



HABITABLE

# A Conceptual Model of Climate Change and Human Mobility Interactions

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D7.1

## D7.1 A Conceptual Model of Climate-Mobility Interactions

The **HABITABLE** project – Linking Climate Change, Habitability and Social Tipping Points: Scenarios for Climate Migration – aims at significantly advance our understanding of the **current interlinkages between climate change impacts and migration** and displacement patterns, and to **better anticipate their future evolution**.

Running for **4 years** (2020-2024), HABITABLE brings together **21 partners**: University of Liège, University of Vienna, Potsdam Institute for Climate Impact Research, University of Exeter, the IDMC, Lund University, Sapienza Università di Roma, adelphi, Université de Neuchâtel, Institut de Recherche pour le Développement, Council of Scientific and Industrial Research, UNESCO, University of Ghana, CARE France, University of Twente, Université Cheikh Anta Diop, Stockholm Environment Institute Asia, Raks Thai Foundation, Addis Ababa University, Institut National de la Statistique du Mali and Samuel Hall.

HABITABLE is the **largest research project on climate change and migration** to have ever been funded by the European Commission's Horizon 2020 programme.

Please visit [www.habitableproject.org](http://www.habitableproject.org) for more information about the project.

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## Table of contents

<i>Acknowledgements</i> .....	4
<i>Scope of the paper</i> .....	5
Scenarios in HABITABLE .....	5
Conceptual model as building block for scenario development.....	5
Research design and structure of the paper .....	6
<i>Conceptual model</i> .....	7
Effects of climate change on mobility .....	8
Cumulative effects of climate change and adaptive capacity.....	9
Feedback effects.....	10
Considering distinct climate hazards and modes of mobility .....	12
<i>Climate vulnerability and adaptation in situ</i> .....	14
Relevance of moderating variables by type of hazard .....	20
Relevance of moderating variables by type of impacts .....	22
Climate vulnerability while and after moving.....	24
<i>Opportunities and constraints to mobility</i> .....	26
Relationship to distinct modes of mobility .....	30
<i>Summary</i> .....	32
<i>Bibliography</i> .....	33
<i>Appendix</i> .....	40

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## Scope of the paper

This paper presents a conceptual model of climate change and human mobility interactions. The model is meant to guide a scenario planning exercise with stakeholders and decision makers as part of the HABITABLE project. It builds mostly on a review of relevant literature and qualitative assumptions based on expert elicitation that are elaborated in the remaining text. Its purpose is to determine central variables and dimensions along which scenarios on climate change and human mobility will be developed in the next stage of the HABITABLE project (see box below).

### Scenarios in HABITABLE

The scenario planning exercise conducted in HABITABLE complements other work in the project in that it conceptualises the inherent uncertainty of future climate-migration dynamics and the social, ecological, economic, political and other factors that shape them. The goal is not to predict the future or discuss the probability of specific events, but rather to envision different plausible possibilities in order to facilitate strategic planning and adaptation. The exercise aims to produce intuitive narratives that will make it easier to engage non-expert audiences.

Scenarios depict situations that could possibly happen and offer multiple plausible visions of the future. They are a useful decision support tool in the face of uncertain climatic and political conditions. Scenarios offer a chance to scan the horizon for potential future challenges and start preparing for them. Going through this exercise, decision-makers are better equipped to face uncertain conditions and opt for robust adaptation options and “no regrets” measures that can perform under different scenarios. Furthermore, scenarios stimulate creative thinking and help overcome preconceived ideas about the future and rigid narratives that act as obstacles to forward-looking policymaking and societal transformation.

Scenarios assume that the future is inherently complex and unknowable. Rather than seeking to assess the probability of future events, scenarios illustrate alternative possibilities and invite flexibility and the consideration of a greater range of options to adapt (see Bressan et al. 2019:12f). They are thus complementary to predictive methods based on the analysis of historical patterns and extrapolation of past trends, which have only limited room for considering different future trajectories.

### Conceptual model as building block for scenario development

Scenario planning can roughly be divided in two phases: in the first phase the scenarios are created; in the second phase the scenarios are used to engage stakeholders and decision-makers and facilitate strategic planning with regard to the opportunities and challenges present in the scenarios. In HABITABLE, the first phase - the scenario development - is again divided into two steps: the first step considers possible cause-effect relations between climate change, human mobility, and relevant intervening and moderating variables (for example, variables that strengthen or attenuate the effect of one variable on another) within the climate-mobility nexus. This step also involves identifying key social, demographic, economic and other conditions that will shape future climate-migration interactions. The second step is about projecting these conditions for different scenarios, each characterised by different scope conditions and hence climate-mobility interactions.

The conceptual model presented in this paper addresses the first of the two steps of scenario development. In particular, it captures key causal pathways and conditions that moderate the relationship between slow and sudden-onset climate events, human mobility, and climate change adaptation. This involves a reflection on what socio-economic, environmental, demographic, and other conditions matter most in shaping and constraining future climate-mobility interactions.

### Research design and structure of the paper

The paper builds on a comprehensive review of the literature, as well as 20 interviews and two workshops with some 50 experts and practitioners from the fields of climate change impact research, human mobility, asylum and integration policies, climate change adaptation and disaster risk reduction, combining expertise on different geographical areas and facets of the climate-mobility nexus.<sup>1</sup> Involving these experts was important to ensure the validity and consistency of the conceptual model and its practical relevance.

Our research allowed us to narrow down a limited number of key sudden and slow-onset hazards, as well as modes of human mobility frequently emphasised by researchers and practitioners in the context of climate change and mobility (see also Quiggin et al. 2021, Birkmann et al. 2022, Cattaneo et al. 2019, Rigaud et al. 2018). Furthermore, engagement with the experts and the literature allowed us to identify and emphasise a number of social, cultural, economic, political, legal, technical, environmental, demographic and behavioural variables that shape present and future climate-migration interactions.

The first section of this paper introduces the main elements of a conceptual model of climate-mobility interactions. Key moderating variables of the model such as exposure and vulnerability to climate change, adaptive capacity, and constraints to mobility are then discussed in more detail in sections two and three.

#### Scope of the HABITABLE scenarios

HABITABLE will produce two distinct sets of scenario narratives:

- **Slow-onset:** This set will consider possible interactions between future slow-onset climatic pressures, as well as long-term trends in climate variability, and migration. The scenarios will have a time horizon of roughly 25 years into the future.
- **Sudden-onset:** This set will focus on displacements in connection with possible future sudden-onset climatic shocks. The scenarios will have a time horizon of roughly 3-5 years.

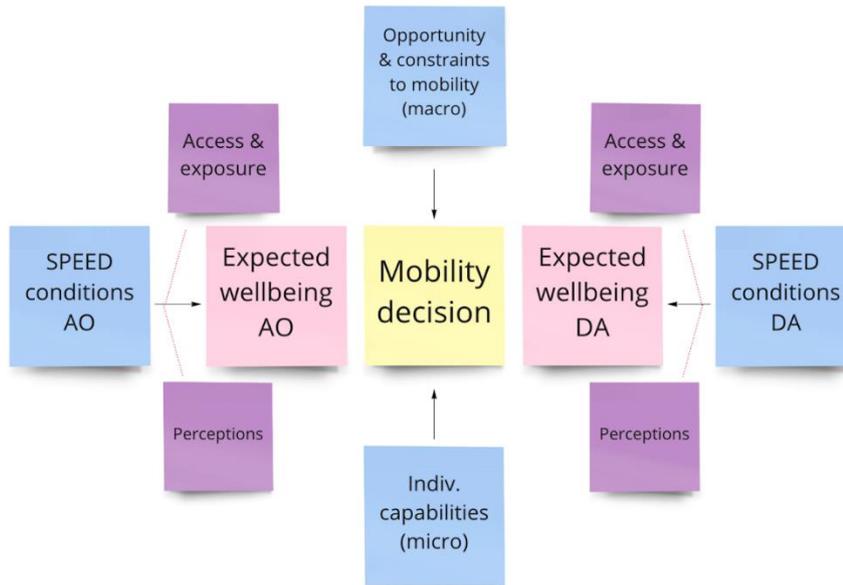
As a consideration of all possible combinations of types of climate events and modes of mobility is beyond the scope of this project, we concentrate here on most likely and most diverse combinations that are also of particular relevance to European stakeholders and their international partners. The scenario narratives will consider both push and pull factors, thereby differentiating between sending and receiving areas, as well as between different effects of migration.

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<sup>1</sup> See Table 3 in the appendix for some summary statistics on gender, regional background, type of organisation, and field of expertise of consulted experts.

## Conceptual model

This section presents a conceptual model of climate change and human mobility interactions (see Figure 1). At the core of the model, mobility decisions are influenced by people's *expectations* of safety, wellbeing, and prospects to lead a dignified life in their *area of origin (AO)* or in potential *destination area (DA)*. Large differences between these expectations are then likely to affect mobility decisions, i.e. people will be motivated to move to a place when they expect to encounter far better opportunities and living conditions there (see Flavell et al. 2020).



**Figure 1:** Mobility motivations and opportunities at the core of the model

These expectations are partly shaped by the social, political, environmental, economic, demographic (*SPEED*) conditions and other relevant features of these places that raise or lower the prospects of wellbeing for potential migrants. For example, access to education and other services, political freedoms, favourable soil conditions for agriculture, and other opportunities might act as incentives to move to a different place, while political tensions, violence, and food insecurity might motivate people to leave or avoid certain places (see Black et al. 2011, Siddiqui et al. 2020, Walelign et al. 2021).

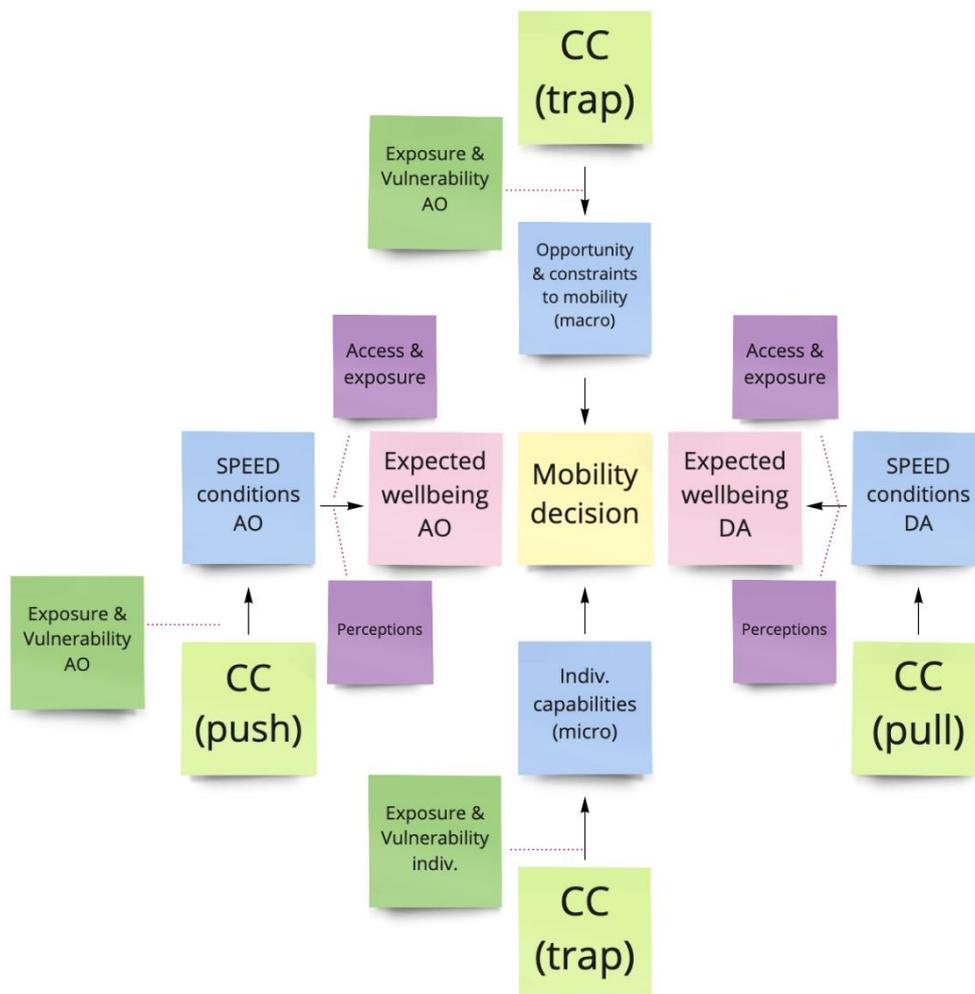
Importantly, expectations of wellbeing are also shaped by people's level of *access and exposure* to opportunities and challenges tied to *SPEED* conditions - for example, people might have different access to resources depending on age, gender, ethnicity and other individual and group characteristics (Cundill et al. 2021, Birkmann et al. 2022, Hunter et al. 2021, Hunter et al. 2017). Importantly, mobility decisions will also be affected by individual or collectively shared *perceptions* and assumptions about *SPEED* conditions in areas of origin and destination (see Sakdapolrak & Sterly 2020, TransRe2018).

Next to motivations for mobility, obstacles and opportunities are also important to consider. We can define *individual capacities to move* in relation to a person's means and access to resources (e.g. natural, financial, human, social, and political capital), as well as to their status and opportunities in society. For instance, research shows that

it is generally easier for wealthier, better educated, and younger people to successfully relocate and live elsewhere (Bohra-Mishra et al. 2016, Rigaud et al. 2018, Vigil Diaz Telenti 2019, Speelman 2021, Stojanov et al. 2021, Gemenne et al. 2017, Nawrotzki & DeWaard 2018). Likewise, we can define *mobility opportunities and constraints* in a person's social, economic, political, physical, etc. environment. For instance, diasporic support networks can facilitate mobility (Kaczan & Orgill-Meyer 2019, Gharbaoui & Blocher 2017, Groth et al. 2020, Nawrotzki & DeWaard 2018); and legal requirements for migrants entering, staying, and working in the destination area can limit or enhance mobility opportunities (Majidi et al. 2020, Yates et al. 2021).

## Effects of climate change on mobility

There are different ways in which climate change and concomitant sudden or slow-onset climatic hazards can affect human mobility (see Figure 2). On the one hand, climatic changes and pressures can disrupt and deteriorate SPEED conditions in areas of origin and thus create incentives to leave. In this sense, climate change can be considered a *push factor* for mobility. Both sudden and slow-onset events can lead to economic losses, such as crop yield losses, and resulting livelihood risks for households depending on climate-sensitive activities (Birkmann et al. 2022, Afifi et al. 2016, Bohra-Mishra et al. 2017, Mastrotrillo et al. 2016, Funke et al. 2020).



**Figure 2:** Effects of climate change on motivations and opportunities to move

On the other hand, impacts of climate change, for example on individual assets and economic conditions in areas of origin, can just as well undermine individual capabilities to move and create incentives to stay in place, for example to support community members and relatives adversely affected by climate change (see Borderon et al. 2019, Cundill et al. 2021, Kaczan & Orgill-Meyer 2019). Similarly, climate impacts can destroy relevant infrastructure and make some places inaccessible (Rigaud et al. 2018). Climate-related disasters can also take social and political resources away from supporting migrants, processing visa demands, etc., which then creates additional constraints to mobility. Thus, the effects of climate change can undermine the ability of people to move and in some cases even *trap* them in at-risk situations (Hunter et al. 2021, Cundill et al. 2021, Zickgraf 2021).

Lastly, positive effects of climate change can increase the attractiveness of potential destination areas, for example by creating more favourable conditions for certain crops and economic activities, and can thus act as a *pull factor* for mobility.

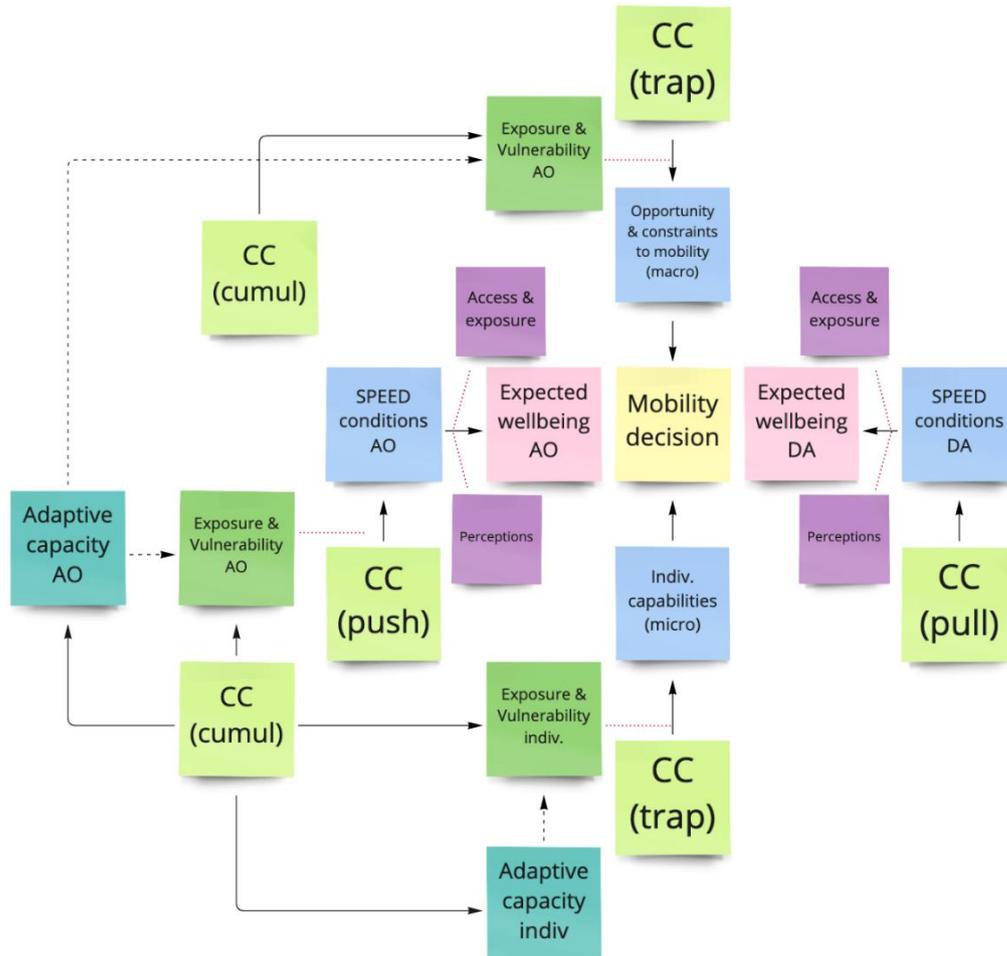
Importantly, the effect of climate change and climate change impacts on SPEED conditions and mobility opportunities are moderated by the level of exposure and vulnerability of individuals, communities and societies to the effects of climate change. For example, people and communities relying heavily on climate-sensitive livelihoods such as agriculture or pastoralism are much more likely to be adversely affected by sudden and slow-onset climatic events (see Black 2011, Cattaneo et al. 2019, Codjoe & Atiglo 2020, Hoffmann et al. 2020, Parsons & Nielsen 2020). Similarly, faulty early warning systems, and poor access to or low trust in climate information increase the vulnerability of people to adverse climatic events (see Ayeb-Karlsson et al. 2019), while people in low-lying settlements are much more susceptible to be hit by coastal and flash floods (see Birkmann et al. 2022).

For simplicity, the moderating influence of climate exposure and sensitivity on the effects of climate change on SPEED conditions in destination areas is left out at this point. Likewise, connections between climate change exposure and vulnerability and more general SPEED conditions in areas of origin and destination are not explicitly modelled, even though they are likely to be correlated in practice.

### **Cumulative effects of climate change and adaptive capacity**

Over time, exposure and vulnerability to the effects of climate change are affected by the *ability* of people, communities, and societies at large *to adapt* (see Figure 3). Depending on the local context and climate impact, adaptation in situ options range from shifting to new crops (Birkmann et al. 2022), installing irrigation systems and building protective infrastructure against climate hazards (Adger et al. 2021) to shifting away from subsistence agriculture to less-climate sensitive economic activities (Van Praag et al. 2021b). Factors such as access to different forms of capital, government support, adaptation knowledge or cultural norms can influence in situ adaptation opportunities (Afifi et al. 2015, Ayeb-Karlsson et al. 2019, Boas et al. 2019, Birkmann et al. 2022, Nielsen 2019).

## D7.1 A Conceptual Model of Climate-Mobility Interactions



**Figure 3:** Cumulative impacts and adaptation to climate change

Furthermore, climate change impacts have a *cumulative effect*, in the sense that they erode people's ability to cope with and adapt to subsequent impacts (see Figure 3). Repeated drought events in Sub-Saharan Africa have been shown to exhaust the capacities of rural households, rendering even long-held successful coping and adaptation strategies obsolete. As drought frequency and severity increase, households lose their ability to respond with low-cost and easily reversible strategies and are progressively forced into strategies that entail more costs, for example selling key productive assets like farmland and breeding livestock (von Uexkull 2014:18). Likewise, slow onset hazards like sea-level rise and progressive coastal erosion and inundation have been shown to increase the exposure and vulnerability of coastal communities to sudden-onset hazards like storm surges and flooding (e.g. see Flavell et al. 2020).

### Feedback effects

The conceptual model includes a number of possible feedback effects of mobility on different model components (see Figure 4). First, mobility can alter *SPEED conditions*, both in areas of origin and destination. For example, out migration can reduce the workforce and productivity with negative repercussions on communities and businesses in areas of origin, as it is usually the younger and better educated who leave (Stojanov et al. 2021, Gemenne & Blocher 2017, TransRe 2018, Bachmann et al. 2019). On the other hand, migrants often bring new knowledge and skills with them or open new businesses that stimulate the economy of destination areas (see Cattaneo et al.



Fourth, mobility can affect *adaptive capacities* in areas of origin and destination. Both financial and social remittances such as new skills and adaptation knowledge shared by migrants can increase adaptive capacity in the area of origin. For example, financial remittances can help to buffer climatic shocks or accumulate savings, which can be used for strategic investments. Migrants can also encourage the adoption of adaptive agricultural and business practices, such as shifting to new crops and breeds of livestock (TransRe 2018). Similarly, migrants can lobby for political support to their country or community of origin, as seen for example after typhoon Haiyan, when the Filipino diaspora in the United States lobbied for the Philippines to be granted temporary protection status (Gemenne & Blocher 2017). There is in fact a growing literature that considers mobility as a strategy to adapt to adverse climatic conditions (see Gemenne & Blocher 2017, Borderon et al. 2019, Majidi et al. 2020, UNEP et al. 2020, Van Praag et al. 2021a, 2021b). But climate-related mobility can also have maladaptive outcomes when migrants find themselves in more vulnerable situations *ex post* (see previous paragraph).

Lastly, acquired resources and knowledge, as well as social networks and support structures established through mobility experiences can create *opportunities* and lower the *costs of mobility* for subsequent migrants (Van Praag et al. 2021b, Groth et al. 2020, Nawrotzki & DeWaard 2018). For instance, cross-border migration between Mexico and the US is facilitated by existing migration routes (Kaczan & Orgill-Meyer 2019). Likewise, migrant communities from Pacific islands in Fiji, New Zealand and the US often assist relatives with the migration process (Yates et al. 2021).

### Considering distinct climate hazards and modes of mobility

Different types of climate hazards will sometimes not only produce distinct effects on SPEED conditions but might also interact in different ways with other model components like exposure and vulnerability, adaptive capacity, or constraints to mobility. For example, it is commonly accepted that slow-onset hazards (e.g. sea-level rise) and events with longer lead periods (e.g. drought) leave people more time to adapt than sudden-onset events like storms and floods (see Cattaneo et al. 2019). Similarly, floods and landslides can create different constraints to mobility - for example, by blocking roads and leaving certain areas inaccessible - than for example droughts, which might more progressively erode people's ability to afford migration (Rigaud et al. 2018).

Meanwhile, socio-economic, demographic, technological and other factors that determine exposure and vulnerability to climate hazards for rural livelihoods and food security will only partly overlap with those that moderate climate hazards for health, physical assets, built infrastructure, or ecosystems. Different specifications of the conceptual model might thus be necessary to accommodate distinct types of climate hazards.

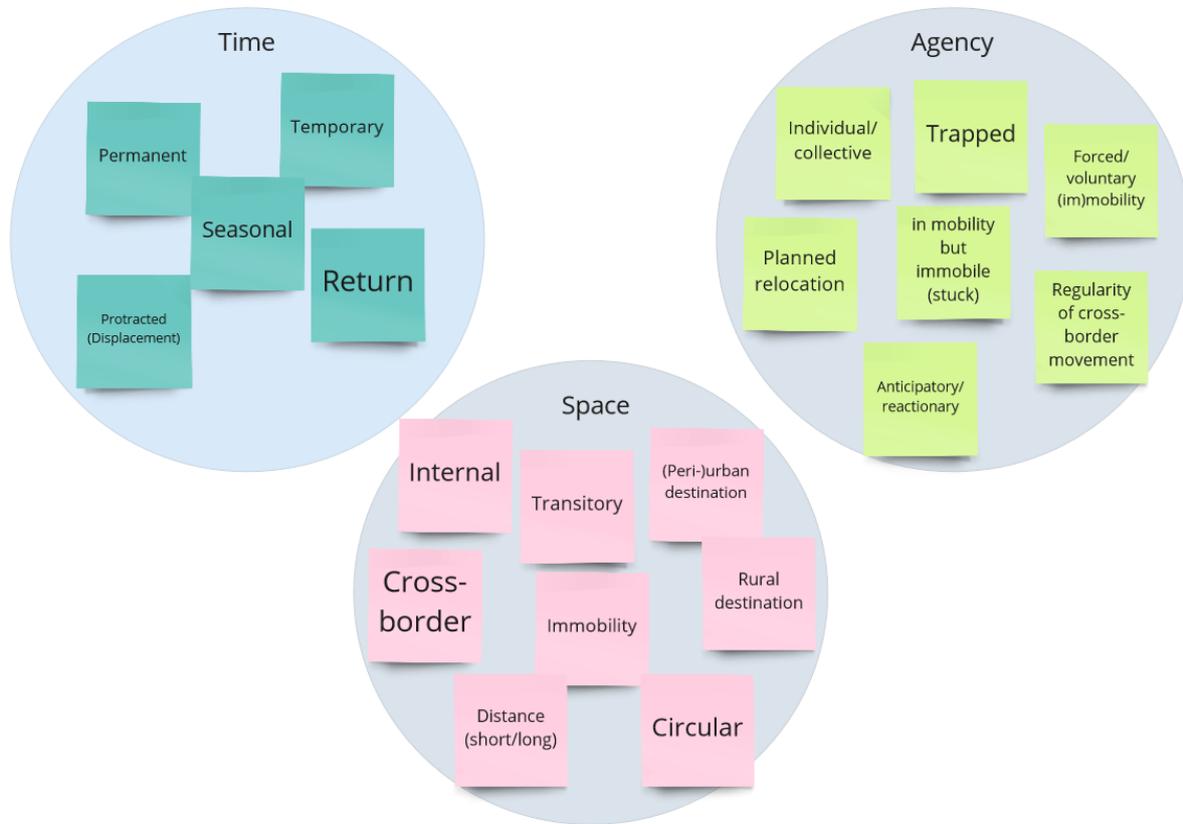
A similar argument can be made for different modes of mobility, which can be distinguished along different dimensions, such as *space*, *time*, and *agency* (see Figure 5). For example, different moderating variables might be relevant when it comes to forced vs more voluntary<sup>2</sup>, precipitated vs. more carefully planned, temporary vs. more permanent, internal vs. international, or rural vs. urban forms of migration (see

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<sup>2</sup> The terms used here do not imply a strict dichotomy. Different forms of mobility rather exist along a continuum between poles like "forced" and "voluntary", "temporary" and "permanent", etc.

## D7.1 A Conceptual Model of Climate-Mobility Interactions

Cattaneo et al. 2019, Kaczan & Orgill-Meyer 2019). These distinctions and their implications for the conceptual model will be further discussed in the following two sections.



**Figure 5:** Dimensions of human mobility. Own creation based on results of expert interviews and workshop discussions. These non-competing and often interacting dimensions provide a starting point from which moderating variables either are influencing mobility types or within these dimensions influence mobility outcomes.

## Climate vulnerability and adaptation in situ

Climate vulnerability<sup>3</sup> and the ability of people to prepare for and adapt to the adverse effects of climate change are central elements of our conceptual model. Together, they determine to what extent climatic hazards can affect people's wellbeing or mobility opportunities and will ultimately influence mobility decisions in connection with slow and sudden-onset climatic events. Climate vulnerability and adaptive capacity are in turn determined by a range of social, political, economic, technological, legal, and behavioural factors, or *moderating variables* that are discussed in more detail in this section.

Table 1 presents an initial overview of moderating variables that influence climate vulnerability and capacity for adaptation in situ. The table shows the moderating variables that featured most prominently in our literature review, expert interviews, and workshop discussions. As such, it is not an exhaustive list of all possible variables, but rather makes an informed selection of the most important variables to consider later during the further development of our scenarios. They are segmented into six overarching categories: social; political; economic; information, knowledge, and technology; legal; and collective attitudes and beliefs.<sup>4</sup> This selection of variables focuses mostly on meso and macro-level conditions (e.g. markets, legal and policy frameworks) that shape people's scope for adaptive action and usually are the level at which political interventions are designed.

We can add to these a range of individual-level characteristics (e.g. age, gender) that also determine people's ability to adapt to changing climatic conditions (Birkmann et al. 2022, Smith et al. 2017). Importantly, these micro-level variables will determine to what extent the variables in Table 1 will have an influence on a person's vulnerability and ability to adapt. Intersecting characteristics like gender, age, disabilities, ethnicity, education or class all have an important influence on a person's position in society, community and household, determining their influence and decision-making power in these different spheres and their rights in important areas with relevance to climate change adaptation, such as land ownership or political participation. For example, numerous studies have made the case that gender (norms) and age are major factors shaping livelihood opportunities and adaptation options (Thompson-Hall et al. 2016, Erwin et al. 2021, Treichel 2020).

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<sup>3</sup> For those exposed to climate hazards, their vulnerability is the degree to which "they are susceptible or unable to cope with" their effects, and their adaptive capacity refers to their ability "to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC 2014). The IPCC defines exposure as "The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected"; vulnerability as "the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt"; and adaptive capacity as "The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences." (IPCC 2014).

<sup>4</sup> This is only one way of sorting potential moderating variables. Other authors, for example, have drawn further distinctions, sorting variables according to macro-, meso-, and micro-level influences (e.g. Black et al. 2011; Rigaud et al. 2018).

## D7.1 A Conceptual Model of Climate-Mobility Interactions

**Table 1.** Key moderating variables for vulnerability and adaptative capacity in-situ

Category	Moderating variable	Effect of moderating variable on climate vulnerability and capacity for adaptation
Social	Strength and inclusivity of social networks	<ul style="list-style-type: none"> <li>• Particularly in countries that have a limited social safety net, the presence of strong community bonds and social networks has been shown to play an important role in organising social protections and leveraging resources for vulnerable people and groups (Birkmann et al. 2022).</li> <li>• A person or household is more likely to adapt in situ if their social network is concentrated in the AO (Majidi 2017).</li> </ul>
	Social cohesion, inclusion and solidarity	<ul style="list-style-type: none"> <li>• AOs with a strong sense of community and solidarity are more likely to have developed community-based support mechanisms that can increase adaptive capacity (McNamara and Buggy 2017) and disaster preparedness (Ngin et al. 2021).</li> <li>• Social groups that are historically marginalised are more vulnerable and less likely to be able to adapt to the adverse effect of climate change (Birkmann et al. 2022).</li> <li>• Cohesive societies are also more likely to overcome potential conflicts in the wake of climate shocks.</li> </ul>
Political	Public support/aid	<ul style="list-style-type: none"> <li>• Individual and societal capacities to cope and adapt depend on the extent to which governmental and national institutions choose or are able to offer support to people at risk.</li> <li>• Public support from the government or international aid can increase the resources available to communities and households for adaptation (Cattaneo et al. 2019).</li> <li>• Climate change adaptation and conventional development strategies must be harmonised to prevent maladaptation (Birkmann et al. 2022).</li> <li>• The ability of governments and civil society organisations to offer support will also be affected by the stability/fragility of the political environment (Black 2011), government spending, levels of corruption and public accountability, as well as the overall effectiveness and inclusivity of public institutions (Rigaud et al. 2018, Birkmann et al. 2022).</li> </ul>
	Access to social services	<ul style="list-style-type: none"> <li>• Insufficient access to basic services and social safety nets increase the likelihood that people will disproportionately suffer from climate change impacts, making adaptation harder (Birkmann et al. 2022).</li> <li>• Inequality in access aggravates this further. In cases where certain groups do not have the same access to basic services, this can increase their vulnerability and potentially lead to grievances.</li> </ul>

## D7.1 A Conceptual Model of Climate-Mobility Interactions

**Table 1.** continued

Category	Moderating variable	Effect of moderating variable on climate vulnerability and capacity for adaptation
Political	Inclusive governance, planning and DRR	<ul style="list-style-type: none"> <li>A lack of citizen participation in the governance of climate change and disaster risks makes communities more vulnerable to the adverse effects of climate change, as it is less likely that planning and policies will consider the specific needs and vulnerabilities of different groups (Stojanov et al. 2021).</li> </ul>
Economic	Physical and financial assets and capital	<ul style="list-style-type: none"> <li>Implementing adaptation measures, particularly those requiring new infrastructure or technology, may require considerable financial capital. Households without sufficient financial resources may send one or more family members away to supplement their income with remittances in order to remain in situ (Gemenne and Blocher 2017).</li> <li>People living in poverty may lack the financial resources to adapt in situ or to migrate as an adaptation strategy, thus becoming “trapped” with little adaptive capacity (Zickgraf 2018, 2021).</li> <li>If a household’s physical assets are fixed in the AO (e.g. land, property), they may have greater incentives and/or capacity to adapt in situ (Kaczan &amp; Orgill-Meyer 2019).</li> </ul>
	Access to markets (food, labour, etc.)	<ul style="list-style-type: none"> <li>Access to roads, markets, and social infrastructure can increase the range of adaptation options available to those facing climate change impacts. (Rigaud et al. 2018, Stojanov et al. 2022). For example, poor households living in settlements with low levels of connectivity to markets are highly likely to be disproportionately affected by climate change impacts (Birkmann et al. 2022).</li> </ul>
	Dependence on climate sensitive activities	<ul style="list-style-type: none"> <li>Communities where livelihoods are highly dependent on ecosystem services, such as agriculture, pastoralism or fisheries, are especially sensitive to climate change impacts (Birkmann et al. 2022, Bohra-Mishra et al. 2016, GIZ 2019, Hoffmann et al. 2022, Afifi et al. 2015).</li> </ul>
	Opportunities to pursue different livelihoods	<ul style="list-style-type: none"> <li>For people highly dependent on climate sensitive activities, the availability of opportunities to pursue different livelihoods in the AO is an important determinant of their capacity to adapt in situ. In developing countries, alternative livelihood options are often limited, particularly in rural areas (Kaczan &amp; Orgill-Meyer 2019).</li> </ul>

## D7.1 A Conceptual Model of Climate-Mobility Interactions

**Table 1.** continued

Category	Moderating variable	Effect of moderating variable on climate vulnerability and capacity for adaptation
Economic	Sustainability of agricultural practices	<ul style="list-style-type: none"> <li>• Unsustainable agricultural practices such as the overexploitation of groundwater, are likely to leave farmers disproportionately more vulnerable to climate change impacts (Kuper et al. 2017).</li> <li>• Climate change adaptation may provide opportunities for upgrading agricultural activities and tapping agricultural business opportunities (TransRe 2018).</li> </ul>
	Access to insurance and credit	<ul style="list-style-type: none"> <li>• Access to risk insurance and credit can increase the adaptive capacity of those exposed and vulnerable to climate change impacts. For example, studies have shown that insurance can increase the resilience of small-scale farmers (Bachmann et al. 2019).</li> </ul>
Information, knowledge, technology	Access to technology and (traditional) knowledge	<ul style="list-style-type: none"> <li>• Positive changes to existing practices can offset the negative effects of climate change. For example, in farming, better seed varieties, improved techniques, the use of fertilisers or a higher frequency of cultivation can serve to increase productivity (Afifi et al. 2015).</li> <li>• Adaptation is likely to be limited in contexts where there is insufficient access to knowledge about the risks of climate change. Raising awareness and understanding is an essential prerequisite for strengthening preparedness and adaptation options in the Global South and among vulnerable groups that have been historically marginalised (Birkmann et al. 2022).</li> <li>• Traditional knowledge can provide important insights to support climate change adaptation, but may also become less reliable as climate change destabilises ecosystems and weather patterns (see below).</li> </ul>
	Access to reliable information	<ul style="list-style-type: none"> <li>• A lack of scientific knowledge and data on the specific impacts of climate change can constrain the development of targeted adaptation measures, particularly in vulnerable and poor communities in the Global South (Birkmann et al. 2022).</li> <li>• Reliable information on impending climatic shocks can facilitate timely evacuations and protection of assets, which may protect livelihoods, thereby affording more options to affected individuals and households in the short term.</li> </ul>

## D7.1 A Conceptual Model of Climate-Mobility Interactions

**Table 1.** continued

Category	Moderating variable	Effect of moderating variable on climate vulnerability and capacity for adaptation
Information, knowledge, technology	Built and natural protection infrastructure	<ul style="list-style-type: none"> <li>Adaptation in situ can often be significantly strengthened by protecting natural infrastructure, for example via mangrove rehabilitation programmes (Adger et al. 2021).</li> <li>The construction of physical infrastructure, such as cyclone shelters or saline embankments can also significantly improve adaptation and disaster risk reduction responses (Adger et al. 2021). For example, during droughts, water supply infrastructure, including irrigation systems, have been shown to play a key role in allowing people to remain in situ (Cattaneo et al. 2019, Codjoe &amp; Atiglo 2020).</li> </ul>
Legal	Access to and control over land/resources	<ul style="list-style-type: none"> <li>Ownership of land can increase a household's capacity and incentives to adapt in situ.</li> <li>Weak land tenure systems may act as a disincentive to leave land unutilised due to the possibility of losing valuable assets (Kaczan &amp; Orgill-Meyer 2019).</li> <li>Landlessness and other forms of socio-economic vulnerability makes it more likely that people will "end up in situations that degrade, rather than improve, their adaptation" (Vigil Diaz Telenti 2019)</li> <li>Groups that have been historically marginalised are more likely to face inequality in their access to and control over land and resources, deepening their vulnerability.</li> </ul>
	Legal options to claim basic rights	<ul style="list-style-type: none"> <li>If certain groups experience discrimination in accessing basic services, such as education, training or government support schemes (e.g. compensation schemes for harvest losses), the availability of legal options to claim these basic rights will play an important role in increasing adaptation options.</li> <li>Groups that have been historically marginalised are more likely to face inequality or discrimination in their access to basic services, such as schooling and social protections.</li> </ul>
Collective attitudes and beliefs	Trust (in information, in the government and in others)	<ul style="list-style-type: none"> <li>Collective trust in information about the risks of climate change and importance of adaptation facilitates the planning and implementation of climate adaptation and disaster risk reduction responses. Conversely, a lack of trust can act as a significant barrier (Birkmann et al. 2022).</li> <li>Trust in experts, long-term forecasts, and government institutions is key to building support for long-term planning and implementation of climate change adaptation responses (Birkmann et al. 2022).</li> <li>Trust in information and institutions may be lower among groups that have been historically marginalised by political authorities, adding to their vulnerability.</li> </ul>

## D7.1 A Conceptual Model of Climate-Mobility Interactions

**Table 1.** continued

Category	Moderating variable	Effect of moderating variable on climate vulnerability and capacity for adaptation
Collective attitudes and beliefs	Common perception of risk and risk aversion in society	<ul style="list-style-type: none"> <li>• Awareness of climate change impacts and the need for adaptation is essential to the development of adaptive solutions.</li> <li>• Prior disaster experience is a key driver of risk perception (see Ayeb-Karlsson et al. 2019), although education can also replace disaster experience when seeking to improve disaster preparedness (Hoffmann and Muttarak 2017).</li> <li>• Religious beliefs and cultural norms also affect the way people react to warnings about impending climate hazards. In some cases, trust in divine providence might even hamper preventive/adaptive action (see Ayeb-Karlsson et al. 2019).</li> <li>• Common perceptions of risk are often established more quickly in the case of sudden-onset events than with more gradual slow-onset events (see below). Here, risks may be perceived much later, especially when it comes to reaching a common understanding of the level of risk beyond individuals at the community level. People may adapt incrementally without realising the changes are part of a long-term trend.</li> </ul>
	Commonly valued objectives	<ul style="list-style-type: none"> <li>• A community may be more likely to adapt in situ if they share beliefs about the intrinsic value of the AO and efforts to conserve it. For example, indigenous communities often have a strong spiritual connection to their land.</li> <li>• In the case of the low-lying Pacific Island states, adaptation measures are necessary to preserve their territorial integrity.</li> </ul>

In our framework, individual characteristics are thus considered as cross-cutting elements that determine a person's relationship to the conditions outlined in Table 1. In this, we recognise that some of these intersectional lines of difference, such as class, religion or ethnicity, as well as other important determinants of vulnerability and adaptive capacity, such as income and wealth, may play out at the household or the group level rather than the individual level. For example, poorer households or minority groups are likely to be more vulnerable than others exposed to climate risks in the same community.

### Relevance of moderating variables by type of hazard

Vulnerability conditions and modalities of climate adaptation are likely to differ across types of climate hazards. As previously explained, slow- and sudden onset hazards imply different time horizons and offer distinct opportunities for adaptation and disaster risk reduction. Thus, in many instances, they also interact in different ways with the moderating variables in Table 1. Based on the results of our expert interviews and workshop discussions we can highlight a number of specificities.<sup>5</sup>

#### Sudden-onset hazards

Sudden-onset climate hazards, namely extreme weather events, such as storms, wildfires and floods, take place over a short period. Often there is little warning before they strike and their immediate effects are highly disruptive across societies, pushing them to the top of the political priority list, at least in the short term. These characteristics have important implications with regard to the relevance and effect of different moderating variables.

**Access to and trust in information:** Given the short lead time to sudden-onset events, early warning systems and evacuation plans are essential to minimising damage and bringing people to safety. For these systems to be effective, people in exposed areas need to receive the information in time, understand it and trust the information enough to act upon it. This may not be the case in areas where access to or trust in information is low, for example due to low literacy levels or a lack of trust in the government or the accuracy of warnings based on prior experiences. For example, in the case of Cyclone Idai that hit Mozambique, Malawi and Zimbabwe in 2019, warnings failed to convey that the storm was of a much greater magnitude than previous storms. This led many people to ignore warnings to stay at home, resulting in a large number of fatalities (Zurich Flood Resilience Alliance PERC 2020).

**Inclusion of people in DRR:** Disaster risk reduction (DRR) and management (DRM) measures, such as evacuation plans, have been shown to be more effective when all affected communities and groups are involved in their planning and implementation. When people are left out of disaster risk reduction and management measures (possibly due to inherent characteristics such as age, disability, gender etc.), they become more vulnerable to disasters. For example, people with disabilities have been shown to be disproportionately vulnerable to disasters, with people with sensory disabilities unable to access warnings and people with physical disabilities experiencing difficulty in accessing protective shelters unless additional measures are taken (Smith et al. 2017).

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<sup>5</sup> Results are based on a ranked voting exercise conducted with the experts during our workshops. Options that were voted on stemmed from our literature review and expert interviews conducted in advance of the workshops.

**Availability of (traditional) knowledge and proven practices:** Quick reactions to sudden-onset shocks are most effective when they are well established and understood throughout the population. To return to the example of evacuation plans, these are most effective when they are practised regularly with all members of society. For example, Cuba takes a comprehensive approach to disaster preparedness, prevention and responses, with people of all ages regularly taking part in drills, simulation exercises and other training. This has played an important role in significantly reducing fatalities during hurricane seasons. (IDMC 2018).

**Government support and humanitarian aid:** In the case of sudden-onset disasters, there is a clear and immediate need for government support and international humanitarian aid to assist with the implementation of emergency protocols, and then afterwards with rebuilding and recovery. Government support and investment in disaster risk reduction measures, such as better infrastructure and early warning systems, can significantly reduce damage and fatalities, and prove highly cost effective when compared to the potential economic costs and losses from disasters (Desai et al. 2021).

**Access to insurance or credit:** Access to insurance or credit can also help to meet the high costs of rebuilding and recovery after a disaster, as well as enabling investment in significant adaptation in situ responses that strengthen resilience and preparedness, such as the construction of cyclone shelters (Adger et al. 2021). New forms of insurance have been developed in recent years to address emerging climate risks from the micro to the macro-level - from affordable micro-insurances to help people avoid or recover from livelihood loss to regional catastrophe risk pools like the African Risk Capacity (Müller et al. 2018, Scherer 2020).

**Risk perception and aversion:** In the case of large-scale rapid-onset events, societies can quickly develop a common perception of risk and act accordingly. Prior disaster experience has therefore been shown to be a key driver of disaster preparedness and the capacity to adapt to future disasters (Harvatt et al. 2011). Achieving a similar collective perception of risk and urgency to act can be harder in the case of gradual, slow-onset climatic changes, but integrating disaster risk reduction into education can serve to increase preparedness (Hoffman and Muttarak 2017).

### Slow-onset hazards

By contrast, other climate hazards occur more gradually, such as sea-level rise and changes in temperature and rainfall. Here longer time horizons allow for more comprehensive planning and implementation of adaptation measures, but it can be harder to establish a collective sense of urgency around such endeavours, particularly in contexts where resources are stretched and more immediate needs take priority. Below, we highlight important implications for the moderating variables in Table 1, that were highlighted prominently in our interviews and workshops:

**Opportunities to pursue alternative livelihoods:** The pursuit of alternative livelihoods is likely to be an important adaptation strategy for people dependent on climate-sensitive livelihoods, such as farming, pastoralism or fishing. Initially, this may be used as a temporary coping strategy to supplement their usual income when, for example, crop yields are lower than expected. However, over time as the impacts of climate change become more pronounced and, for example, crops repeatedly fail, they may face

no choice but to leave behind their previous way of life. Workshop participants identified alternative livelihood options as an important condition for adaptation in the context of droughts and other slow-onset climatic pressures.

**Access to markets:** Access to markets may depend on a number of factors, for example, sufficient income, education, or connectivity via roads and transport. In cases where access is possible, it can increase the number of adaptation options available to a person or household. For example, access to food markets makes it easier to substitute for crop yield losses and access to labour markets can open avenues for pursuing livelihoods that are less sensitive to the effect of climate change (see above).

**Access to education:** Access to education can open up alternative livelihood opportunities for people dependent on climate sensitive activities. Increasing access to education and vocational training can therefore serve as an important long-term adaptation strategy, particularly in countries where a large proportion of the workforce is employed or engaged in agriculture, pastoralism or fishing (see above). Education can also support sustainable development by providing access to information (including on climate change) and empowering vulnerable groups (Birkmann et al. 2022).

**Access to technology and (traditional) knowledge (including knowledge and understanding of risks):** Workshop participants highlighted the changing influence of traditional knowledge with regard to adaptation. On the one hand, indigenous peoples and their traditional knowledge of the land, sea and sky can provide important insights into the impacts of climate change on ecosystems and biodiversity, as well as community-based adaptation measures to strengthen resilience in more extreme climates (Raygorodetsky 2017). However, on the other hand, as climate change impacts become more pronounced, traditional knowledge and practices relating to climate-sensitive activities may become increasingly unreliable. An example discussed in our workshops was farmers not being able to rely on their traditional methods for deciding when to plant crops. In this case, raising awareness and fostering an understanding that incremental changes in, for example, rainfall patterns are part of long-term climatic changes is essential to gain support for adequate long-term adaptation strategies. Other climate change impacts, such as soil salinisation, or more indirect impacts such as more frequent or different outbreaks of pests may also bring new challenges that farmers have not previously encountered. In this case, key adaptation strategies may include providing information and accurate forecasting to support farmers in understanding changing weather patterns and new threats, and the provision of new technology such as water storage and irrigation systems.

**(In)equality in the above:** The access and opportunities mentioned above are unlikely to be distributed equally across society, and adaptation measures are likely to be more effective if they consider these inequalities and direct support toward marginalised groups. If support for adaptation is not equally available to vulnerable groups, this may lead to greater competition for resources, grievances and, in more fragile contexts, conflict (see Fjelde & von Uexkull 2012, Detges 2017).

### Relevance of moderating variables by type of impacts

Likewise, vulnerability conditions and modalities of adaptation are likely to differ across impacts of climate change. For example, climate impacts on built infrastructure will differ in many ways from climate impacts on health or economic opportunities and hence also be affected by different moderating variables. In the following, we

offer a brief summary of relevant distinctions identified in our expert interviews and workshop discussions.

**Impacts on ecosystems and biodiversity:** Climate change impacts on ecosystems and biodiversity can have negative, destabilising impacts on natural infrastructure, such as rainforests, mangroves and wetlands. Given the range of ecosystem services these places provide, their protection and preservation also constitute important adaptation strategies. Workshop participants emphasised the importance of agricultural practices and technologies as moderating variables in scenarios that explored these impacts. Resource governance and tenure security were thought to play an important role, influencing for example the options available to farmers in managing their land. A further climate change impact emphasised in this area was how increasing temperatures or changing rainfall patterns could also allow pests and invasive plants to thrive in areas where they were previously unknown, creating enormous challenges for people dependent on rural livelihoods. For example, higher than average temperatures and shifts in rainfall patterns created ideal breeding conditions for the plagues of locusts that swarmed across East Africa in 2019 and 2020 (McCabe et al. 2021).

**Impacts on housing and assets:** Workshop participants emphasised that the rising cost of climate change impacts on housing, infrastructure and other assets would increase the importance of some moderating variables, such as insurance and credit, financial capital, government support and humanitarian aid. Unequal access to such measures was considered to exacerbate existing socio-economic inequalities and vulnerabilities, given high upfront costs of repair and recovery in the wake of extreme weather events, and adaptation and disaster-proofing measures to protect housing and assets in anticipation of worsening climate impacts.

**Impacts on rural livelihoods:** Climate change will have particularly severe impacts on rural livelihoods, given their sensitivity to changes in soil salinity, temperature and rainfall in the case of farming and pastoralism, and rising water temperatures and acidification in the case of fishing. Workshop participants viewed access to financial capital, sustainable agricultural practices and technologies, and access to reliable information on risks and adaptation strategies as particularly important when adapting to these impacts. Access to government support and social services/transfers, and resource governance and tenure security also gained several votes each, given their influence on a household's wealth and income and by consequence their ability to invest in adaptation measures. This discussion highlighted access to education and training, as well as labour markets as important when seeking out alternative livelihoods.

**Impacts on food security:** The vulnerability of people dependent on subsistence agriculture and rural livelihoods was also highlighted with respect to food security, along with the importance of sustainable agricultural practices and technologies for adaptation in situ. Access to markets to supplement food supplies in times of scarcity and drought was also considered a key coping and adaptation strategy for rural communities, with this access predicated on sufficient financial means - potentially supplemented by government support and social transfers - and connectivity via roads and transport. One participant pointed out the strong focus on rural livelihoods in climate mobility research and made the case for also designing scenarios exploring food security impacts in urban settings, given the worldwide trend towards urbanisation.

**Impacts on health:** While economic and technological considerations dominated in discussions about the previous impacts, social factors came to the fore with regard to

impacts on health. Consulted experts suggested that gender and social norms would influence vulnerability and adaptation options most in this category. Climate change impacts on health were viewed as strongly linked to socio-economic status, with poor and marginalised communities much more vulnerable to the effects of temperature extremes or the spread of disease - especially if government support and access to social services was limited. For example, while high income households are likely to be able to afford air-conditioning, those who cannot afford it and/or work outside (e.g. construction workers) are likely to suffer disproportionately during heatwaves. The importance of built and natural infrastructure for adapting to potential health impacts was also highlighted. For example, outbreaks of water-borne diseases following floods are more likely to be severe in informal slum settlements without adequate sanitation.

### **Climate vulnerability while and after moving**

Previous sections have emphasised the climate vulnerability and resilience of people in situ. Yet, when thinking about climate and mobility interactions, it is also important to reflect the specific vulnerabilities and obstacles for climate adaptation faced by migrants and displaced people in transit and destination areas.

Mobility, at least initially, diminishes a household's/individual's resources. Mobility can be very expensive and immediately post or during mobility, financial resources may be depleted, meaning that when individuals or households are exposed to a shock, climatic or otherwise, it may be difficult for them to adapt to the circumstances (Kaczan & Orgill-Meyer 2019, Warner and Afifi 2014, von Uexkull 2014). Even with resources potentially available, the shock itself may limit access to these resources, for example a conflict may suspend or limit access to resources (Majidi et al. 2020).

Often mobility may follow a pattern from rural to urban areas, due to economic prospects in cities, but the urban destination itself is also exposed to the effects of climate change, which can create new challenges for arriving people. This is the case for many migrants in Dhaka, Bangladesh, who are vulnerable to a host of climatic shocks, including variations in temperature, excessive rainfall (and as a result floods), cyclones and more (Rabbani et al. 2011). This being said, it can also be the case that the destination area is far enough from the area of origin that any climate shocks felt in the latter are not felt in the former area and vice versa. This presents an opportunity for households where, for example, only part of the family is in an urban setting, which thereby diversifies its exposure to potential climate hazards and impacts on livelihoods.

Vulnerability is also shaped by individual characteristics (and their meaning in particular social and cultural contexts). This is the case with gender and gender norms, where for example in Mali, consulted experts noted how female migration may be frowned upon, due to negatively perceived views of autonomy and independence, which can make women more vulnerable in destination areas. This is in addition to women generally being more vulnerable to sexual and gender-based violence, especially in the aftermath of climate shocks where institutions and institutional resources that may previously have protected them have been weakened (Desai and Mandal 2021). Individual characteristics like religious affiliation can also reduce the vulnerability of migrants. For example, one expert noted that in the Philippines migrants could rely on social networks in destination areas with special services afforded to members of the same religious group.

## D7.1 A Conceptual Model of Climate-Mobility Interactions

Lastly, individual characteristics also affect the reception of migrants in transit and destination areas where cultural barriers or cultural ignorance and insensitivity can exclude migrants from needed support, services, and access to local resources, thus increasing their vulnerability. Social marginalisation may also interact with an increased exposure to climate hazards, for example when migrants settle in low-lying areas that are prone to floods. Exclusion and marginalisation of migrants may also negatively affect access to information and early warnings, further increasing vulnerability (Birkmann et al. 2022).

## Opportunities and constraints to mobility

In this final chapter we emphasise moderating variables that shape opportunities and constraints for human mobility in the context of climate change: another central component of our conceptual model. By this we mean the conditions that facilitate or prevent mobility per se, as well as conditions that can affect the success of mobility as a strategy to adapt to climate change. Based on our literature review, expert interviews and workshop discussions, we identify a number of social, political, economic, technological, legal, and behavioural variables that are presented in Table 2.

In analogy to our approach in the previous chapter, we emphasise macro-level variables that define migrants' scope of action and that usually also are the target of political interventions. In addition to this, we consider again another layer of intersecting individual-level characteristics (e.g. age, gender, ethnicity, education, class) that influence a person's relationship to the macro-level conditions outlined in Table 2. Their function within the climate-migration nexus is not explicitly stated in the table, but it is easy to conceive how individual characteristics like age or gender might affect a person's ability to move, her access to social networks, or the economic opportunities she can pursue in the destination areas (see also Gioli and Milan 2018).

## D7.1 A Conceptual Model of Climate-Mobility Interactions

**Table 2.** Key moderating variables with regard to mobility constraints and opportunities

Category	Moderating variable	Effect of moderating variable on ease of mobility and likelihood of migratory strategies to succeed
Social	Access to social networks	<ul style="list-style-type: none"> <li>Having access to social networks means having easier access to information, financial resources, and connections that facilitate mobility and make mobility-based adaptation strategies more likely to succeed (Kaczan &amp; Orgill-Meyer 2019, Groth et al. 2020). For example, Majidi (2017) highlights the role of social networks in access to safety nets and how the lack of social networks serves as an obstacle to benefit from economic opportunities in destination areas.</li> </ul>
	Shared language and culture	<ul style="list-style-type: none"> <li>Shared language and culture can make access to job markets, social resources, and information easier (Ayeb-Karlsson et al. 2019), while also supporting more acceptance of migrants from the local population in destination areas (Ngin et al. 2021).</li> </ul>
Political	Public transfers to migrants and access to social services	<ul style="list-style-type: none"> <li>The availability of cash transfers to migrants can in the first order support their decision to move and prospects to start a new life in the destination area (c.f. Gavonel et al. 2021).</li> <li>More generally, access to social services in destination areas can be crucial in supporting successful adaptation through relocation (Yates et al. 2021). For instance, the Free Movement of Persons policy of OECS enables people affected by natural disasters to move to other member states and access social services there (GIZ 2019).</li> </ul>
	State-migrant relations and political participation	<ul style="list-style-type: none"> <li>Migrants are more likely to thrive when they have the possibility to partake in political life and help shape political decisions and outcomes in areas of destination. Their ability to do so might be constrained by citizenship and voting rights (Gavonel et al. 2021).</li> <li>Likewise, migrants will find better living conditions in areas where they have a positive, or at least neutral relationship with political authorities and are safe from political discrimination or persecution (see Majidi et al. 2017).</li> </ul>

## D7.1 A Conceptual Model of Climate-Mobility Interactions

**Table 2.** Continued

Category	Moderating variable	Effect of moderating variable on ease of mobility and likelihood of migratory strategies to succeed
Economic	Access to labour markets and opportunities for livelihood diversification	<ul style="list-style-type: none"> <li>• Access to labour markets in the destination area often serves as a decisive pull factor for migration to certain areas (Yates et al. 2021, Bachmann et al. 2019). Economic opportunities allow for households to diversify their livelihoods and will facilitate climate adaptation of migrants, their families, and communities of origin - e.g. via remittances (Bachmann et al. 2019, TransRe 2018, Vinke et al. 2020).</li> <li>• Economic opportunities in the destination area allow for diversification of livelihoods serving as an opportunity for households whose livelihoods may have been negatively affected by climatic shocks to shift to less climate-sensitive activities (Vinke et al. 2020)</li> <li>• Studies of rural farming communities have shown when alternative livelihood opportunities are limited in the AO, temporary or seasonal migration of at least one household member to find alternative work can serve as an important adaptation strategy. Remittances can then allow the remainder of the household to remain in situ (IOM 2017).</li> </ul>
	Access to insurance, credit and financial capital	<ul style="list-style-type: none"> <li>• Access to insurance and credit facilitate risk adaptation strategies in connection with mobility (Stojanov et al. 2021, Kaczan &amp; Orgill-Meyer 2019).</li> <li>• Access to financial capital and (micro) credit also allow for more flexibility in the mobility decisions of cash-strapped people, whose options might be limited without additional financial means (Cattaneo et al. 2019).</li> </ul>
Information, knowledge, technology	Access to reliable information and knowledge	<ul style="list-style-type: none"> <li>• Access to credible information and knowledge about mobility opportunities and constraints is key on several fronts, and links to many of the other moderating variables discussed in this table. Having more information on economic opportunity and legal entry and stay requirements, or knowledge of languages and cultural specificities in prospective destination areas all facilitate informed decision making that can improve mobility outcomes (Siddiqui et al. 2003, Majidi 2017, Van Praag et al. 2021b).</li> </ul>
	Trust in information	<ul style="list-style-type: none"> <li>• Trust in the information received is also key to perceptions of mobility constraints and adaptation/livelihood opportunities in prospective areas of destination.</li> </ul>

## D7.1 A Conceptual Model of Climate-Mobility Interactions

**Table 2.** Continued

Category	Moderating variable	Effect of moderating variable on ease of mobility and likelihood of migratory strategies to succeed
Legal	Legal entry and staying requirements	<ul style="list-style-type: none"> <li>Legal frameworks allowing for entry and longer-term stays serve as an unambiguous opportunity for mobility. Whether ECOWAS' Protocol on Free Movement or streamlined entry permit processes, the presence of such frameworks influences mobility modes as they facilitate cross-border movement and stays (GIZ 2019). On the other hand, legal frameworks and policies that restrict movement lead to immobility (Cundill et al. 2021, Majidi et al. 2020).</li> </ul>
	Labour rights of migrants	<ul style="list-style-type: none"> <li>Clearly defined laws and regulations around work permits and visas and workers comp for migrants can reduce risk and vulnerability of migrants in the destination area.</li> </ul>
	Individual rights and legal protection	<ul style="list-style-type: none"> <li>Legal protection (and de facto respect) of the human rights of migrants, displaced, or relocated persons in transit and destination areas is essential for enabling safe migration and mobility as an adaptation strategy. These overlap partly with legal entry and staying requirements, but also with access to services and social protections (Stojanov et al. 2021, Cundill et al. 2021). This moderating variable is especially important in the context of cross-border mobility (see below).</li> </ul>
	Protection of assets left behind	<ul style="list-style-type: none"> <li>The perspective of losing one's immobile assets (e.g. land) when relocating can affect migration decisions and act as another constraint to mobility (Kaczan &amp; Orgill-Meyer 2019, Borderon et al. 2020). Conversely, where mobile individuals or households have assurances that their assets and tenure would be safe, this is likely to reduce hesitancy towards initial outward mobility, but possibly also mobility modes themselves, e.g. towards safer/more confident seasonal and circular migration (Vigil Diaz Telenti 2019).</li> </ul>
Collective attitudes and beliefs	Shared sense of belonging and place attachment	<ul style="list-style-type: none"> <li>Place attachment and a sense of shared belonging is an important, yet less tangible factor that is weighed against other mobility constraints and opportunities (Yates et al. 2021, Birkmann et al. 2022). It per se neither constrains or makes mobility more opportune but will factor in when making a mobility decision, whether this leads to planned return/circular mobility, opting for more seasonal models of migration - if this allows for diversification of household livelihood strategies - or whether this leads people not to pursue mobility at all (Zickgraf 2021).</li> </ul>

## Relationship to distinct modes of mobility

The discussion above treated mobility to some extent rather homogeneously but as outlined in Figure 5 (page 13) mobility occurs in a number of different ways along different dimensions, such as space, time, and agency. Moderating variables in Table 2 might have diverging effects on the likely success of distinct modes of mobility when used as an adaptation strategy, just as they might influence what modes of mobility are likely to emerge in the first place. The latter is often the case with moderating variables affecting for example the permanence of mobility, whether mobility is cross-border, the possibility of seasonal migration, etc.

The results from our workshop discussions on the relevance of different moderating variables in relation to different types of mobility were fairly consistent across both *sudden-* and *slow-onset climatic events*. Therefore, moderating variables in Table 2 apply in the context of both types of climatic shocks, though the type of climatic shock will also affect the type of mobility in some cases. For example, sudden-onset events are more often associated with displacement and temporary mobility (Cundill et al. 2021), though our interviews also indicated that the repetition of sudden-onset events, and thereby an increase in perceived climate-related risk, also increase the likelihood to see more permanent outmigration. Increasing patterns of disruption to regular seasonal livelihood opportunities may also influence other seasonal mobility patterns (Flavell et al. 2020). Conversely there are also mobility outcomes that are nearly exclusively connected to slow-onset events. One example here that was mentioned often in consultations with experts is planned relocation in the context of sea-level rise.

Below is an overview of the moderating variables deemed most important in affecting the likelihood to see different patterns of mobility and mobility outcomes.<sup>6</sup>

***Access to labour markets and economic opportunities in the destination area:*** Access to labour markets was deemed a deciding factor on whether mobility was permanent or temporary. Without a sustaining financial output, the option to make a move permanent is less likely (Nielsen 2019). This is especially the case in contexts where one family member has migrated to an urban area in order to send remittances to family members in the area of origin (ibid.). If there are no sustained economic opportunities that would provide remittances, then the permanence of a move would certainly come into question. The workshops and interviews also indicated that labour market access was viewed as decisive in whether migration was to urban areas or rural areas, with the prevailing sentiment that if opportunities were available in urban areas, this would be the preferred destination.

***Access to social networks:*** Good access to social networks was seen as a deciding factor for whether mobility was cross-border as opposed to internal when this was an option, as a facilitator of more successful urban moves, cementing permanent stays and also in facilitating more reactive responses to potential sudden-onset climatic events. The importance of access to social networks cannot be understated. They facilitate the sharing of knowledge about the availability of many of the other moderating variables deemed important to inclusive and successful mobility, such as economic opportunities (Majidi 2017), accessibility of social services and safety nets

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<sup>6</sup> The discussion is based on our literature review, expert interviews, and workshops discussions: Workshop results are based on a voting exercise conducted with workshop participants that ranked moderating variables based on their effect on- and likelihood to bring about specific modes of mobility. Options that were voted on stemmed from our literature review and expert interviews conducted in advance of the workshops.

(Majidi et al. 2020), housing opportunities, and legal entry and staying requirements to name a few.

***Social inclusion of migrants:*** Related to this notion is also the acceptance and social inclusion of migrants, where increased social inclusion could contribute to the permanence of a move. Potential language barriers were also viewed as a factor in this context, though more so in the short term, presumably as language barriers can be overcome in time. Another factor supporting permanence was whether assets left behind were deemed to be safe. This has its point of departure both in local property customs, where in some contexts land rights are decided by the local communities and also through the strength of property rights in the respective countries (indicated in the workshops).

***Further important moderating variables (bolded):*** Particularly relevant in the case of a mobility outcome between internal and cross-border movement is the possibility for **legal entry and the local staying requirements** (Rigaud et al. 2018). Where cross-border movement is legally allowed, it is also seen as a more viable and safe option.

The presence of **social services and safety nets** in destination areas was seen as key to determining whether migrants moved to cities or not, where the uncertainty of economic security in cities coupled with generally establishing oneself could be hedged via the availability of social services (Yates et al. 2021).

Seasonal migration patterns seem to be facilitated and encouraged in large part by the presence of established **mobility corridors and safety/security issues (conflict)** (indicated in interviews and the workshops). The workshop discussions also emphasised the role of **gender norms** in determining both who would be moving in seasonal patterns, and also the safety associated with those types of mobility.

More specifically for short term mobility and especially in the context of sudden onset shocks, **timely access to and trust in information** was among the most discussed moderating variables in the workshop focussing on sudden-onset events. This aspect has also long been reflected in the literature (Longstaff and Yang, 2008, Ayeb-Karlsson et al. 2019, Birkmann et al. 2022, Hunter et al. 2021, Ngin et al. 2021) and by far the most important one in determining whether mobility was anticipatory vs reactionary. **Access to credit and financial resources** was also highlighted in this context. The logic here is that having access to credit can for example help to finance anticipatory measures such as moving assets or insurance premiums.

## Summary

This paper has presented a conceptual model of climate change and human mobility interactions, which will guide our scenario planning exercise as part of the HABITABLE project. The model summarises relevant cause-effect relations between climate change, human mobility, as well as a number of *intervening variables* that *moderate* the relationship between them. These social, political, economic, technological, legal, and behavioural variables are of particular importance for scenario planning. On the one hand, they serve as building blocks and dimensions along which our scenarios will be differentiated. For example, one could contrast a politically stable- with an unstable scenario. On the other hand, they represent sensible targets for policy interventions aiming at increasing people's resilience in situ and while/after moving. For example, policies could aim at promoting education and access to livelihoods that are less climate-sensitive (see also Detges & Foong 2022). These moderating variables are therefore central in the further course of the project.

The paper further discussed a number of particularities with regard to different types of climate hazards, climate impacts, and human mobility. We showed for example that some moderating variables play a different role in the context of slow vs. sudden-onset events and that they can also influence mobility modes themselves. These differences must be considered in the further course of the project, when specifying climate-mobility interactions and relevant moderating variables for specific geographies and sectors. If there is one thing this paper illustrates, it is that there is no one-size-fits-all solution for modelling climate- mobility interactions but that model assumptions and moderating variables need to be adjusted in line with the climatic and migratory patterns at hand in a specific situation.

Despite its aim to capture climate and mobility interactions, many parts of our conceptual model and argument apply more generally, that is to mobility patterns that are not necessarily connected to climate change. In particular our core model and many parts of our discussion of mobility opportunities and constraints hold irrespective of whether climatic triggers are present or not. In fact, we do not necessarily expect climate change to create new modes or dynamics of mobility. We rather expect climate hazards to act as catalysts or inhibitors in established systems of mobility that are embedded in their specific contexts and that comprise a diverse set of variables - climate-related and other. These contexts and systems need to be studied and understood before being able to discuss potential disruptions or changes in connection with sudden and slow-onset climatic events.

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## Appendix

**Table 3.** Statistics on numbers of experts consulted during workshops and interviews

Gender	
Women	31
Men	19
Regional background	
Africa	6
Americas	9
Asia & Pacific	9
Europe	26
Type of organisation	
Academic research	22
Think tank	12
National implementing agency	3
Regional or international organisation	5
NGO & Advocacy group	8
Core field of expertise (multiple fields per person possible)	
Displacements	5
Human mobility (in general)	9
Demography	2
Asylum & (legal) protection of migrants	3
Climate impacts & adaptation	11
Disaster risk reduction (DRR)	7
Climate-mobility interactions	15