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People on the Move in a Changing Climate

1.1 Introduction

People are regularly on the move; it is a defining feature of our species. We move on a daily basis within our homes, neighborhoods, and communities: doing chores, going to work or school, meeting friends for coffee, checking in on loved ones, or dropping off or picking up children at activities or childcare. We move to meet basic needs, which might involve going to a grocery store to purchase food or going out into a field or barn where we produce our own food. We also, though less frequently, move across longer distances and for extended periods of time. We move to live with other people, to seek out new opportunities, to vacation, to pursue higher education or skills training, or to retire somewhere pleasant (if we can afford to do so). Young adults are often tempted to go out and "see the world," for the sheer adventure of travel and being somewhere new. Unfortunately, we also sometimes move because we have no choice, as factors beyond our control force us from our homes, sometimes never to return. Some people are continuously on the move because of a lack of permanent shelter, no place to call home.

This book is about particular types of movement – migration (a voluntary move resulting in a change of residence for an extended period of time) and displacement (being forced to move) – and how they are shaped by climate and changes in the climate. There are more migrants and displaced people today than at any previous time in human history, and their numbers are growing. As of the year 2020, over 280 million people were living in countries other than the one in which they were born – that is, they are international migrants – and hundreds of millions of other people moved within the geographical confines of their home countries (International Organization for Migration 2024). In the 1970s, the total number of international migrants was less than one-third of the current number. In addition to people who moved voluntarily, at the end of the year 2023 an estimated 75.9 million people globally were involuntarily displaced within their home countries,

primarily for reasons related to conflicts, violence, and environmental hazards, and over 40 million people had fled from their home countries as refugees, seeking asylum in another country (Internal Displacement Monitoring Centre 2024, International Organization for Migration 2024).

Most people on the move today, whether voluntarily or involuntarily, are moving or have moved for reasons not directly linked to climate. But some have moved for climate-related reasons, and their numbers are growing. In the year 2023, approximately 20.3 million people around the world were displaced by floods, storms, droughts, wildfires, and other climate-related weather hazards (Internal Displacement Monitoring Centre 2024) – an average year based on statistics that have been kept since 2010, with the previous year (2022) having set the record for weather and climate-related displacements at 32 million people globally. It is not so easy to estimate the number of people who move voluntarily because of climate (we explain the reasons why in subsequent chapters), but it is safe to say that they number in the tens of millions at very least.

It is not surprising that large numbers of people are on the move for reasons related to climate, and their numbers are set to grow for two key reasons. First, there are simply more people on the planet with each passing year – over twice as many today as in 1970 – and more people than ever are living in locations that are highly exposed to climatic hazards. Second, we are rapidly changing the climate itself by pumping ever-increasing amounts of carbon dioxide, methane, and other heat-trapping greenhouse gases (GHGs) into the atmosphere, thereby increasing the frequency and severity of floods, storms, droughts, wildfires, and climate hazards. In addition, sea levels are starting to rise because of the growing amount of heat accumulating in the surface layer of ocean water. The mean rate of sea level rise was initially slow – an increase of roughly 1.8 mm per year in the first part of the twentieth century – but seas are now rising at 3.6 mm per year, and the pace is accelerating (Oppenheimer et al. 2019). The combination of more people living in high-risk locations and more climate hazards taking place will inevitably lead to more people being on the move because of climate change. The World Bank has warned that over 200 million people in low- and middle-income countries could move due to climatic hazards by the year 2050 if we do not act collectively to control GHG emissions and make significant advancements in sustainable economic development in those countries (Clement et al. 2021).

The actual number of people who end up moving in the future for reasons directly or indirectly related to climate change will depend heavily on three key factors:

- the extent to which we act to control and reduce GHG emissions (which will in turn determine the frequency and severity of future climate hazards),

- the ability of people and communities to adapt to climate hazards through means other than moving
- how governments approach migration and displacement policy and management

This book takes a deep dive into how each of these three factors will influence the movement of people in a changing climate and in doing so details the available data, the key natural and social science concepts on which current knowledge is based, and the policy options available to us.

There are many books on migration and displacement, and many about climate change and its impacts, but there are relatively few that focus directly and exclusively on climate-related migration and displacement. There are two important reasons why books like this one are needed. First, climate change is not simply just another variable to be added to long lists of other things that influence migration decisions and outcomes, such as household incomes, social networks, political processes, and cultural norms. Climate change not only interacts in a compounding way with other variables to influence migration decisions, but its impacts also have the ability to fundamentally alter the other variables – by undermining livelihoods, depriving people of the basic necessities of life, generating political and economic stability, rupturing social networks, and making locations where people currently live unlivable. Unchecked, climate change will make the physical environment unlike anything people have experienced before, and we will consequently see migration and displacement patterns unlike any we have experienced before.

Second, a common vocabulary and clear understanding of the connections between climate and migration is needed to support national and international actions to address anthropogenic (i.e. human-caused) climate change. The key international agreement for doing so is the UN Framework Convention on Climate Change (UNFCCC), and late each calendar year its signatories meet at an annual Conference of the Parties (COP) to negotiate next steps in reducing GHG emissions and helping vulnerable people and countries adapt to the impacts. Climate-related migration and displacement are increasingly featuring in these negotiations, and a Loss and Damage Fund agreed to at the 2023 COP will almost certainly, once fully established, become a vehicle through which low-income countries will seek financial assistance to help them cope with climate-related displacements. As more government agencies and multilateral organizations that have not historically been involved in migration management and policymaking become concerned with it because of climate change – or indeed, as more organizations that have historically been concerned with migration and displacement become engaged with climate policy – there is a need to ensure everyone is speaking a common language and has a common, fact-based understanding of the fundamentals of climate processes,

migration/displacement processes, and their interactions. This book aims to provide such an understanding.

The remainder of this chapter provides:

- an introduction to climate-related migration and displacement in the distant and more recent past
- an overview of the basic natural science processes behind anthropogenic climate change for readers that require one (feel free to skip past if you do not)
- a review of how the impacts of climate change in a general sense present risks to individuals, households, and communities, and how vulnerability and adaptation shape these risks
- a summary of the social science on how migration decisions are made and the general types of patterns and outcomes that emerge
- a consolidated picture of how climate hazards interact with nonclimatic processes to shape migration and displacement

A series of text boxes are included to help readers understand concepts and terminology with which they may not already be familiar (Boxes 1.1 and 1.2). By the end of this chapter, the reader will have the background information and key concepts necessary to take a deep dive in subsequent chapters into how particular types of climate hazards affect migration and displacement, modeling tools being used by researchers to expand our understanding of climate-related migration, and the options available to policymakers hoping to respond to it. We wrap up the book with a look to the future, identifying important areas for future research.

Box 1.1
Key Terms: Mobility, Migration, Displacement, Immobility, and Climate-Related Migration

Humans are a mobile species. We move for a variety of reasons and purposes, across distances short and long. *Mobility* is a generic, umbrella term used to describe movement of any type, distance, and duration. It includes daily movements of people as they travel from their homes to places of school or work; short-duration trips taken for vacations, visiting friends and relatives, and similar purposes; and other journeys that do not involve changing one's ordinary place of residence. Although these types of movements can be influenced by climate, they are not a subject of interest for this book. Instead, we focus on two other broad categories of mobility and, perhaps counterintuitively, situations where people might move but do not. The first and broadest category of movement addressed in this book is *migration*, which refers to circumstances when people change their place of residence for a permanent or semipermanent period of time (this definition is taken from a widely cited paper by Lee [1966]), and in doing so, they travel some distance longer than simply moving to

a different home in the same town, city, or immediate vicinity. Also important is that the term migration implies a voluntary decision to move. People who move voluntarily are referred to in this book as *migrants*.

A second type of movement discussed frequently in this book is *displacement*, which refers to situations when people have no choice but to move in the face of immediate threats to their lives, livelihoods, and/or well-being. The two most common reasons why people become displaced are (1) acts of violence or conflict and (2) environmental hazards. In this book, we are specifically interested in displacement that is caused directly or indirectly by a specific subset of environmental hazards, namely climate-related hazards. Other types of environmental hazards, such as geotechnical hazards (e.g. tsunamis and earthquakes) and environmental toxins, may also lead to displacement but are not assessed in any detail in this book. People who experience climate-related hazards might be displaced for short periods of time, after which they return immediately to their place of residence, or indefinite periods, sometimes never being able to return to their former homes. The distances they move during their period of displacement can vary considerably. People who are displaced are generally referred to in this book as *displacees*, and where appropriate we use the term *evacuees* to describe people who are displaced for very short periods of time and expect to return to their homes quickly after a hazardous event, and the terms *involuntary migration* and *involuntary migrants* in reference to displacees who must relocate permanently elsewhere.

A third aspect of mobility we discuss often in this book is *immobility* – a condition where people might move or might be expected to move under particular circumstances but do not. Immobility can be *voluntary* or *involuntary*. As with migration and displacement, in this book, we consider immobility only in the context of climate-related events and conditions. For example, we describe cases in Chapter 4 of people who live on small islands threatened by rising sea levels, some of whom want to move to safer islands but lack the means to do so, and others who plan to remain where they are, even in the face of severe risks to their lives and livelihoods.

Many terms have been used over the years by scholars, governments, the media, and the wider public to describe people who move for reasons directly or indirectly related to climate, including *environmental refugees* and *climate refugees*. We deliberately avoid using the word "refugee" in this context, as there is a clear, internationally recognized definition of a refugee under the 1951 *United Nations Convention Relating to the Status of Refugees*, and this definition does *not* apply to people who are forced to move for reasons related to weather, climate, or the environment more generally. It is possible that individual governments or the international community might choose to recognize people who move for environmental reasons as "refugees" under national or international law (see Chapter 6), but for the purposes of this book – and indeed, in any general discussion of the connections between climate and the movement of people – it is important that the term "refugee" be reserved for people fleeing across international borders for fears of violence and persecution.

In this book, we use the adjective "climate-related" to describe migration, displacement, and immobility that are directly or indirectly influenced by weather events, climatic conditions, and/or longer term changes in the climate. *Climate-related migration*, climate-related displacement, and climate-related immobility are not legal terms, but they are clear and consistent with the broad base of scholarly research that has emerged in recent decades. They are also the same terms used in the Intergovernmental Panel on Climate Change (IPCC) 2022 Working Group II Assessment Report (Cissé et al. 2022), which is important, for it is the key reference document used in international negotiations of the UNFCCC, which is in turn the main international agreement through which global action is coordinated to tackle climate change and respond to its impacts, including migration, displacement, and immobility (see Box 1.4 for more information on the IPCC). Too often, academic researchers unnecessarily use language and terminology that are unfamiliar to decision-makers and the wider public, causing their work to be poorly understood or ignored. We choose not to make that mistake here.

We use the term climate-related migration and not the shorter "climate migration" to reflect how there is rarely a single reason why people move (or don't move). Mobility decisions are often multicausal. Even when confronted with an imminent, potentially life-threatening climate hazard, people's short- and longer-term decisions about whether to stay or leave, when to leave, where to go, and whether they go back to the places where they once lived are influenced by a wide range of economic, social, cultural, political, and other nonclimatic factors (Black et al. 2011). People who work in the field often summarize the reasons for migration as being a combination of *push factors and pull factors*: things that make people leave one place and things that make another one more attractive. Climate can work as both a push factor and a pull factor. The strength of its push or pull influence varies from one individual, household, or community to another and from one climate event to another. For some people or in some circumstances, climate may be the primary factor influencing their mobility decisions. For others, it may be a secondary reason, or just one reason among many. And in many cases, climate has no particular influence at all. Using the term "climate-related" provides a clear, consistent, generic way of capturing those circumstances under which climate (or climate change) has an influence on migration, displacement, and immobility from those when it does not.

1.1.1 Migration in the Context of Human Adaptation to a Naturally Changing Climate

Apart from Antarctica and the hottest, driest parts of a small number of deserts, there are few terrestrial spots on this planet where people have not lived or attempted to live on a permanent basis. The history of our species since it emerged approximately 200,000 years ago is of people on the move, and for most of that

history, climate played an important role. Radiating out from our origins in East Africa, *Homo sapiens* have over the millennia moved and adapted biologically, behaviorally, and technologically to a wide range of environments. Hot or cold, wet or dry, rugged or flat, continental or island, if people could get there, they did, and attempted to establish homes and livelihoods. Sometimes "home" was not a single location, but a wider territory over which people would travel as they hunted, fished, and gathered, often in synchronicity with the seasons. In other locations where resources and climate permitted, people established fixed settlements, some of which over time prospered and grew into towns and cities, while others dwindled and were abandoned (McLeman 2011). The act of moving around in search of favorable locations was an important component of larger processes of behavioral adaptation that made our species so successful, if we measure "success" in ecological terms such as the number of individuals in a species (eight billion and counting in our case) and the wide variety of habitats we occupy.

There are, however, limits to physical and behavioral adaptation. Humans are biologically incapable of withstanding exposure to very hot or very cold temperatures for extended periods of time, and we must have a supply of water to drink daily. In this sense, climate places an important check on the types of places to which people are able to move; it defines our geographical range, to import another term from ecology. Within areas that are biologically and climatically viable for us, the distribution and density of human settlements is neither uniform nor random; instead, settlement patterns historically reflected the availability, quality, and distribution of resources critical for our survival, with climate again playing a determining factor. Its influence varies across scales from the global to the local. Resources potentially available for human use vary considerably among Arctic, temperate, and tropical environments due to climate; they also vary between the north side and the south side of a hill, and windward and leeward sides of a coastal mountain. Large- and small-scale variations in climatic conditions interact with other ecological processes to render certain locations more desirable than others for human settlements.

The geographical expansion of the human population over the millennia has been further shaped by continuous and ongoing changes in the Earth's climate over long and short periods of time due to natural processes. Human populations have learned how to adapt to the seasonality of the Earth's climate and the inevitable and generally predictable year-to-year variations in temperatures, precipitation, growing season length, and other weather conditions that affect livelihoods (see Box 1.2). People have also had to adapt to changes in climate that unfold over longer periods of times, along with unexpected short-term fluctuations triggered by natural processes that occur within and beyond the Earth's atmosphere. One of the more obvious long-term climatic processes that has shaped human population

movements and patterns has been the slow climatic cycle of ice age to warm interglacial period and back again to ice age. These glacial/interglacial periods play out over thousands of years, driven principally by Milankovitch cycles, named after the physicist who first documented them (NASA 2020). These are small variations in the orbit of the Earth around the Sun, in the tilt of the Earth's axis, and in the steadiness of the Earth's spin on its axis. Milankovitch cycles change the distance of the Earth from the Sun (the closer we are, the more solar energy we receive, and average global temperatures warm up) and the orientation of the Earth's surface toward the Sun (locations that are more perpendicular to the Sun receive more radiation and become warmer than others).

Box 1.2
Distinction between "Weather" and "Climate"

Tropical cyclones, thunderstorms, tornadoes, and blizzards are among many phenomena that are alternatively described as "extreme weather events" and "climate-related hazards." This begs the question, what is the distinction between *weather* and *climate*? The official – and somewhat vague – definition of *weather* given by the World Meteorological Organization (WMO) is, "the state of the atmosphere at a particular time, as defined by the various meteorological elements." "Meteorological elements" can describe a wide range of phenomena, with the most commonly measured ones being temperature, precipitation, wind, humidity, and air pressure. The key thing is that weather refers to conditions experienced at a specific place and time. Weather is temporary in nature, described and recorded in short increments of time: hours, days, weeks, months, and seasons. The term *climate* refers to average weather conditions as measured over an extended period of time, with 30 years being the shortest measuring period typically used by scientists. The term *climate change* therefore refers to changes in long-term average weather patterns and conditions as observed over multiple decades, centuries, or longer. Scientists further distinguish between natural and *anthropogenic climate change*, the latter referring to change that is attributable to human activities such as the burning of fossil fuels and removal of forest cover. When referring to the range of potential fluctuations in climatic conditions over a given period of time (as opposed to changes in average conditions), scientists typically use the term "climate variability." For example, average daily July temperatures in Ottawa, Canada, are approximately 21°C and in January are –10°C. However, overnight, July temperatures can easily dip below 10°C (an especially mild January day might also see temperatures reach 10°C). A hot summer July day in Ottawa might see temperatures soar into the mid-30s – temperatures more associated with the American capital of Washington DC than Canada's capital city. All of these are examples of the inherent variability of the Ottawa climate, and none are examples of the impacts of climate change – unless they happen so frequently year after year that they cause longer term average temperatures to shift.

Global climate patterns can fluctuate irregularly due to natural processes such as volcanic activity and fluctuations in solar radiation. Recent centuries have seen only occasional large volcanic eruptions and a somewhat steady occurrence of small ones, but in periods when there has been a lot of volcanic activity fluctuations in global climate conditions have occurred. The specific effects of volcanic eruptions on climate are complicated to disentangle (Chim et al. 2023). Ash, particulate matter, and sulfur gasses emitted into the air during eruptions exert a cooling effect on the climate, but carbon dioxide and water vapor that are also emitted into the air trap heat, and the combined effects may be to temporarily cool the climate and then subsequently warm it (but not always). Temporary variations in the amount of energy received from the Sun can also stimulate changes in the climate. On average, the amount of solar energy received from the Sun equals 341 watts per square meter, but there can be variations over relatively short periods of time. The amount of energy emitted by the Sun varies very slightly over the course of a 11-year cycle, and on occasions there are storms on the surface of the Sun that cause flares or bursts of additional energy to be emitted (often referred to as "sunspots," for that is how they appear to us from the Earth) (NASA 2024). Should a solar flare happen to point toward the Earth when it occurs, our planet can receive a slight increase in the amount of energy received, in turn leading to a slight temporary warming. In addition to variations in climate stimulated by orbital variations, volcanic activity, and solar flares, there are multiple naturally occurring, cyclical oscillations in the Earth's climate driven by interactions between oceans and atmosphere, the best known of which is the El Niño Southern Oscillation (ENSO) (Box 1.3).

Throughout the longer course of human history, there have been many times and places when naturally occurring short- and long-term changes in climatic conditions have led to large-scale movements of people into and out of particular areas. In the past thousand years, two periods stand out as being particularly notable for the extent to which climatic changes affected the movements and distribution of people. The first is the Medieval Warm Period (MWP) that ran from the tenth to the early fourteenth centuries CE, a time when average temperatures across much of Europe, Central Asia, Africa, and the Americas were as warm or warmer than they are today (Mann et al. 2008). Excluding present-day climate, average temperatures during the twelfth-century peak of the MWP were likely the warmest experienced since the last ice age (i.e. the last ten thousand years). The impacts of the MWP were favorable for people in Europe, where the climate of the preceding thousand years had been highly variable, characterized by long periods of harsh winters, droughts, extreme storm events, and notable sea level change along the coasts (Lamb 1995, Grove 2002). The MWP created a benign climate that

Box 1.3
El Niño Southern Oscillation (ENSO)

The ENSO is a natural climate event that occurs on an irregular basis roughly once or twice per decade and lasts on average from one to two years. The exact circumstances that trigger an ENSO event are not entirely known. ENSO events pass through three phases, first the El Niño phase, then a neutral phase, and finally a La Niña phase before returning to neutral (National Ocean Service 2024). In its first phase, surface winds over the central Pacific Ocean which normally blow from east to west weaken or reverse direction. This allows warm surface waters from shallow parts of the western Pacific to migrate eastward and spread north and south along the west coast of the Americas. South American fisherman gave the phenomenon the name El Niño to reflect how they would notice these ocean warming events in December, near Christmastime (El Niño being the Spanish word for a boy child, the baby Jesus). The El Niño phase has distinct impacts on weather conditions worldwide and leads to more frequent extreme events in many places (World Meteorological Organization 2024). Warmer and drier than average conditions tend to occur over Canada and the northern US, wetter conditions in the southeastern US, droughts in Central America and northern South America, and wet conditions in southern South America. In Africa, southern and western regions often experience severe droughts, while other regions that are typically dry may receive unusually high amounts of rain. Southeast Asia, an area associated with warm, wet weather, is usually drier than usual during this first phase of the cycle, and wildfire risks may increase. Average global temperatures tend to rise during this phase.

After an intermediate phase in which atmospheric conditions revert to neutral, the third La Niña phase sees a re-intensification of east-to-west winds over the central Pacific and a cooling of sea surface temperatures there. Regions of the world that are typically wet become wetter than usual, dry regions may become drier, cold regions become colder and warm regions warmer than usual – in other words, the weather conditions we would ordinarily expect in a given area do not immediately return to normal, but go past this to exhibit an amplification of expected conditions for several months before returning to normal.

led to increased European agricultural productivity and expansion northward of warm weather crop production, even leading to the establishment of vineyards in southern England (Grove 2002). During the MWP, Scandinavian Norse (popularly known as the Vikings) began migrating to and establishing permanent settlements on the Faroes, Iceland, and Greenland (the coastal areas of which were indeed green during the summers of the MWP), and the building of smaller, ephemeral hunting and fishing settlements on Newfoundland (Dugmore et al. 2012). Inuit settlements across the North American Arctic and Greenland also expanded during this period of relatively mild conditions (Friesen et al. 2020). Elsewhere, MWP