ISSUE BRIEF

Drivers of mobility in mountain areas
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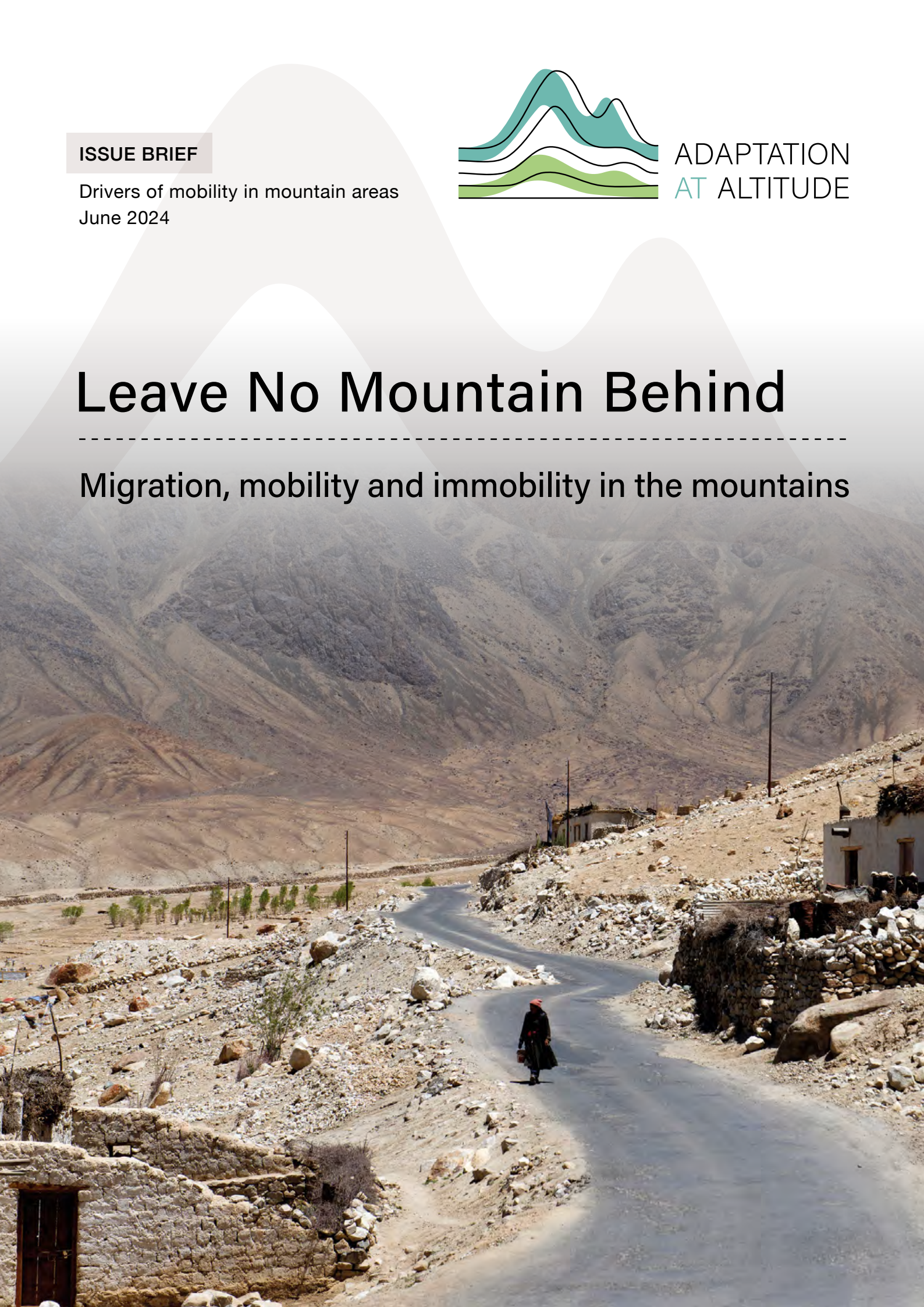
ADAPTATION AT ALTITUDE

Leave No Mountain Behind

Migration, mobility and immobility in the mountains



Adaptation at Altitude, a collaborative programme launched and co-supported by the Swiss Agency for Development and Cooperation, assists mountain communities and those working with them by improving the knowledge of appropriate climate change adaptation and disaster risk reduction strategies in the mountains, and by transferring that knowledge through science–policy platforms to inform decision-making in national, regional and global policy processes. This issue brief is an example of that work.

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Key messages

- Rural mountain communities in developing countries are amongst the most vulnerable in the world due to their remoteness from economic centres, high incidences of food insecurity, low levels of service provision, and dependence on agriculture and natural resources, which in turn makes them highly vulnerable to climate change.

- Seasonal and longer-term migration are long-used and important livelihood diversification strategies for rural mountain communities in developing countries. Choices to migrate are typically driven by socioeconomic factors: mountain households predominantly migrate to gain additional income and access to services to improve their lives and enable them to retain assets, cope with past economic shocks, and as a risk management strategy for absorbing future economic shocks.

- Migration – whether seasonal or long-term – is not an option that is available to all. Without sufficient assets and capacities, and in the face of other factors such as marginalisation, migration can be a high-risk strategy. As a result, many of the poorest and most vulnerable households are immobile.

- Climate change is making mountain regions even more challenging places to live in, and this situation is set to worsen. It is indirectly contributing to migration in the mountains through adversely impacting agricultural productivity and natural resources on which the majority of households depend. These impacts are felt most keenly by the poorest households, for whom migration may not be an option or a high-risk last resort due to a lack of capacity and assets.

- Climate change adaptation interventions – adaptation 'solutions' – can counteract and reduce the vulnerability of mountain communities to the negative impacts of climate change. These adaptation solutions include interventions aimed at increasing water security, improving agricultural productivity, and diversifying livelihoods. Implemented successfully, adaptation interventions can enable households to live better lives in situ, reducing the need for migration as a livelihood strategy.

- As climate change progresses, the limits to climate change adaptation may be met in many rural mountain areas. In these instances, the relocation of communities to new locations may be required. Much has been learned from relocation efforts to date, in particular the need to fund projects that are led by, engage with, understand, and work with affected communities in all aspects of decision-making and implementation.

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Leave No Mountain Behind

Migration, mobility and immobility in the mountains

Leave no one behind. That is the promise made by the United Nations in the 2030 Agenda for Sustainable Development with its commitment to eradicate poverty, end discrimination and exclusion, and reduce the inequalities and vulnerabilities that undermine the potential of both individuals and humanity as a whole. Three years after launching the 2030 Agenda in 2015, the United Nations also adopted the Global Compact for safe, orderly and regular migration, an initiative to foster international cooperation and help governments to address issues around migration.

To meet the aspirations expressed in these accords, it is becoming ever more urgent to highlight the importance of migration, understand how climate change is impacting people's mobility, and provide solutions that help communities to adapt to climate change, build resilience, and improve their lives and livelihoods. Nowhere is this more pressing than in the world's mountains, where climate change is having greater impacts than in many lowland regions.

Mountains cover one quarter of the world's land surface and are home to more than 1.2 billion people in more than 100 countries, with about one third of these people living in cities (Ehrlich et al., 2021). Distinguished by rich biological and cultural diversity, mountains provide vital goods and services to those living in upland regions and downstream (Adler et al., 2022). Some of the ecosystem services they provide – such as freshwater – are particularly important in the lowlands and beyond.

The IPCC (2022) reports observable climate change impacts with serious consequences for people and ecosystems in many mountain regions. These impacts include reductions in snow cover extent and duration, loss of glacier mass, thawing of permafrost, increases in the number and size of glacial lakes, and changes in seasonal weather patterns, all of which are related to higher temperatures. Accelerated warming at high elevations in combination with the large number of people who depend on mountain services such as food, water, energy and medicine place mountain regions in a unique and sensitive position in the context of sustainable development under climate change (Adler et al., 2022).

Sustainable development in mountainous areas helps countries and regions adapt to climate change, reduce disaster risks, and achieve the Sustainable Development Goals. But mountain communities are often left behind economically and politically. Following the celebration in 2022 of the International Year of Sustainable Mountain Development, there is much work to do to honour the commitment to leave no one – and no mountain – behind.

Addressing drivers of migration and immobility in the mountains

For people across the world, changing location to avoid disaster and access better resources and livelihoods is an ancient strategy. This practice continues today in mountain areas, where permanent relocation, seasonal (circular), and longer-term temporary migration away from places of usual residence are used to reduce disaster risk, supplement annual incomes and access new opportunities (Gautam, 2017).

Climate change – together with development failures and growing mountain populations – is altering and hastening these patterns of migration. Climate change impacts are both directly and indirectly intensifying the socioeconomic factors that typically cause people to migrate. These factors – including low financial income, limited livelihood choices, food and water insecurity, and poor access to services – are already acute for many remote mountain communities.

This brief looks at long-term migration in mountain areas and its drivers as well as its impacts on communities and wider society. It explores how climate change is contributing to increased migration in mountain areas and provides examples of climate change adaptation interventions that can help address these drivers and improve the lives of those who choose to stay. Lastly, it discusses the planned relocation of communities: when this may be needed and how this has been done to date. Our focus is on rural mountain communities in low- and middle-income countries that are the most vulnerable to climate change and have the most to gain (and lose) through migration.

What are migration and mobility?

Definitions of migration and mobility vary. United Nations Framework Convention on Climate Change UNFCCC (2011) uses the term 'mobility' to refer to three forms of population movement: i) migration, ii) displacement and iii) planned relocation

International Organization for Migration IOM (2021) suggests migration is defined broadly as the movement of people away from their usual place of residence.

The 2030 Agenda recognises migration as a core development consideration, marking the first time that migration has been integrated explicitly into the global development agenda, and indicates that migration should include all types of movement, including displacement (United Nations, 2015).

This brief adopts the International Organisation for Migration's definition of migration: the movement of people away from their usual place of residence (IOM, 2021). This definition includes climate migration, internal migration, international migration, irregular migration, labour migration, and displacement.

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1. Life in the mountains

More than 1.2 billion people live in mountains around the world. More than half of these people are in Asia, and almost a quarter live in Africa. The majority of these people – around 90% – live in mountains in developing countries and more than half of these people – around 65% – live in rural mountain areas. Asia and Africa have the largest rural mountain populations, while In Latin America and Central Asia more people live in urban mountain areas than in rural mountain areas (Romeo et al., 2020). The number of people living in mountains continues to grow. In developing countries, mountain populations increased from 780 million in 2000 to 1 billion in 2017 (Romeo et al., 2020).

Livelihoods and reliance on natural resources

The remoteness and rugged topography of many rural mountain settlements impedes the development of major infrastructure including transport routes and services, telecommunications, and grid-based energy and water. This can restrict communications and the movement of people and goods, and with it access to health, education and financial services, affordable goods and resources, information, and participation in wider regional economic activity. These factors also impede the development of industries in mountainous regions. As a result, mountain communities typically have fewer livelihood choices available to them than their lowland neighbours. The nature of mountain landscapes and climates also means that those communities are often exposed to multiple hazards, including landslides, extreme weather events, and glacial lake outburst floods (GLOFs) (Saalismaa & Huges, 2022). In some areas, safe living space and land for cultivation are limited and increasingly under pressure from population growth and development.

Agriculture plays a central role in rural mountain livelihoods. Crop-based farming and animal husbandry provide sustenance and income. These are especially important in higher elevation and more remote communities who have limited access to other livelihoods and traded goods (Milan & Ho, 2014). Some people increase their resilience by diversifying their livelihoods including through producing cash crops, trading in high-value products such as medicinal plants, meat, animal fibres and traditional crafts, and engaging in tourism (Bachmann et al., 2019; Gioli et al., 2019; Kollmair & Banerjee, 2011). Access to non-agricultural livelihood options is important as income from these activities can exceed agricultural income (Milan & Ho, 2014).

Rural mountain communities rely on their surrounding environment for everyday needs. Nearby streams and lakes fed by seasonal precipitation and snow and glacial melt provide water for consumption, sanitation, and agriculture. In many regions these flows also power large- and small-scale hydropower installations that provide electricity to mountain households (Lutz et al., 2014). Collectively managed landscapes, including forests and pastures, support mountain livelihoods through the ecosystem services they provide, including grazing and winter fodder for livestock, and as a source of materials, foraged food, and medicinal plants for trade; they also play an essential role in local water management and supply (Kollmair & Banerjee, 2011; Salvatierra & Mogrovejo, 2017).

Poverty and food insecurity in mountain regions in developing countries are high and increasing. The Food and Agriculture Organization of the United Nations estimates that more than half of the people living in rural mountain areas are vulnerable to food insecurity (Romeo et al., 2020). Comparisons of studies in 2000, 2012, and 2017 show that both the number of people living in the mountains and the proportion of these people that are vulnerable to food insecurity are increasing, with one in two people in mountain areas facing food insecurity (Romeo et al., 2020).

Vulnerability to climate change

The reliance of rural mountain communities on their local environment and the ecosystem services it provides makes them highly vulnerable to the impacts of climate change (Adler et al., 2022; Warner & Afifi, 2014). In the mountains, ambient temperatures are rising faster than the global average due to elevation-dependent warming (Adler et al., 2022). In some cases, this rate of warming is more than three times the global average.

McKinnon et al., (2022) noted that, with few exceptions, the impacts of climate change are negative in most regions, countries, scenarios, and timeframes. Climate change is altering patterns in the amount and timing of rain- and snowfall and the seasonal melt of glaciers. In most areas of high elevation around the world, snow, glacier, and permafrost coverage and depth are in decline. These changes are already contributing to water insecurity, both for mountain communities and populations living downstream, and negatively impacting agricultural productivity and hydropower energy generation (Rasul et al., 2020). They are also driving shifts in the distribution of many plant and animal species and declines in numerous species. This degradation of mountain ecosystems is resulting in the loss of ecosystem including:

- water storage,
- slope stabilisation,
- pollination, and
- provision of forage and materials.

Climate change is also contributing towards more frequent and more severe extreme weather events, including heavy rain events and floods that erode soil, wash away crops, degrade agricultural land, and destroy infrastructure.

Climate change impacts are especially challenging for rural mountain communities with limited livelihood options, who have less capacity to adapt due to limited information, poor access to services and low ownership of productive assets (Gentle & Maraseni, 2012).

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2. Migration and mobility in the mountains

Migration has long been an important livelihood strategy for mountain communities. Seasonal migration to gain employment outside of periods of high agricultural activity is commonly used to supplement household income. This form of labour migration provides a lifeline for some households, for whom life would otherwise be unsustainable. It is so important in parts of Nepal that "the status of temporary migrant worker is passed down from father to son" (Bruslé, 2008). For those who aspire to migrate more permanently, seasonal migration can help build the capital required to move and gain more secure employment (Bruslé, 2008).

More significant changes – to the home community and household income – come from longer-term internal or international 'out-migration', where migrants do not return home for long periods of time, or may move away permanently. While out-migration can deplete communities, the financial and social remittances sent home by migrants can improve the wellbeing of mountain households and allow families to retain land and connections to place. For example, in the Central Highlands of Peru, people migrate to local urban centres to supplement scarce income from agriculture rather than abandon their land and home community (Milan & Ho, 2014). Out-migration can also create significant challenges for rural mountains communities. For example, in the Hindu Kush Himalaya, while out-migration can be a source of remittances, it can also lead to labour shortages on farms, impacting local agricultural productivity (HICAP, 2015).

While many areas are seeing out-migration as people seek safer and more affluent lives, some mountain areas are seeing in-migration as people look to take advantage of their amenity value and opportunities arising from activities such as tourism. Both in-migration and out-migration have wide-ranging ramifications for the human capacity and economies of local mountain communities and wider society (Bachmann et al., 2019).

However, not everyone can or will move. Those who are most impoverished and vulnerable to climate change are also those least able to migrate to supplement their income.

Immobility: When people cannot – or will not – move

Not everyone can or wants to move (Schewel, 2020). People need resources to be able to migrate. These include adequate funds to travel and live until employment is secured, social connections to facilitate the finding of new employment and housing, possession of employable skills, and reliable knowledge of how and where to seek new opportunities. Migrating without these assets in place risks increased hardship. Those who can migrate do not always want to: people's sense of place, cultural connections to and knowledge of the mountains, and other factors such as age, health and social embeddedness in the area, can make it difficult to leave (Schewel, 2020).

The socioeconomic challenges faced by impoverished and remote mountain communities, including poverty, limited social networks and low knowledge of the wider region, what opportunities are available, and how to access them, mean that migration is not always an option (Black et al., 2011). Legal and political barriers to migration, and factors such as marginalisation and gender, also impede people's ability to migrate (Black et al., 2011). Low capacity to migrate can lead to mountain households becoming immobile and left behind.

This situation is expected to worsen under climate change. Through adversely impacting mountain communities' livelihoods, climate change is diminishing the resources available to them and thereby their ability to migrate (Benveniste et al., 2022). This immobility can increase communities' vulnerability to subsequent climate change impacts and risk them falling into deeper poverty.

Patterns in global and mountain migration

Approximately 1 billion people worldwide are international or internal migrants (IOM–GMDAC 2016:5). Globally, migration is increasing. There were approximately 281 million international migrants in 2020 (3.6% of the world's population), up from approximately 84 million in 1970 (2.3% of the world's population) (IOM, 2021; Kaczmarska & Ono, 2022). Just less than half of these – 135 million – were women (Kaczmarska & Ono, 2022).

Estimates of the number of internal migrants – including those moving from and to the mountains – are more problematic and rely on country-level census data and surveys. The number of internal migrants globally was estimated at 740 million in 2009, or over three times the number of international migrants at the time (Esmer et al., 2009), and 763 million people in 2013 (UN DESA, 2015).

Patterns of international versus internal migration vary strongly across mountain regions. In Nepal, where around a quarter of all households report at least one member absent, 57% of migrants are internal migrants, while in Rwanda internal migration accounted for less than 10% of migrants between 2011 and 2014 (Bachmann et al., 2019). Which members of the household are migrants also varies strongly across regions. In Bolivia around half of international migrants and more than half of internal migrants are women, typically young, well-educated and from wealthy households, while in Nepal, around 88% of international migrants are young men. While most people migrate from rural to urban areas, this is not the case everywhere. In Nepal, Bolivia and Georgia, most people move from rural mountain areas to the lowlands and cities, while in Rwanda more people migrate from rural to rural areas than migrate from rural to urban areas (Bachmann et al., 2019). Wealth is a factor in most regions, with more reported migrants from wealthy families compared to the poorest households (Bachmann et al., 2019).

Following the global COVID-19 pandemic, it has become more evident that decision-makers and policymakers need reliable information on movements over both short and long distances, internally and internationally. Now, with increasing rates of migration globally, the focus needs to be increased on mobility monitoring and tracking, particularly in mountain regions.

Impacts of migration on communities

Each mountain region and culture are unique, and this remains true for the patterns and impacts of migration seen in these areas. Yet, there are also common negative and positive impacts that can be observed.

The positive impacts of migration

Migration can provide migrants with greater opportunities and better living standards. Migrants to urban centres, in Bolivia for example, can earn four times more than their rural counterparts and typically have better access to sanitation, health, finance and education services (Grau & Aide, 2007).

Migration can also increase the resilience of home mountain communities and their ability to absorb and adapt to the impacts of climate change. This happens mainly through the contribution of financial remittances and non-monetary social remittances, such as the transfer of skills and knowledge.

The money sent home by migrants can increase the economic sustainability of mountain households in the longer term. Remittances can be used to cover household expenses and may also contribute to local economic growth through enabling larger

strategic investments. In 2022 remittance flows to low- and middle-income countries were $657 billion, and are expected to reach $840 billion in 2023, despite estimates that global economic growth is expected to decelerate (World Bank, 2023). These remittances can significantly impact countries' gross domestic product (GDP). For example, remittances corresponded to 29% of Nepal's GDP in 2017 – nearly four times the contribution from tourism that year (Bachmann et al., 2019).

Social remittances can lead to changes and adaptation within a community. Although harder to measure, migration can engender new perspectives and opinions, and can increase the potential for technical, social, economic, and institutional innovation through the sharing of new skills, experiences, and technologies. This enhanced knowledge can help foster the development and uptake of new methods and livelihoods. Expanded social connections created by migrants can help communities access new trade opportunities, networks and supply chains.

While out-migration from mountain communities is often perceived as leading toward their abandonment, in-migration to mountain communities is also occurring and positively contributing to their socioeconomic development. In some cases, people are moving towards mountain areas in regions with a growing industry. For example, the rise of the tourism sector in the Annapura region of Nepal has led to migration from the hills and lowlands to major urban hubs in the mountains as people take advantage of new employment opportunities (Kollmair & Banerjee, 2011).

The migration of people from rural communities to urban centres may also serve to reduce the pressure on mountain ecosystems by decreasing the intensity of land use for agriculture (Grau & Aide, 2007).

Out-migration and community challenges

In many cases, the impact of financial and social remittances makes out-migration a net benefit to mountain communities. However, this relies on migrants staying connected with their home households. How beneficial they are is also determined by how readily migrants can communicate with people at home, and the ease and efficiency of sending money.

Migration can detract from home communities through the loss of key members of the community and local workforce. Migrants are typically younger people, and their out-migration impacts local demographics, knowledge capacity, and manual labour capacity.

Outmigration can contribute to demographic challenges including low fertility rates, aging, and, ultimately, depopulation. For example, in Georgia, reduced numbers of women of childbearing age and lower birth rates have resulted in aging in rural communities reaching drastic levels, with settlements at higher altitudes being increasingly deserted (Kohler et al., 2017). Out-migration can also contribute to labour shortages and issues with childcare, especially in communities seeing a high outflow of young people. For example, in the remote subsistence community of Lvea Krang (Varin District), Cambodia, where 81% of migrants are young males (23.4 years of age on average), the biggest consequences of migration were perceived to be labour shortages (50%) child welfare concerns (50%) and female safety (7%) (Jacobson et al., 2019). In some cases, these challenges can be abated by in-migration from the lowlands and urban centres. However, the penetration of urban lifestyles and tourism-related commodification also risks the annihilation of local traditions and cultures, together with the possibility of land-grabbing and increasing socioeconomic disparity (Visser & Spoor, 2011). This risks further marginalisation of poorer members of the community or rural mountains communities.

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3. Drivers of migration in mountain areas

Understanding migration decision-making

Ultimately the decision to migrate is an individual one, and is driven by numerous, intertwined, and often compounding factors. Numerous studies have sought to understand individuals' reasons for migration by engaging with mountain communities. These studies offer important insights into the realities and decisions facing mountain households. However, it is important to remember that while many of the challenges facing these individuals are shared between households and communities regionally, findings from the household level cannot be considered to reflect an entire region, especially given the diverse contexts and realities of different communities living at different altitudes, with different climates, different cultures, different clusters of available livelihood choices, and different levels of connectivity to neighbouring communities and urban centres.

Our understanding of factors contributing to immobility is also limited. Historically, migration research has focused on the factors that have driven people to move, but far less on those that have limited choices to do so (Schewel, 2020). Studies of immobility in mountain communities are an important area of research given the importance of migration as a livelihood strategy for both the migrant and their home communities. Understanding why certain people are immobile is necessary for prioritising interventions that enhance the choices available to them.

Migration is shaped by non-climatic factors

While global studies of the movement of people suggest that climate change plays a prominent role in driving migration, at the household level the picture is complex. While communities may be temporarily or permanently displaced by climate-related disasters, few studies conducted with households show a direct relationship between migration and slow-onset climate change impacts such as environmental degradation and changes in hydrology.

Migrants rarely cite climate change as a driver of their decision-making. Instead, the decision to move is typically the result of complex interactions between a variety of factors (Black et al., 2011) (see Figure 1). These may include: environmental factors, such as reducing exposure to hazards and food and water insecurity; economic drivers, including seeking better employment opportunities, wages and wellbeing; political factors, such as avoiding discrimination and escaping persecution and conflict; demographic factors including population size, density and structure, particularly in relation to having safe living space and being able to build a family; and cultural and social drivers such as education and proximity to family members. Additionally, an individual's decision to migrate is also determined by their capacity to do so: whether they have sufficient funds, knowledge and social connections to safely migrate without risking falling into poverty. This in turn is determined by their age, gender, level of education, ethnicity, wealth, language, religion and marital status, and how easy it is – in terms of transport as well as governance and political frameworks – to access and work in their destination of choice.

A commonality amongst findings of migration studies of households – in the mountains and globally – is the key role of socioeconomic factors in driving migration: in general, most migrants are migrating in search of better livelihoods and quality of life for themselves and their families.

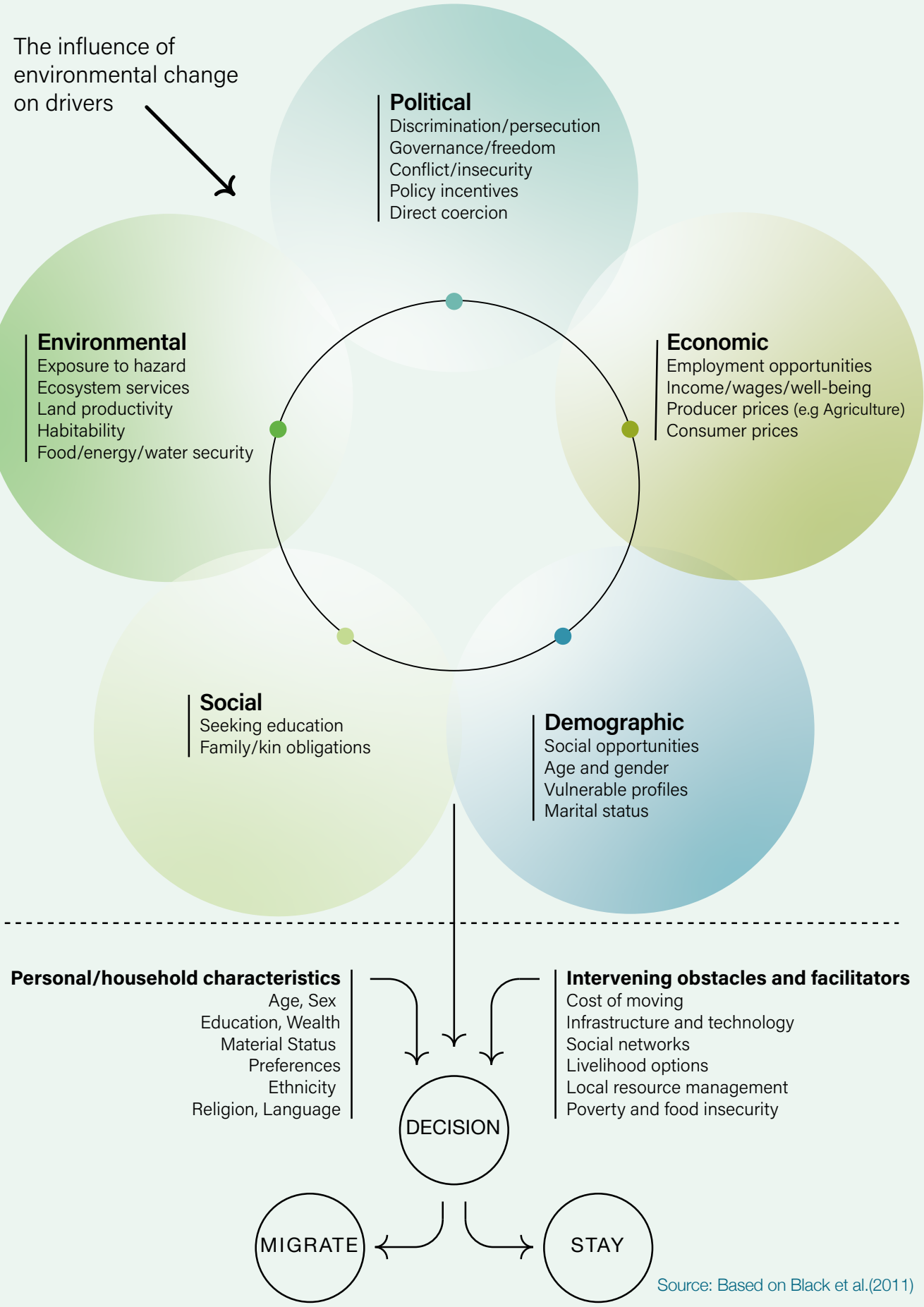
In mountains communities strongly reliant on agriculture, low and falling agricultural activity is contributing to reduced incomes and increased food insecurity, especially where access to alternative livelihoods is restricted. A lack of and erosion of viable agricultural land, environmental stresses including droughts and extreme precipitation events, a lack of irrigation and mechanisation to cope with stresses and improve production, challenging environmental conditions including low soil fertility and erosion, barriers to participating in markets and falling commodity prices, make it difficult for mountain households to secure consistent food supply and income (Kollmair & Banerjee, 2011). In some regions these factors are exacerbated by population growth and resulting pressure on local employment, services and natural resources.

For example, in the high plateau of Bolivia reductions in the land available for farming due to factors including the creation of mining enclaves, desertification and climate variability resulted in impoverishment and increased migration amongst the indigenous population (O'Hare & Rivas, 2007). A study of households in Humla, Nepal found that structural poverty is the root cause of seasonal migration of men from poor and mainly low-caste households, who migrate to seek low-paying unskilled wage work in Uttarakhand, India, during the winter and use the income gained to repay debts incurred during food shortages (Gautam, 2017). Households in the West Karakoram of Pakistan are migrating to nearby urban centres to gain additional income to help cope with past environmental shocks and enhance their ability to absorb future environmental shocks (Gioli et al., 2019). Here, "non-migrant households [households who could not migrate due to a lack of assets] are more likely to be caught in the poverty trap" (Gioli et al., 2019). In Rwanda, land scarcity and a lack of public services are key drivers of migration (Bachmann et al., 2019).

It is not just push factors at home that drive migration: there are also socioeconomic pull factors, including increased economic and employment opportunities, and access to better services and amenities (Kollmair & Banerjee, 2011). For example, access to better child and higher education services were amongst the key drivers for migrants leaving rural areas in Ladakh, India (Goodall, 2004), the far west of Nepal (Poertner et al., 2011), Bhutan (Gosai & Sulewski, 2014), and Bolivia (Kollmair & Banerjee, 2011).

Other factors such as transport and communications infrastructure, government policies, and instability and conflict also strongly influence migration decision-making. For example, improved infrastructure and ease of movement through the Rural Roads Programme in Peru has enabled more households to migrate seasonally to increase their income (Bravo, 2002). Policies can limit or promote migration through imposing or removing barriers to movement, for example requiring costly documentation to gain employment, opening national borders and removing visa obligations (Kollmair & Banerjee, 2011).

Figure 1 - **Drivers of mobility**



Source: Based on Black et al.(2011)

The role of climate change in migration decision-making

Slow-onset climate change impacts mountain systems over timescales of months to years. These impacts can be pervasive, undermining existing livelihoods, living conditions and wellbeing. They typically contribute indirectly to decisions to migrate as people struggle to address changes wrought by climate-induced stress on ecological and hydrological systems and related resources. This is a trend that will continue and intensify in the coming decades as climate change progresses (Adler et al., 2022).

Climate change is driving changes in rainfall and water flow that are impacting agricultural productivity, contributing to diminished incomes and food insecurity. In the Andes, studies of glaciers indicate that peak water will occur sooner than previously thought (Millan et al., 2022). Glaciers in Venezuela and East Africa are expected to disappear altogether before the middle of this century, with significant and irreversible impacts on downstream ecosystems, landscapes and communities (Knight, 2023; Llambí et al., 2021). The occurrence of extended droughts is also increasing, accelerating land degradation in many regions and undermining agricultural livelihoods (FAO and UNCCD, 2019). Agricultural productivity and dietary diversity are also being affected by the negative impacts of climate change on biodiversity and related ecosystem services, including decreases in numbers of pollinators and increases in agricultural pests (Adler et al., 2022). The impacts of climate change, including increasing temper- atures, increasing risk of drought, flooding and other extreme weather events, could lead to increasing levels of anticipatory migration when agricultural livelihoods become impacted gradually or when sudden-onset events destroy harvests and resources (Bergmann et al., 2021).

These changes are being felt at the household level. In a study of livelihood and mobility patterns of households located at different altitudes in the Central Highlands of Peru, where rain-fed agriculture is a key livelihood strategy, more than four fifths of the population noted changes in rainfall patterns and their negative effect on livelihoods (Gautam, 2017). Likewise, 70% of the households surveyed in the Semien Mountains, northwest Ethiopia, felt climate change undermined land productivity (Yohannes et al., 2020). In the Jumla District of Nepal, changing weather patterns are challenging communities' livelihoods by driving resource degradation and food scarcity; these impacts are compounding challenges wrought by a lack of basic services and contributing to increasing social inequalities (Gentle & Maraseni, 2012). In Gorkha district, Nepal, over 70% of household survey respondents from the Chepang community, one of the most marginalised indigenous groups in Nepal, reported a decrease in crop yields during the last 20 years (Duwal et al., 2017). Mountain pastoralist communities are also being affected by drought-induced degradation of rangelands and pastures, which is reducing the productivity of their livestock (Adler et al., 2022).

Migration has and continues to be an important strategy for absorbing past shocks and increasing resilience to future ones. In the Upper Indus Basin, in Kyrgyzstan, and in climate-sensitive areas in South Asia, studies of migration behaviour found that migration is adopted by households as a strategic response to environmental pressure, both to mitigate the potential of future decreases and uncertainty in agricultural production, and to cope with losses induced by past environmental shocks (Gioli et al., 2019; Maharjan et al., 2020; Sagynbekova, 2017).

As in the lowlands, the poorest mountain communities are disproportionally affected by climate change. Their status, low levels of literacy and education, and lack of assets means that they have fewer livelihood options available to them, and so they tend to rely more on increasingly fragile resource-dependent livelihoods such as rainfed arable and pastoral farming. These households are also more likely to be immobile due to their lack of assets and social networks.

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4. Promoting adaptation and resilience in the mountains

Climate change adaptation interventions reduce the negative impacts of climate change on mountain communities' livelihoods, enabling communities to improve their livelihoods in situ. In doing so, they can reduce the need for permanent migration (Rasul et al., 2020). By increasing household income, they may also enable migration (seasonal or longer-term), particularly amongst poorer households currently unable to migrate. They may also encourage in-migration to mountain settlements if people can find more prosperous and sustainable livelihoods there.

Chosen from among the options presented on the Adaptation at Altitude Solutions Portal, which brings together tried-and-tested interventions specifically for mountain regions, the adaptation solutions detailed below provide examples of how some of the stressors on communities can be addressed, and of new livelihood opportunities that can increase mountain communities' wellbeing and resilience.

4.1 Improved water security

Solution 1 – *Sustainable watershed management in glacial mountain ecosystems in Peru*

Peru holds 71% of the world's tropical glaciers. Over the last 40 years, due to the impacts of climate change, the glacial surface of 18 snow-capped mountain ranges in the country has been reduced by 53%. Glacial melt is affecting both freshwater ecosystems and the flora and fauna that rely on them, as well as local communities who are increasingly exposed to natural hazards such as landslides and flash floods.

The Glaciares+ project aimed to build and strengthen capacities for adaptation to climate change and the reduction of risks associated with the retreat of local glaciers while taking advantage of opportunities to manage water resources. The project saw community-led, multi-stakeholder coalitions of scientists and public and private sector actors collaboratively develop water resource management plans to sustainably manage more than 200 new lakes.

As part of those plans, communities working with other stakeholders protected and restored wetlands by planting native species, protecting grassland and forests around important spring water resources and fencing tributaries for restoration of vegetation. They also established sustainable communal grazing plans to prevent overgrazing.

The project also trained smallholder farmers in the sustainable use of highland water resources such as periglacial lagoons and small water reservoirs (cochas). These were combined with other measures, including building dams, storing rainwater and protecting wetlands, and the design and implementation of early disaster warning systems.

The project strengthened governance by building collective management by the community together with public, private, and academic institutions. This included the creation or strengthening of 34 water and sanitation service boards to sustainably manage natural and water resources. It also strengthened womens' representation, including by creating four women-owned and -operated companies to sustainably produce and market products such as coffee, granadilla and honey. Public employees in regional and national entities were also trained in glacial-related disaster risk management.

As a result of the Glaciares+ project, communities now have better access to water, improved income and strengthened capability and knowledge to manage climate change risks and water resources. The improved scientific knowledge, better public policies and local implementation skills enabled through the project also contribute to long-term poverty alleviation in Peru.

Sustainable watershed management in glacial mountain ecosystems in Peru | Adaptation At Altitude

Solution 2 – *Restoring traditional crop systems*

The community of Mireshelli in Agdam district is nestled in the foothills of the Lesser Caucasus, where the local inhabitants rely on agriculture for their livelihoods. Agdam is among the districts in Azerbaijan hardest hit by water scarcity and poverty, which is also contributing to forced economic migration within Azerbaijan or abroad. The communities cannot afford the cost of groundwater extraction, resulting in a lack of drinking and irrigation water.

A recent initiative aimed to rehabilitate the traditional Khariz system in the community. Khariz systems use a gallery dug from the mountains to lower lands with a slight slope to transport water from groundwater aquifers using gravity alone. This allows water to be transported from areas of higher rainfall to other locations. Because they are sited below ground, Khariz systems allow water to travel over long distances without loss of much of the water to evaporation, even in hot and dry climates. This system is sustainable and low-cost.

In Agdam, the Khariz system, locally called Shamsi, was rehabilitated to provide all households with improved access to water. The initiative also included the reintroduction of traditional masons, called Kankan, to build and maintain this infrastructure.

The solution is built on a community-driven approach to tackle cross-cutting issues, including a gender dimension to improve the living and working conditions of women who are traditionally responsible for collecting water. Water resources are now more reliable and can be fetched closer to people's homes, which is reducing the workload for many women, and helps reduce the likelihood of families or communities migrating from the region due to limited water resources.

Renewing the flow of water in Mireshelli, Azerbaijan | Adaptation At Altitude

Solution 3 – *A solution for multiple regions:*

the restoration of traditional water management infrastructure has been used to enhance the water security of communities across the world. In the United Republic of Tanzania, where farmers have traditionally relied on rain-fed agriculture, the construction of traditional Ndivas is helping to reduce the impact of water scarcity caused by frequent dry spells while meeting increasing demand for water resources arising from a rapidly growing population. Ndivas are human-made reservoirs connected to crops via conveyance channels that can carry water over a distance of 500 metres (but can also reach 3,000 metres) and serve more than one farm, providing community members with a stable source of water with which to irrigate their crops.

Use of traditional Ndivas in Tanzania | Adaptation At Altitude

4.2 More resilient agriculture

Solution 4 – *Restoring traditional crop systems*

Agricultural practices can be severely impacted by climate change and can lead to cascading impacts on communities' livelihoods. This solution supports communities in growing more versatile and resistant crops to adapt to climate change and encourages capacity development to expand knowledge of the crops grown.

The Andean tubers ibia/oca (Oxalis tuberosa Molina), cubio/mashua/isañu (Tropaelum tuberosum Ruíz & Pavón), and ruba/melloco/olluco/papa lisa (Ullucus tuberosus), usually catalogued as marginal, undervalued or underutilised, have been cultivated in the mountainous areas of Boyacá since pre-Hispanic times. They remain an important part of the food and medicinal culture of the current population, who have inherited the techniques of their cultivation, management and use.

Because of their great capacity to adapt to different climatic conditions, resistance to pest attacks and tolerance to drought, Andean tubers can be cultivated in different ecological zones at 2400-4000 m above sea level. These characteristics, together with their nutritional and medicinal properties, give them high potential as crops that can reduce climatic and food vulnerability, in addition to strengthening the adaptive capacity of Andean farmers.

The solution implemented in three municipalities of Boyacá promoted the cultivation and use of tubers through participatory information generation processes based on traditional knowledge possessed by local farmers.

Reconversion of conventional production systems to traditional agroecological systems as a climate change adaptation strategy for small producers in Boyaca-Colombia | Adaptation At Altitude

Solution 5 – *Reducing soil erosion through planting shade for coffee*

Due to land degradation and loss of vegetation cover, the hilly areas of Burundi are experiencing high levels of soil erosion. These losses are being driven by unsustainable agricultural and land-use practices and high annual population growth of around 3.3%, which adds to the pressures on land in the already densely populated country. As Predicted increases and shifts in precipitation pose additional challenges for retaining soil.

Coffee represents about 20% of Burundi's exports. However, issues including land degradation have led to a decline in production, with major ramifications for the livelihoods of many people.

The Sustainable Coffee Landscape Project aimed to tackle these issues by focusing on four main aspects: (1) landscapes degraded by sun-grown coffee monocropping; (2) protected areas degraded by agricultural encroachment and firewood collection; (3) water resources polluted by environmentally unsound practices in coffee production; and (4) low-quality coffee production and limited marketing.

To combat erosion in hillside plantations, coffee farmers in three provinces were trained in shade-cropping and sustainable land and water management. Shade cultivation systems involve intercropping coffee with other crops, such as bananas, beans or corn, which protect the coffee plants from strong sun and winds.

More than 18,700 people benefited from the project's solutions, and more than 4,400 hectares were restored through sustainable land management practices. Shade-grown coffee production increased by 26%, and of the 9,600 households that adopted the practice, half were headed by women. In addition, over 2 million coffee trees were planted, and each tree in shaded production areas increased its production by 101 grams on average. These practices have benefited the environment by restoring landscapes, and households have seen increased food security, income from coffee production, and resilience to climate change, therefore decreasing the likelihood of migration due to lack of economic opportunities or available resources.

Planting shade for coffee - The Sustainable Coffee Landscapes Project in Burundi | Adaptation At Altitude

Solution 6 – *Climate-smart livestock production in Ecuador*

The climate-smart livestock production project aimed to reduce the climate vulnerability of the livestock sector and communities in the Ecuadorian Andes and to help enhance their adaptive capacities. Where communities are vulnerable to climate impacts, reduced adaptive capacity can prompt increased permanent migration.

Small and medium-scale livestock production in the Ecuadorian Andes represents an important and growing sector. However, its expansion also contributes to the loss of forest and paramo remnants, including their vital ecosystem services, through conversion to extensive low-productivity grazing. Added to this is are climate risks from increased temperatures, changes in rainfall patterns, and more frequent droughts and torrential rains, which make livestock systems highly vulnerable. The solution focused on reducing this vulnerability and strengthening the adaptive capacity of farming systems and livelihoods by sustainably increasing productivity, while also reducing greenhouse gas emissions.

Through the project, a set of locally tailored practices were designed and implemented in response to the needs of each area. These included paddock gauging; rotational grazing: electric fencing; pasture management and renewal; implementation of forage mixtures; forage banks; herd health and reproductive management; establishment of silvopastures; training and capacity-building; empowerment of women; access to incentives and financial mechanisms; promotion of public policies; and strengthening of livestock governance.

The project trained technicians from different government institutions, conducted local climate vulnerability assessments in each intervention province, undertook a climate risk assessment of the livestock sector at the national level, mapped and zoned pasture use at the national level and in each intervention province, developed systems for monitoring emissions and climate risk, and trained livestock producers in 165 pilot farms. The producers in pilot farms agreed to implement climate-smart practices, participate in training, use the materials and inputs provided by the project in a sustainable manner, and complement the investments to implement measures with their own resources. The project also established a climate credit line for producers in the pilot farms.

This solution supported communities' resilience and built adaptive capacity to the impacts of climate change, reducing climate vulnerability and consequently reducing the likelihood of permanent migration due to limited opportunities or resources.

Climate-Smart Livestock Production in Ecuador: climate change adaptation for small and medium-sized livestock producers, with special focus on the Imbabura and Loja provinces | Adaptation At Altitude

Solution 7 – *Women-centric approach to enhance resilience in Kavre district, Nepal*

In the past 20–30 years, an increase in hazard risk due to changes in rainfall patterns has been observed in Kavre district of Nepal. Drought is the most severe challenge impacting agricultural production, the livelihood mainstay for over two thirds of the population. In addition, crops are being affected by higher incidences of insect pest attacks. This in turn is forcing farmers to apply higher doses of "red-labelled" chemical pesticides, creating severe health hazards for people and the environment.

Based on a risk assessment and participatory planning, this project addressed water scarcity, soil fertility, crop productivity, information gaps, risk reduction and institutional linkages. The actions were deliberately kept simple and affordable to ensure easy uptake for farmers, and to enable practices to be shared by word of mouth among communities not directly participating.

The project took a holistic approach to simultaneously address various aspects of resilience enhancement using three action areas:

- Capacity building for climate resilience and DRR: the project tested, demonstrated, and disseminated a number of technologies and practices based in traditional and scientific knowledge. These included the introduction of Jholmal, a cattle-urine-based biopesticide and fertiliser, improved cropping practices such as crop rotation, mixed cropping, intercropping, manure and mulching to maintain soil nutrients, harvesting of rain- and wastewater, affordable drip and sprinkler irrigation, promotion of biogas and solar energy, and practices to reduce the amount of energy required for agriculture.

- Interventions for socioeconomic resilience: these focused on improving women's access to knowledge, tools and resources to sustainably manage households and farms, strengthening women's and farmers' groups for peer sharing and decision-making, and working closely with village- and district-level governments to institutionalise practices and ensure ownership.

- Interventions for future resilience: these included establishing phone-based crop, weather and market advisories, and equipping schools with meteorological stations to gather weather data while providing students with an opportunity to learn about climate change.

The project has directly benefited 1,089 households, of which 13% are dalit and 21% are ethnic minority. Female participation was high (83%), partly because the project encouraged women to join, but also because of the high level of male outmigration – in almost 40% of the households in the region, at least one man had migrated.

Longer-term solutions such as this example have improved climate resilience techniques for agriculture and water resource management while also working with women to increase capacity and share knowledge.

Women-centric approach to enhance resilience in Kavre district, Nepal | Adaptation At Altitude

4.3 Livelihood diversification

Solution 8 – *The case of beekeeping in the Eastern Arc Mountains of Tanzania*

Agricultural practices can be severely impacted by Udzungwa Mountains National Park in the Eastern Arc Mountains, south-central Tanzania, is a habitat for many endemic species of fauna and flora. The park's mountains serve as a water tower for communities in the region and many agricultural livelihoods rely on this water source. However, people also put pressure on the park's natural resources through poaching, unsustainable timber harvesting and cutting down trees for cooking fuel. Higher temperatures, lower precipitation and increased incidence of crop pests and diseases are all affecting agricultural productivity, prompting communities to turn to forest resources to supplement and sustain their livelihoods.

In 2012 a series of beekeeping projects sought to provide alternative livelihoods for rural communities in several districts adjacent to the protected areas of the national park. These projects have been highly effective, with community members using part of their land to plant trees to conserve the environment and house the hives.

The solution has benefited 1,570 villagers, who have been trained in modern beekeeping techniques. More than 80 groups of beekeepers were supplied with 1,352 modern hives. Women are among the beneficiaries and are an active part of the groups.

Since the start of the project in 2012, it is estimated that more than 14,000 litres of honey and more than 500 kilograms of beeswax have been collected per year, generating sales revenue equivalent to about $33,000. This has reduced pressure on the forest in the protected areas, as people no longer see the need to trespass in the forest to make a living.

By supporting livelihoods in a sustainable manner, this solution is also building longer-term community resilience to climate change, and therefore reducing the likelihood migration in search of better resources and livelihoods.

Buzz-boosting techniques - The case of beekeeping in the Eastern Arc Mountains of Tanzania | Adaptation At Altitude

Solution 9 – *A solution for multiple regions:*

A similar solution has been implemented in the Ambrolauri municipality in Georgia involving women who had been affected by natural disasters and were living in poor conditions. The project aimed to strengthen women's involvement in business, diversify and improve their livelihoods, and support the local agricultural sector. Supported by a local shop offering a permanent free place for women to sell their honey and generate revenue, the project has resulted in the women promoting beekeeping and biodiversity conservation measures within their communities and beyond.

Women in bees-ness in Georgia | Adaptation At Altitude

Solution 10 – *Thrive with ecotourism*

The effects of climate change are being felt in the south of the United Republic of Tanzania, with the highlands particularly affected. Temperatures are rising and rainfall has become unpredictable, leading to severe droughts. These shifts greatly affect the ecosystem services on which the livelihoods of the region's people depend.

The Resilient Natural Resource Management for Tourism and Growth (REGROW) project has the combined objective of improving the management of protected areas and their ecosystems in the southern highlands of Tanzania and creating livelihood opportunities that enable economic development and growth for the targeted communities. The project was designed for the "Southern Circuit", which includes the national parks of Katavi, Kitulo, Mahale, Udzungwa, Mikumi, and the Ruaha Mountains.

Tanzania's tourism is predominantly wildlife-based, but the decline in species has reduced the attractiveness of the sector. Moreover, the limited infrastructure of the Southern Circuit, such as airstrips, visitor services, and logistical facilities, is another obstacle to attracting tourists.

The REGROW project combines three key objectives:

- Strengthened management and improved infrastructure in priority protected areas
- Strengthened alternative livelihoods for targeted communities
- Strengthened landscape management and infrastructure investments in and upstream of the Ruaha National Park

The project is supporting the development of local tourism programmes by: improving tourism infrastructures such as roads, transport and communication services that ameliorate access to natural parks; identifying and building linkages between the range of attractions in southern Tanzania; and increasing recognition of southern Tanzania as a tourist destination. In parallel, the project is supporting conservation-related community-based initiatives, including through:

- improving governance frameworks for conservation-related community-based initiatives, including benefit-sharing, technical assistance, and building a strategy for the development of cultural/historical tourism; and
- increasing economic opportunities for local communities by developing new livelihoods, providing education opportunities and otherwise building capacities for livelihoods connected to tourism and conservation.

The economic opportunities offered by this project aim to improve communities' livelihoods and reduce their vulnerability to the effects of climate change. The planned measures also reduce pressure on natural resources, which benefits both the flora and fauna of these ecosystems, as well as the communities. These outcomes can make community members less likely to migrate from the area due to socioeconomic challenges.

Thrive with ecotourism - The case of the REGROW project in Tanzania | Adaptation At Altitude

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5. Reaching the limits of adaptation: relocation

“There is a rapidly closing window of opportunity to secure a liveable and sustainable future for all (very high confidence).”

“Adaptation options that are feasible and effective today will become constrained and less effective with increasing global warming.”

“Planned relocations by governments of settlements and populations exposed to climatic hazards are not presently commonplace, although the need is expected to grow in coming decades.”

(IPCC, 2022)

If implemented effectively and soon, adaptation interventions can counteract many climate change impacts, reduce vulnerabilities and enhance the opportunities and wellbeing of mountain communities. However, in regions where environmental change is progressing quickly and in some aspects, such as loss of glaciers, is irreversible, such interventions may still fall short – and mountains are amongst the fastest changing environments on Earth.

The limits to adaptation – "The point at which an actor's objectives (or system needs) cannot be secured from intolerable risks through adaptive actions" (IPCC, 2022) – will likely be surpassed in some mountain communities in the coming decades. The limits may be reached because there are no available solutions that would enable adaptation to the extent needed (or for a sufficient period of time where conditions are worsening), the cost of available solutions is too high compared to relocation, or there is insufficient social capacity to adapt (Dow et al., 2013; Thomas et al., 2021). For communities where the limits to adaptation have been reached, relocation – the permanent removal of a community from one location to another – may be the best option for reducing their vulnerability and enhancing their wellbeing.

Relocation is a significant undertaking for the communities involved, and relocation processes should only be considered when there is local agreement that in situ adaptation options have been exhausted (IPCC, 2022). Depending on how it is implemented, relocation can have net positive benefits for communities; it can be transformative in highlighting and addressing issues of equity (Siders et al., 2021); it can also provide a pathway to better public service provision and broader migratory corridors that enable communities to further diversify their livelihoods and enhance their resilience (Entzinger & Scholten, 2016). However, organised relocations are also "expensive, contentious, create multiple challenges for governments, and generate short- and longer-term disruptions for the people involved" (IPCC, 2022). For example, relocations of small Indigenous communities in coastal Alaska and villages in the Solomon Islands and Fiji suggest that relocated people can experience significant financial and emotional distress as cultural and spiritual bonds to place and livelihoods are disrupted (Albert et al., 2018; IPCC, 2022; Neef et al., 2018; Yates et al., 2022).

Improving the feasibility of planned relocation and resettlement is a high priority for managing climate risks (IPCC, 2022). Cases of relocation in response to climate-induced environmental stress are still relatively few, and fewer still for mountain areas, but provide key insights on considerations and good practices for future relocation projects. They also foreground the need for more research on relocation efforts, including how they can be done equitably and how they can contribute to sustainable increases in community wellbeing and resilience.

Lessons from completed and ongoing relocation projects

- **Understanding and meeting stakeholders' needs and expectations:** Meaningful engagement of all stakeholders in the decision to relocate and throughout the planned relocation process is essential to ensure buy-in from the community and that the process is tailored to their realities and needs. Relocation efforts that do not meet the needs of communities, for example through poor location selection, are likely to result in communities returning home or migrating elsewhere. For example, in Tan An, Viet Nam, many relocated households sold their new land and moved back to their original homes or moved to urban centres because the new location was too far from the coast to engage in traditional fishery and shrimping activities (Entzinger & Scholten, 2016).

- **Preserving and improving standards of living:** the place of relocation should enable community members to improve or at least maintain their standards of living, including access to suitable infrastructure, services, and livelihoods. Combining relocation efforts with broader programmes of development, including establishing schools, industries, marketplaces, and health services, makes these relocations zones more attractive to households and provides opportunities for livelihood diversification and income growth (Entzinger & Scholten, 2016). This may include clear legal and institutional frameworks aimed at reducing socioeconomic inequalities. For example, a case of disaster resettlement in the Qinling Mountains, China, highlights the importance of institutional support, including "employment and entrepreneurship assistance, legal guarantee mechanisms, and social security" to support peasants who had been resettled due to flood risks (Guo & Kapucu, 2018).

- **Consideration of social, cultural and affective ties:** relocation efforts should attempt to preserve the social fabric of a community, which is sometimes closely connected to place. For example, following the resettlement of communities due to dam construction in Lesotho, many women said that their lives had deteriorated because they lost the social support system they had shared with extended family members and friends (Kotelo-Molaoa, 2007). Attachment to place for cultural and affective reasons is also a key factor. For some groups resettled after the eruption of Mt Pinatubo, Philippines, in 1991, resettlement was often associated with "an unacceptable uprooting from the birth and death place of the ancestors" (Gaillard, 2008). Arrangements that allow communities to regularly reconnect with their lands of origin can preserve those cultural and affective ties.

- **Planning to avoid marginalisation and conflict:** it is important to map and communicate, coordinate and build trust with all stakeholders that will be impacted by the relocation, since impact on existing communities can lead to tensions with and marginalisation of relocated households. This should involve clearly identifying and communicating the benefits associated with the relocation. For example, in Georgia, the relocation of economic migrants of different ethnicity to the recipient population has at times resulted in significant tensions in these communities; this could have been avoided through better planning and the development and implementation of relevant policies (Trier & Turashvili, 2007).

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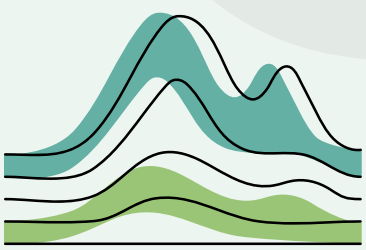

ADAPTATION
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