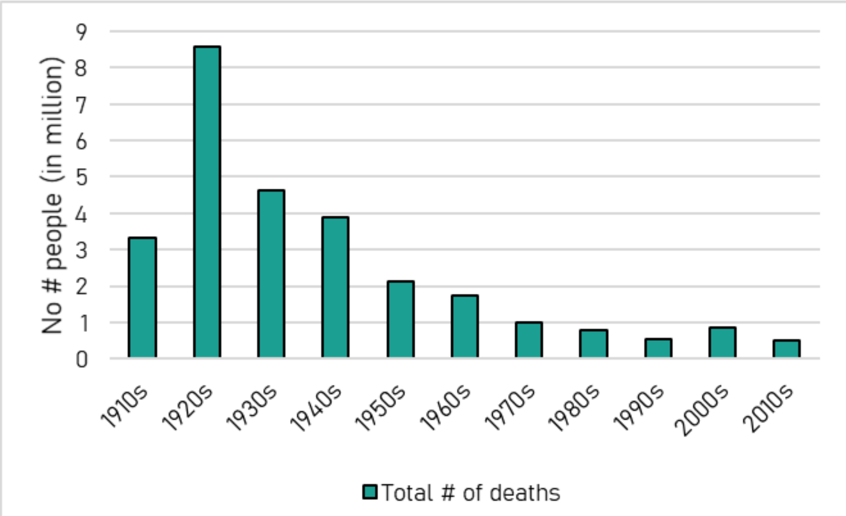
As a result, natural disasters lead to much fewer fatalities today than in any other period since the year 1900. Between 2010 and 2020 the death toll of weather and climate related natural disasters was on average 60,000 people per year (Figure 3.2). This is just 0.33 percent of all people severely affected by such disasters. Additionally, it is almost 90 percent less than during the period 1900-1950 when, on average, 520.000 people were killed annually (Figure 3.2). In relative terms, the mortality risk reduction is even more impressive when considering that the world population has increased fourfold between the 1920s and today.

To summarise: The number of people exposed to weather-related natural disasters has increased over the past decades while the risk of being killed during such a disaster is drastically reduced compared to earlier times, resulting in both a significant decline of mortality rates and much smaller absolute numbers of deaths.

In 2021, out of 38 million displaced people, some 23.7 million people were displaced because of so-called natural disasters (2020: 30.7 million): most of them – 23.3 million – as a result of weather-related disasters (IDMC 2022). The majority of these displacements can be linked to storms (11.5 mn) or floods (10.1 mn), while the sudden impact of wildfires (0.4 mn), landslides (37,000) and of extreme heat waves and droughts (20,000), has been significantly smaller (Figure 3.3).

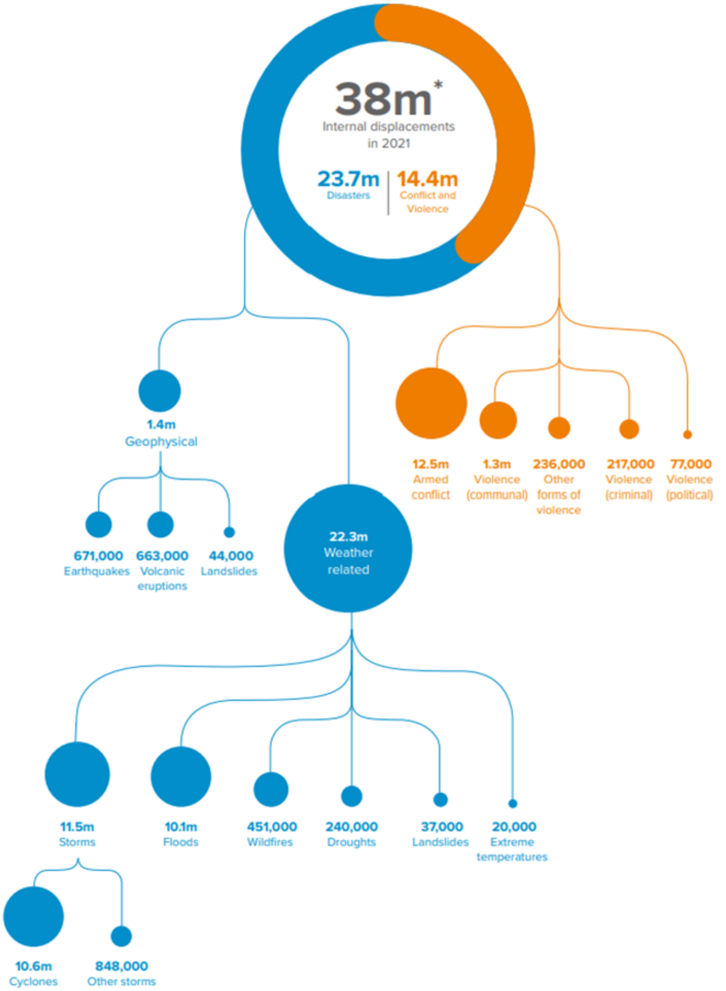
Figure 3.2 Number of people affected by weather-related natural disasters and deaths due to weather-related natural disasters, 1910-2020, in million per decade





Note: Figures are aggregate annual numbers over ten-year periods. Disasters include all meteorological, hydrological, and climatological events including extreme temperatures, landslides, droughts, wildfires, storms, and flooding. People affected are those requiring immediate assistance during an emergency situation.
Source: CREF, EM-DAT 2021

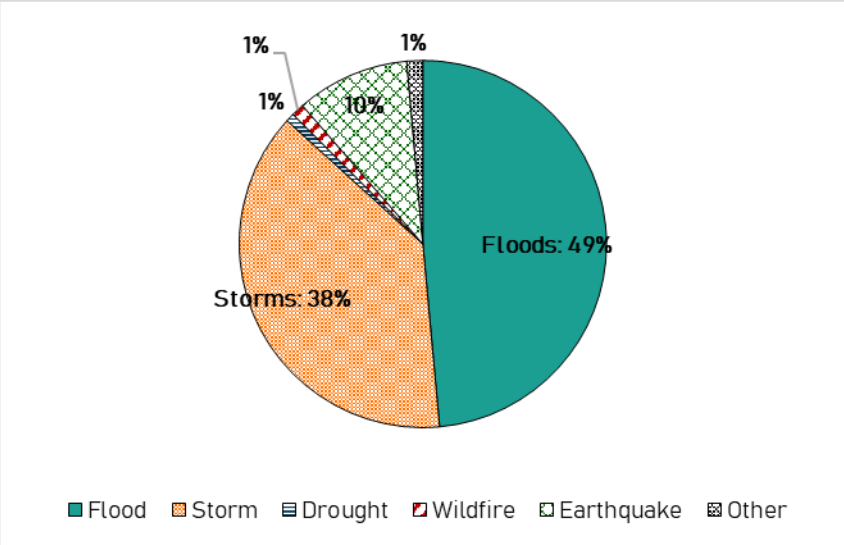
Figure 3.3 Global displacements by type of disasters; new displacements in 2021



Note: Actual numbers could be higher as some displacements might not have been reported or monitored.
Source: IDMC 2022

Between 2008 and 2021, almost 10,000 natural hazardous events with impact on livelihoods were reported. They have displaced about 343 million people – on average 24.5 million per year. While both the number of natural disasters (Figure 3.1) and the number of negatively affected people (Figure 3.2) are steadily rising, the number of new displacements does not show a clear upward trend over the past 15 years (Figure 3.5). Since 2008, most people displaced by extreme weather conditions and other natural disasters were victims of floods (156 million = 49 %) and storms (119 million = 37 %). Wildfires (3.4 million = 1 %), droughts and extreme temperatures only played a minor role (Figure 3.4). Geophysical events such as earthquakes, volcano eruptions, and tsunamis – which are unrelated to weather and climate conditions – were responsible for only 11 percent of all displacements (34.4 million; Figure 3.4).

Figure 3.4 Global numbers of displaced people by type of natural disasters; 342 million new displacements, 2008-2022

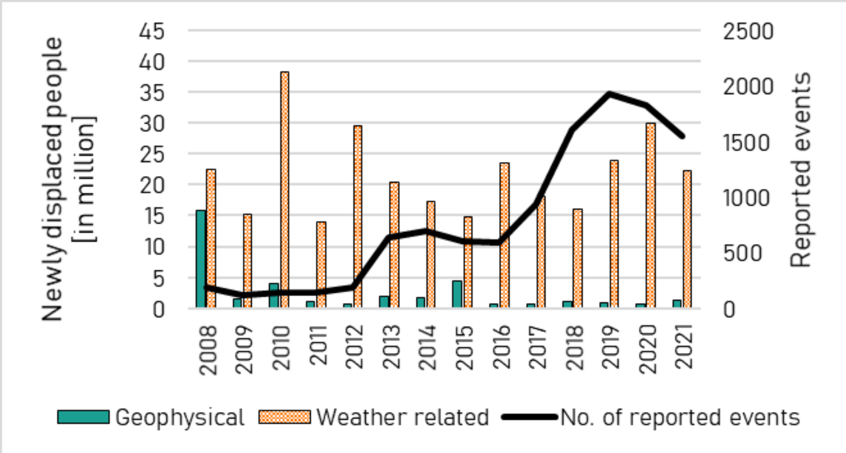


Source: IDMC 2022

We cannot ascertain exactly to what extent climate change is responsible for displacement after sudden onset events. This has to do with the fact that reliable data on annual numbers of displaced people only exists since the year 2008. During that time, the annual number of reported natural disasters has increased from about 200 in 2008 to almost 2000 in 2019 (Figure 3.5) while declining to 1600 in 2021. At the same time, the annual number of people who were newly displaced by (weather-related) disasters has fluctuated considerably. The highest numbers were reported in 2010 (38 million) followed by 30 million in 2020 and 29 million in 2012. The lowest numbers were reported in 2011 (14 million) followed by 15 million in 2009 and 2015.

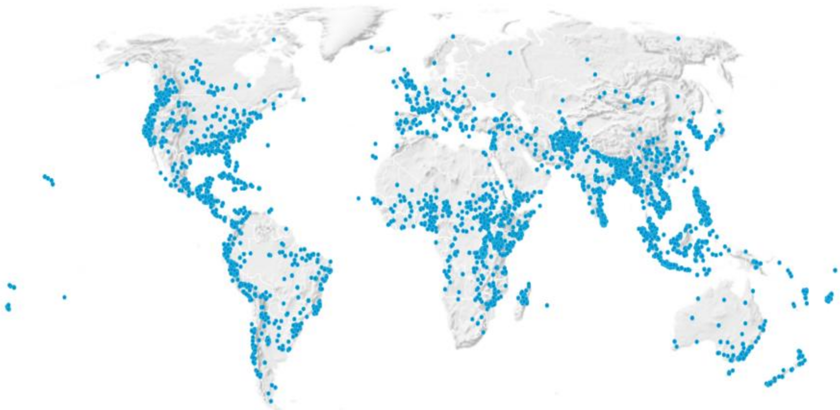
While the number of reported disasters is clearly on the rise, the timeline since 2008 does not display any clear upward (or downward) trend in displaced people (Figure 3.5).

Figure 3.5 Global number of newly displaced people by type of natural disasters; number of reported events, 2008-2021



Source: IDMC 2022

Figure 3.6 New displacements caused by natural disasters, by location 2020



Source: IDMC 2021

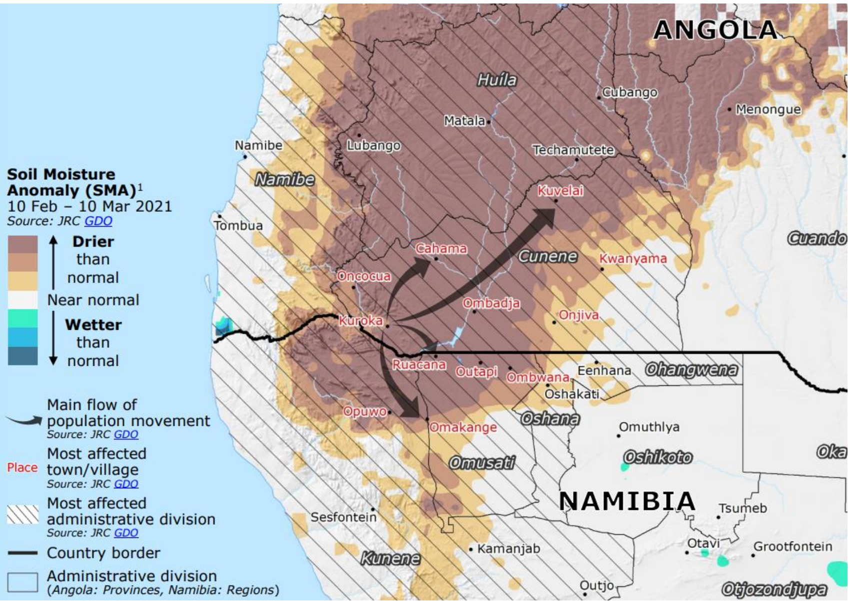
Extreme weather conditions are reported from around the globe, but they can only lead to displacement of people when occurring in populated regions (Figure 3.6).[20] The number of people affected by displacement is therefore not

[20] Hazardous events that do not cause large-scale fatalities and/or property damage or occur in unpopulated areas (e.g., central Sahara, Antarctica, Northern Siberia) are not classified as natural disasters, and consequently, do not cause disaster-induced displacement by definition.

just the result of climate change and extreme weather conditions. Population density, spatial distribution of population, settlement conditions, robustness of buildings and infrastructure, as well as already existing preventive measures also play an important role.

Despite large numbers of people involved, incidences of displacement by natural disasters have – so far – neither led to any significant cross border migration nor to an equally large stock of internally displaced people unable or unwilling to return (Bohra-Mishra et al. 2014, Neumayer 2005). On the contrary, most of the people displaced by natural disasters and extreme weather conditions – unlike people fleeing political violence or armed conflicts – manage to return often (yet not always) with practical or financial support from their own national and local governments, private insurance schemes as well as international donors and globally operating aid organisations. As a result, the majority either remain in their region of origin or even get back to the place where they had lived before displacement.

Figure 3.7 Displacement caused by the drought in the Kunene River basin, Feb.-March 2020



Source: European Commission, DG ECHO

Even though most disaster-induced displacements are rather short-distance and only last for a relatively short period, some cases of displacement caused by natural disasters may lead to cross-border movements. For example, the 2020 drought affecting the Kunene River basin and neighbouring regions caused some people to move from the Western part of Angola's Cunene province to neighbouring Namibia (Figure 3.7).

Another example are the floods along the Sava and the Drina River in 2014. During this disaster about 90.000 people were displaced in both Bosnia and in Croatia with some Bosnians finding shelter in Croatia and Serbia (Figure 3.8).[21] We can assume that some of them did not return to their hometown or village as Bosnia-Hercegovina is a country with considerable net emigration;[22] and many displaced people with ethnic Serbian and Croatian background had kin in neighbouring regions across the Sava and Drina rivers on Serbian and Croatian territory.

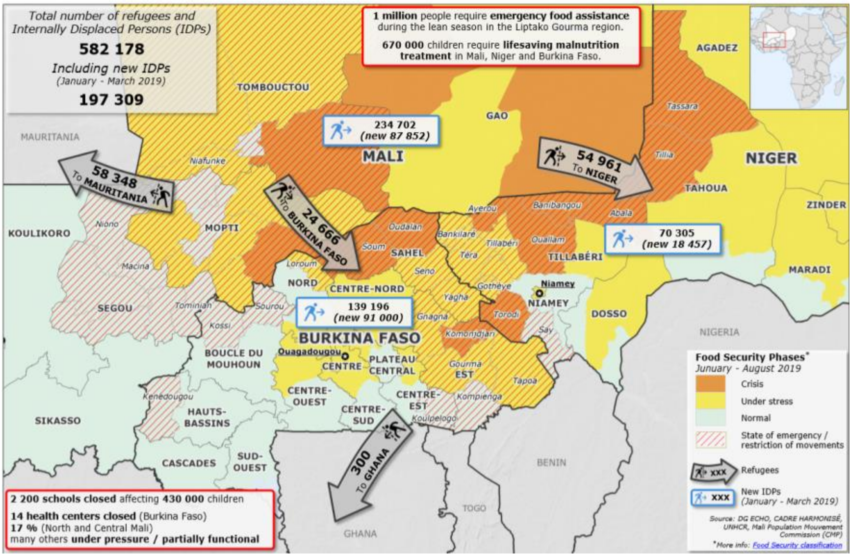
Figure 3.8 Displacement caused by floods along the Sava and the Drina River in May 2014

Source: https://en.wikipedia.org/wiki/2014_Southeast_Europe_floods

[21] http://labos.ulg.ac.be/hugo/wp-content/uploads/sites/38/2017/11/The-State-of-Environmental-Migration-2015-186-202.pdf

[22] https://www.macrotrends.net/countries/BIH/bosnia-and-herzegovina/net-migration

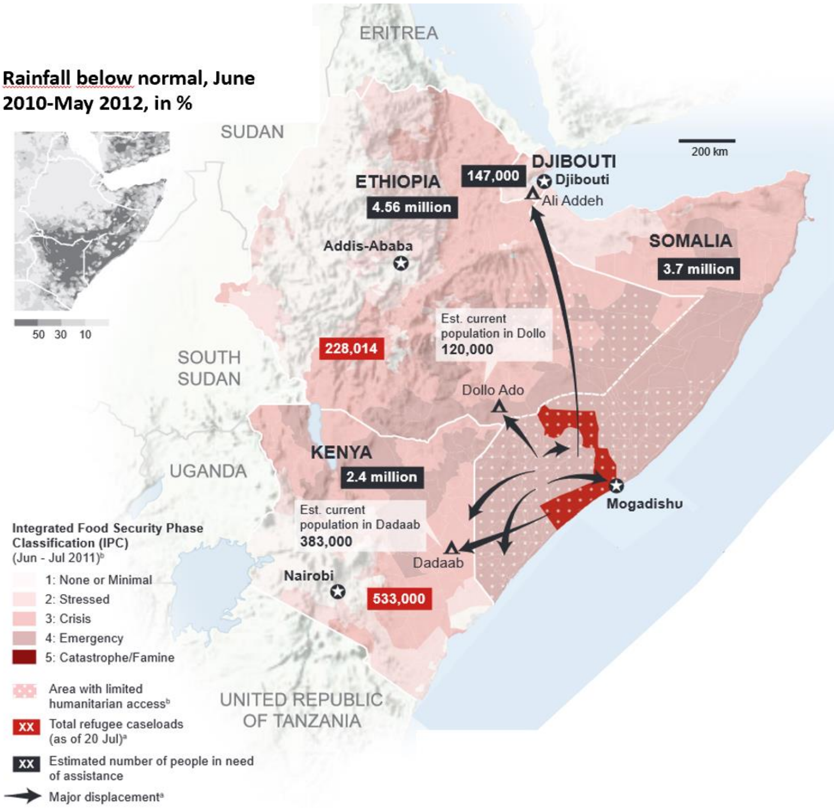
Figure 3.9 Internal displacement and cross-border migration during the Sahel food crisis, 2019



Source: European Commission, DG ECHO

Furthermore, some evidence suggests that multiple repeated disasters in fragile states – possibly coinciding with political tensions or violence – contribute to long-term displacement (Abel et al. 2019) and eventually to international migration flows. For instance, droughts affecting food security in the Sahel region, a region that is also suffering from violent local political conflicts and Islamist terror, is an example of a combination of drivers (Figure 3.9).

Figure 3.10 Internal displacement and cross-border migration during the Somalian drought food crisis, Jan.- June 2011



Source: UNHCR, OCHA, NOAA, UNCS, FEWS NET[23]

Another example are subsequent droughts in parts of Somalia which have led to periods of food stress and shortage of freshwater supply. As some of the regions were affected by ongoing political conflict and civil war, which severely hampered relief efforts, some people left these regions for neighbouring countries.[24] In 2011, their number exceeded 0.8 million. Most of them headed to Kenia and Ethiopia, a small number also to Djibouti (Figure 3.10).

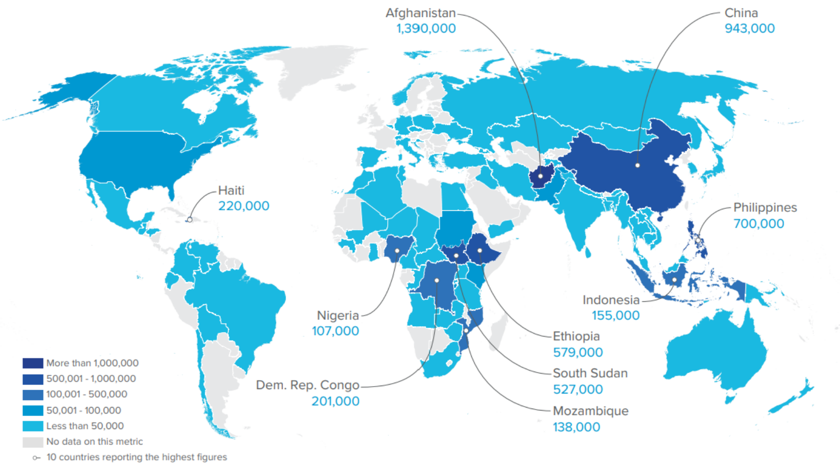
At the end of 2021, about 6 million victims of natural disasters were reported to be living in long-term displacement because of disasters in 84 countries (down from 7 million in 2020). In 2021, more than half of them where living in

[23] OCHA (2011) https://reliefweb.int/sites/reliefweb.int/files/resources/DR-2011-000029-KEN_0720_1.pdf

[24] https://www.bpb.de/gesellschaft/migration/newsletter/56853/hungersnot

Asia (1.4 million in Afghanistan, 0.9 million in China, 0.7 million in the Philippines, 155,000 in Indonesia), followed by sub-Saharan Africa (e.g., 579,000 people in Ethiopia, 527.000 in South Sudan, 201,000 in DR Congo and 138,000 in Mozambique) (Figure 3.11). Information on the duration and the possible protractedness of displacements is not available. However, the fact that the number of IDPs at the end of 2021 are 'only' 2.1 percent of all people who were displaced by natural disasters since 2008 suggests a high return rate after disaster-induced internal displacements. In contrast to the consequences of violent political conflicts and civil wars, long-term displacement after natural disasters is rather the exception than the rule.

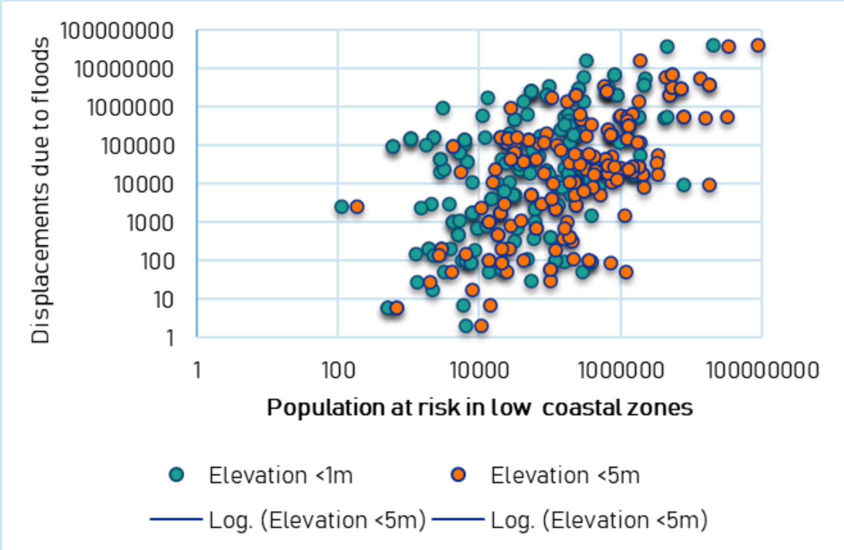
Figure 3.11 Global stock of people who have not returned to the place from which they were displaced because of natural disasters by country; protracted displacements, 2021



Source: IDMC 2022

Yet, part of the protractedness of displacement following natural disasters can be explained by ongoing violent political conflicts (Afghanistan, Ethiopia, Yemen) or severely weakened central governments (Afghanistan, DR Congo, South Sudan) hampering return and reconstruction efforts or rendering them impossible – particularly in remote rural areas.

Figure 3.12 People at risk in 2010 in low elevation coastal areas and number of displacements due to floods in 2008-2020 (N = 202 countries and territories)



Note: Dots in Figure 3.12: green = people living at 0-1 m above sea level; orange = people living at 1-5 meters above sea level.
Source: Own elaboration based on data from IDMC (2021) and NASA SEDAC (2021).

In Bangladesh, India,[25] and Pakistan, however, permanent displacement can be linked to a permanent loss of livelihoods in coastal areas. Similar developments are affecting people living on small islands with low elevation as well as settlements along exposed shorelines and river deltas.

Already today there is a high correlation between the number of people living in coastal regions at risk of being detrimentally affected by floods and storm surges because of rising sea levels and higher tides, and the number of people who are displaced from or within these regions. Available data show an unsurprising correlation: coastal and river delta regions with larger populations also report larger numbers of displaced people in case of floods while regions populated by fewer people also display less displacement. This is true both for people literally settling at sea level (elevation below 1

[25] Tropical storm Amphan damaged or destroyed over 3 million homes in the Indian state of West Bengal and adjacent regions of neighbouring Bangladesh in May 2020; at the end of December 2021 almost 100,000 people were still displaced (both countries combined; IDMC 2022).

meters)[26] and for people settling in slightly more elevated areas (1-5 meters; Figure 3.12).

As a result, the number of people displaced from low elevation coastal areas due to sudden onset floods depends not only on the meteorological conditions affected by climate change but also on population density in high-risk coastal areas. At the same time actual displacement also depends on the capacity of states, regions and local communities to mitigate risks due to hazards and extreme weather conditions. This mitigation of (the risks of) displacement is determined by the fiscal, economic and technical capacity as well as by political will.

Table 3.1 Displacement risk in populated low elevation coastal zones and river deltas (less than 5m above higher high tide levels)

Income level	Total population living below 5m above sea level (2010)	Total number of people displaced at least once by floods (2008-2020)	Displace-ment risk
High income non-OECD	6,226,012	50,174	1 %
High income OECD	55,733,172	1,448,306	3 %
Upper middle-income	115,881,414	52,332,722	45 %
Lower middle-income	122,117,599	76,610,289	63 %
Low-income	26,680,544	18,131,213	68 %
World	328,856,273	148,580,806	45 %

Source: Source: Own elaboration based on data from IDMC (2021) and NASA SEDAC (2021).

Data for the period between 2008 and 2020 show the following: in highly developed (OECD and non-OECD) economies, displacement risk for populations living in coastal areas with elevation below 5 meters has been between 1 and 3 per cent over the whole period 2008-2020, the risks are at 45 percent for upper middle-income, 63 percent for lower middle-income countries and peak at 68 percent for low-income countries (Table 3.1).

[26] Above current sea levels defined as Mean Higher High Water mark (MHHW = the arithmetic average of the elevations of the Higher High Waters of a Mixed Tide over two decades).

Accordingly, the findings clearly illustrate that the resolve and fiscal capacity to protect citizens against the effects of foreseeable forms of natural disasters is the most decisive factor in mitigating displacements risks.

3.2 Slow onset changes, domestic mobility, and international migration

In the context of slow-onset changes in our habitats, the potential triggers of involuntary or anticipatory mobility are slightly different when compared to sudden-onset events. People living in the following habitats are most affected.

- Livelihoods impacted by lasting droughts, progressive desertification, or soil salination
- Habitats exposed to increasing risk/numbers of tropical storms (cyclones[27] in particular)
- Settlements at exposed continental coast lines and on small islands with low elevation
- Densely populated river basins and deltas exposed to floods and/or rising sea levels
- Arctic settlements built on gradually melting permafrost soil

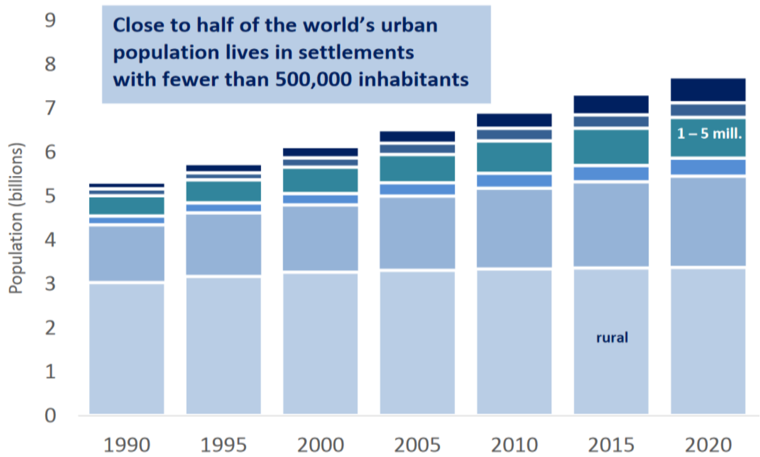
When habitat and livelihood degradation due to slow-onset changes takes place in areas exposed to floods and storms, sudden-onset disasters often serve as a tipping point event by which a process of gradual outflow of migrants (usually) to other urban and metropolitan areas becomes more likely.

Various forms of voluntary or forced mobility linked to slow-onset changes of habitats occur gradually. Consequently, they usually neither trigger immediate public attention nor policy responses and are therefore less documented and monitored. In many parts of the world even some very basic information on the number of people who have moved their place of residence within their country is incomplete, or not available at all. Based on data for the early 2000s, an estimate by the UN Development Program put the number of people living in their country of birth, but outside their region of birth, at 740 million (UNDP 2009). Given that the world population has increased by 30 percent between 2000 and 2021 while (as shown in Figures 3.13, 3.14) urbanisation continued at considerable pace, the current number might be well above 2 billion people.

[27] Also called hurricanes or typhoons.

Today, more than 50 percent of the world's population live in cities, half of them in larger urban centres (above 0.5 million inhabitants) and the other half in smaller towns and cities (below 0.5 million inhabitants). While the total number of people living in cities has grown from 1.7 to 4.4 billion – that is 2.5 times – between 1980 and 2020, the rural population has only increased slightly (from 3.0 billion in 1990) and remains stable at around 3.3 billion since 2010 (Figure 3.13).[28]

Figure 3.13 Global population growth by size of settlements, 1950-2020, in billions

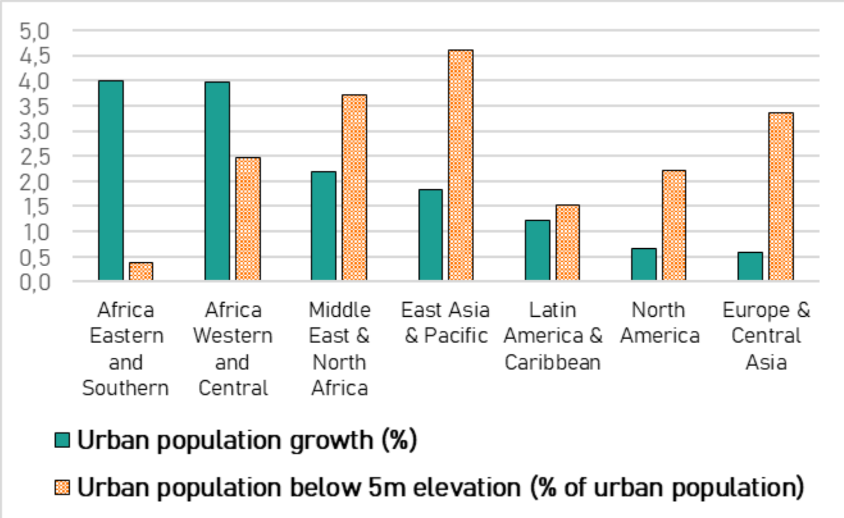


Source: UN DESA (2020)

[28] We need to take into account that the UN is occasionally changing the definition of "urban settlements" and "rural settlements" which makes data from time series not fully comparable. https://news.gallup.com/opinion/methodology/287189/approves-new-define-cities-urban-rural-areas.aspx

Globally, the increase in urban dwellers amounts to +2.7 billion during the past 40 years (1980-2020). In absolute terms, the population of larger cities grew at a larger pace than the population of smaller cities (Figure 3.13). We can assume that – on a net base – most of this increase is the result of rural-to-urban mobility within countries as well as international migration with larger cities being the main destination of many cross-border migrants seeking employment opportunities. Most urban population growth is taking place in Sub-Saharan Africa, the Middle East and in Asia, often in coastal areas involving enhanced exposure to sea level rise and storm floods (Figure 3.14).

Figure 3.14 Growth in the world's urban populations (in 2020) and share of urban population living in low areas (in 2020) by world region, in percent



Source: Own elaboration based on WDI (2021)

This has to do with historical settlement structures. In the past, major settlements developed along major rivers, at shorelines (usually at places with natural harbours) and near river deltas.[29] On the one hand, these places emerged as key trading places (also becoming administrative and partly industrial centres, provincial and national capitals); on the other hand, it was (and partly still is) easier to provide food and energy supply to settlements

[29] http://www.coastalwiki.org/wiki/Coastal_Cities

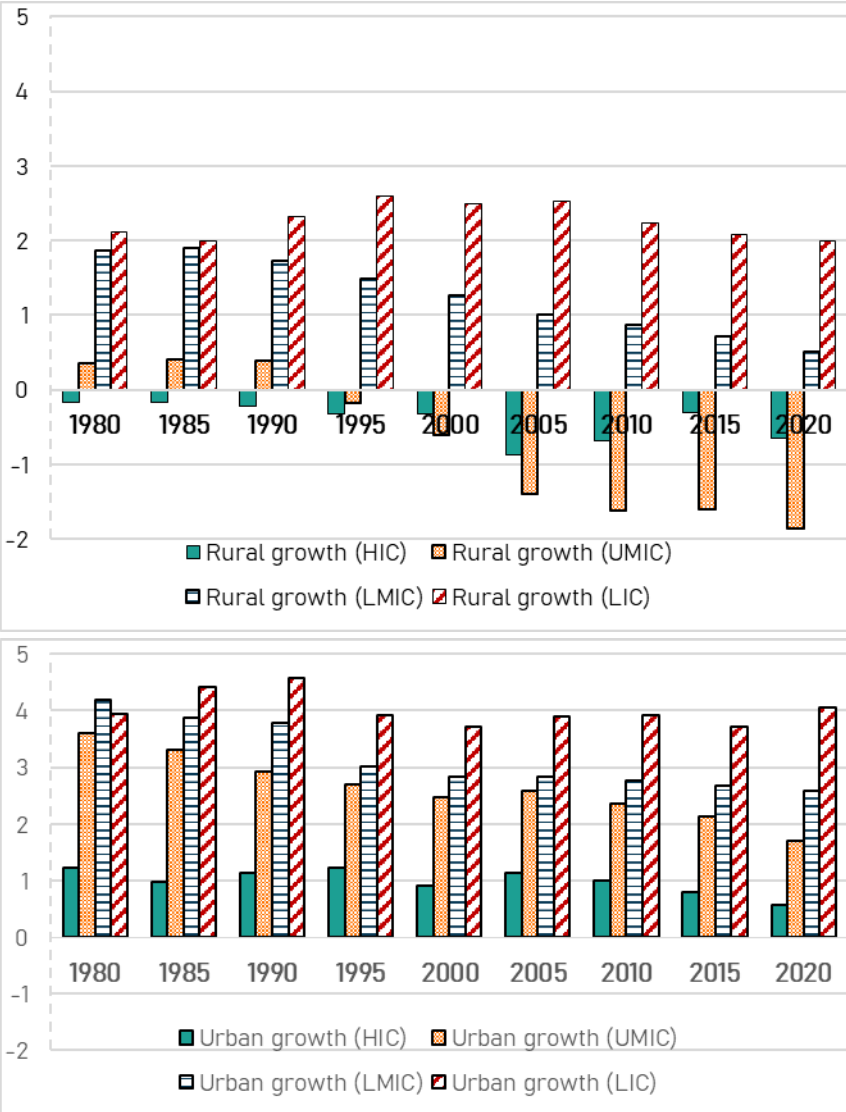
that can be reached by ship.[30] This creates economic opportunities influencing rural-to-urban mobility. At the same time, the quality of educational institutions and health care as well as food security are usually also higher in major cities than in rural areas. This is particularly true for Sub-Saharan Africa, North Africa, the Middle East, and other parts of Asia explaining why urbanisation continues there at a higher pace[31] as urbanisation rates in the majority of middle- and low-income countries are still significantly behind those of in high income countries (Figure 3.15).

The number of children per family is usually higher in rural areas than in towns and larger cities. Yet, rural populations in high and upper middle-income countries are declining in the early 21st century at a pace of 0.5 to 1.8 percent per year, while rural populations in poorer countries are increasing at a reduced pace (since 2000; lower-middle income: +0.5 to 1 %; low income 2 to 2.5 % per year). At the same time, urban populations are growing globally (+0.5 to 1 % per year in rich countries; +2 to +4 % per year in poorer countries; Figure 3.15). It can be concluded that the main reason behind this dynamic is continued rural-urban mobility as well as international migration towards urban centres. The pace of urbanisation is higher in poorer countries, as these countries still have a larger share of people living in rural areas, thereby serving as demographic base for further urbanisation.

[30] In the Northern hemisphere this played a major role in pre-industrial/early industrial times when neither roads with sufficient transport capacity nor railways existed. In certain lower middle- and low-income countries with deficient road and rail infrastructure it is still complicated to distribute emergency aid.

[31] Cardoso et al. (2019).

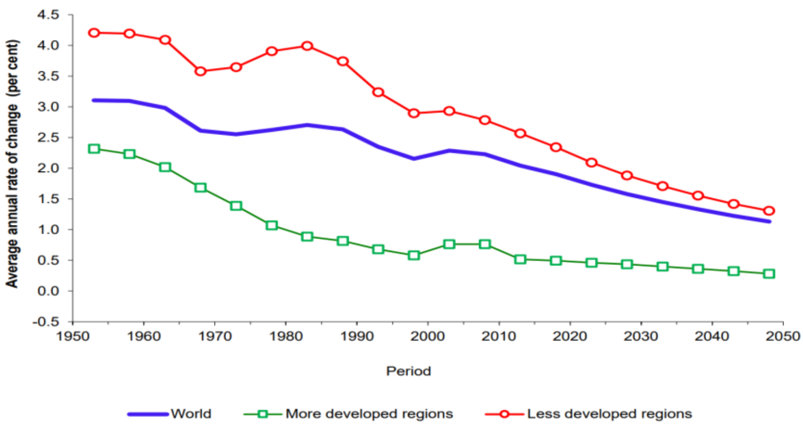
Figure 3.15 Growth/decline in rural and urban populations by countries' income level, 1980-2020



Note: HIC = high-income country, UMIC = upper middle-income country, LMIC = lowermiddle-income country, LIC = low-income country.
Source: Own elaboration based on WDI (2021)

The exposure of rural areas to gradual (slow onset) climate and environmental change that reduces the ability of inhabitants to sustain themselves is one of the drivers of mobility and migration towards urban centres. As this rural-to-urban mobility also occurs in environmentally non-exposed regions, the share of increasing urbanisation linked to climate change cannot easily be measured. A comparison over time shows that the pace of urbanisation has not increased since the 1950s, but rather decreased and is projected to decrease further (Figure 3.16).

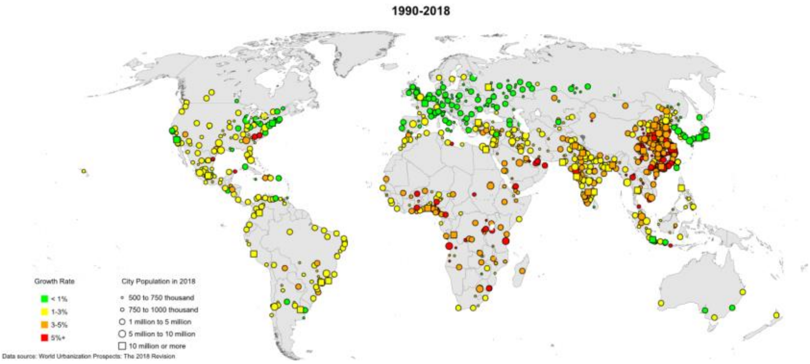
Figure 3.16 Average annual rate of change of the urban populations of the world for more and less developed regions, 1950-2020 (actual), 2020-2050 (projected)



Source: UN DESA 2019

This decrease in the pace of urbanisation is particularly true for Central and South America, as well as for Western, Southern and South-eastern Asia, while the global temperature, desertification and sea levels clearly were on the rise causing slow-onset changes affecting habitats and livelihoods (Figure 3.17).

Figure 3.17 Pace of urbanisation: growth of cities with more than 0.5 million inhabitants, 1990-2018, annual growth rate in percent



Source: UN DESA (2019)[32]

As the number of urban dwellers increases – partly because of slow-onset environmental degradation and climate change – this urbanisation exposes more people to sudden-onset disasters (floods in particular; Figure 3.18, Table 3.2). This is already evident when looking at recent displacements. Between 2008 and 2020 flood related natural disasters accounted for almost 50 percent of all disasters leading to displacement (Figure 3.5).

In general, floods affect rural and sparsely populated river deltas and coastal regions as well as cities equally. However, in regions with a high population density, they impact the lives of more people. In recent years (2008-2020), around 156 million people were displaced by floods. The vast majority (149 million) of them were living in coastal regions and river deltas (mostly in upper middle- and lower middle-income countries; Table 3.1). About 80 percent of them were living in cities (Figure 3.18).

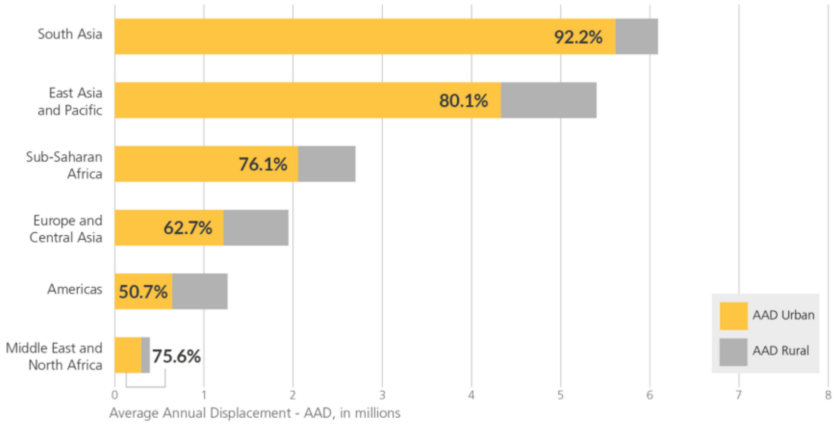
In absolute terms, the number of affected people was highest in South Asia (average: 6.1 million per year) and East Asia (5.4 million per year), followed by Sub-Saharan Africa (2.7 million per year). On average, much fewer people were displaced in Europe/Central Asia (1.9 million), as well as in North America (1.3 million). In the Middle East and North Africa, flood risks were comparatively small (0.4 million), as these are regions with a small amount of rainfall and, apart from Morocco, no exposure to oceans with high tides.

In relative terms, South Asia (92 %), East Asia (80 %) and Sub-Saharan Africa (76 %) had the highest shares of urban dwellers among all people displaced by

[32] https://population.un.org/wup/Maps/

floods. The share was lower in Europe (63 %)[33] as well as in North and South America (51 %) (Figure 3.18). This can be explained by differences in settlement structures, more solid construction, more advanced early warning systems and better flood protection of habitats in Europe, North America, and parts of South America. All of this can reduce both the overall risk exposure, in particular for urban dwellers, and the likelihood that extreme weather conditions have a detrimental impact on citizens. As a result, the likelihood of coastal populations being displaced by floods clearly varies between lower risk in upper-income countries and much higher risk in lower-middle and low-income countries (Table 3.1).

Figure 3.18 Total number displaced by flood related disasters and share of urban population, in percent of all people displaced by floods, annual average 2008-2018



Source: IDMC 2019

A growing number of people are currently residing in low elevation coastal zones. Long-term projections for 2100 indicate that more than one per cent of an estimated 9.5-10.0 billion world population will live in areas at or below today's sea level (elevation lower than 1 meter above current sea levels). That is a projected number of 115 million people compared to 74 million in 2020. Almost 500 million people will be living in habitats lower than 5 meter above today's sea level (2020: 327 mn), and more than one billion people will live in habitats lower than 10 meter above sea level (2020: 700 mn; Table 3.2). Many if not all of them could therefore be at risk in the absence of effective protective and preventive measures.

[33] Including Central Asia.

This projection is based on the current geographic distribution of settlements and assumed population growth, indicating the dimension of future exposure of people to the risk of flooding. The projection does not account for massive individual mobility or collective resettlement efforts away from shorelines, nor does it account for protective measures (such as dams, flood gates, tidal water management systems) in response to rising sea levels. This would help reduce populations at risk.

Table 3.2 Population residing in low elevation coastal and river delta zones, by elevation and type of area; actual figures for 1990, 2020, trend projection for 2100, in million, and in percent of total population

	1990		2020		2100 (projection)	
Elevation below 1m	**57**	**1.1 %**	**74**	**1.1 %**	**115**	**1.2 %**
Urban	34	0.7 %	42	0.6 %	68	0.7 %
Rural	23	0.5 %	32	0.5 %	47	0.5 %
Elevation below 5m	**250**	**5.0 %**	**327**	**5.0 %**	**490**	**5.0 %**
Urban	134	2.7 %	185	2.8 %	257	2.6 %
Rural	116	2.3 %	142	2.2 %	232	2.4 %
Elevation below 10m	**528**	**10.4 %**	**700**	**10.6 %**	**1064**	**10.9 %**
Urban	300	5.9 %	417	6.3 %	586	6.0 %
Rural	227	4.5 %	283	4.3 %	477	4.9 %

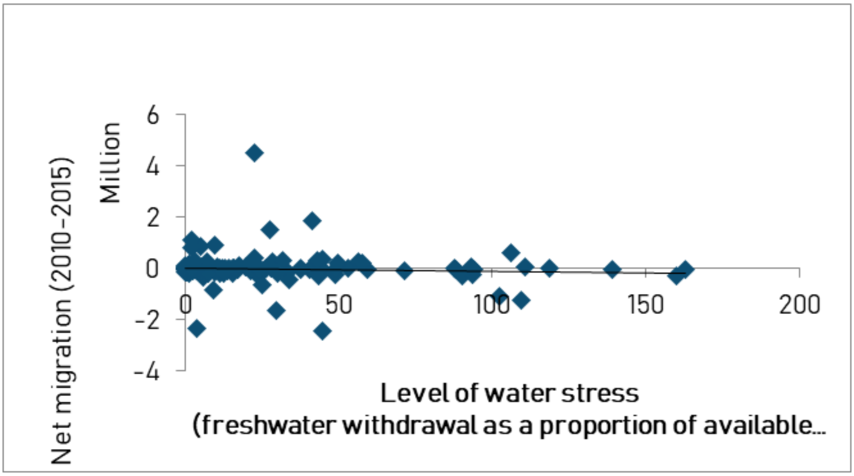
Source: NASA SEDAC (2021), NASA Earth Observing System Data and Information System (EOSDIS)

In the longer term, we may therefore also see an increase in urban-to-urban migration. That is, populations leaving urban areas in coastal areas for smaller towns and larger cities in areas that are not directly exposed to the risk of storm floods, rising tides, and coastal erosion.

In the past such urban-to-urban moves were partly linked to the relocation of key government functions from traditional coastal metropolises to new capital cities, established far away from shorelines: Rio de Janeiro to Brasilia (Brazil), Lagos to Abuja (Nigeria), Abidjan to Yamoussoukro (Ivory Coast), Dar es Salam to Dodoma (Tanzania), Rangoon to Naypyidaw (Myanmar). While the idea of moving bureaucracies, parliaments and governments away from a humid coastal climate has played a role in choosing inland locations, the only relocation explicitly linked to climate change and rising sea levels is the one planned in Indonesia: the establishing of a new capital city to be named Nusantara (replacing Jakarta as seat of government).

Another reason for future domestic mobility and international migration could be due to water stress: lack of fresh drinking water but also freshwater for irrigation. In this case, lack of environmental resources is not only the reason why people may leave water-scarce urban and rural areas, but are also a relevant factor in deciding *where* to go. Whether water stress establishes an important driver of internal or even international migration is unclear. So far, it seems to not be a measurable factor. Available data shows that, over the past decade, there was no correlation between the level of international net migration and the level of water stress (Figure 3.19).

Figure 3.19 International (net) migration flows (in million) and of level of water stress, by country



Source: Own elaboration based on data from World Bank (2020).

3.3 Conclusion

There is robust evidence of a direct link between the effects of climate and weather-related disasters and displacements – of which many occur in urban areas. However, most displaced persons sooner or later return to the original place of settlement.

In contrast to climate and weather-related disasters, we have some indication that slow-onset degradation of livelihoods can trigger a long-term or permanent change of residence. As a result, voluntary and involuntary mobility, mostly from rural areas to urban areas within countries, and to a smaller extent also across international borders is likely to increase. Rural-to-urban migration takes place even though exposure to sudden-onset risks in urban areas is rising and expected to further increase.

For this reason, chapter 4 discusses future migration and mobility scenarios for projected slow-onset changes, but not for natural disasters, which are less likely to contribute to long-term displacements.

4. Future climate scenarios

The following chapter presents possible scenarios in relation to the future of climate change and its implications for displacement and mobility. While it is difficult to predict future flows of international migrants and mobile citizens, this chapter tries to assess who will be exposed to increased risks: from heat waves and freshwater scarcity to floods and shoreline erosion. Based on recent studies, we try to differentiate geographically between these risks and try to quantify how many people will be negatively affected across multiple geospheres and world regions under specific climate scenarios. We also discuss the range of possible future developments explaining different types of uncertainties in these scenarios.

4.1 Global warming

The number of people that will be affected in the future by adverse effects of environmental and climate change is hard to predict as the pace and impact of climate change in the 21st century is uncertain and dependent on various possible countermeasures reducing greenhouse gas emissions that will (or will not) be taken in the coming years and decades. It is also dependent on measures implemented (or not implemented) that strengthen the resilience of resident population.

Global surface temperature changes relative to the early industrial period of 1850-1900 are projected to vary between +1.6 and +2.4 °C in the mid-term (2040-2060) and between +1.4 and +4.4 °C in the long-term (2080-2100) depending on the scenario (Table 4.1). A level of +1.2 °C has already been reached (see Figure 1.1).

Table 4.1 Changes in global surface temperature relative to the average global surface temperature of the period 1850–1900 based on five illustrative emissions scenarios, 2015-2100, in °C

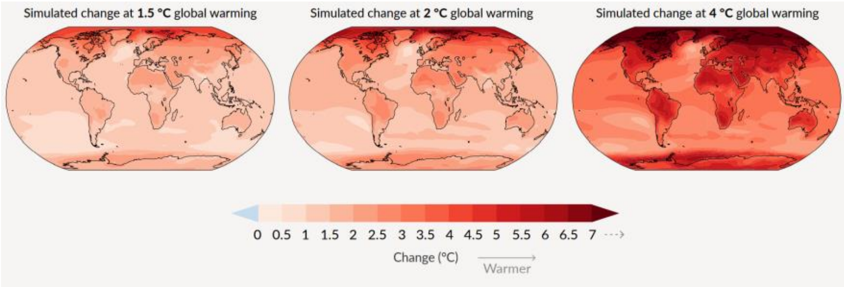
	Near term 2021-2040		Mid-term 2041-2060		Long-term 2081-2100	
Scenario	Best Estimate (°C)	*Very likely* range (°C)	Best Estimate (°C)	*Very likely* range (°C)	Best Estimate (°C)	*Very likely* range (°C)
SSP1-1.9	1.5	1.2 to 1.7	1.6	1.2 to 2.0	1.4	1.0 to 1.8
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 2.4
SSP2-4.5	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5
SSP3-7.0	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	2.8 to 4.6
SSP5-8.5	1.5	1.3 to 1.9	2.4	1.9 to 3.0	4.4	3.3 to 5.7

Note: Scenarios describe very low or low greenhouse gas (CO2, Methane) emissions (SSP1-1.9 and SSP1-2.6) based on immediate action, a medium assumption (SSP2-4.5) based on incremental change and scenarios with relative to high and very high greenhouse gas emissions scenarios (SSP3-7.0 or SSP5-8.5)
Source: IPCC 2021.

The effects of climate change will not be evenly distributed around the globe as – even within each of the five scenarios presented in the report of the International Panel on Climate Change (IPCC, 2021).[34] The rise in temperature at land and sea will vary geographically. By and large, the Artic and the continental land masses of the Northern hemisphere (including Northern Africa and the Sahel) will be more affected than the Southern hemisphere. Temperature increases are expected to be smallest in the Indian subcontinent, Southeast Asia, and Southern and Eastern China (Figure 4.1). This smaller impact is also expected for most parts of the Atlantic, the Southern Pacific, and the Southern Indian Ocean. The latter is, however, of small relevance for the number of people at risk.

[34] https://www.ipcc.ch/; https://www.ipcc.ch/assessment-report/ar6/

Figure 4.1 Simulated regional distribution of annual mean temperature change relative to 1850-1900 based on five illustrative emissions scenarios, 2015-2100, in °C



Source: IPCC 2021

The most obvious consequences impacting habitat and human livelihoods are:

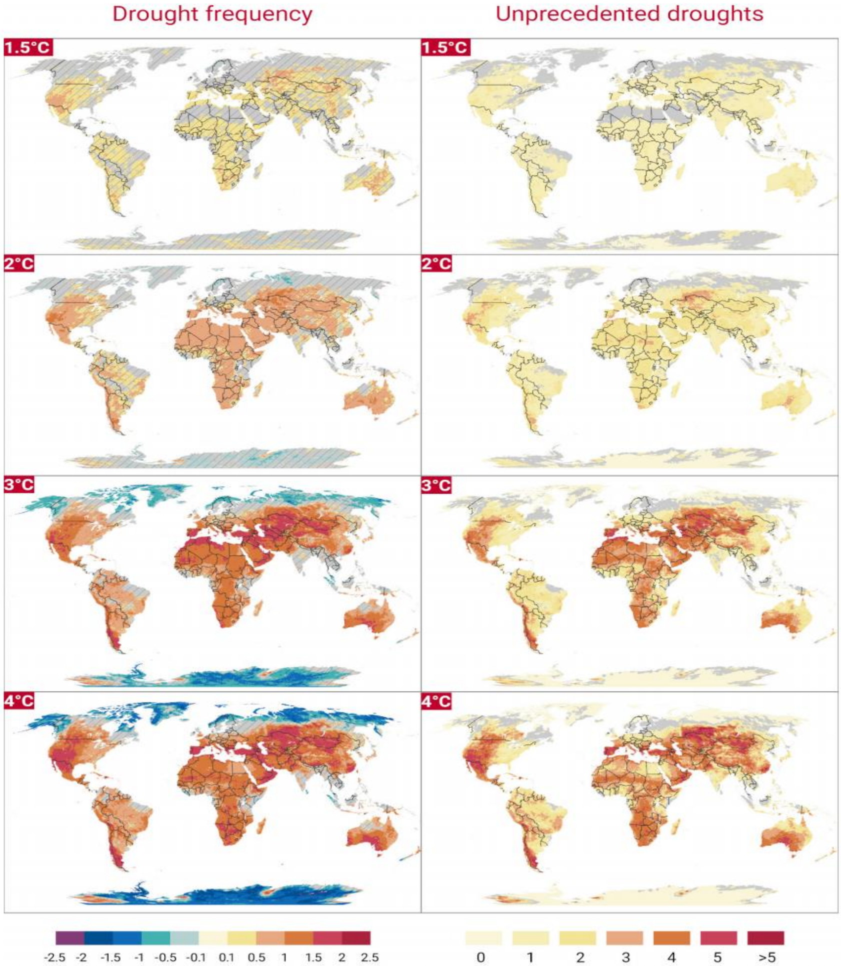
- Future changes in rainfall causing – depending on the affected regions – an increase in droughts and freshwater stress, or flooding of settlements and arable land.
- Protracted heat waves endangering the lives and well-being of affected populations.
- The projected rise of sea levels due to the melting of the Arctic and Antarctic ice shelf caused by higher surface temperature/less snowfall as well as due to volume (encaustic) expansion of oceans as water temperature rises.

4.2 Droughts

While occasional droughts can be mitigated through enhanced water management, irrigation and emergency measures, a permanent drop in average rainfall translates into permanent consequences for soil moisture and groundwater levels. This negatively affects both agriculture as well as freshwater supply (Figure 4.2). In combination with higher surface temperature this also leads to a higher probability of wildfires.

According to simulations published by the UN Office for Disaster Risk Reduction (UN DRR) based on assumed temperature changes, the frequency of droughts will increase in Southern Europe and the whole Mediterranean region, in Western Asia, Central Asia, Western China, North Africa and the Sahel region, in Central and Southern Africa, in Central and Southwestern parts of the USA, Central America, many parts of South America, as well as in most parts of Australia (Figure 4.3).

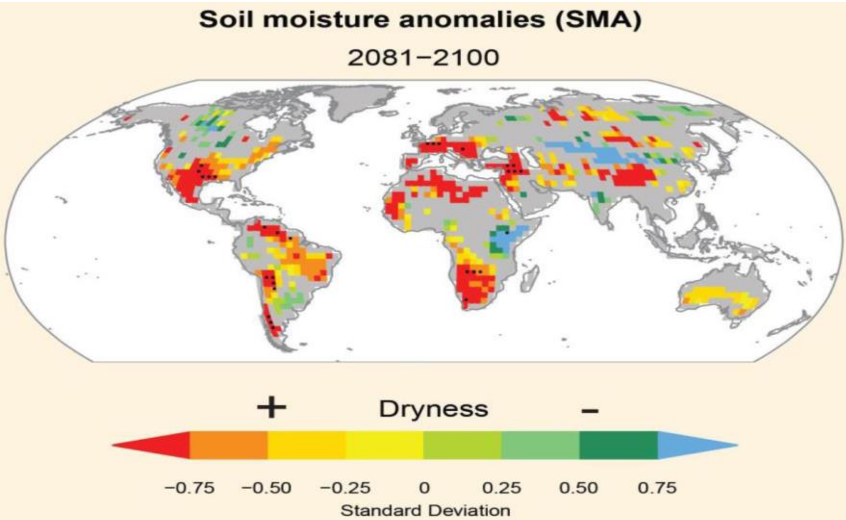
Figure 4.2 Simulated change in meteorological drought frequency



Note: Figure 4.2 shows events per decade in 2100 compared to recent past (1981–2010) (left side); and change in number of unprecedented drought events in 2100 with stronger severity than ever recorded in the recent past (1981–2010) (right side); four projected warming levels of global surface air temperature
Source: UNDRR 2021

Because of heat waves and frequent droughts, the vulnerability of agricultural systems is expected to increase in several parts of the world. Simulations project that the highest decrease in soil moisture with risks for local agricultural productions will occur in North Africa and parts of Western Africa, Southern Africa, Western and Mediterranean Europe, the Balkans, the Caucasus Region and parts of Western Asia, the eastern Himalayan region, Southern USA, Mexico, North-eastern Brazil, and the Andean highlands (Figure 4.3).

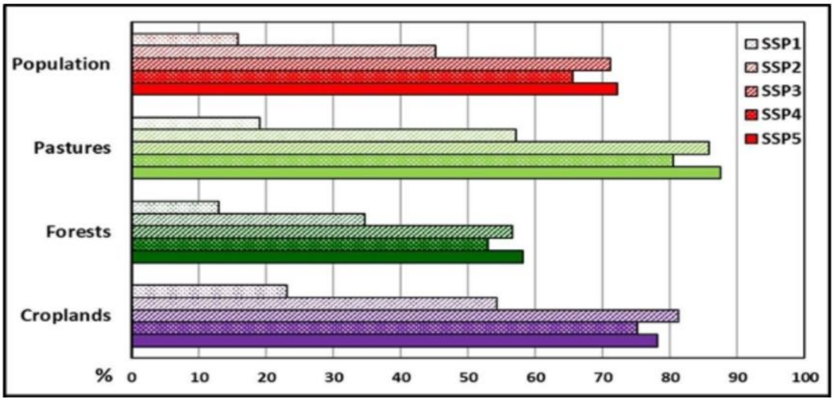
Figure 4.3 Drought vulnerability based on projected soil moisture anomalies, 2080-2100



Note: Dryer = yellow and red; wetter = green and blue
Source: Kurnik 2015

The share of the global population that will be affected by agricultural vulnerability, food insecurity, and freshwater stress will depend both on the frequency and duration of droughts and on efforts to mitigate climate change inter alia through modification and change of crops, improvements on irrigation systems, and enhanced freshwater management (including enhanced retention systems, water purification and desalination, as well as water recycling). The conservative SPP2 scenario – assuming a 2 °C increase in global surface temperature – predicts that 45 percent of the world population and some 55 percent of pastures, croplands, and forest (35 %) will suffer from droughts (Figure 4.4).

Figure 4.4 Percentage of areas and total population and extent of land-use classes subject to an increase in meteorological drought frequency and severity from 1981 to 2100



Note: The projections until 2100 are shown in accordance with the highest warming level assumed in five SSPs (1.5 °C with SSP1, 2 °C with SSP2, 3 °C with SSP4, and 4 °C with SSP3 and SSP5)
Source: UNDRR 2021

In 2018, the UN/World Bank High Level Panel on Water predicted that *"up to 700 million people were at risk of being displaced as a result of drought by 2030"* (Kirezci et al. 2020), but these figures are not easy to assess due to unclear model calculations and assumptions. As we do not know how the authors calculated this upper limit, we cannot easily support or dismiss the prospect of 700 million people becoming mobile because of droughts until 2030. Additionally, the UN/World Bank High Level Panel on Water did not specify whether they expect long-term or rather short-term displacement during droughts.

It is, however, clear that the upper bound of the projection would translate into an average of 54 million people displaced by droughts per year between 2018 and 2030. As we already have data available for 2018 to 2021, there is little evidence for such a large-scale drought-related displacement during the initial years of the projected period.

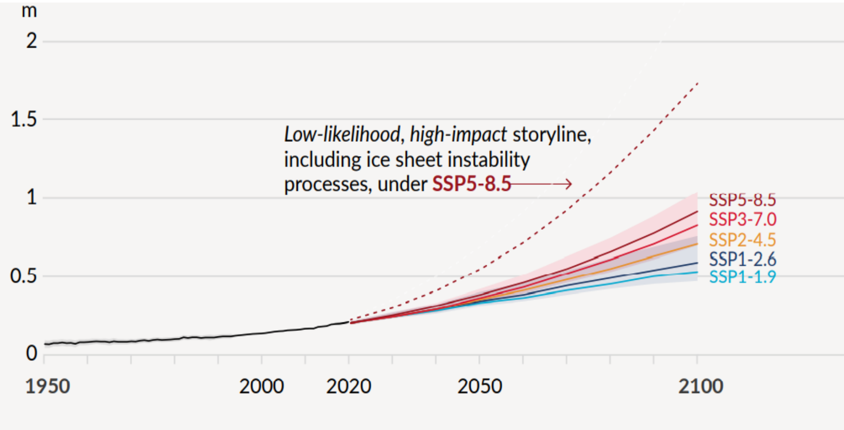
Protracted heat waves do not only negatively affect agriculture, forestry, livestock/animal breeding, and fishery. They can also directly endanger the lives and well-being of affected populations in general and urban dwellers. The latter are more exposed (in the absence of effective air condition) as cities are, on average, hotter than their non-urban surroundings (Zielinski 2014).

4.3 Sea level rise

While people (as well as animals, arable land and forests) potentially exposed to droughts are at risk of a diminishing water supply, those potentially exposed to floods have to deal with an abundance of water, though not necessarily freshwater.

Digital Elevation Models (DEM) based on geoinformation systems show the following: in 2021, approximately 700 million people occupied land with an elevation less than 10 meter above current sea levels (Table 3.2). Of them, 250 million live in habitats located at 0 to 2 meters above current sea levels (defined as Mean Higher High Water)[35] including those already living below sea level (Kulp and Strauss 2019).[36] The rise in sea levels has already forced an unknown, number of people to relocate.[37] This trend will continue to increase. At what pace though is unclear (Hauer et al. 2020).

Figure 4.5 Global mean sea level change relative to 1900 depending on the warming level assumed in five



Note: The five scenarios are SSPs (+1.5 °C with SSP1, +2 °C with SSP2, +3 °C with SSP4, and +4 °C with SSP3 and SSP5)
Source: IPCC 2021

[35] Mean Higher High Water (MHHW = the arithmetic average of the elevations of the Higher High Waters of a Mixed Tide over two decades).

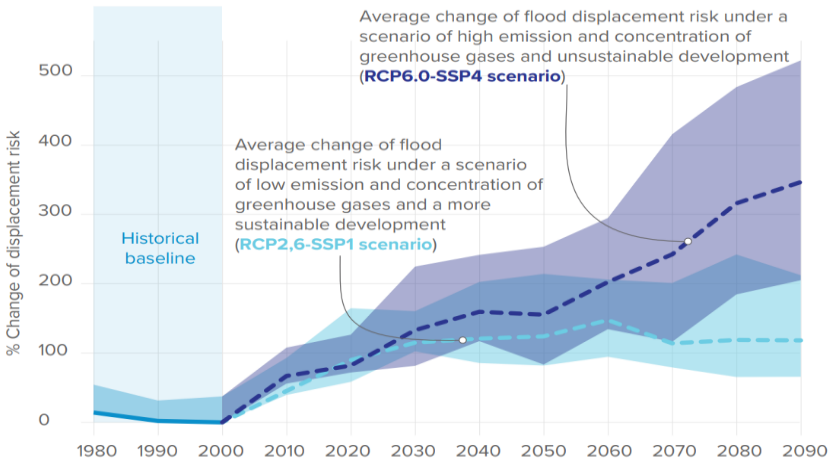
[36] The latter usually protected by dikes and tidal water management systems (for example, people living in Amsterdam or in lower parts of Jakarta).

[37] The effect is well documented for people living on islands in the Ganges-Brahmaputra delta in Bangladesh as well as people who had to relocate from low elevation parts of some small Pacific island states.

Even with drastic and immediate cuts to carbon emissions (which is the basic assumption of the most optimistic climate scenario SSP 1), global average sea levels will rise at least another 0.5 meter until the year 2100. Under scenarios assuming higher emissions (SSP 3, SSP 5), 21st century rise in sea levels may approach 0.8-0.9 meters in 2100, or even exceed this level in case of quicker than expected Antarctic ice sheet instability (SSP 5 extreme variant; Figure 4.5).[38]

In the optimistic scenario, the model-based risk of permanent displacement would increase on average by +100 to +140 percent until 2050 and stay at that level (with a range of uncertainty between + 70 % and +200 % at the end of the 21st century). In the pessimistic scenario, the risk would on average rise to +340 percent until the end of the 21st century (with a range of uncertainty between +200 % and +510 %) (Figure 4.6).

Figure 4.6 Simulated average risk of displacement of people living along shorelines and in river deltas resulting from sea level change in an optimistic (+1.5 °C, SSP1) and a pessimistic climate change scenario (+4 °C with SSP4)



Source: Kam et al. 2021

Most estimates of future mean sea-level rise by the end of this century expect an increase below 1 meter (Kam et al. 2021), but this increase will not be the same for all shorelines. The overall population exposed to these risks depends on future population density and settlement structure in coastal regions. Data from Digital Elevation Models (DEM) show that of all people currently settling

[38] See also Kopp et al. (2017).

on implicated land and are at risk of future displacement due to rising sea levels and related floods, 70 percent are living in eight countries of Asia: Bangladesh, China, India, Indonesia, Japan, the Philippines, Thailand, and Vietnam (Kulp and Strauss 2019).

China alone accounts for 18–32 percent of globally exposed people depending upon the scenario. Chinese coastal regions, now home to a total of 43 million Chinese, could be below sea level (MHHW)[39] by the year 2100; or in the worst-case scenario of an Antarctic ice shield instability (SSP 5-8.5), the Chinese population at risk could rise to 57 million people (Kulp and Strauss 2019).

Bangladesh, Thailand, and Vietnam are also home to about 10 million people living on land with very low elevation. By 2100, this would implicate 21–30 million people, even under the low emissions scenario (SSP 1); and another 7–20 million living on coastal land and in river deltas threatened by annual storm surges. As a result, these three countries, by the year 2100, face high tide flooding of permanently settled land that is now home to 19 percent of Bangladesh's population, 26 percent of Vietnam's population, and 17 percent of Thailand's current population.[40] This estimate does not account for episodic flooding events.[41]

In a worst-case scenario, continued high emissions coupled with Antarctic ice shield instability (SSP 5-8.5) could lead to the potential flooding of land currently home to roughly one third of Bangladesh's and Vietnam's population (Kulp and Strauss 2019).

Another 20 countries are expected to see land currently home to 10 percent or more of their total populations falling below high tide lines by the end of the 21st century (based on median estimates), even under the deep emissions cuts (SSP 1), bringing the total to 23 countries. 17 of these 23 countries with more than 10 percent of their population at risk are island nations.[42] The most important affected non-island states are Djibouti, Guyana, and the Netherlands.[43]

[39] Mean Higher High Water (MHHW) is the arithmetic average of the elevations of the Higher High Waters of a Mixed Tide distribution over two decades.

[40] See also Figure 4.8.

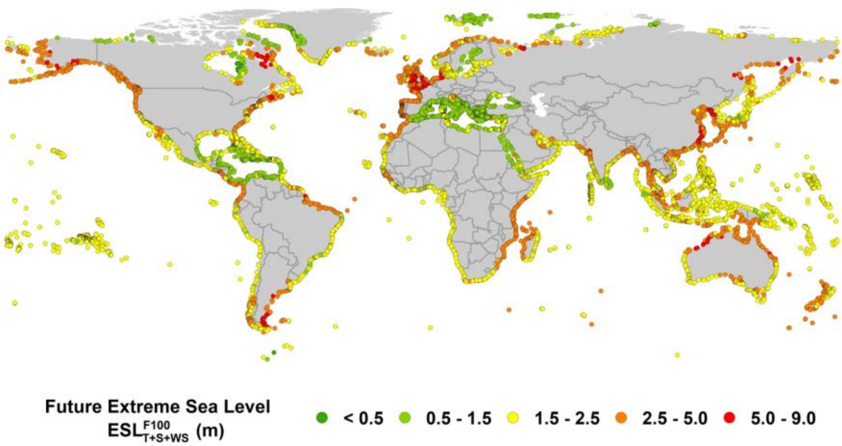
[41] See also Abadie et al. (2020).

[42] 13 of them are classified by the United Nations as Small Island Developing States (SIDS).

[43] The Netherlands (together with Germany) with the already existing North Sea dikes, flood gates, and tidal water management system might be fully able to cope with the rising sea level without having to relocate its citizens living in coastal and low elevation areas.

Even though rising sea levels are clearly a slow-onset process, one can expect that most displacement or pre-emptive emergency relocation of coastal settlers will be caused by tidal floods linked to occasional extreme weather conditions. For this reason, it is important to consider not only the average rise in sea levels, but to focus also on episodic coastal flooding linked to storms, exceptionally high tides and floods caused by heavy rainfall. The risk is unevenly distributed across the globe.

Figure 4.7 Projected hotspot regions vulnerable to episodic coastal flooding, in meters, end of the 21st century



Source: Kirezci et al. 2020

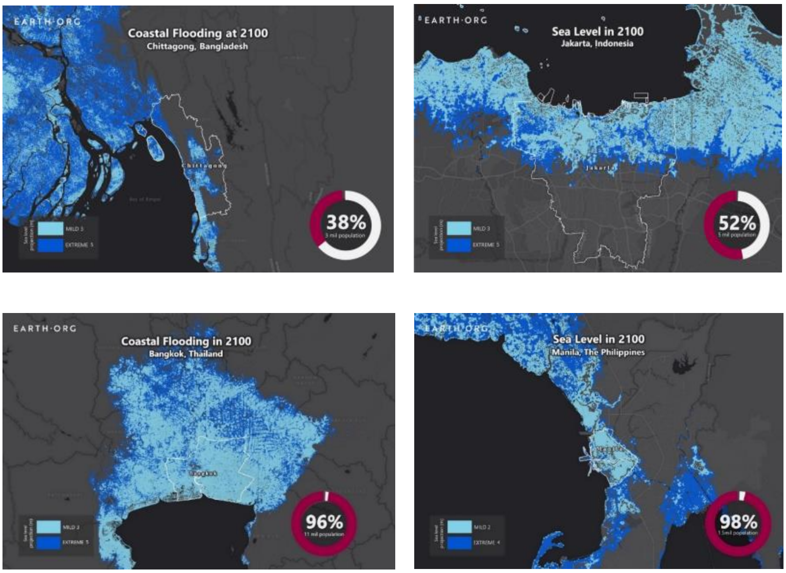
According to model-based projections,[44] the risk will be highest along the Atlantic coasts of North-western Europe and the Iberian peninsula, Morocco, US North Atlantic coasts, Brazil's North-eastern and Argentina's South Atlantic coast. Other highly affected regions include the Northern and Eastern shoreline of the Gulf of Bengal and the Malacca strait, China's, Japan's and Korea's East and South China Sea coast. In addition, Australia's Northern and New Zealand's West coast, East Africa's Eastern and Madagascar's Western coast, the Pacific coast of Alaska, Canada and North-western USA, as well as the Pacific coast between El Salvador and Ecuador will be affected. Other hotspots include India's Arabian Sea coast, Russia's Far East cost along the Okhotsk Sea and Papua-New Guinea's/West Irian's southern shoreline (Figure 4.7).

[44] https://www.researchgate.net/publication/343327740_Projections_of_global-scale_extreme_sea_levels_and_resulting_episodic_coastal_flooding_over_the_21st_Century

Several of these most affected coastal regions and river deltas are densely populated. Some are hosting metropolitan areas with millions of inhabitants at risk including, for example, Mombasa, Mumbai, Kolkata, Yangon, Guangdong, Shanghai, and Panama City, but also Seattle, Vancouver, Lisbon, London and Amsterdam.

Some metropolitan areas are affected due to their topographic exposure. Digital Elevation Models show, for example, that by the end of the 21st century, even under optimistic assumptions, areas hosting 38 percent of Chittagong's population (Bangladesh), 52 percent of Jakarta's population (Indonesia), and 98 percent of Manila's population (Philippines) would be living below current sea level (Figure 4.8). This does not mean that all of them will have to relocate.

Figure 4.8 Projected exposed territory and number of people on exposed territory below mean higher tide level in Chittagong, Bangkok, Jakarta, and Manila, by 2100, 2 scenarios[45]



Source: Map by O. Mulheren (see footnote 46)

The examples of the Netherlands and Lower Saxony (Germany) show that dams, river, and tidal water management systems allow large-scale permanent settlement below tide lines. Italy has implemented a system

[45]https://earth.org/data_visualization/sea-level-rise-by-the-end-of-the-century-chittagong; https://earth.org/data_visualization/sea-level-rise-by-2100-jakarta/; https://earth.org/data_visualization/sea-level-rise-by-the-end-of-the-century-bangkok/; https://earth.org/data_visualization/sea-level-rise-by-2100-manila/

protecting the city of Venice from floods caused by storms and high tides. For this reason, we cannot draw a direct line between the population at risk as predicted by elevation models and future long-term displacement or resettlement needs.

4.4 Thawing Permafrost soil

In contrast to floods and droughts, the expected melting of parts of the Arctic and Subarctic permafrost soil is much less discussed as a factor putting people at risk. Today, permafrost soil contains nearly half of all organic carbon stored within the planet's soil and covers 24 percent of the surface the Northern hemisphere. This includes large parts of Siberia and the Russian Far East, neighbouring northern parts of Mongolia and Chinese Manchuria, Tibet, the Scandes Mountains in Norway and Sweden, as well as the northern Part of Canada and most of Alaska (Figure 4.9).

Figure 4.9 Permafrost coverage of the Northern hemisphere

Source: Romanovsky et al. 2007 in UNEP 2007

With temperatures in the Northern Hemisphere (in particular in the Arctic) rising at much faster pace[46] than globally, permafrost layers are already melting. A 3 °C increase in global temperatures could induce the thawing of 30 to 85 percent of the top permafrost layers currently existing within the Arctic region. This would have two detrimental effects. Firstly, this process would release an unprecedented amount of carbon dioxide and methane into the

[46] Over the past 30 years permafrost soil temperatures have risen between 1.5 to 2.5 °C in the last 30 years (Bykova 2020).

atmosphere with dramatic consequences not only for the Arctic region, but globally.[47] Secondly, the thawing of frozen soil would destroy human settlements and infrastructure built on it.[48]

While regions with discontinuous coverage have already developed coping strategies such as preventing the collapse of buildings and the break-up or break-down of critical infrastructure, people settling on continuous permafrost are at risk of displacement due to the thawing soil. This does not only affect sparsely populated regions around the Artic Circle, but also Arctic metropolitan areas: for example, Yakutsk with more than 330,000 inhabitants,[49] and Norilsk, home to more than 150,000 people.[50]

4.5 Mobility and migration scenarios: certain and uncertain factors

We can already anticipate today which populations will be negatively affected by future slow-onset climate and environmental change, as well as sudden impact events (Figure 4.10):

- People settling in the northern parts of the Northern Hemisphere will be affected due to the melting of the Arctic ice shield and permafrost soil.
- People settling in the Caribbean and the Gulf of Mexico, the Western coast of Mexico, in and around Madagascar, in the eastern part of the Indian Ocean, in the East and the South China Sea and other parts of the Pacific are already today affected by heavy tropical storms which will increase in frequency and intensity.
- People settling in parts of the Mediterranean region, the Black Sea region, parts of Western Asia, South and East Asia, the Sahel, the Swahili coast, parts of Southern Africa, as well as parts of North and South America will be affected by reduced rainfall, droughts, and lack of freshwater.
- People (urban dwellers in particular) settling along ocean shorelines will be affected by rising sea levels and storm induced flooding.

[47] The world's permafrost contains up to 1,700 billion tonnes of carbon, which is about four times more than all man-made emissions since beginning of the Industrial Revolution. https://www.unep.org/news-and-stories/story/thawing-arctic-peatlands-risk-unlocking-huge-amounts-carbon

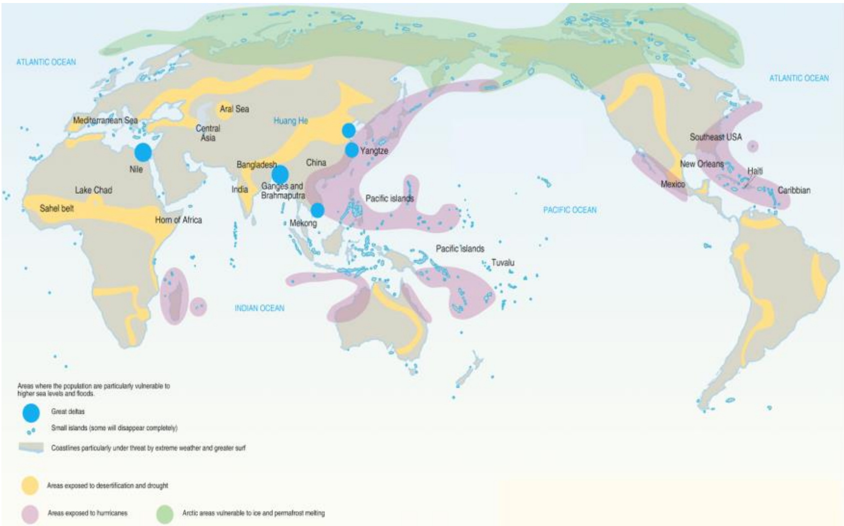
[48] https://www.bbc.com/future/article/20210303-the-unsure-future-of-roads-and-buildings-on-melting-ground

[49] https://worldpopulationreview.com/world-cities/yakutsk-population

[50] Rzhevsky, S. (2022); https://russiatrek.org/blog/cities/norilsk-the-view-from-above/

- People settling in great river deltas (Brahmaputra/Ganges, Huang He, Indus, Irrawaddy, Mekong, Mississippi, Yangtse)[51] will be affected by both downstream floods following heavy rainfall and storm induced tidal flooding aggravated by rising sea levels.
- People settling on islands with low elevation in the Western and Southwestern Pacific, the Indian Ocean, and the Caribbean.

Figure 4.10 Regions with vulnerable populations potentially affected by different impacts of extreme weather conditions and climate change



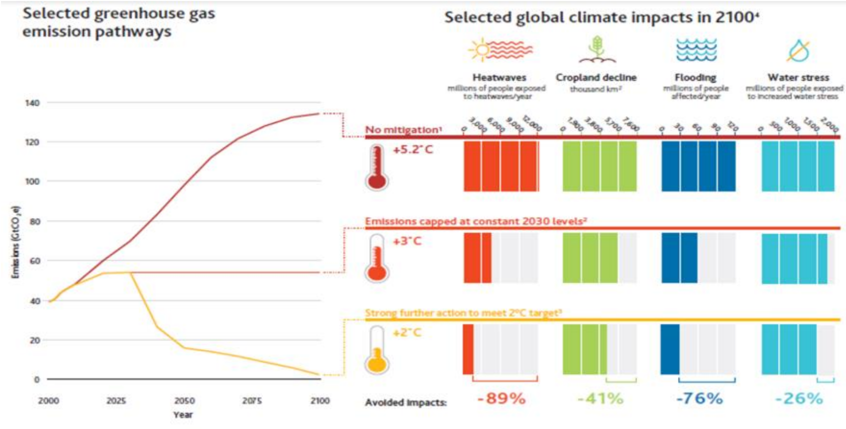
Source: E. Bournay, Monde Diplomatique based on Myers 2005, Lisert 2007

We can assume that by 2050, according to the IPCC Report of 2022, between 3.3 and 3.7 billion people, which correspond to 30-40 percent of the global population, is or might become – in one way or another – vulnerable, as they settle in one of the listed regions at risk. At the same time, model calculations show that a moderate increase in average global surface temperature (+2 °C; SSP2 requiring immediate action to cut greenhouse gas emissions) until the year 2100 could still expose about 2 billion people annually to prolonged heat waves, 30 million annually to disruptive floods, and about 1.5 billion annually to at least temporary water stress. A medium scenario (+3 °C with emission increase only stopped in 2030) could expose up to 5 billion people annually to

[51] The Nile delta is also often cited as example for an exposed river delta (see, for example, the map Figure 4.10) but rise of the Mediterranean Sea level is expected to be small, spring tides do not occur while floods caused by heavy rainfall are extremely unlikely given the arid climate of Egypt.

prolonged heat waves, 60 million annually to disruptive floods, and about 1.8 billion annually to at least temporary water stress (Figure 4.11).

Figure 4.11 Projected (model based) numbers of people affected by selected dimensions of climate impact according to different climate scenarios, 2100



Source: UK Met Office, World Bank (Clement et al. 2021

Evidence (as presented in Chapter 3) suggests that sudden-onset events are more likely to result in short-term displacement or evacuation of people at risk. This is usually followed by a return to the place or at least to the subregion of involuntary departure. It might, however, be that successive fast-onset events and disasters cause deteriorating living conditions or deplete household assets which may, in turn, encourage long-term outflows from affected regions (UK Government 2011).

In contrast to natural disasters, slow-onset environmental and climate changes are more likely to result in long-term or even permanent outflows to other parts of the country of residence, and possibly – but to a much smaller degree – also to international migration. Because of the uncertainties and unknowns already discussed (for example, pace and upper limit of global warming, intensity of rise in sea levels, effects of Artic and Antarctic ice sheet instability), it is, however, extremely difficult to seriously forecast the total number and regional distribution of people becoming directly affected.

We can anticipate climate change related degradation and disruption of livelihoods both in low- and high-income countries, but future mobility will not solely depend on the scale of climate change. We also must assume the human ability to cope and adapt, which opens up possibilities for people to stay and survive in affected regions. What remains uncertain, however, is the political will and collective resolve to invest in prevention and adaptation. This depends on the allocation of fiscal, as well as private, resources. For all these reasons it is almost impossible to predict the number of people who will become mobile because of climate change.

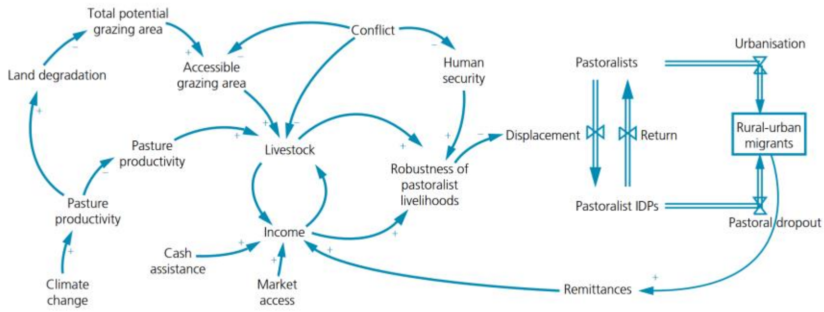
There is, however, key empirical evidence from the past which hints at our ability to adapt. Since the beginning of the 20th century, annual casualties caused by natural disasters have been reduced by more than 90 percent (Figure 3.2) despite a considerable increase in the frequency of such disasters (Figure 3.1) and the size of exposed populations (Figure 3.2). This clearly shows that building capacity to withstand adverse effects of climate change without being forced to relocate as well as coping capacities (i.e., building resilience) has been successful in the past and is therefore a likely strategy in the future.

Hence, any environmental determinism that draws a direct link between the size of populations exposed to environmental stress and their future mobility within a country as well as international migration would be misleading (de Sherbinin 2020). Environmental circumstances are just one among several factors that drive the decision to become mobile. By the same token, individual mobility and collective relocation are by far not the only ways that populations cope with climate change (see Chapter 2). It is, nevertheless, possible to highlight likely trends and establish a certain plausible range.

What can be taken for granted is a continuing rural-to-urban mobility in countries with urbanisation rates below 70 percent (Ritchie and Roser 2018). We can therefore expect this type of mobility to continue mainly in sub-Saharan Africa, South Asia, and Southeast Asia, but to a lesser extent also in the Balkans, Central Asia, China, and only in a small number of Latin American countries.[52] Part of this ongoing trend will be environmentally triggered mobility of people who suffer from droughts, soil salination, food insecurity and lack of freshwater supply, or from deteriorating income opportunities related to environmental degradation.

[52] The Balkans, Central Asia and most parts of Latin America have already reached high levels of urbanisation.

Figure 4.12 The complex relationship between climate change, pastoralism, conflict and mobility



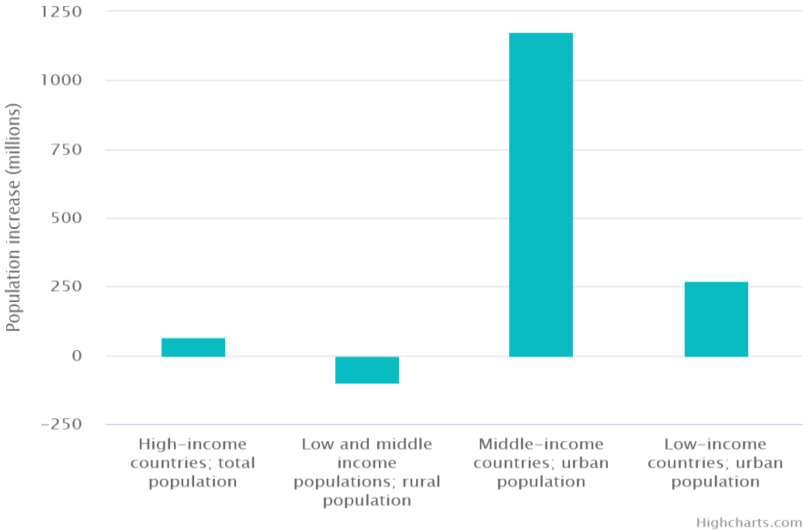
Source: IDMC 2014

A good example for this is the impact of climate change on rural communities of herders. Some of these communities lose their income and subsistence base as a result of climate change-induced droughts, land degradation (incl. soil erosion), and subsequent reduction of both grazing area and pasture productivity. This can force herders to reduce their livestock which negatively impact their earning capacity and their own food security. Conflict or competition between herder and farmer communities over scarcer land and freshwater resources have similar effects. Such constellations make it more likely that people belonging to herder communities move to urban agglomerations. Quite often the main motivation is not just to increase economic opportunities and food security, but also to get access to cash income which allows remittances supporting the community 'back home' (Figure 4.12).

The relation is, however, not straightforward. In pastoralist ecosystems, for example, persistent droughts and lack of freshwater supply may in fact mean that nomadic herders become less mobile owing to the loss of livestock. In that case, climate change can reduce mobility.

Furthermore, it is not a given that people manage to reduce risk exposure by becoming mobile. Many coastal cities and densely populated low-lying delta regions remain popular destination areas for people leaving rural areas despite their exposure to storm-induced tidal floods and rising sea levels (de Sherbinin 2020), as well as to heat waves (Zielinski 2014). Partly because of this mobility, during the next two decades (2020-2040), the urban population of middle-income countries is expected to rise by 1.2 billion people (Figure 4.13) reaching 5.6 billion in 2040.

Figure 4.13 The distribution of global population growth across rural and urban areas, 2020-2040



Source: Satterthwite 2020

As a result, rural-to-urban mobility which is partly caused by slow-onset environmental degradation will not necessarily decrease the population at risk as many people will move to urban and coastal environments with an even higher sudden-onset risks (flooding, heat waves).

For the two 'Groundswell' reports, commissioned by the World Bank, a group of experts tried to project how many people will become mobile for environmental reasons (Rigaud et al. 2019, Clement et al. 2021). Middle- and low-income countries in six development regions home to some 84 percent of the global population were covered by the analysis based on a complex model. The experts first identified areas with serious degradation (desertification, soil erosion or salination, permanent freshwater stress, coastal erosion, etc.) at a relatively small scale (25 by 25 km). In a second step, the population at risk living in these regions was quantified. Finally, the experts projected how many of those exposed to environmental degradation will change their place of residence within their country according to three climate and development scenarios.[53]

- In an optimistic climate scenario, the total number of people becoming mobile within their country of residence between 2020 and 2050 was

[53] A similar approach for Africa can be found in Migali and Natale (2021).

projected to be 78.4 million globally (median value; 1.1 % of total population) with a range of uncertainty between 44.1 and 112.6 million (Table 4.2).

- In a moderate development scenario, the number was assumed to be 125.2 million (median value; 1.7 % of total population) with a range of uncertainty between 90.9 and 159.7 million.
- In a pessimistic scenario, the number was assumed to be 170.3 million (median value; 2.3 % of total population) with a range of uncertainty between 124.6 and 216.1 million.

In all scenarios, covering the period between 2020 and 2050, the largest numbers are expected in Sub-Saharan Africa (28-71 million), followed by East Asia/Pacific (20-36 million) and South Asia (17-36 million). Mobility caused by environmental change was assumed to be smaller in Latin America (6-11 million) and in Central Asia (3-4 million). Relative to population size, the projections are highest for North Africa (6-13 million = 2-6 % of total population; Table 4.2). Most of the projected mobility is assumed to take place from rural to urban regions.

In the worst-case scenario, over a period of 30 years, 125 to 216 million people, corresponding to about 1.5 to 3 percent of the total population living in the analysed regions, would have to become mobile within their countries for ecological reasons. That equals 0.05 to 0.1 percent per year, which is well below current regular annual domestic mobility rates. From that perspective even “worst-case” rates appear low and manageable, but it should not be overlooked that this type of mobility will be regionally highly concentrated (Figure 4.14). That might lead to challenges – such as shortage of housing, pressure on infrastructure, labour markets, freshwater supply, sewage systems, etcetera – and possibly even conflict over shared resources at regional level (for example, availability of transport and public services).

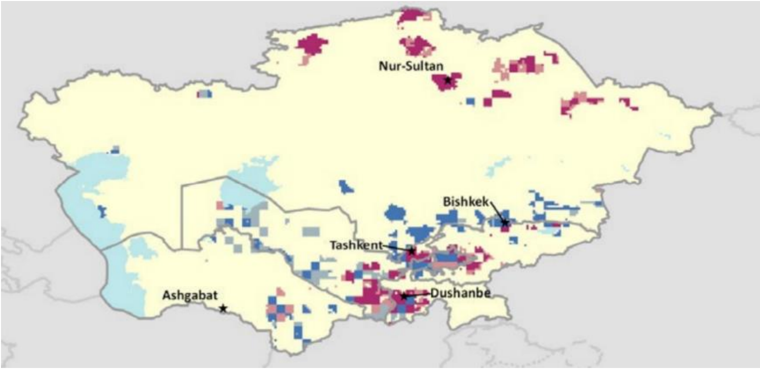
Table 4.2 Projected number of people who become mobile within countries for environmental reasons, 2020-2050, absolute numbers, in millions, and relative to total population, in percent, median values for 3 scenarios

	Scenarios					
2020–2050	Optimistic climate scenario (SSP 4 – 2.6)		More inclusive development scenario (SSP 2)		Pessimistic scenario (SSP 4 – 8.5)	
Macro-region	Absolute numbers in mill.	In % of tot. population	Absolute numbers in mill.	In % of tot. population	Absolute numbers in mill.	In % of tot. population
North Africa	4.5	2.1	9.9	4.2	13.0	6.1
Sub-Saharan Africa	28.3	1.4	53.4	3.0	71.1	3.5
Eastern Europe	1.0	0.7	1.1	0.7	1.3	0.8
Central Asia	1.7	2.4	1.9	2.6	2.4	3.5
South Asia	16.9	0.7	21.1	0.9	35.7	1.6
East Asia, Pacific	20.2	1.1	27.3	1.4	36.2	1.9
Latin America, Caribbean	5.8	0.9	10.6	1.5	10.7	1.6
Total for all analysed macro regions	**78.4**	**1.1**	**125.2**	**1.7**	**170.5**	**2.3**

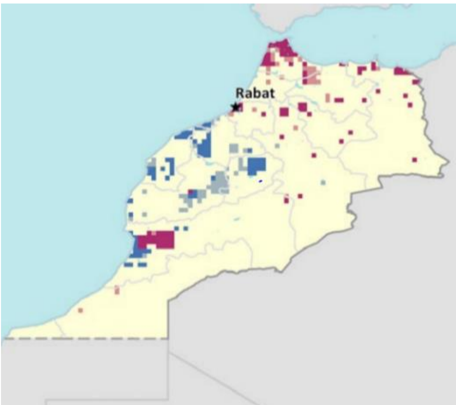
Note: Model calculations provide a range of uncertainty for each scenario described in the text above the table.
Source: Clement et al. (2021)

Figure 4.14 Projected internal climate mobility: examples from selected countries, 2020-2050, in absolute numbers (inflows: red; outflows: blue)

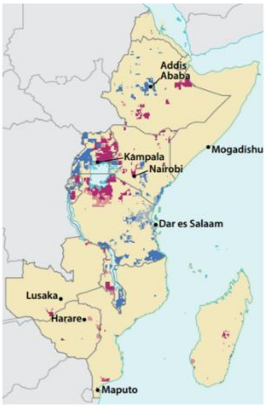
Central Asia



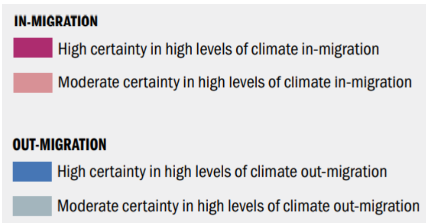
Morocco



Eastern Africa



Vietnam



Note: Based on small-scale regional analysis of domestic mobility; analysis excludes cross-border migration
Source: Clement et al. 2021, Rigaud et al. 2019

The projections published in the two Groundswell reports do not include the majority of people displaced by natural disasters as they usually do not leave their region of settlement. Another limitation is also evident: international migration caused by environmental degradation or natural disasters was not included in the projection. Political considerations might have been responsible for this.

The Groundswell reports project a wide range of future climate induced mobility. It is not only based on assumed climate change, but also on demographic and socio-economic factors influencing future human mobility. Ultimately the size and regional distribution of potentially vulnerable groups will depend on two factors:

1. On the speed and regional distribution of surface temperature increases (Figures 1.1 and 4.1); and
2. On population growth/decline in affected regions (Figures 3.15 and 4.14).

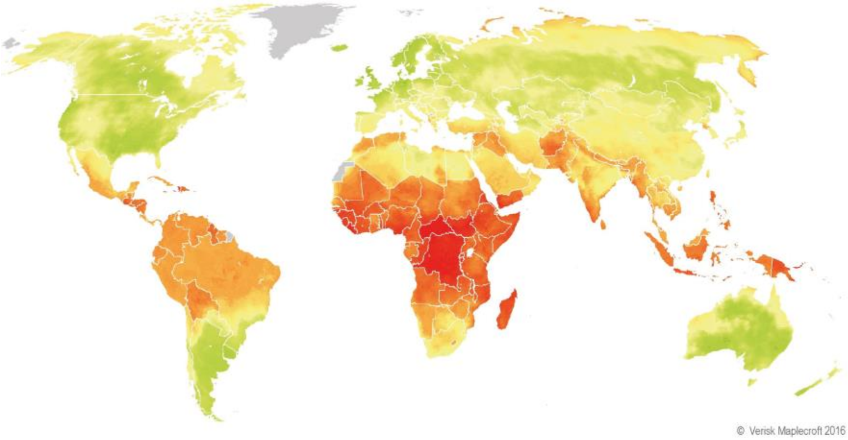
Whether people will be individually affected (under any scenario), will depend mainly on two factors:

- On the willingness and ability of individuals to reduce risks by changing residence.
- On the ability and resolve of national, regional, and local governments, economic actors, and civil societies to further engage and invest in prevention, adaption, and mitigation which would help reduce exposure to negative effects of climate change and create alternatives to climate induced mobility.

A Climate Change Vulnerability Index (like the one developed by Verisk Maplecroft[54]; Figure 4.15) combines the likely (model based) impacts of climate change leading to human climate stressors and a country-by-country assessment of national capacities to adapt to the negative effects of this change. The index suggests that future heat waves, flooding, droughts, soil salination, and other climate related slow-onset changes have the largest impact in countries heavily relying on farming, particularly subsistence farming, and lacking both preventive and adaptive capacity. Since climate change is likely to result in reduced and more variable crop yields, without adaptation to this trend, the negative impacts on economies and livelihoods may well be significant.

[54] https://www.environmental-finance.com/content/analysis/cop-blog-whos-got-most-to-lose-if-the-paris-agreement-fails.html

Figure 4.15 Climate change vulnerability based on assumed negative exposure to selected dimensions of climate change and the ability to cope



Source: Verisk Maplecroft 2016

While trends over the past 20 years indicate that reliance of economically active people on agriculture and fishery is decreasing globally and will continue to do so, some Central American, South and Southeast Asian as well as many sub-Saharan African regions are not only most vulnerable to climate change but are also heavily dependent on farming with a considerable share of subsistence farming. The same is true for some low-income countries with densely populated and exposed coastal regions and river basins. In the absence of large-scale engagement of donors and investors (including development banks) from the Global North, such countries with little fiscal space and poor public governance structures will neither have the capacity to build dams, drainage, river and tidal water management systems against floods and rising sea levels, nor have the capacity to build water retention and irrigation systems to mitigate droughts. The same is true at the individual level. Reducing the use of water resources in agriculture and animal breeding requires investment in water saving technology. Creating sustainable jobs that offer alternatives to farming requires investment in skills that can be marketed.

In 2008, the International Organisation for Migration (IOM) published a research report dismissing the often-quoted range of 150–200 million climate refugees as "*heroic extrapolation*" (Brown 2008: 12). The author of the IOM report concluded that

> [...] repetition does not make the figure any more accurate. While the scientific argument for climate change is increasingly confident, the consequences of climate change for human population distribution are unclear and unpredictable. With so many other social, economic and environmental factors at work establishing a linear, causative relationship between anthropogenic climate change and migration has, to date, been difficult.
>
> Brown 2008: 9

4.6 Conclusion

When making informed assumptions about future climate change, it is possible to identify regions undergoing significant environmental changes with adverse effects, such as prolonged droughts and heat waves, river floods, rising sea levels, and permafrost thawing. Based on these models, we can estimate the number of people who are, and will be living, in such regions, and in the absence of mitigation strategies, will be exposed to environmental risks.

However, it is impossible to calculate the number of people who will move within their country of birth or even to another country. Exposure to environmental risks does not automatically translate into human mobility. There is a possibility that people decide to stay or are forced to stay despite facing disadvantages. At the same time, there are other coping strategies beyond mobility, and there are ways in which the resilience of people and regions facing the impact of climate change can be strengthened.

While mobility will be one of the assumed coping strategies, we can infer that – based on current knowledge and available evidence – only a minority, which could still be a substantive number in absolute terms, of the affected population will become internationally mobile.

5. Implications for European policy making

The final chapter puts the focus on implications for Europe and European policy makers who must deal with climate change. It presents policy options and addresses the political challenges in preparing for climate change, reducing its impact, and managing or avoiding environmentally induced migration and mobility.

5.1 Humanitarian intervention and disaster relief

Natural disasters require rapid intervention addressing the immediate needs of negatively affected and displaced populations. EU member states and other European countries have established intervention capacity at local, regional, and national levels. However, when national authorities are overwhelmed, a solidarity amongst countries can be found, in which responsibility and capacities are shared. Upon request, the European Commission coordinates joint response efforts through the Civil Protection Mechanism.[55] By pooling together civil protection capacities and other resources, it allows for a stronger and often more rapid collective response, as capacities are deployed from different EU Member States.

When necessary, and through the Civil Protection Mechanism, the EU also offers assistance to affected countries and populations outside of Europe. When providing such humanitarian aid, the European Commission shares its competence with EU member states. The European Commission can allocate funds by its own discretion, but also financially and logistically support action taken by member states. Both types of financial 'intervention' have to be in line with the EU's Multiannual Financial Framework (i.e. 7-years budget) that is decided in advance by EU Member States and the European Parliament.[56]

When it comes to civil protection and disaster relief operations, the EU assumes a supporting role, providing (if necessary) financial support and coordinating voluntary contributions of in-kind assistance from countries

[55] The 27 EU countries as well as Iceland, Montenegro, North Macedonia, Norway, Serbia, and Turkey. https://ec.europa.eu/echo/what/civil-protection/eu-civil-protection-mechanism_en

[56] https://www.consilium.europa.eu/en/policies/the-eu-budget/long-term-eu-budget-2021-2027/

participating in the EU Civil Protection Mechanism.[57] Such activities are primarily taking place within the EU, but can extend to neighbouring non-EU countries (e.g., in North Africa, the Western Balkans, and Ukraine).

In addition, the European Commission promotes the coordination between civilian and military actors in emergencies (Humanitarian Civil-Military Coordination). The main aim of this coordination is to avoid competition between civilian and military capacities.[58]

Considering the increasing number of natural disasters linked to extreme weather conditions and climate change, it is of outmost importance to strengthen and upgrade civilian and humanitarian intervention capacities in those regions that are most affected. As an important donor and actor in the field of international development cooperation, the EU has a key role to play in this effort. Beyond immediate disaster response, the main aim of Europe's support outside of the EU should be to increase preparedness and resilience through enhanced civilian and humanitarian capacities for dealing with natural disasters in order to save lives, reduce human suffering, and prevent protracted or permanent displacement.

5.2 Prevention and adaptation

Prevention and mitigation strategies look at medium to long-term solutions to tackle climate change – primarily through reducing greenhouse gas emissions – rather than minimising the immediate impact of drivers that force people out of their homes.

European Policy addressing challenges linked to global climate change needs to start 'at home.' The European Union and most of its Member States are committed to the COP19 Paris Climate goal of preventing average global surface temperature from rising beyond +1.5 to +2.0 °C above pre-industrial levels. One feasible medium to long-term strategy against displacement, involuntary mobility, and climate related migration is therefore the reduction of greenhouse gas emissions[59] in European countries, and the reduction of European activities that trigger such emissions abroad.[60]

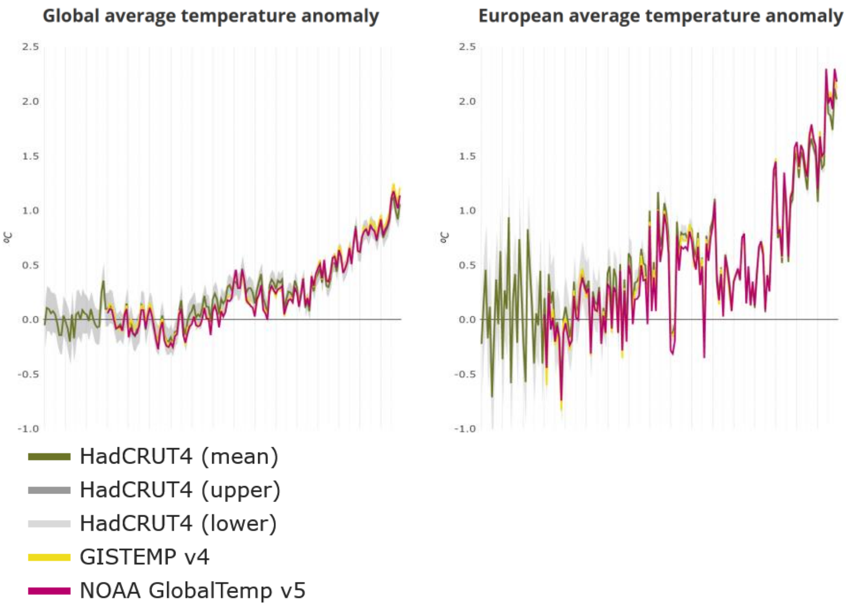
[57] Between 2001 and 2021, about 420 joint post-disaster interventions were coordinated through the Civil Protection Mechanism.

[58] https://ec.europa.eu/echo/partnerships/relations/civil-military-cooperation-emergencies_en

[59] Carbon dioxide (CO2), Methane (CH4) and Nitrous oxide (N2O) in particular.

[60] For example, the long-distance import of timber, palm oil and products containing palm oil as well as animal feed (such as soybeans).

Figure 5.1 Change in global surface temperature as observed, global averages, European averages, 1850-2020, in °C



HadCRUT4: Met Office Hadley Centre and Climatic Research Unit (Morice et al. 2012)
GISTEMP v4: NASA Goddard Institute for Space Studies (Lenssen et al. 2019).
NOAA GlobalTemp v5: National Oceanic and Atmospheric Administration (Karl et al. 2015, Zhang et al. 2019).

Source: https://www.eea.europa.eu/data-and-maps/indicators/global-and-european-temperature-10/assessment

At a European level the 'Green Deal' proposed by the European Commission in 2019[61] is the main vehicle. It is, essentially, a growth strategy to enable the European Union to attain climate neutrality by 2050. The ultimate aim is to achieve a zero-carbon footprint by balancing the amount of carbon dioxide (CO2) that is released with the carbon removed from the atmosphere or fixed by plants. The European Commission proposes to further cut greenhouse gas emission from the initially agreed 40 percent[62] by at least 50 percent and, if possible, by 55 percent That is, below 1990 levels by 2030. This proposal will require instruments such as the Emissions Trading System and further directives related to changes in land use.

The EU 'Green Deal' and national targets as well as implementation strategies set by European countries are – first of all – in the genuine interest of Europeans as the EU and its neighbourhood will be more affected by the rise

[61] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

[62] European Commission: 2030 climate & energy framework (europa.eu)

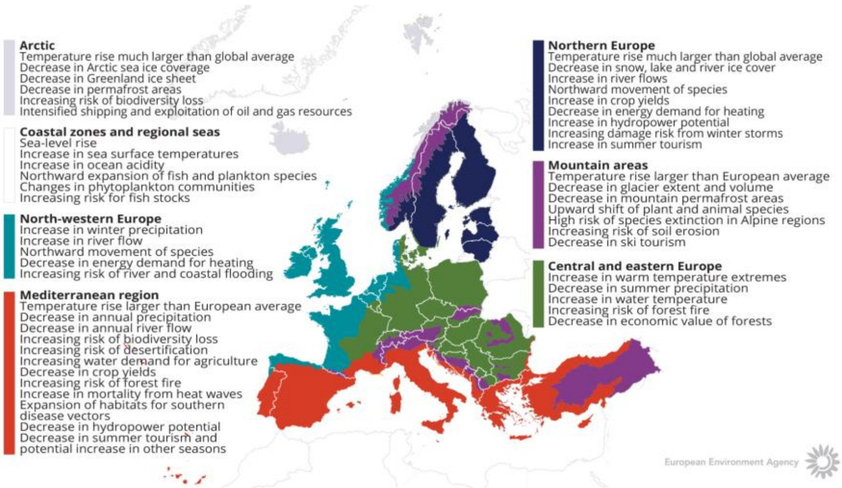
in global temperature than other parts of the world (Figure 5.1) with a wide range of implications.

Projected impacts for Europe are multifold, ranging from reduced ice shields in the Arctic and Greenland as well as rising sea levels in the North Atlantic and North Sea, higher precipitation and flood risks in Northwestern Europe to significantly decreasing precipitation in the Mediterranean region as well as Central, Eastern and South-eastern Europe increasing not only freshwater stress but also the risk of heat waves and wildfires.

Not all changes will be negative (e.g., higher crop yields in Northern Europe, better prospects for Winter tourism in the Mediterranean), but overall expected changes are challenging or even disruptive calling for early adaption and mitigation strategies (Figure 5.2).

The 'Green Deal' and national implication strategies also have an indirect impact on future climate-induced mobility and migration, even if this impact cannot be directly quantified.

Figure 5.2 Projected impact of climate change on Europe's macro regions



Source: Kurnik 2015

As the EU27, the UK, Norway, and Switzerland are responsible for only about 9 percent of global greenhouse gas emissions, any sustainable strategy needs to build alliances with other main emitters, namely China (32 %), the USA (14 %), India (7 %), Russia (5 %), and Japan (3 %)[63] in order to credibly implement global reduction strategies.[64]

This is not only a position that assumes global responsibility but would directly benefit EU Member States as well neighbouring countries. Compared to pre-industrial levels, Europe (as part of the Eurasian land mass of the Northern hemisphere) is more exposed to global warming than many other parts of the world. Since the year 2015, the European average surface temperature is already +2.2 °C (2020) above pre-industrial levels (Figure 5.1) and is likely to increase further.

With the prospect of a new Cold War following Russia's war against and occupation of Ukraine, a climate agreement between the EU and Russia containing binding emission targets has become unlikely. Western attempts to reduce dependency on Siberian gas might also include a later phasing out of electric power plants using coal and lignite, thereby making the goal to meet emission targets less likely.

Table 5.1 Land area and people negatively exposed to sea-level rise in the North Sea and the Baltic Sea, different scenarios

	North Sea		Baltic Sea	
Scenario	Area (km^2)	People	Area (km^2)	People
Increase of 1.8 °C with coastal protection	476	1,400	585	4,077
Increase of 3.7 °C with coastal protection	513	1,654	644	5,982
Increase of 3.7 °C without coastal protection	8096	619,317	908	7,563

Source: Schuldt et al. 2020

[63] Figures for 2020, data source: https://ourworldindata.org/grapher/annual-co-emissions-by-region

[64] The final communique of the G20 summit 2021 documents that we are still far away from global consensus among the main greenhouse gas emitting economies: https://www.reuters.com/world/g20-leaders-have-reached-deal-climate-language-final-communique-source-2021-10-31/

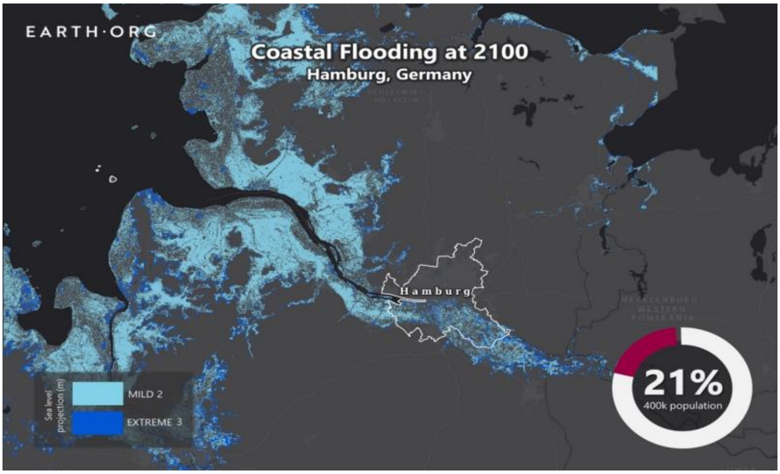
5.3 Mitigation

In contrast to prevention strategies, climate mitigation and adaptation activities are more geared towards increasing the resilience within communities to cope with environmental stress. The main rationale of climate adaptation aiming at reducing displacement risk is twofold:

1. To minimise the adverse impact of climate change that induces people to leave their areas of origin, and
2. To provide assistance to vulnerable populations who remain, without locking them into areas that become increasingly unviable and unsustainable. Ultimately, the aim is to support people at risk of displacement in becoming more resilient, alleviating pressures on local resources and infrastructure, and, by extension, reducing tensions between displaced or mobilised people and their host communities.

Extreme weather events causing floods and droughts are already increasing (Figure 3.2). In order to avoid scenarios in which European citizens are displaced, European countries and regions need to invest in climate change adaption and mitigation. The most obvious strategies are investments that help to prevent inland and tidal floods, but also investment in drainage systems.

Figure 5.3 Projected exposed territory and number of people on exposed territory below mean higher tide level in Hamburg, Lower Saxony and Schleswig-Holstein, by 2100, 2 scenarios[65]

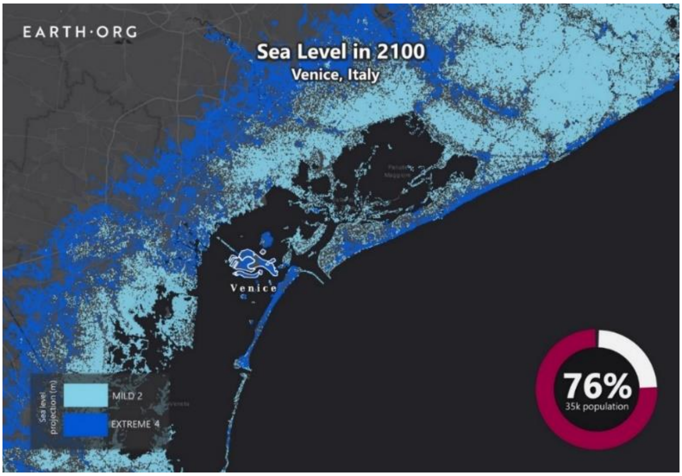


Source: Map by O. Mulheren (2020)

[65] https://earth.org/data_visualization/sea-level-rise-by-2100-hamburg/

European populations living along the North Atlantic coast as well as along the British, Dutch, and German North Sea coast are highly exposed to risks related to rising sea levels and tidal floods caused by storms (for example: Figure 5.3). Belgium, Germany (Schuldt et al. 2020), and the Netherlands[66] will need to improve their dike and flood gate systems along the North Sea coast. A model calculation for Germany's coastal regions (North Sea, Baltic Sea) indicates that without additional coastal protection, higher dikes and flood barriers, around 620,000 people might need permanent resettlement (Table 5.1, Figure 5.3).

Figure 5.4 Projected exposed territory and number of people on exposed territory below mean higher tide level in Venice, by 2100, 2 scenarios[67]



Source: Map by O. Mulheren (2021)

Relevant examples are not limited to exposed regions at Europe's North Sea coast. Italy established a floating flood barrier system (MOSE) in 2020 that is able to protect the city of Venice and surrounding island settlements from floods of up to 3 meters above average sea level.[68]

Projections show, however, that by the end of the 21st century, the established barriers protecting the three natural entries to the Venice lagoon might not be

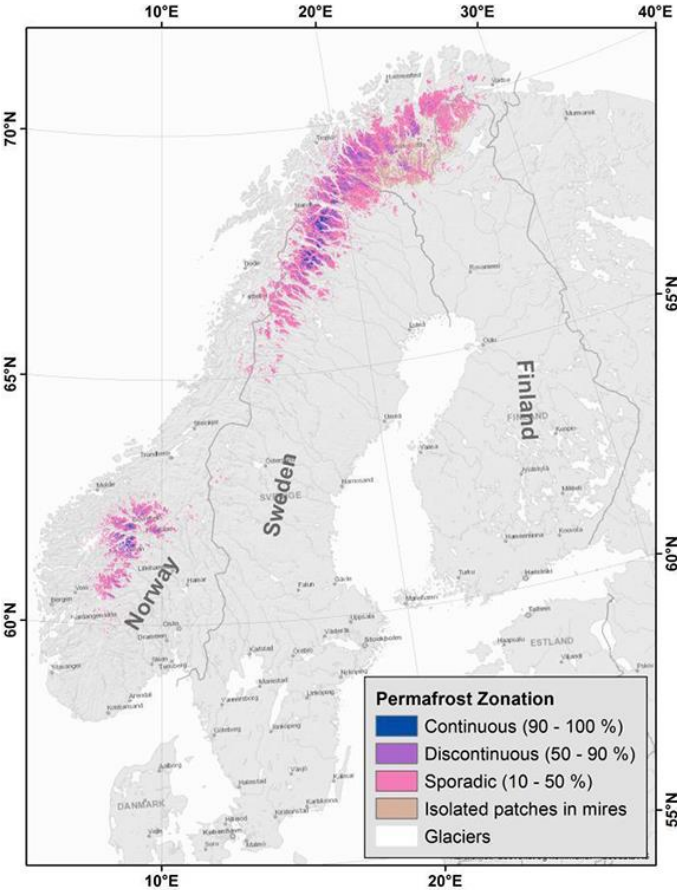
[66] https://www.vn.nl/rising-sea-levels-netherlands/

[67] https://earth.org/data_visualization/sea-level-rise-by-the-end-of-the-century-venice/

[68] https://www.designboom.com/architecture/mose-flood-barrier-venice-storm-alex-10-05-2020/. See also Molinaroli et al. 2017

enough, in case of a higher-than-expected rise in Mediterranean Sea levels (Figure 5.4).

Figure 5.5 Permafrost coverage in the Scandic Mountains[69]



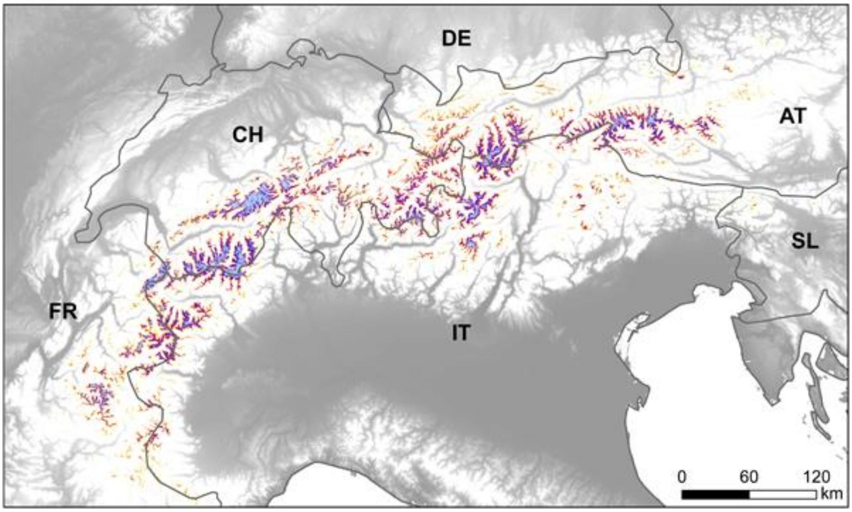
Source: Gisnås 2016

Floods are not the only risk. In Europe, thawing permafrost soil exists not only in Scandinavia's Arctic regions and the Scandes Mountains (Figure 5.5), but also in the Alps (Figure 5.6) and to a much small extent in the Pyrenees. Global warming will therefore lead to an increasing number of massive rockslides affecting human settlements, farms, tourist resorts, and infrastructure in mountain valleys. Adaption strategies will have to include alarm systems and possibly also the anticipatory relocation of populations.

[69]https://www.mn.uio.no/geo/forskning/aktuelt/arrangementer/disputaser/2016/pdf/gisnas_permafrostscandinavia700px.jpg

At the same time, rising temperatures, higher variability in rainfall, and prolonged dryness puts stress on Europe's forests, in particular mountain forests, which protect human settlements from snow avalanches and mudslides.

Figure 5.6 Permafrost coverage in the Alps



Source: Permanent, Univ. of Zurich (2018)[70]

5.4 External intervention and support for enhancing resilience outside Europe

One main aim of Europe's external strategy should be to promote increased resilience of economies and societies of middle- and low-income countries. For countries with a large agricultural sector, a prime climate adaptation and mitigation strategy would mean reducing the dependency on subsistence farming by developing alternative income opportunities. This would reduce people's vulnerability as related to climate change. Furthermore, the market-oriented part of the agricultural sector could profit from the transfer of knowledge, thereby informing about, for example, drought resistant crops, aquaculture and sustainable fishing, water efficient irrigation and retention systems, etcetera.[71]

[70] https://www.geo.uzh.ch/microsite/cryodata/PF_map_explanation.html

[71] https://donortracker.org/insights/financing-future-climate-finance-and-role-oda

Additionally, European and international donors as well as development banks[72] can play a key role in building or upgrading climate-resilient infrastructure, for example by investing in climate- and flood-resilient housing; building dams, dikes and flood gates protecting settlers in coastal regions, and river basins coupled with flood-proofing and upgraded warning systems. All of these measures reduce fatalities and decrease the risk of displacement for exposed populations. This is particularly important in areas that are prone to climate-induced loss of land and damages, such as low-lying coastal areas (e.g., in Bangladesh, Vietnam) or countries that are frequently hit by storms (e.g., the Caribbean and the Pacific region). At a European level, the European Investment Bank (EIB) has already increased its lending directed at enhancing climate resilience.[73] National development banks[74] have established programmes with similar targets.[75]

5.5 Insurance and capital market instruments

Climate risk financing instruments are other means to increase resilience for people dependent on farming income. For instance, risk transfers in form of climate insurances (crop insurance in particular,[76] but also elementary loss insurance), provide a quick (if disbursed swiftly) and efficient way to compensate for climate-induced loss and damage for those covered by this instrument. As a result, insurance coverage can protect vulnerable populations from the risk of permanent displacement as well as destitution. Unlike investments in infrastructure – like dams, floodgates, etcetera. – climate risk financing can be undertaken both at macro and micro levels to directly target affected and vulnerable populations.

Crop insurances,[77] for example, are available to farmers selling their products at markets. Crop-yield insurance protects the expected revenue due to unexpected drops in harvest or entire crop loss caused by wildfire, drought, flooding, exceptionally low temperatures, or animal disease or pests. Crop-revenue insurance also covers expected revenue loss owing to market

[72] https://publications.iadb.org/en/2018-joint-report-multilateral-development-banks-climate-finance

[73] https://www.eib.org/en/about/priorities/climate-action/index.htm

[74] Such as the French 'Agence Française de Dévelopment' (AFD), the German 'Kreditanstalt für Wiederaufbau' (KfW), and the Italian 'Banca Italiana di Svilupo' (BIS).

[75] https://www.climatechangenews.com/2019/12/13/development-banks-propose-common-framework-climate-resilience/

[76] https://www.climatechangenews.com/2019/12/13/development-banks-propose-common-framework-climate-resilience/

[77] https://www.fao.org/3/y5996e/y5996e02.htm; see also Mahul and Stutley (2010).

fluctuations of crop selling prices. Such insurance schemes were first set up by government agencies: at first in the USA already in the 1930 and after World War II also in Europe.

Since the 1990s, catastrophe (CAT) bonds issued and traded at capital markets serve as re-insurance to climate insurers.[78] They are high-yield conditional debt instruments designed to raise money for companies in the insurance industry, helping them share their financial risks resulting from claims following natural disasters. A CAT bond allows the issuer to receive funding from the bond to reinsure specific risks defined in advance. The risk is then shared between the issuing insurance company and the investor holding the bond. If an event protected by the bond, such as an earthquake, hurricane, or flood, activates a payout by the insurance company, the obligation to pay interest on the bond or even to repay the bond is either deferred or completely forgiven. Conditions are set in advance. Investors do not get their money back if the costs of the covered natural disasters exceed the total amount raised from the bond issuance. However, if the costs to cover the disaster do not exceed the specified amount during the time until the bond matures, the invested money is paid back. In “regular times” (without insured losses from disasters) the investor also benefits from receiving high interest payments in return for holding the bond.

In most developing countries, climate risk insurance is not yet well established at a scale that would give populations at risk of displacement or loss of harvest the possibility to withstand a major disaster. This is partly due to inadequate regulations and a lack of risk data in countries and regions that would need the coverage most urgently. Additionally, there is not enough capital available to create/establish insurances.

In this context, European countries and the European Commission can contribute to develop this sector with meteorological and disaster-register data, know-how, and grants. Europe is also able to provide necessary capital through the European Investment Bank (EIB) and national development banks.

There is, however, a problem that cannot be solved by better data or capital transfer. Many farmers and herders in low-income countries are subsistence oriented and do not produce for markets. As a result, they do not have access to cash income which would be necessary to buy insurance covering unexpected losses. This clearly shows the limits of insurance companies and capital markets: They cannot absorb the environmental risks that

[78] https://www.artemis.bm/library/what-is-a-catastrophe-bond/

impoverished and vulnerable populations living at the margin of (or outside) the cash economy is exposed to.

5.6 Permanent resettlement to destinations within a country and or to other countries

One of the most effective, but also costly, forms of adaptation is the pre-emptive relocation of people living in places at risk of coastal erosion and spring tides, repetitive or permanent flooding, or similar natural hazards.[79] In Europe, such projects are usually limited to smaller habitats with high flood risks in the vicinity of rivers. People settling in exposed places with a high risk of being hit by avalanches in mountain regions are occasionally profiting from organised and state-sponsored relocation. Outside of Europe, such relocation projects will become more important with rising sea levels already under way.

In 2021, a mapping exercise documented more than 300 relocation projects globally (Figure 5.7). For instance, in 2018, the World Bank approved a credit line of up to US $ 30 million (IDA credit) for the development of a permanent relocation site with adequate housing and social infrastructure for populations living in at-risk coastal areas in Saint-Louis, Senegal.[80]

The most ambitious of these projects is still under discussion: the relocation of Indonesia's key government functions from the current political centre Jakarta on the island of Java to a new capital to be named Nusantara in East Kalimantan on the island of Borneo. The move is part of a plan to reduce the population of Jakarta, which already has a populated city territory below sea level and is expected to be partially flooded on a permanent basis (Figure 4.8).[81]

[79] https://news.un.org/en/story/2019/07/1043551

[80] https://projects.worldbank.org/en/projects-operations/project-detail/P166538

[81] The first stage of establishing Nusantara is expected to cost $33 billion, of which the government will fund about 20 %. The remaining funds are anticipated to come from private-public partnerships and private investment. https://www.aljazeera.com/news/2019/08/indonesia-capital-located-borneo-island-190826074218708.html. The relocation had been temporarily put on hold as the government reallocated funds to support its COVID-19 response and the post-CoVid 19 recovery https://www.reuters.com/article/us-health-coronavirus-indonesia-capital/indonesias-capital-relocation-on-hold-shifts-budget-to-fight-pandemic-idUSKCN2260L7; https://www.theborneopost.com/2021/06/03/indonesias-new-capital-city-project-in-east-kalimantan-postponed-again/; Since 2022 the relocation project is back on track https://www.theguardian.com/world/2022/jan/18/indonesia-names-new-capital-nusantara-replacing-sinking-city-of-jakarta

European countries and the European Commission could support such resettlement projects, helping to share best practices as the number of successful relocations of entire populations will increase.

Figure 5.7 Started or completed permanent relocation projects of people in response to hydrometeorological and environmental hazard, absolute numbers of projects by country, 2021

Source: Bower and Weerasinghe 2021

5.7 Towards an international policy framework

EU Member States have signed several – non-binding – multilateral declarations and recommendations developed under the umbrella of the United Nations which address mobility and displacement in the context of climate change and natural disasters.[82] The majority of them propose ambitious goals but (with the exception of the GCM 2018) do not include detailed policy guidance.

- In 2010, the Cancun Adaptation Framework (2010) invited States to coordinate and cooperate on “climate induced displacement, migration and planned relocation.”[83]
- The Paris Climate Conference (COP 21) in 2015 announced the creation of an advisory body to “avert, minimize and address displacement related to the adverse impacts of climate change” (UNFCCC 2015).

[82] For an overview see IOM (2018), Stojanov et al. (2021).

[83] https://unfccc.int/process/conferences/pastconferences/cancun-climate-change-conference-november-2010/statements-and-resources/Agreements

- The Sendai Framework for Disaster Risk Reduction (2015) called on "strengthening the resilience of people and communities."[84]
- The Global Compact for Safe, Orderly and Regular Migration (GCM 2018) called on involuntary movements to be reduced and prevented. It included a set of policy recommendations for managing movements induced by "*natural disasters, the adverse effects of climate change and environmental degradation*" (UN GA 2018).

Unlike political violence and individual persecution, under current asylum regimes, the loss of livelihoods due to natural disasters does not constitute a legitimate reason to ask for admission in another country. Neither the Geneva Convention nor the European Refugee Convention or any asylum law at EU Member State level includes such provisions. Therefore, from a purely legal point of view, 'climate refugees' do not exist. UNHCR, the UN agency for refugees, has made it clear since the beginning of the 21st century that they do not seek any extension of their mandate to include and protect people forced to move for ecological reasons (UNHCR 2002: 13). The agency even advocates to avoid using the term 'refugee' to describe people displaced by natural disasters and the impact of climate change.

UNHCR is instead advocating for a clear distinction between 'climate migrants' and genuine (i.e., political) refugees. "*Lumping both groups together under the same heading would further cloud the issues and could undermine efforts to help and protect either group and to address the root causes of either type of displacement*" (UNHCR 2002: 13).[85]

By no means does this exclude the possibility that future migrants will cross international borders and try to settle in another country for ecological reasons. There will be, however, no legal obligation to offer them protection as long as the Geneva Convention, European and national asylum laws are not amended which is not very likely to happen.

In this context, the cases of small island states with low elevation[86] (thus in danger of disappearing altogether) and of fragile or failed states unable to protect their own citizens, merits particular attention. Both type of countries

[84] https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030

[85] As a result, people currently displaced because of natural disasters or climate change are not included in UNHCR's annual report on refugees and displaced persons (e.g., UNHCR 2021b). For a critical assessment of this, see McNamara (2007).

[86] The EU supports the Pacific Climate Change and Migration project addressing the challenge. https://www.unescap.org/subregional-office/pacific/pacific-climate-change-and-migration-project

might not offer domestic alternatives to people who are forced to leave their habitat. To address such cases in which relocation within a country is not an option, the European Commission and EU Member States could help through developing pro-active resettlement programmes. Currently, this option only exists for political refugees.[87] In the future, environmental migration will require a more comprehensive policy framework.[88] Europe should therefore invest in developing and implementing such a policy framework as mobility and migration caused by climate change will stay on the political agenda for more time to come.

The impact is to be expected well beyond considerations of protection. Future international migrants will also take the environmental conditions in destination countries into account when choosing their next place of residence.

[87] https://ec.europa.eu/home-affairs/policies/migration-and-asylum/legal-migration-and-integration/resettlement-and-other-pathways-protection_en; https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_21_3628

[88] See Aleinikoff (2020), Martin (2010).

6. Conclusions

Climate change is evident as global temperatures rise and extreme weather conditions become more frequent, thereby triggering an acceleration of severe disasters. These disasters are meteorological and hydrological by nature but increasingly man made through past and present greenhouse gas emissions. It is, however, less evident how this change translates into domestic mobility and international migration.

It is well documented that natural disasters – most of them related to extreme weather conditions (i.e., climate-induced natural disasters) – cause the displacement or evacuation of 15-30 million people per year. Between 2008 and 2021, an estimated total of 344 million people were internally displaced by natural disasters.

However, natural disasters and extreme weather events rarely lead to displacement across international borders. That is, most people displaced by extreme weather conditions do not become long-term migrants in another country. In fact, short-term displacement or evacuation of the most severely affected people is usually – that is, for most yet not all – followed by a return to the same place, or at least to the subregion of origin. Rapid return after displacement resulting from climate and weather-related disasters is often (yet not always) linked to and accompanied by relief and reconstruction efforts. As a result, out of the 344 million people (2008-2021) displaced by extreme weather conditions and natural disasters, only 6 million people did not return to the subregion or place from which they were displaced. This differs sharply from the impact of civil wars and targeted political violence usually leading both to large-scale protracted internal displacement and to subsequent secondary movement of refugees/asylum seekers across international borders.

It must, however, be mentioned that a series of successive environmental shocks and natural disasters may lead to the persistent deterioration of living conditions and/or depletion of household assets. This, in turn, could encourage internal mobility, and in the mid- to long-term, potentially also international outmigration. Even though emigration may not be directly linked to a particular disaster, the point of departure may nevertheless be linked to a certain tipping point event.

In contrast to the (in most cases) obvious impact of sudden-onset natural disasters, the implications of gradual slow-onset environmental degradation induced by climate change on internal mobility and international migration decisions are more complex to assess and predict.

Slow-onset environmental and climate changes materialise, for instance, in rising sea-levels, extended heat waves, prolonged or unprecedented dry seasons and reduced rainfall causing freshwater shortages, soil salination, or erosion of arable land. Such developments are more likely to result in long-term or even permanent outflows of people to other parts of their country of residence, and to a smaller degree to cross-border migration, mostly into neighbouring countries. Thus, large-scale, long distance migration movements as a *direct* consequence of slow-onset climate change are unlikely in the foreseeable future.

However, beyond its direct impact, gradual environmental degradation can indirectly impact mobility and migration, as this degradation reduces the ability of people to economically sustain themselves. Therefore, despite living in a region negatively affected by climate change, most people move temporarily or more permanently for economic and livelihood reasons.

In general, environmental stress separates affected populations into (resource-endowed) potential and actual movers and (resource-scarce, and therefore, trapped) stayers. The distribution between these two groups is uneven and not even fully determined by access to resources as many endowed people decide to stay (at least for a while). Unlike political violence uprooting and displacing large numbers of people, many, if not most people negatively affected by environmental change do not become mobile. Some of them stay and adapt based on a more or less voluntary decision. Others lack financial, social, and informational resources leaving them geographically trapped despite an environmentally induced deterioration of living conditions.

In many countries domestic mobility is only partly documented, but a rough estimate puts the number of people who have moved from rural areas to larger towns and urban agglomerations over the last 40 years at more than 2 billion. We do not know how many of them did so in response to climate-related reasons and environmental degradation. It is, however, clear that negative effects on freshwater supply, agricultural output, and rural livelihoods in general have intensified rural-to-urban mobility as well as cross-border migration to urban agglomerations in other countries.

Most people moving out of rural areas in response to slow-onset deterioration of livelihoods caused by climate change and environmental stress (e.g., droughts, soil erosion, protracted heat waves, reduced agricultural productivity, etc.) move to larger cities, often in coastal regions and densely populated river deltas. These people seek to improve income opportunities, but also to reduce their vulnerability and risk exposure to environmental change. As a result, however, their mobility triggered by negative slow-onset effects of climate change will not necessarily reduce their exposure to environmental risk. They may, instead, be confronted with different risks as their new places of residence will be increasingly affected by floods and storms, rising sea levels, coastal erosion and possibly salination of freshwater. Thus, by reducing their exposure to visible or predictable slow onset change, these people increase their exposure to much less predictable natural disasters.

Future population size or demographic ageing can be forecasted with relative certainty. They are largely determined by the current age structure and changing fertility and declining mortality rates. Forecasting future climate change is more difficult as the outcome depends to a significant extent on current political decisions and collective action for managing and facilitating urgent ecological transitions of economies and societies. In fact, it very much depends on global collective action that the global community, or at least the major emitters of greenhouse gases, take within the next one or two decades. It also depends on the ability (and willingness) of countries to cope with the already unavoidable but increasingly harmful consequences. Forecasting future mobility and migration directly or indirectly caused by climate change is therefore hardly possible due to uncertainties about current and future political actions.

Another source of uncertainty is our limited understanding of the complex links between environmentally induced changes in rural and urban livelihoods, people's adaptation and resilience capacity, and migration and relocation propensities. Accordingly, it is clear that any environmental determinism that draws a direct causal link from past, current, or projected future climate changes to past, current, or predicted future (internal and international) human mobility is misleading and unreliable.

Numerous studies indicate that the (actual, perceived or anticipated) negative impact of environmental degradation on human livelihoods and well-being is only one among several factors explaining large-scale domestic mobility and international migration. The majority of people negatively affected by climate change do not leave their place of residence or quickly return after a sudden onset event. However, there is evidence that under certain circumstances people change their place of residence because of constellations influenced by irreversible environmental degradation of livelihoods.

At the same time, potential movers have difficulties anticipating their own decisions. An opinion poll carried out in 2015-16 suggested that about 500 million people around the globe thought that they might need to move to another country because of environmental problems within the next five years. We now know that – so far – this was an overestimation as this sort of large-scale international migration as a direct consequence of environmental stress has not materialised.

Identifying ecological drivers of mobility and international migration by asking people about their intentions and motivation concerning internal mobility and international migration also faces another challenge. Many people living in middle- and low-income countries are not familiar with the concept of 'climate change' (Johnston 2020) and its possible implications. Interviews show that many have never heard of 'climate change'. Even if they may be aware of aspects of environmental change and weather conditions affecting their livelihoods, they would not give the expected answer in an opinion poll using that concept. Beyond that, it might well be that people not aware of climate change might link perceived extreme weather conditions (heat waves, droughts, floods) not to a trend (i.e. climate 'change') but to an unexpectedly harsh period that would be followed by the old 'normal'.

Forecasts can, however, indicate the future number of *people at risk*, that is, living in areas exposed to adverse effects of climate change. Hence, we can also assess which type of climate related risk is likely to affect them.

Reliable, model-based forecasts predict that, by the year 2050, more than 3 billion people will live in regions with severe adverse effects of climate change on livelihoods. While in geographical terms most of the affected parts of the world are not densely populated rural and coastal regions or even uninhabited zones, the majority of people potentially at risk will be urban dwellers. Model calculations published by the World Bank assume that, until 2050, between 78 and 175 million people will be moving out of territories negatively affected by climate change. Most of them will search for a new place of residence within their own country. Based on current knowledge and available evidence, we can infer that only a minority, which could still be a substantive number in absolute terms, of the affected population will become internationally mobile.

Populations at high risk of permanent displacement and therefore in need of relocation include about one billion people settled on land with an elevation of less than 10 meter above current sea levels. 250 million people are at severe risk by living less than one meter above current sea levels (or already living in areas below sea levels protected by dams, dikes and flood gates).

When looking into the future, we must consider both the case of small island states with low elevation that are in danger of disappearing altogether and the case of fragile or failed states unable to protect their citizens from negative consequences of climate change – namely floods, rising sea levels, droughts, soil erosion, and wildfires.

At the same time, states, the private sector, and other actors have the possibility to engage in prevention, adaptation, and mitigation strategies, in order to protect their exposed populations from the most severe effects and outcomes of climate change. Time series from the last 120 years show that since the beginning of the 20th century, annual casualties caused by natural disasters have been reduced by more than 90 percent, despite a considerable increase in the frequency of such disasters and the size of exposed populations. This clearly shows that building resilience as well as coping capacities has been successful in the past and remains a likely effective strategy in the future.

The most obvious action to be taken is the immediate and rapid reduction of greenhouse gas emissions. Given the negative impact of rising global temperatures on our biosphere, this is a mitigation strategy in its own right, but it also helps reduce the risk of people to lose their ability to sustain themselves and to leave their place and region of settlement.

In contrast to global mitigation strategies, impact mitigation and adaptation activities are more geared towards increasing the resilience of communities and people at risk of their lives and livelihoods to cope with environmental stress. Developing impact mitigation and adaptation activities is in part in Europe's self-interest as the continent will be facing a rise in temperature above the global average. But it is also Europe’s global responsibility as it is, historically and still contemporarily, a major emitter of greenhouse gases. Europe could and should take a leading role in its external strategy to make middle- and low-income economies and societies more resilient. This includes knowledge and technology transfer, but also financial investment and the establishing of insurance schemes.

In sum, the key insights regarding the scope of climate-induced mobility are:

1. Natural disasters – mostly caused by extreme weather events – have internally displaced about 344 million people between 2008 and 2021. Sudden-onset disasters usually cause an immediate, but temporary, displacement or evacuation of those most severely affected, which is usually followed by a relatively quick return to the same place, or at least to the subregion of origin.

2. Natural disasters and extreme weather events rarely lead to long-term emigration or displacement across international borders. Rapid return after displacement resulting from climate and weather-related disasters is often linked to, and supported by, immediate relief and reconstruction efforts supported by national and local governments, facilitated through pay-outs from insurance companies and supported by international donors. This differs sharply from the impact of civil wars and targeted political violence usually leading to large-scale protracted internal displacement and to subsequent secondary movement of refugees/asylum seekers across international borders. As a result, during the period of 2008 to 2021, out of the 344 million people displaced by natural disasters, only about 6 million did not return to the subregion or place from which they were displaced.
3. Exposure to displacement risk is very unevenly distributed across the globe. People living in low-income countries are at a much larger displacement risk. Global inequality is reflected in the likelihood to lose premises and assets as a result of floods and storms.
4. Available evidence and literature show that the implications of gradual (i.e., slow onset) environmental degradation induced by climate change on internal mobility and international migration are more complex to assess and predict than the direct effects of sudden-onset natural disasters. Slow-onset environmental and climate changes materialise, for instance, through rising sea-levels, extended heat waves, prolonged or unprecedented dry seasons and reduced rainfall causing freshwater shortages, soil salination or erosion of arable land. Such developments are more likely to result in long-term or even permanent outflows of people to other parts in the country of residence, and to a smaller degree to cross-border migration mostly into neighbouring countries. It is unlikely that long distance migration of larger populations is, or will become, a direct consequence of slow-onset climate change in the foreseeable future. Gradual environmental degradation can nevertheless have an *indirect* impact on mobility and migration as this degradation reduces the ability of people to economically sustain themselves. Therefore, despite living in a region negatively affected by climate change many people see their mobility as primarily economically motivated.
5. In general, environmental degradation separates affected populations into movers and stayers. Many, if not most, vulnerable people do *not* become mobile as a consequence of environmental stress. While some stay more or less voluntarily (e.g., due to strong place attachment), others lack financial, social, and informational resources which leave

them geographically trapped despite an environmentally induced deterioration of living conditions.

6. Therefore, voluntary mobility within the country of residence and planned relocation as an adaptation strategy is generally not available to all people who are negatively affected by the multiple manifestations of gradual climate change, but primarily to those who are relatively 'better off' (i.e., endowed with resources). This is even more true for international migration which requires legal access to another country, or at least the ability to reach the territory of another country which is dependent on the possession of travel documents, the availability of cash to pay for the travel and ideally also skills that can be deployed in the country of destination.
7. At the same time, over the last 40 years, more than 2 billion people have moved from rural areas to larger towns and urban agglomerations. Even though we do not know how many of them did so in response to climate-related reasons and environmental degradation, it is clear that negative effects on freshwater supply, agricultural output and rural livelihoods in general have intensified rural-to-urban mobility including migration to urban agglomerations in other countries. By moving from the rural areas to larger cities and metropolitan areas, people seek to reduce their vulnerability, exposure, and risks. However, in reality, such movements might just exchange exposure to slow onset degradation affecting rural areas (droughts, soil erosion, etc.) for urban exposure to floods, rising sea levels, coastal erosion, etcetera.
8. By the year 2050, predictions are that up to 3 billion people will be living in regions with severe adverse effects of climate change on livelihoods. Most of these geographical areas will be urban. Based on current knowledge and available evidence, we can, however, infer that only a minority of the affected population will become internationally mobile. Model calculations assume that, until 2050, between 78 and 175 million people will be moving out of regions negatively affected by climate change (but mostly not crossing borders).
9. Populations at high risk for permanent displacement to more sustainable places and outmigration to other countries include about one billion people settled on land with an elevation of less than 10 meter above current sea levels. 250 million people are at severe risk by living less than one meter above current sea levels (or already living in protected areas below sea levels).
10. Most people moving out of rural areas in response to slow-onset deterioration of livelihoods caused by climate change and environmental stress move to larger cities, often in coastal regions and densely

populated river deltas. As a result, their mobility triggered by negative slow-onset effects of climate change will not necessarily reduce their exposure to environmental risk as their new places of residence will be more exposed to floods and storm. By reducing their exposure to visible or predictable slow onset change, these people increase their exposure to natural disasters that are less predictable.

11. An opinion poll carried out in 2015-16 suggested that (back then) about 500 million people globally thought they may need to move to another country because of environmental problems within the next five years. As this time period has elapsed, we see that there is little evidence that such cross-border movements might have occurred at such a magnitude since 2015. So far, large-scale international migration as a direct consequence of environmental stress has not materialised. In the near future, we must consider, however, both the case of small island states with low elevation that are in danger of disappearing altogether and the case of fragile states unable to protect their citizens from negative consequences of climate change – namely floods, rising sea levels, coastal erosion, protracted droughts, shortage of freshwater and wildfires.

12. The future of climate-induced internal mobility and international migration is uncertain for three reasons. First, the pace of future global warming is still unknown as it depends not least on (collective) action of major greenhouse gas emitters (including the EU, US, China) in drastically reducing emissions in this and the next decade. Second, it is unclear to what extent states are able and willing to engage in effective prevention, adaptation and mitigation mechanisms protecting against the most severe effects and outcomes of climate change. Finally, despite evidence from local and regional studies we still do not know enough to fully assess and quantify the phenomenon called environmentally induced migration and mobility.

13. To sum up: While we can anticipate, to a certain degree, climate change related degradation and disruption of livelihoods both in low- and high-income countries, this cannot easily be done for future mobility and migration. We also must consider and factor in the human ability to cope and adapt, which opens up possibilities for people to stay and survive in affected regions. What remains uncertain is the political will and collective resolve to invest in prevention and adaptation. This depends on the allocation of fiscal, as well as private, resources. For all these reasons it is almost impossible to predict the number of people who will become mobile because of climate change. Therefore, any environmental determinism that draws a direct causal, and often linear,

link from past, current, or projected future climate developments to predictions about the exact scale of future human mobility and international migration is misleading.

References

Abadie, L. M., Jackson, L.P., Sainz de Murieta, E., Jevrejeva, S. and Galarraga, I. (2020). 'Comparing Urban Coastal Flood Risk in 136 Cities under Two Alternative Sea-Level Projections: RCP 8.5 and an Expert Opinion-Based High-End Scenario'. *Ocean & Coastal Management, 193*: 105249. https://doi.org/10.1016/j.ocecoaman.2020.105249

Abel, G.J., Brottrager, M., Crespo Cuaresma, J. and Muttarak, R. (2019). 'Climate, Conflict and Forced Migration'. *Global Environmental Change, 54*: 239-249.

Abu, M., Codjoe, S. and Sward, J. (2014). 'Climate Change and Internal Migration Intentions in the Forest-Savannah Transition Zone of Ghana'*. Population and Environment*, *35*: 341-364.

Adams, H. (2016). 'Why Populations Persist: Mobility, Place attachment and Climate Change'. *Population and Environment, 37* (4): 429-448.

Adams, R. H., Cuecuecha, A., and Page J. (2008). *The Impact of Remittances on Poverty and Inequality in Ghana.* Policy Research Working Paper No. 4732. Washington DC: World Bank. https://doi.org/10.1596/1813-9450-4732

Adams, H. and Kay, S. (2019). 'Migration as a Human Affair: Integrating Individual Stress Thresholds into Quantitative Models of Climate Migration'. *Environmental Science and Policy, 93:* 129–138.

ADB. (2012). *Global Crisis, Remittances and Poverty in Asia.* Manila: Asian Development Bank. Available at: http://hdl.handle.net/11540/102

Afifi, T. (2011). 'Economic or Environmental Migration? The Push Factors in Niger'. *International Migration, 49* (1): 95-124.

African Development Bank, Asian Development Bank, European Bank for Reconstruction and Development, European Investment Bank, Inter American Development Bank, Islamic Development Bank, World Bank (2019). '2018 Joint Report on Multilateral Development Banks Climate Finance' Available at: https://publications.iadb.org/en/2018-joint-report-multilateral-development-banks-climate-finance

Aleinikoff, A. (2020). 'Commentary: Environmental Mobility: The Responsibility of the International Community'. *International Migration, 58* (6): 254-257.

Al Jazeera. (2019). 'Indonesia's new capital to be moved to Borneo island'. *Al Jazeera*, 26 August 2019. Available at: https://www.aljazeera.com/news/2019/08/indonesia-capital-located-borneo-island-190826074218708.html

Artemis. (n.d) What is a catastrophe bond (or cat bond)?' Avaliable at: https://www.artemis.bm/library/what-is-a-catastrophe-bond/Backhaus,

A., Martinez-Zarzoso, I. and Muris, C. (2015). 'Do Climate Variations Explain Bilateral Migration? A gravity Model Analysis'. *IZA Journal of Migration and Development, 4*(1): 1-15. https://doi.org/10.1186/s40176-014-0026-3

Baraniuk, C. (2021). ' The fragile future of roads and buildings built on permafrost'*. BBC*, 5 March 2021. Avaliable at: https://www.bbc.com/future/article/20210303-the-unsure-future-of-roads-and-buildings-on-melting-ground

Barnes, H. (2013). 'How Many Climate Migrants Will There Be?'. *BBC* News, 2 September. Available at: https://www.bbc.com/news/magazine-23899195

Beine, M. and Parsons, C. (2015). 'Climatic Factors as Determinants of International Migration'. *The Scandinavian Journal of Economics, 117* (2): 723-767.

Berlemann, M. and Steinhardt. M. (2017). 'Climate Change, Natural Disasters, and Migration – a Survey of the Empirical Evidence'. *CESifo Economic Studies, 63*(4): 353-385. https://doi.org/10.1093/cesifo/ifx019

Bijak, J., and Czaika, M. (2020a). Assessing Uncertain Migration Futures: A Typology of the Unknown (QuantMig Background Paper Deliverable D1.1). Southampton: University of Southampton.

Bijak, J., and Czaika, M. (2020b). 'Black Swans and Grey Rhinos: Migration Policy Under Uncertainty'. *Migration Policy Practice, 10*(4): 14-18.

Black, R., Adger, W.N., Arnell, N.W. Dercon, S. Geddes, A. and Thomas, D. (2011). 'The Effect of Environmental Change on Human Migration'. *Global Environmental Change, 21*: 3-11.

Boeckli, L., Brenning, A., Gruber, S. and Noetzli, J. (2012). 'Permafrost Distribution in the European Alps: Calculation and Evaluation of an Index Map and Summary Statistics'. *The Cryosphere, 6*(4): 807–820.

Bohra-Mishra, P., Oppenheimer, M. and Hsiang, S.M. (2014). 'Nonlinear Permanent Migration Response to Climatic Variations but Minimal Response to Disasters'. *PNAS, 111*(27): 9780-9785.

Bower, E. and Weerasinghe, S. (2021). *Leaving Place, Restoring Home: Enhancing the Evidence Base on Planned Relocation Cases in the Context of Hazards, Disasters and Climate Change.* Platform on Disaster Displacement and Andrew & Renata Kaldor Centre for International Refugee Law. Sidney: UNSW, Kaldor Center.

Brady, M. (2016). 'Permafrost Thaw Threatens Mountains'. *The Norwegian American*, 26 August. Available at: https://www.norwegianamerican.com/permafrost-thaw-threatens-mountains/

Brown, L. A., and Moore, E.G. (1970). 'The intra-urban migration process: A perspective'. Geografiska Annaler. Series B, *Human Geography 52*(1): 1-13

Brown, L., McGrath, P. and Stokes, B. (1976). Twenty-two Dimensions of the Population Problem*. Worldwatch Paper No. 5.* Washington DC: Worldwatch Institute.

Brown, O. (2008). Migration and Climate Change. *IOM Migration Research Series Paper No. 31*. Geneva: IOM.

Brottem, L. (2021). 'The Growing Complexity of Farmer-Herder Conflict in West and Central Africa'. *Africa Security Brief No. 39*. Africa Center for Strategic Studies. Available at: https://africacenter.org/publication/growing-complexity-farmer-herder-conflict-west-central-africa/

Butcher. M. (2021). 'Lisbon's Startup Scene Rises as Portugal Gears Up to be a European Tech Tiger'. *TechCrunch*, 1 July. Available at: https://techcrunch.com/2021/01/07/

Bykova, A. (2020). 'Permafrost Thaw in a Warming World: Permafrost Series Fall-Winter 2020'. The Arctic Institute, 1 October. Available at: https://www.thearcticinstitute.org/permafrost-thaw-warming-world-arctic-institute-permafrost-series-fall-winter-2020/

Cai, R., Feng, S., Oppenheimer, M. and Pytlikova, M. (2016). 'Climate Variability and International Migration: The Importance of the Agricultural Linkage'. *Journal of Environmental Economics and Management, 79*: 135-151.

Carling, J. (2002). 'Migration in the Age of Involuntary Immobility: Theoretical Reflections and Cape Verdean Experiences'. *Journal of Ethnic and Migration Studies, 28*(1): 5–42.

Carling, J., and Schewel, K. (2018). 'Revisiting Aspiration and Ability in International Migration'. *Journal of Ethnic and Migration Studies, 44*(6): 945-963.

Cattaneo, C., Beine, M., Fröhlich, C. J., Kniveton, D., Martinez-Zarzoso, I., Mastrorillo, M. and Schraven, B. (2019). 'Human Migration in the Era of Climate Change'. *Review of Environmental Economics and Policy, 13*(2): 189-206.

Clement, V., Rigaud, K. K., de Sherbinin, A., Jones, B., Adamo, S., Schewe, J., Sadiq, N. and Shabahat, E. (2021*). Groundswell Part 2: Acting on Internal Climate Migration.* Washington DC: World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/36248

Climate Diplomacy (n.d). '*Pastoralist and Farmer-Herder Conflicts in the Sahel'*. Available at: https://climate-diplomacy.org/case-studies/pastoralist-and-farmer-herder-conflicts-sahel

Codjoe, S. N. A., Nyamedor, F. H., Sward, J. and Dovie, D. B. (2017). 'Environmental Hazard and Migration Intentions in a Coastal Area in Ghana: A Case of Sea Flooding'. *Population and Environment, 39*(2): 39–146. doi: 10.1007/s11111-017-0284-0

Council of Europe. (2006). 'The Problem of Environmental Refugees'. Parliamentary Assembly Doc. 11084, October 23, 2006. Strasburg: CoE.

Council of the European Union. (2022). 'Long-term EU budget 2021-2027 and recovery package: A budget powering the recovery from COVID-19. Available at: https://www.consilium.europa.eu/en/policies/the-eu-budget/long-term-eu-budget-2021-2027/

Czaika, M. (2015). 'Migration and Economic Prospects'. *Journal of Ethnic and Migration Studies, 41*(1): 58–82.

Czaika, M. ed. (2018). *High-Skilled Migration: Drivers and Policies*. Oxford: Oxford University Press.

Czaika, M., and Reinprecht, C. (2020). *Drivers of Migration. A Synthesis of Knowledge.* IMI working paper No. 163. Oxford: International Migration Institute (IMI).

Czaika, M., and Reinprecht, C. (2022). 'Why Do People Stay Put in Environmentally Stressful Regions? Cognitive Bias and Heuristics in Migration Decision-Making'. *Regional Environmental Change, 22:* 84. https://doi.org/10.1007/s10113-022-01934-y

de Sherbinin, A. (2020). *Impacts of Climate Change as Drivers of Migration.* Washington DC: MPI.

Dwyer, S. Johnson, Z. and Zühr, R. (2020) 'Financing for the future: Climate finance and the role of ODA'. Donor Tracker Insights, 3 Aug. 2020. Available at: https://donortracker.org/insights/financing-future-climate-finance-and-role-oda

EM-DAT (2022) The International Disaster Database, Centre for the Research of the Epidemiology of Disasters, University of Louvain (UCLouvain), www.cred.be

Esipova, N., Ray, J. and Pugliese, A. (2018). Gallup World Poll: The Many Faces of Global Migration. *MRS No. 43*. Geneva: IOM, Gallup. Available at: https://publications.iom.int/system/files/pdf/mrs43.pdf

European Commission. (2020). '2030 climate & energy framework'. Available at: https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2030-climate-energy-framework_en

European Commission (2021). 'Providing protection through joint leadership: stepping up resettlement and complementary legal pathways'. Available at: https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_21_3628

European Commission. (2022). 'A European Green Deal: Striving to be the first climate-neutral continent'. Available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

European Commission, DG ECHO. (2022). 'European Civil Protection and Humanitarian Aid Operations: EU Civil Protection Mechanism'. For the European Commission. Avaliable at: https://ec.europa.eu/echo/what/civil-protection/eu-civil-protection-mechanism_en

European Commission, DG ECHO. (n.d.) 'Civil-Military Cooperation in Emergencies'. Available at: https://ec.europa.eu/echo/partnerships/relations/civil-military-cooperation-emergencies_en

European Commission, DG Migration and Home Affairs (n.d). 'Resettlement and other pathways to protection'. Available at: https://ec.europa.eu/home-affairs/policies/migration-and-asylum/legal-migration-and-integration/resettlement-and-other-pathways-protection_en

European Investment Bank (2020) 'Our priorities. Climate and environmental sustainability. Addressing the climate and environment emergency in the critical decade 2021-2030 to leave no one behind'. Luxemburg: EIB. Available at: https://www.eib.org/en/about/priorities/climate-action/index.htm

Ewers, M. C. and Dicce, R. (2018). 'High-Skilled Migration and the Attractiveness of Cities'. In: Czaika, M. (ed.) *High-Skilled Migration: Drivers and Policies*. Oxford: Oxford University Press: pp. 176-194

Faust, E. and Lang, A. (2022). 'Series of Hot Years and More Extreme Weather: Climate Change and its Consequences'. *Munich RE*, 30 June. Available at: https://www.munichre.com/topics-online/de/climate-change-and-natural-disasters/climate-change/climate-change-heat-records-and-extreme-weather.html

Fernandez-Mayoralas, V.G. and Rojo, F. (2004). 'International Retirement Migration: Retired Europeans Living on the Costa Del Sol, Spain'. *Population Review 43*(1), 1-36.

Ferris, E. (2013). *A Complex Constellation: Displacement, Climate Change and Arctic Peoples.* Washington DC: Brookings Institute.

Florczyk, A. J., Corbane, C., Ehrlich, D., Freire, S., Kemper, T., Maffenini, L., Melchiorri, M., Politis, P., Schiavina, M., Sabo, F. and Zanchetta, L. (2019). *GHSL Data Package 2019.* Luxembourg: Publications Office of the European Union. doi:10.2760/0726

Friends of the Earth. (2007). A Citizen's Guide to Climate Refugees, Fact Sheet Four: Predictions of Climate Refugees to 2050. London: FotE.

Gemenne, F. (2009). *Environmental Migration: Normative Frameworks and Policy Prescriptions.* PhD Thesis. Paris: Sciences Po.

Gemenne, F. (2022). *The Impacts of Migration for Adaptation and Vulnerability.* Delmi Research Overview 2022:2. Stockholm: Migration Studies Delegation.

Gisnås, K. (2016). *Permafrost Modelling Over Different Scales in Arctic and High-Mountain Environments.* PhD Thesis. Oslo: University of Oslo, Department of Geosciences and CEED.

Gottlieb, P.D. and Joseph, G. (2006). 'College-to-Work Migration of Technology Graduates and Holders of Doctorates within the US'. *Journal of Regional Science, 46*(4): 627-659.

Green, T. F., and Olshansky, R. B. (2012). 'Rebuilding Housing in New Orleans: The Road Home Program After the Hurricane Katrina Disaster'. *Housing Policy Debate, 22*(1): 75-99.

Groen, J. A. and Polivka, A. E. (2010). 'Going Home After Hurricane Katrina: Determinants of Return Migration and Changes in Affected Areas'. *Demography 47* (4): 821–844.

Gu, D. (2019). *Exposure and Vulnerability to Natural Disasters for World's Cities*. UN Population Division Technical Paper 2019/4. New York: UN DESA.

Hauer, M.E., Fussell, E. and Mueller, V. et al. (2020). 'Sea-Level Rise and Human Migration'. *Nature Reviews Earth and Environment, 1*: 28–39. https://doi.org/10.1038/s43017-019-0002-9

Helbling, M., Auer, D., Meierrieks, D., Mistry, M. and Schaub, M. (2021). 'Climate Change Literacy and Migration Potential: Micro-Level Evidence from Africa'. *Climatic Change, 169* (1): 1-13.

Hillmann, F., Tang, M. and Argüello Guerra, F. (2022). *Forschungsstand und Forschungsbedarfe zum Zusammenhang von Klimawandel, Migration und Sozialpolitik*. Duisburg: DIFIS.

Hoffmann, R., Sedov, B. and Vinke, K. (2021). 'Improving the Evidence Base: A Methodological Review of the Quantitative Climate Migration Literature'. *Global Environmental Change, 71*: 102367.

Homer-Dixon, T.F. (1994). *'Environmental Scarcities and Violent Conflict'. International Security, 19* (1): 5-40.

IDMC. (2014). *Annual Report 2014*. Geneva: Internal Displacement Monitoring Center. Available at: https://www.internal-displacement.org/publications/annual-report-2014

IDMC. (2019). *Global Report on Internal Displacement 2018*. Geneva: Internal Displacement Monitoring Center

IDMC. (2021). *Global Report on Internal Displacement 2020.* Geneva: Internal Displacement Monitoring Center.

IDMC. (2022). *Global Report on International Displacement 2022*. Geneva: Internal Displacement Monitoring Center.

Insurance Information Institute. (n.d.) ‘Understanding crop insurance’. New York: IIS. Available at: https://www.iii.org/article/understanding-crop-insurance

Inter-American Development Bank (2019). ‘Development banks propose common framework for climate resilience’. Available at: https://www.climatechangenews.com/2019/12/13/development-banks-propose-common-framework-climate-resilience/

IOM. (2014). *IOM Outlook on Migration, Environment and Climate Change.* Geneva: International Organization for Migration. Available at: https://publications.iom.int/books/iom-outlook-migration-environment-and-climate-change

IOM. (2018*). Mapping Human Mobility and Climate Change in Relevant National Policies and Institutional Frameworks.* Geneva: International Organization for Migration.

IOM. (2019). *World Migration Report 2020*. Geneva: International Organization for Migration. Available at: https://publications.iom.int/system/files/pdf/wmr_2020.pdf

IOM.(2021). *World Migration Report 2022*. Geneva: International Organization for Migration. Available at: https://publications.iom.int/books/world-migration-report-2022

Ionesco D., Mokhnacheva, D. and Gemenne, F. (2017). *The Atlas of Environmental Migration*. Geneva: IOM; Abingdon: Routledge.

IPCC. (1992). *Climate Change: The IPCC 1990 and 1992 Assessments*. Paris: WMO, UNEP.

IPCC. (2021). *Climate Change 2021: The Physical Science Basis.* Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva-Nairobi: WMO, UNEP. In press, doi:10.1017/9781009157896

IPCC. (2022). *AR6 Synthesis Report: Climate Change 2022.* Geneva-Nairobi: WMO, UNEP. Available at: https://www.ipcc.ch/report/sixth-assessment-report-cycle/

Islam, M. R. (2017). ‘Climate Change, Natural Disasters and Socioeconomic Livelihood Vulnerabilities: Migration Decision Among the Char Land People in Bangladesh’. *Social Indicators Research, 136*: 575–593.

Jacobson, J.L. (1988). *Environmental Refugees: A Yardstick of Habitability*. Worldwatch paper No. 86. Washington DC: Worldwatch Institute.

Jakobeit, C. and Methmann, C. (2007). *Klimaflüchtlinge – Die verleugnete Katastrophe.* Hamburg: Greenpeace.

Jayawardhan, S. (2017). 'Vulnerability and Climate Change Induced Human Displacement'. *Consilience: The Journal of Sustainable Development, 17* (1): 103–142.

Jónsson, G. (2010). *The Environmental Factor in Migration Dynamics - a Review of African Case Studies.* IMI Working Papers No. 21. Oxford: International Migration Institute.

Johnston, J.D. (2020). 'Climate Change Literacy to Combat Climate Change and Its Impacts'. In: Leal Filho, W.L., Marisa, A., Brandli, L., Gökcin Özyar, P. and Wall, T. eds. *Climate Action. Encyclopedia of the UN Sustainable Development Goals.* New York-Basel: Springer International Publishing: 1-14.

Joseph, G. and Wodon, Q. (2013). 'Is internal Migration in Yemen Driven by Climate or Socio-Economic Factors?'. *Review of International Economics, 21* (2): 295–310.

Kam, P.M., Aznar-Siguan, G. Schewe, J. Milano, L. Ginnetti, J. Willner, S. McCaughey, J.W. and Bresch, D.N. (2021). 'Global warming and population change both heighten future risk of human displacement due to river floods'. Environ. Res. Lett. 16: 044026

Kieckens, E. (2021). 'Barcelona – a European Innovation Hub with a Future'. *Innovation Origins*, 5 January. Available at: https://innovationorigins.com/en/barcelona-a-european-innovation-hub-with-a-future/

King, R., and Skeldon, R. (2010). "Mind the gap!' Integrating Approaches to Internal and International Migration'. *Journal of Ethnic and Migration Studies 36*(10): 1619-1646.

Khavarian-Garmsir, A.R., Pourahmad, A., Hataminejad, H. and Farhoodi, R. (2019). 'Climate Change and Environmental Degradation and the Drivers of Migration in the Context of Shrinking Cities: A Case Study of Khuzestan province, Iran'. *Sustainable Cities and Society 47*: 101-148. doi:10.1016/J.SCS.2019.101480

Kirezci, E., Young, I.R., Ranasinghe, R., Muis, S., Nicholls, R.J., Lincke, D. and Hinckel, J. (2020). 'Pro-jections of Global-Scale Extreme Sea Levels and

Resulting Episodic Coastal Flooding over the 21st Century'. *Scientific Reports 10*: 11629

Kóczán, Z. and Loyola, F. (2018). *How Do Migration and Remittances Affect Inequality? A Case Study of Mexico*. IMF Working Papers 18/136. Washington DC: International Monetary Fund.

Kolmannskog, V. (2008). *Future Floods of Refugees: A Comment on Climate Change, Conflict and Forced Migration*. Oslo: Norwegian Refugee Council.

Kopp, R.E., DeConto, R.M., Bader, D.A., Hay, C.C., Horton, R.M., Kulp, S., Oppenheimer, M., Pollard, D. and Strauss, B.H. (2017). 'Evolving Understanding of Antarctic Ice-Sheet Physics and Ambiguity in Probabilistic Sea-Level Projections'. *Earth's Future, 5*(12): 117–123.

Kopp, R.E., Horton, R.M., Little, C.M., Mitrovica, J.X., Oppenheimer, M., Rasmussen, D.J., Strauss, B.H. and Tebaldi, C. (2014). 'Probabilistic 21st and 22nd Century Sea-Level Projections at a Global Network of Tide-Gauge Sites'. *Earth's Future, 2*(8): 383–406.

Kulp, S.A., and Strauss, B.H. (2019). 'New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding'. *Nature communications, 10*(1): 1-12.

Kuntara, S. (2021). 'Why Miami Is The Next Hot Tech Hub: 'This Is Not A Retirement Decision''. *Crunchbase News*, 5 January. Available at: https://news.crunchbase.com/venture/why-miami-is-the-next-hot-tech-hub/

Kurnik, B. (2015). 'Use of climate projections for EEA climate change assessments' [PowerPoint Presentation]. *European Environment Agency*. Available at: https://www.ecmwf.int/sites/default/files/elibrary/2015/13506-use-climate-projections-eea-climate-change-assessments.pdf

Lane, A. (2007). 'New Orleans: a national humiliation'. *New Statesman*, 23 August, available at: https://www.newstatesman.com/long-reads/2007/08/city-katrina-nagin-state

Mahul, O., Stutley, C.J. (2010). *Government Support to Agricultural Insurance. Challenges and Options for Developing Countries*. Washington DC: The World Bank. Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/2432/538810PUB0Gove101Official0Use0Only1.pdf?sequence=1

Mallick, B. and Vogt, J. (2012). 'Cyclone, Coastal Society and Migration: Empirical Evidence from Bangladesh'. *International Development Planning Review, 34*(3): 217–24.

Marchiori, L., Maystadt, J.-F. and Schumacher, I. (2012). *The Impact of Weather Anomalies on Migration in sub-Saharan Africa*. IRES Discussion Paper 2011-34. Louvain: UCL.

Martin, M., Billah, M., Siddiqui, T., Abrar, C., Black, R., & Kniveton, D. (2014). 'Climate-related migration in rural Bangladesh: a behavioural model'. *Population and environment, 36*(1): 85-110.

Martin, S. (2010). *WMR 2010 Background Paper: Climate Change and International Migration*. Geneva: International Organization for Migration (IOM). Available at: https://sdgs.un.org/publications/wmr-2010-background-paper-climate-change-and-international-migration-susan-martin

Martin, S., Singh, L., Taylor, A. and Wahedi, L. (2021). *Dynamic Model of Displacement* (Working Paper). Washington DC: Georgetown University.

McGregor, J., Marazzi, L. and Mpofu, B. (2011). *Conflict, Migration and the Environment: The Case of Zimbabwe.* London: The Government Office for Science.

McLeman, R.A. (2014). *Climate and Human Migration: Past Experiences, Future Challenges*. New York: Cambridge University Press.

McLeman, R.A. (2016). *Interconnectivity of Climate Change, Ecosystems, Livelihoods, and Migration: Implications for Long Term, Climate-Resilient Development Planning.* Background Paper for: Groundswell – Preparing for Internal Climate Migration. Washington DC: World Bank.

McNamara, K.E. (2007). 'We Do Not Want to Leave Our Land: Pacific Ambassadors at the United Nations Resist the Category of Climate Refugees'. *Population and Environment, 29*(1): 12-24.

Migration Policy Practice. (2020). Special Issue on Data, Mobility and the Environment – *MECC & DTM Joint Contribution. 10*(1).

Migali, S., Natale, F. and Münz, R. (2018). *Many More to Come? Migration Within and From Africa.* Luxemburg: Publications Office of the European Union. doi:10.2760/1702

Migali, S., and Natale, F. eds. (2021). *Population Exposure and Migration Linked to Climate Change in Africa: Evidence from the Recent Past and Scenarios for* *the Future*. Luxemburg: Publications Office of the European Union. doi:10.2760/4151

Molinaroli, E., Guerzoni, St. and Suman, D. (2017). 'Adaptations to Sea Level Rise: A Tale of Two Cities – Venice and Miami'. Open Science Foundation paper. MarXiv, May 21. doi: 10.31230/osf.io/73a25

Mora, J. and Taylor, J.E. (2006). *Does Migration Reshape Expenditures in Rural Households? Evidence from Mexico*. World Bank Policy Research Working Paper No. 3842. Washington DC: World Bank.

Mortreux, C. and Barnett, J. (2009). 'Climate Change, Migration and Adaptation in Funafuti, Tuvalu'. *Global Environmental Change, 19* (1): 105-112.

Mulheren, O. (2020). Sea Level Rise Projection Maps – Bangkok, Chittagong, Hamburg, Jakarta, Manila, Venice. Earth.org, 30 June. Avaliable at: https://earth.org/data_visualization/sea-level-rise-by-the-end-of-the-century-bangkok/; https://earth.org/data_visualization/sea-level-rise-by-the-end-of-the-century-chittagong; https://earth.org/data_visualization/sea-level-rise-by-2100-jakarta/; https://earth.org/data_visualization/sea-level-rise-by-2100-manila/; https://earth.org/data_visualization/sea-level-rise-by-the-end-of-the-century-venice/

Myers, N. (1997). 'Environmental Refugees'. *Population and Environment, 19* (2): 167–182.

Myers, N. (2005). 'Environmental Refugees: An Emergent Security Issue'. 13th OSCE Economic Forum. Prague, 23-27 May. Prague: OSCE.

Myers, N. (2007). *Human Tide: The Real Migration Crisis*. London: Christian Aid.

NASA Socioeconomic Data and Application Center (SEDAC). New York: Columbia University. Available at: https://sedac.ciesin.columbia.edu/

Naudé, W. (2010). 'The Determinants of Migration from Sub-Saharan African Countries'. *Journal of African Economies*, 19(3): 330–356.

Nawrotzki, R.J., Daniel M., Runfola, D.M., Hunter, L.M. and Riosmena, F. (2016). 'Domestic and International Climate Migration from Rural Mexico'. *Human Ecology Interdisciplinary Journal, 44*(6): 687–699.

Nawrotzki, R. J. and DeWaard, J. (2018). 'Putting Trapped Populations into Place: Climate Change and Inter-District Migration Flows in Zambia'. *Regional Environmental Change, 18*(2): 533–546.

Neumann, K. and Hermans, F. (2017). 'What Drives Human Migration in Sahelian Countries? A Meta-analysis'. *Population, Space and Place, 23*(1): e1962. doi: 10.1002/psp.1962

Neumayer, E. (2005). 'Bogus Refugees? The Determinants of Asylum Migration to Western Europe'. *International Studies Quarterly, 49*(4): 29–51.

Obokata, R., Veronis, L. and McLeman, R. (2014). 'Empirical research on international environmental migration: a systematic review'. *Population and Environment, 36*: 111–135.

Ordonhas Viseu Cardoso, R., Meijers, E., van Ham, M., Burger, M. and de Vos, D. (2019). 'Why Bright City Lights Dazzle and Illuminate – A Cognitive Science Approach to Urban Promises'. *Urban Studies, 56*(2), 452- 470. https://doi.org/10.1177/0042098018804762

Piguet, E., Pécoud, A., and de Guchteneire, P. eds. (2011). *Migration and Climate Change*. Paris: UNESCO.

Poston, D.L, Zhang, L. Gotcher, D.J. and Gu, Y. (2009). 'The effect of climate on migration: United States, 1995–2000', *Social Science Research, 38* (3).

Ratcliffe, R. (2022). 'Indonesia names new capital Nusantara, replacing sinking Jakarta'*. The Guardian*, 18 January. Available at: https://www.theguardian.com/world/2022/jan/18/indonesia-names-new-capital-nusantara-replacing-sinking-city-of-jakarta

Renaud, F.G., Dun, O., Warner, K. and Bogardi, J. (2011). 'A Decision Framework for Environmentally Induced Migration'. *International Migration, 49*: 5-29

Reuters. (2020). 'Indonesia's capital relocation on hold, shifts budget to fight pandemic'. *Reuters*, 24 April. Avaliable at: https://www.reuters.com/article/us-health-coronavirus-indonesia-capital/indonesias-capital-relocation-on-hold-shifts-budget-to-fight-pandemic-idUSKCN2260L7

Rigaud, K. K, de Sherbinin, A., Jones, B., Bergmann, J., Clement, V., Ober, K., Schewe, J., Adamo, S., McCusker, B., Heuser, S. and Midgley, A. (2019). *Groundswell – Preparing for internal climate migration*. Washington DC: World Bank.

Rigaud, K.K. de Sherbinin, A. Jones, B. Adamo, S. Maleki, D. Abu-Ata, N.E.. Casals Fernandez, A.T. Arora, A. Chai-Onn, T. and Mills, B. (2021). *Groundswell Africa : Internal Climate Migration in West African Countries*. World Bank, Washington, DC. Available at:

https://openknowledge.worldbank.org/handle/10986/36404 License: CC BY 3.0 IGO.

Ritchie, H & Roser, M (2018) – 'Urbanization'. Published online at OurWorldInData.org. Available at: https://ourworldindata.org/urbanization

Roberts R.A.J. (2005). 'Insurance of crops in developing countries'. Food and Agriculture Organization of the United Nations. Available at: https://www.fao.org/3/y5996e/y5996e02.htm

Romanovsky, V.E. Gruber, S. Instanes, A. Jin, H. Marchenko, S.S. Smith, S.L. Trombotto, D. and Walter, K.M. (2007). 'Frozen ground' in: United Nations Environment Programme (2007). Global outlook for ice and snow. Nairobi: UNEP 182-200.

Ruyssen, I., Everaert, G. and Rayp, G. (2014). 'Determinants and Dynamics of Migration to OECD Countries in a Three-Dimensional Panel Framework'. *Empirical economics, 46*(1): 175-197.

Rzhevsky, S. (2022). Norilsk – the view from above. Russiatrack. Available at: https://russiatrek.org/blog/cities/norilsk-the-view-from-above/

Satterthwaite, D. (2020). 'An Urbanising World'. *International Institute for Environment and Development (IIED) Blog*, 9 April. Available at: https://www.iied.org/urbanising-world.

Schewel, K. (2020). 'Understanding Immobility: Moving Beyond the Mobility Bias in Migration Studies'. *International Migration Review, 54*(2): 328-355.

Schewel, K. and Fransen, S. (2020). *Who Aspires to Stay? Imobility Aspirations Among Youth in Ethiopia, India, Peru, and Vietnam*. IMI Working Paper No. 161. Oxford: International Migration Institute (IMI).

Schuldt, C., Schiewe, J. and Kröger, J. (2020). 'Sea-Level Rise in Northern Germany: A GIS-Based Simulation and Visualization'. *Journal of Cartography and Geographic Information, 70*: 145–154.

Schuttenhelm, R. (2019). 'In face of rising sea levels the Netherlands must consider controlled withdrawal'. *Vrij Nederland*, 7 January. Avaliable at: https://www.vn.nl/rising-sea-levels-netherlands/

Shen, S. and Binns, T. (2012). 'Pathways, Motivations and Challenges: Contemporary Tuvaluan Migration to New Zealand'. *GeoJournal, 77*(1): 63-82.

Sirkeci, I., Cohen, J.H. and Ratha, D. eds. (2012). *Migration and Remittances during the Global Financial Crisis and Beyond*. Washington DC: World Bank. Available at: https://documents1.worldbank.org/curated/en/701621468149081927/pdf/693130PUB0publ067926B09780821388266.pdf

Smith, M., Bastin, G. and Chewings, V. (2011). *Environment and Non-Environmental Drivers of Migration from Global Drylands.* The Government Office for Science, London. Available at: http://www.bis.gov.uk/foresight/migration.

Spear, T. (2020). 'MOSE flood barrier protects Venice - see how it works'. *Designboom*, 5 October. Avaliable at: https://www.designboom.com/architecture/mose-flood-barrier-venice-storm-alex-10-05-2020/

Statista (2021). 'Natural Disasters - Statistics & Facts'. *Statista Research Department,* 1 April. Available at: https://www.statista.com/topics/2155/natural-disasters/.

Stern, N. ed. (2006). *The Economics of Climate Change: The Stern Review.* Cambridge: Cambridge University Press.

Stojanov, R., Rosengaertner, S., de Sherbinin, A. and Nawrotzki, R. (2021). 'Climate Mobility and Development Cooperation'. *Population and Environment 43*(1): 209-231. Doi:10.1007/s11111-021-00387-5

Strupczewski, J. and Jones, G. (2021). 'G20 leaders have *Reuters* reached deal on climate language in final communique – source'., 31 October. Avaliable at: https://www.reuters.com/world/g20-leaders-have-reached-deal-climate-language-final-communique-source-2021-10-31/

Sunil, Th., Rojas, V. and Bradley, D. (2007). 'United States' International Retirement Migration: The Reasons for Retiring to the Environs of Lake Chapala, Mexico'. *Ageing and Society, 27*: 489–510.

The Borneo Post. (2021). 'Indonesia's new capital city project in East Kalimantan postponed again'. *Borneo Post*, 3 June. https://www.theborneopost.com/2021/06/03/indonesias-new-capital-city-project-in-east-kalimantan-postponed-again/

The World Bank. (2020) '*Senegal - Saint-Louis Emergency Recovery and Resilience Project'*. Washington DC: WB. Avaliable at: https://projects.worldbank.org/en/projects-operations/project-detail/P166538

The Government Office for Science. (2011). *Foresight: Migration and Global Environmental Change. Final Project Report*. London: The Government Office for Science.

Tolba, M. K. (1989). 'Our Biological Heritage under Siege'. *Bioscience, 39*(4): 725–728.

UN DESA. (2019). *World Urbanization Prospects.* The 2018 Revision. New York: UN. Available at: https://digitallibrary.un.org/record/3833745; https://population.un.org/wup/

UN DESA. (2020). *International Migration Report 2020*. New York: United Nations. Available at: https://www.un.org/en/desa/international-migration-2020-highlights

UN DESA. (2020a). *'International Migrant Stock Dataset'*. UN New York. Available at: https://www.un.org/development/desa/pd/content/international-migrant-stock

UN Development Programme. (2009). *Human Development Report 2009 – Overcoming Barriers: Human Mobility and Development*. Houndmills, Basingstoke: Palgrave Macmillan. Available at: http://hdr.undp.org/sites/default/files/reports/269/hdr_2009_en_complete.pdf

UN DRR. (2021). *Global Assessment Report on Disaster Risk Reduction. Special Report on Drought.* New York: UN.

UN DRR. (2015). *'Sendai Framework for Disaster Risk Reduction 2015 – 2030*. United Nations. Avaliable at: https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030

UN FCCC. (2015). 'Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015'. UN FCCC/CP/2015/10/Add.1. New York: United Nations Framework Convention on Climate Change. Available at: https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf

UN FCCC. (2010). *Cancun Agreements.* New York: United Nations Framework Convention on Climate Change. Available at : https://unfccc.int/process/conferences/pastconferences/cancun-climate-change-conference-november-2010/statements-and-resources/Agreements

United Nations. (2019). 'Migration and the climate crisis: the UN's search for solutions'. *UN News*. Available at: https://news.un.org/en/story/2019/07/1043551

United Nations Environment Programme. (2019). *'Thawing Arctic peatlands risk unlocking huge amounts of carbon'*. Nairobi: UNEP. Avaliable at: https://www.unep.org/news-and-stories/story/thawing-arctic-peatlands-risk-unlocking-huge-amounts-carbon

United Nations Office for the Coordination of Humanitarian Affairs Unsigned. (2011). '*Eastern Africa: Drought – Humanitarian Snapshot*'. New York: OCHA. Available at: https://reliefweb.int/sites/reliefweb.int/files/resources/DR-2011-000029-KEN_0720_1.pdf

UN GA. (2009). 'Climate Change and Its Possible Security Implications: Report of the Secretary-General'. UN General Assembly, Sixty-fourth session, Item 114 of the provisional agenda. New York: UN. Available at: https://digitallibrary.un.org/record/667264#record-files-collapse-header

UN GA. (2018). 'Global Compact for Safe, Orderly and Regular migration'. Resolution adopted by the UN General Assembly on 19 December 2018, A/RES/73/195.

UNHCR. (2002). 'A Critical Time for the Environment'. *Refugees, No.127*. Geneva: UNHCR

University of Zurich (n.d). 'Alpine Permafrost Index Map (APIM)' Available at: https://www.geo.uzh.ch/microsite/cryodata/PF_map_explanation.html
Ourworldindata. (n.d.) 'Annual CO_2 emissions from fossil fuels, by world region' Available at: https://ourworldindata.org/grapher/annual-co-emissions-by-region

Van der Geest, K. (2011). 'North-South Migration in Ghana: What Role for the Environment?'. *International Migration, 49*(1): 69–94. Doi: 10.1111/j.1468-2435.2010.00645.x

Verisk Maplecroft. (2016). 'COP blog: Who's got most to lose if the Paris Agreement fails?' Avaliable at: https://www.environmental-finance.com/content/analysis/cop-blog-whos-got-most-to-lose-if-the-paris-agreement-fails.html

Veronis, L. and McLeman, R. (2014). *'Environmental Influences on African Migration to Canada: Focus Group Findings from Ottawa-Gatineau'. Population and Environment, 36*(2): 234–251.

Vigil, S. (2017). *Addressing the Land Degradation-Migration Nexus: The Role of the United Nations Convention to Combat Desertification*. IOM: Geneva.

Warner, K. (2010). 'Global Environmental Change and Migration: Governance Challenges'. *Global Environmental Change, 20*: 402-413.

Warner, K., Hamza, M., Oliver-Smith, A., Renaud, F. and Julca, A. (2010). Climate Change, Environmental Degradation and Migration. *Natural Hazards, 55*(3): 689–715. https://doi.org/10.1007/s11069-009-9419-7

Wodon, Q., Liverani, A., Joseph, G. and Bougnoux, N. eds. (2014). *Climate Change and Migration: Evidence from the Middle East and North Africa*. Washington DC:

World Bank.World Food Program. (2017). *At the Root of Exodus: Food Security, Conflict and International Migration.* Rome: WFP. Available at: https://docs.wfp.org/api/documents/WFP-0000015358/download/

World Population Review. (2022). 'Yakutsk Population 2022'. Avaliable at: https://worldpopulationreview.com/world-cities/yakutsk-population

World Population Review. (n.d). 'Norilsk Population'. Avaliable at: https://worldpopulationreview.com/world-cities/norilsk-population

Zielinski, S. (2014). 'Why the City Is (Usually) Hotter than the Countryside'. *Smithonian Magazine*, 9 July.

Appendix

Table 6 Overview of climate change and macro trends on livelihoods in key ecosystems of middle- and low-income countries, possible mobility and migration trends by 2050

Main climatic influence on mobility/ migration	Other relevant macro trends	Impact on livelihoods	Possible mobility trends	Strength of evidence, based on existing data
Drylands				
Extreme heat events, droughts, dryness, and precipitation variability	-Growing intensification and market-orientation of agriculture -Land degradation, water scarcity, and depletion of soil nutrients -Increasing enclosures and land grabs	-Pastoralism declines -Specialized livestock pasturing increases -Average farm size shrinks -Small-scale farms lack capital to intensify -Outside interests acquire farms on best, most accessible land	-Domestic mobility and international migration increase -Rural to urban migration increases -Extreme events increase distress migration	-Strong statistical and case-based evidence for coastal states in Asia and Oceania -Fewer data and cases for Africa

Main climatic influence on mobility/ migration	Other relevant macro trends	Impact on livelihoods	Possible mobility trends	Strength of evidence, based on existing data
Forest regions				
Increased extreme heat periods and rainfall variability, increase in wildfires	-High rates of deforestation in the Americas, Central Africa, and Southeast Asia -Loss of biodiversity -Land degradation -Smallholder farmers as key drivers of forest change in Africa -Commercial players as key drivers of forest change in the Americas and in Asia	-Indigenous and customary forest users squeezed out -Smaller market-oriented farms created, bought, and sold -Operators of larger, capital intensive farms and plantations acquire best lands	-Churning mobility patterns appear in forest frontier areas -Higher labour mobility among young adult labor leaving more established farming areas increase	-Strong case-based evidence of migration processes in the Americas and Southeast Asia -More evidence from Africa desirable

Main climatic influence on mobility/ migration	Other relevant macro trends	Impact on livelihoods	Possible mobility trends	Strength of evidence, based on existing data
Coastal zones				
-Rising sea levels and increased intensity of storms, causing floods, erosion, soil salinization, aquifer salinisation -Increasing ocean temperatures affecting reef health; -Increased variability in quantity and duration of rainfall	-Rapid urbanization and industrial development in river delta regions of Asia -Loss of protective features (mangroves, marshes) -Expanding aquaculture across coastal Asia -Declining offshore fish stocks	-Economic opportunity increasingly urban based -Small-scale fishing declines in many regions -Coastal farms under increasingly intensive cultivation -Some farms in Southeast Asia converted to shrimp aquaculture	-Higher rates of rural to urban mobility (temporary and permanent) -Displacement from smaller atolls and seaward edge of river deltas as a result of erosion and salinization	-Strong statistical and case-based evidence for coastal states in Asia and Oceania -Fewer data and cases for Africa

Main climatic influence on mobility/ migration	Other relevant macro trends	Impact on livelihoods	Possible mobility trends	Strength of evidence, based on existing data
Mountain regions				
-Increased precipitation variability and warming temperatures, leading to growing seasonal and interannual water scarcity; flash floods and landslides of increasing magnitudes; effects vary widely across regions because of inherent heterogeneity of mountain environments	-Reinforced endemic poverty through remoteness, lack of physical and social infra-structure -Destabilising deforestation around many mountain settlements	-Declining Pastoralism, but larger livestock kept by less mobile farmers -Subsistence farmers lack food security -Livelihoods become highly diversified -Seasonal and longer-term mobility and emigration become essential to livelihoods	-Further increases in already high rates of rural to urban mobility within countries with mountain regions -Emigration to foreign countries	-Strong case-based evidence from Ecuador, India, Nepal, Pakistan, and Peru -Statistical evidence on inter-national migration weak for Nepal -Good predictability at larger scale, but local experience varies a lot

Main climatic influence on mobility/ migration	Other relevant macro trends	Impact on livelihoods	Possible mobility trends	Strength of evidence, based on existing data
Smallholder cropping regions				
	-Global and regional population growth drives growing demand for food -Greater pressure towards intensive production in all regions, especially in Africa and South Asia, where yield gaps are greatest	-Small-scale farmers and herders increasingly squeezed off best land -Trend to intensify production increases need for capital to invest in seeds, fertilisers, irrigation, harvesting technologies etc. -Market oriented production generates cash income -Some areas in Asia under irrigation may need to revert to rainfed agriculture, reducing household incomes -Productivity in some regions and of some crops may decline: trends will vary by region and crop type	-Rural to urban mobility and migration to foreign countries (temporary and long-term) increase	-Strong statistical evidence based on current crop production -Models of future crop productivity display variability -Quantitative studies from several countries in Latin America, Asia, and Sub-Saharan Africa provide strong evidence of climate related rural income driven mobility and emigration to foreign countries -Large array of case-based evidence from all continents

Authors

Mathias Czaika

Mathias Czaika is a University Professor in Migration and Integration and Head of the Department for Migration and Globalisation at Danube University, Krems, Austria. In this role, he is leading a team of more than 20 researchers and support staff, and he is also the Coordinator of the PhD Programme in Migration Studies.

Mathias Czaika holds a Master's degree in Economics from University of Konstanz, and a PhD in Political Economy from University of Freiburg, Germany. After finishing his PhD in 2008, he worked as an economic policy analyst and advisor for the German Development Cooperation Agency (GIZ) in Frankfurt, Germany. Between 2010 and 2017, he was a Senior Researcher and Associate Professor at the University of Oxford, UK. In 2016, he became director of the International Migration Institute at the University of Oxford.

Mathias Czaika's main research interests cover areas as wide as international migration processes, social transformations, globalization, development, poverty, and inequality; relative deprivation, aspirations, and migration decision making; migration policy formation, policy impact evaluation; labour migration, asylum and refugees. He has published widely in journals including Demography, Population Development Review, International Migration Review, or the Journal of Peace Research.

Contact: Mathias.Czaika@donau-uni.ac.at

Rainer Münz

Rainer Münz is an expert in Demography and international migration. During his career he has been working as an academic, in the private sector and as government adviser. He currently teaches as visiting professor at the Central European University (Department of Public Policy) and at the Diplomatic Academy in Vienna.

Between 2015 and 2019 he was Adviser on Migration and Demography at the European Political Strategy Centre (EPSC), the in-house think tank advising European Commission President J.C. Juncker during his time in office. In 2020-21 he worked at the Knowledge Centre on Migration and Demography (JRC-KCMD) of the European Commission in Ispra, Italy.

Prior to joining the European Commission, Rainer Münz was – between 2005 and 2015 – Head of Research and Development at Erste Group, a Central European retail bank headquartered in Vienna. He also worked as Senior Fellow at the European macro-economic think tank Bruegel (Brussels), the Hamburg Institute of International Economics (HWWI) and at the Migration Policy Institute (MPI, Washington DC).

Until 2004, Rainer Münz had an academic career as researcher at the Austrian Academy of Sciences, 1980-1992, and at the Department of Mathematics of Finance/ TU Vienna, 2002-2004, as well as a tenured university professor at Humboldt University, Berlin, 1993-2003. He also was visiting professor at the Universities of Bamberg, UC Berkeley, AU Cairo, Frankfurt/M., HU Jerusalem, Klagenfurt, St. Gallen (HSG), Vienna and Zurich.

In 2000-01, Rainer Münz was member of the German commission on immigration reform (Suessmuth commission). Between 2008 and 2010, he was Member of the high level 'Reflection Group Horizon 2020-2030 of the European Council (Gonzales commission). Between 2015 and 2019, he was chair of Migration Advisory Board of the UN Organisation on International Migration (IOM). Currently he is one of the working group chairs of the World Bank's Global Knowledge Partnership on Migration and Development (KNOMAD). He also is member of the Experts Council on Integration advising the Austrian government.

Contact: rainer.muenz54@gmail.com

List of previous publications

Report and Policy Brief 2014:1, *Radikala högerpartier och attityder till invandring i Europa*, Mikael Hjerm and Andrea Bohman.

Report and Policy Brief 2015:1, *Internationell migration och remitteringar i Etiopien*, Lisa Andersson.

Research Overview 2015:2, *Politiska remitteringar*, Emma Lundgren Jörum and Åsa Lundgren.

Research Overview 2015:3, *Integrationspolitik och arbetsmarknad*, Patrick Joyce.

Research Overview 2015:4, *Migration och företagens internationalisering*, Andreas Hatzigeorgiou and Magnus Lodefalk.

Report and Policy Brief 2015:5, *Svenskt medborgarskap: reglering och förändring i ett skandinaviskt perspektiv*, Mikael Spång.

Report and Policy Brief 2015:6, *Vem blir medborgare och vad händer sen? Naturalisering i Danmark, Norge och Sverige*, Pieter Bevelander, Jonas Helgertz, Bernt Bratsberg and Anna Tegunimataka.

Research Overview 2015:7, *Kategoriernas dilemman: En kunskapsöversikt om kategorisering utifrån nationellt och etniskt ursprung i offentlig politik och forskning*, Per Strömblad and Gunnar Myrberg.

Report and Policy Brief 2015:8, *Valet och Vägen: Syriska flyktingar i Sverige*, Emma Jörum Lundgren.

Report and Policy Brief 2015:9, *Arbetskraft från hela världen: Hur blev det med 2008 års reform?,* Catharina Calleman och Petra Herzfeld Olsson (eds.).

Research Overview 2016:1, *Alla tiders migration!: immigrationens betydelse för Sveriges utveckling och välstånd*, Dick Harrison.

Report and Policy Brief 2016:2, *Invandringens arbetsmarknadseffekter: Lärdomar från den internationella litteraturen och svenska resultat*, Mattias Engdahl.

Report and Policy Brief 2016:3, *Irreguljär migration och Europas gränskontroller*, Ruben Andersson.

Research Overview 2016:4, *Diaspora – ett begrepp i utveckling*, Erik Olsson.

Research Overview 2016:5*, Migration within and from Africa*, Aderanti Adepoju.

Report and Policy Brief 2016:6, *Invandring, mediebilder och radikala högerpopulistiska partier i Norden*, Anders Hellström and Anna-Lena Lodenius.

Research Overview 2016:7, *Invandring och företagande*, Martin Klinthäll, Craig Mitchell, Tobias Schölin, Zoran Slavnić and Susanne Urban.

Report and Policy Brief 2016:8, *Invandringens effekter på Sveriges ekonomiska utveckling*, Bo Malmberg, Thomas Wimark, Jani Turunen and Linn Axelsson.

Research Overview 2017:1, *De invandringskritiska partiernas politiska inflytande i Europa*, Maria Tyrberg and Carl Dahlström.

Research Overview 2017:2, *Hatbrott med främlingsfientliga och rasistiska motiv*, Berit Wigerfelt and Anders S Wigerfelt.

Dissertation Series 2017:3*, Vägen till arbete. Utlandsföddas möte med den svenska arbetsmarknaden*, André Asplund, Caroline Tovatt and Sara Thalberg (eds.).

Policy Brief 2017:4, *Integration och tillit – långsiktiga konsekvenser av den stora invandringen till Norge*, Grete Brochmann.

Research Overview 2017:5, *Invandringens historia – från "folkhemmet" till dagens Sverige*, Mikael Byström and Pär Frohnert.

Report and Policy Brief 2017:6, *Invandring i medierna – Hur rapporterade svenska tidningar åren 2010–2015?,* Jesper Strömbäck, Felicia Andersson and Evelina Nedlund.

Report and Policy Brief 2017:7, *Valdeltagande och representation – Om invandring och politisk integration i Sverige*, Pieter Bevelander and Mikael Spång (eds.).

Report and Policy Brief 2017:8, *Responsibility Sharing for Refugees in the Middle East and North Africa*, Susan Martin.

Report and Policy Brief 2017:9, *Reforming the Common European Asylum System*, Bernd Parusel and Jan Schneider.

Report and Policy Brief 2017:10, *A Fair Share: Refugees and Responsibility-Sharing*, Alexander Betts, Cathryn Costello and Natascha Zaun.

Report and Policy Brief 2018:1, *Somali Diaspora Groups in Sweden – Engagement in Development and Relief Work in the Horn of Africa*, Nauja Kleist.

Report and Policy Brief 2018:2, *Akademiskt utbyte och internationell migration – En studie av stipendiater inom Svenska institutets Visbyprogram 1997–2015*, Andreas Åkerlund, Astrid Collsiöö and Mikael Börjesson.

Report and Policy Brief 2018:3, *Ensamkommande barns och ungas väg in i det svenska samhället,* Eskil Wadensjö and Aycan Çelikaksoy.

Report and Policy Brief 2018:4, *Attityder till invandring – en analys av förändringar och medieeffekter i Sverige 2014–2016*, Jesper Strömbäck and Nora Theorin.

Report and Policy Brief 2018:5, F*amilj, medborgarskap, migration – Sveriges politik för anhöriginvandring i ett jämförande perspektiv*, Karin Borevi.

Dissertation Series 2018:6*, Barn och migration*, André Asplund, Caroline Tovatt and Sara Thalberg (eds.).

Policy Brief 2018:7, *Människohandel och människosmuggling i den irreguljära migrationen*, Ryszard Piotrowicz.

Report and Policy Brief 2018:8, *Asylsökandes möte med Sverige – Lärdomar från en panelundersökning*, Peter Esaiasson and Jacob Sohlberg.

Policy Brief 2018:9, *Medborgarskapslagar – en global jämförelse*, Rainer Bauböck.

Report and Policy Brief 2019:1, *Bridging the Gaps – Linking Research to Public Debates and Policy-making on Migration and integration"*, Martin Ruhs, Kristof Tamas and Joakim Palme. The report can be read via Delmi's website or via Oxford University Press: http://fdslive.oup.com/www.oup.com/academic/pdf/openaccess/9780198834557.pdf

Report and Policy Brief 2019:2, *Från Afrikas horn till Sverige: Smuggling, informella nätverk och diasporans engagemang*, Tekalign Ayalew Mengiste and Erik Olsson.

Report and Policy Brief 2019:3, *Thai berry pickers in Sweden – A migration corridor to a low-wage sector*, Charlotta Hedberg, Linn Axelsson and Manolo Abella.

Report and Policy Brief 2019:4, *Internationella studenter i Sverige – Avgiftsreformens påverkan på inflödet av studenter*, André Bryntesson and Mikael Börjesson.

Research Overview and Policy Brief 2019:5, *Migration and development - The role for development aid*, Robert E.B. Lucas.

Policy Brief 2019:6, *Åter till grunderna – Läsförmåga, immigration och arbetsmarknadsutfall i Sverige*, Jon Kristian Pareliussen.

Policy Brief 2019:7, *Ålder vid invandring och arbetsmarknadsintegration – det svenska exemplet*, Torun Österberg.

Policy Brief 2019:8, *Barn med posttraumatisk stress – utvärdering av en gruppintervention för ensamkommande flyktingbarn med symptom på posttraumatisk stress*, Anna Sarkadi.

Policy Brief 2019:9, *Suicidalt beteende och vård – skillnader mellan flyktingar, andra migranter och personer födda i Sverige*, Ellenor Mittendorfer-Rutz.

Policy Brief 2019:10, *Fri rörlighet för arbetstagare i EU och dess effekter på statsfinanserna*, Marcus Österman, Joakim Palme and Martin Ruhs.

Report and Policy Brief 2020:1, *De som inte får stanna: Att implementera återvändandepolitik*, Henrik Malm Lindberg.

Report and Policy Brief 2020:2, *Laglig migration för arbete och studier - Möjligheter att få uppehållstillstånd i Sverige för personer som saknar skyddsbehov*, Bernd Parusel.

Report and Policy Brief 2020:3, *Effekten av krig – Posttraumatisk stress och social tillit hos flyktingar*, Jonathan Hall and Dennis Kahn.

Report and Policy Brief 2020:4, *Åtgärder mot människosmuggling och människohandel: Är de förenliga med EU-stadgan om de grundläggande rättigheterna?,* Vladislava Stoyanova.

Policy Brief 2020:5, *Den reglerade invandringen och barnets bästa*, Louise Dane.

Policy Brief 2020:6, *Migrationspolitik, välfärd och jämlikhet*, Björn Östbring.

Dissertation Series 2020:7, *Migranters möte med svensk hälso- och sjukvård*, André Asplund, Raoul Galli, Iris Luthman and Sara Thalberg (eds.).

Policy Brief 2020:8, *Språkkaféet som arena för språkträning*, Gunilla Jansson and Silvia Kunitz.

Policy Brief 2020:9*, Nyanlända elever och lärande på gymnasieskolans språkintroduktionsprogram*, Päivi Juvonen.

Report 2021:X, *European Asylum Challenges, Debates and Reforms*, Dietrich Thränhardt, Agnieszka Kulesa, Cláudia de Freitas and Bernd Parusel. The report can be read via Delmi's website or via Bertelsmann Stiftung: Asylum Challenges, Debates and Reforms: Bertelsmann Stiftung (bertelsmann-stiftung.de)

Report and Policy Brief 2021:1, *Idrott och hälsa bland flickor - Uppfattningar och erfarenheter bland föräldrar från Somalia, Eritrea, Syrien och Sverige*, Anders Kassman and Åsa Kneck.

Policy Brief 2021:2, *Miljonprogram, migranter och utsatthet för covid-19*, Erik Hansson, Lina Al-Nahar, Maria Albin, Eskil Jakobsson, Maria Magnusson and Kristina Jakobsson.

Report and Policy Brief 2021:3, *Lokalsamhälletillit i Sverige före och efter flyktingkrisen*, Susanne Wallman Lundåsen.

Research Overview 2021:4, *Tolkfunktionen i asylprocessen*, Cecilia Wadensjö, Hanna Sofia Rehnberg and Zoe Nikolaidou.

Dissertation Series 2021:5, *Tidsbegränsade uppehållstillstånd, egenföretagande och skolsegregation - Aktuella avhandlingar om utrikes födda på arbetsmarknaden*, Johanna Hemberg and Linus Liljeberg (eds.).

Report and Policy Brief 2021:6, *Ungas uppväxtvillkor och integration*, Sara Thalberg, André Asplund and Daniel Silberstein (eds.).

Policy Brief 2021:7, *Invandring och välfärdsstaten*, Tina Goldschmidt.

Policy Brief 2021:8, *Interaktiv rasism på internet, i pressen och politiken*, Mattias Ekman.

Policy Brief 2021:9, *Polariserad demokrati. Hur uppfattade hot påverkar främlingsfientlighet och spänningar mellan olika grupper i samhället*, Emma A. Renström and Hanna Bäck.

Report and Policy Brief 2021:10, *Those who were sent back – Return and reintegration of rejected asylum seekers to Afghanistan and Iraq*, Constanza Vera Larrucea, Henrik Malm Lindberg, and André Asplund.

Report and Policy Brief 2021:11, *Trade Agreements as a Venue for Migration governance – Potential and Challenges for the European Union*, Sandra Lavenex and Tamirace Fakhoury.

Policy Brief 2021:12, *The evolving policy coherence for development. Risk or opportunity for the EU as a development actor?*, Anna Michalski.

Dissertation Series 2021:13, *Nya perspektiv på segregation: skola, psykisk hälsa och bosättningsmönster*, Embla Holmgren and Linus Liljeberg (eds.).

Research Overview 2022:1, *Exillitteratur i Sverige 1969 till 2019*, Daniel Pedersen.

Research Overview 2022:2 *The impacts of migration for adaptation and vulnerability*, François Gemenne.

Policy Brief 2022:3 *How large will the Ukrainian refugee flow be, and which EU countries will they seek refuge in?*, Mikael Elinder, Oscar Erixson and Olle Hammar.

Policy Brief 2022:4 *The Temporary Protection Directive: EU's response to the Ukrainian exodus: The 'why', 'who', 'what', 'where' and 'how' of temporary protection*, Eleni Karageorgiou, and Vladislava Stoyanova.

Report and Policy Brief 2022:5 *Invandring och integration i svensk opinion*, Anders Westholm

Report and Policy Brief 2022:6 *Hur gemensamma är de gemensamma EU-reglerna? Svensk asylrätt i europeiskt perspektiv*, Vladislava Stoyanova and Eleni Karageourgiou.

Policy Brief 2022:7 *Vilka är mest benägna att rösta i svenska lokala val? Lokalt valdeltagandet bland utrikesfödda i Sverige*, Pieter Bevelander.

Report 2022:8 *Nyanländas integration: En enkätstudie om språkstuderandes erfarenheter av livet i Sverige*, Sara Thalberg and Linus Liljeberg.

To which extent does climate change affect mobility, displacement, and migration, and what are the political measures that can address both the actual and potential impact of change on migration? In this Delmi research overview, Mathias Czaika and Rainer Münz present the complex impact that contemporary climate and environmental change has on the drivers and outcomes of mobility, displacement, immobility, and migration. While natural disasters and extreme weather events can cause the destruction of assets and livelihoods, they seldom lead to long-term migration or displacement across borders. Slow onset climate change, while influencing assets and livelihoods, is often perceived as an indirect effect as it interacts with other potentially relevant drivers of internal mobility and international migration.

The Migration Studies Delegation is an independent committee that initiates studies and supplies research results as a basis for future migration policy decisions and contribute to public debate.

Delmi

SWEDISH GOVERNMENT INQUIRIES
The Migration Studies Delegation
JU 2013:17