



Climate (im)mobilities in the Eastern Hindu Kush: The case of Lotkuh Valley, Pakistan

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Abstract

The relationship between climate, environment, and human mobility is complex as (im)mobility outcomes are influenced by multiple socioeconomic, political, and environmental factors. The current debate is focused on migration as an adaptation strategy in the face of climate change but largely ignores the immobility aspect, particularly in the Eastern Hindu Kush where mountain livelihoods are strongly dependent on local environmental conditions. In this study, we examine the interrelations between climate change and the environment as drivers of human mobility and immobility in the mountain communities of Lotkuh valley, Chitral, in north Pakistan. We employed a mixed methods approach grounded in migration theory to describe the relationship between climate change, environment, and (im)mobility outcomes. The study reveals that climate (im)mobilities are the outcome of a complex interplay between climate change, extreme events, and local livelihoods. The primary drivers of (im)mobility are socioeconomic factors. Forced displacement is driven by a multitude of extreme events in the area. Three critical aspects of livelihoods—land resources, crop productivity, and livestock farming—are identified as significant factors influencing mobility and immobility outcomes. Recurring extreme events such as floods and landslides exacerbate soil erosion and the loss of fertile farmlands, leading to food insecurity and compelling households to resort to labor migration as an adaptation strategy. Conversely, for households facing severe income stress and depleted economic assets, immobility becomes the only viable option due to insufficient resources for migration. Moreover, the study reveals that some households adopt a mixed strategy by sending select members to other areas while others remain in their places of origin to sustain their livelihoods. The study has implications for policymakers, government, and development organizations in the region suggesting sustainable livelihoods and adaptation measures to address the specific challenges faced by mountain communities in the Lotkuh valley and the wider region.

Keywords Migration · Human mobility · Immobility · Climate adaptation · Sustainable livelihoods · Natural hazards

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Introduction

With the increase in research on climate change and its impacts, the academic and public policy discourse on the linkages between environment, climate, and human migration has also gathered momentum (Piguet, 2010, 2022; Wiegel et al., 2019). These linkages are intricate and multifaceted and (im)mobility decisions are influenced by a multitude of drivers (Boas et al., 2019; Boas et al., 2022; McLeman & Gemenne, 2018; Parsons & Nielsen, 2021). The purpose of this study is twofold: (i) to examine current mobility and immobility patterns and their drivers in the Eastern Hindu Kush and (ii) to assess the influence of climate change on these patterns by analyzing its effects on mountain livelihoods. We provide empirical evidence to fill a knowledge gap in the field of climate change and human (im)mobilities in the Eastern Hindu Kush and conceptualize our findings to contribute to the wider literature on climate (im)mobilities.

Our research builds on the two subsets of the climate change and (im)mobility nexus literature: firstly, the debate on climate change, environment, and (im) mobility and, secondly, the empirical evidence of climate change impacts on the livelihoods and their relationships with (im)mobility patterns in the mountain regions. To achieve this, we employ a mixed-method approach in this study. Theoretically, the study invokes a synthesis of the new economics of labor migration, the aspirations and capabilities framework, the livelihoods approach, and the foresight framework, to show the complexity of links between climate and human (im)mobility. The remainder of this paper is structured as follows: We begin with an overview of the environment, climate change, and (im)mobility nexus by including the mountain communities in this debate, followed by our theoretical positioning and a description of the study area. Next, we present our data collection and analytical methods, presenting results covering mobility patterns, drivers of mobility and mobility, mountain livelihoods, and climate (im)mobility. We then discuss our findings in relation to existing climate migration literature in the “[Discussion](#)” section. The paper concludes by highlighting our key contributions to climate mobilities literature.

Environment, climate change, and human (im)mobility nexus

The debate on climate change and migration nexus began with earlier studies that predicted mass migration of “climate refugees” due to the supposed failure of millions of people to adapt to the adverse impacts of climate change (Biermann & Boas, 2010; Myers, 2002). This “alarmist” view considered the mass exodus to have implications for security and stability globally, thus dominating the climate change-security agenda (Wiegel et al., 2019). The main criticism of this view is the assumption of the monocausal link between climate change and people’s movement (Black, Adger, et al., 2011; Doevenspeck, 2011; Wiegel et al., 2019). These estimates are based on a deterministic view and ignore socioeconomic, political,

and cultural drivers and human agency in migration decision-making (Black, Adger, et al., 2011; Gemenne, 2011; Romankiewicz & Doevenspeck, 2015).

The criticism of the alarmist perspective led to the rise of the “migration as adaptation” discourse in which the relationship between climate, environment, and migration is considered complex (Wiegel et al., 2019). Most scholars argue that migration is influenced by a multitude of factors including individual agency, adaptation capacity, and the broader sociocultural, economic, and political context (Black, Adger, et al., 2011; Boas et al., 2019; Romankiewicz et al., 2016). Migration has always been an important adaptation strategy to the changes in the socio-economic, political, and natural environment (Groth et al., 2020; Hunter & Simon, 2022; McLeman, 2018; Wiegel et al., 2019). Furthermore, migration is a multicausal phenomenon, and environmental factors are among many other drivers that impact migration decisions (Kaczan & Orgill-Meyer, 2020; Morales-Muñoz et al., 2020). The focus of empirical research has largely been on human mobility or migration, with limited attention given to immobility, i.e., on the people who stay despite facing adverse conditions, often termed as “trapped populations” (Zickgraf, 2018, 2021b). However, immobilities in the face of climate change are the subject of an increasing number of studies (Ayeb-Karlsson, 2020; Khatun et al., 2022; Piggott-McKellar & McMichael, 2021; Schewel, 2020).

In the recent debate on the climate change and migration nexus, there has been a shift from climate or environmental migration toward “climate mobilities” (Boas et al., 2019; Cundill et al., 2021). This perspective advocates for a broader understanding of the relationship between human movement and climate change which covers the diversity of movement rooted in the local historical, structural, and political context (Boas et al., 2022; Wiegel et al., 2019). Moreover, it entails that human movements in the context of climate change take shapes of different mobilities and immobilities such as short-distance forced displacement, long-distance migration, and rural-to-urban migration (Boas et al., 2022). In addition, it also involves the immobility of people when they cannot or do not want to move out of areas of climate risk. Therefore, the plurality of various mobilities cannot be captured by the term migration in the context of climate change (Boas et al., 2019). The climate mobilities perspective is molded in the broader “mobilities paradigm” (Sheller & Urry, 2006) which involves analyzing how movement plays a fundamental role in social institutions and practices and exploring various forms of mobility and their diverse combinations (Sheller & Urry, 2016).

Environmental changes can influence mobility directly by posing risks to the life and health of vulnerable people or through their interaction with socioeconomic and political drivers (Hoffmann et al., 2020). The direct link between a rapid-onset event (e.g., floods) and mobility could be if, for instance, the destruction of homes or their livelihoods, such as erosion of agricultural land, forces people to relocate or be displaced to another place. Such movement is generally for a short duration and over a short distance, and people return to rehabilitate their damaged houses and property (Cattaneo et al., 2019; McLeman & Gemenne, 2018). Indirect links are where slow-onset events (e.g., droughts, land degradation, changes in precipitation) impact local environmental and agroecological conditions, resulting in some people moving to other places because of the decline in agricultural productivity in the area (Anjum

& Fraser, 2021; Zickgraf, 2021a). Slow-onset changes and extreme natural events interact with contextual factors (e.g., income, land tenure, and gender) and affect a household's vulnerability and capability differently (Kaczan & Orgill-Meyer, 2020). Generally, rapid-onset events or extreme events deplete the household's asset base and undermine their ability to migrate, while the slow-onset requires people to adjust to these changes by choosing out-migration (Cattaneo et al., 2019; Kaczan & Orgill-Meyer, 2020). However, this decision-making is dependent on the macro-level socioeconomic and political conditions of the area (Hoffmann et al., 2020).

Overall, the relationship between climate change and migration is stronger in areas where people's livelihoods are dependent on the environment (Piguët, 2022). In such regions, people's livelihoods are threatened by the impacts of natural hazards (both rapid-onset and slow-onset events) and exacerbate the preexisting socioeconomic vulnerabilities, which in turn affect their migration decisions (Cundill et al., 2021). However, the poorest communities who lack the resources to undertake migration may not be able to move and thus could become "trapped" populations (Black, Bennett, et al., 2011; DeWaard et al., 2022). Apart from this involuntary immobility, some households voluntarily prefer to stay in their places of origin and lack migration aspirations (Rabbani et al., 2022; Zickgraf, 2018).

Climate change has significant implications for mountain communities, including those in the Hindu Kush, Karakoram, and Himalaya (HKH) region, with the reduction in glacier cover, changes in water supply, increased hydro-meteorological hazards, and changes in land cover (Khan et al., 2022; Kulkarni et al., 2013; Sabin et al., 2020; Wester et al., 2019). These climatic and environmental changes affect livelihoods, which are heavily dependent on the local environment, limited agriculture, fragile and scarce resource base, and structural dependence on lowland areas (McDowell et al., 2019; Siddiqui et al., 2019). Migration plays a significant role in the diversification of the livelihoods of mountain communities in addition to providing better education and better life opportunities (Gioli et al., 2016; Siddiqui et al., 2019). However, remittances from migration are prioritized for household consumption, education, and healthcare needs over investment in agriculture or adaptation measures in the HKH region (Siddiqui et al., 2019). The frequent natural hazards such as torrential rains, floods, avalanches, and landslides coupled with socioeconomic, political, and demographic changes have outcomes for their mobility and immobility. Studies on climate, environment, and migration have been conducted in parts of HKH (Benz, 2016; Childs et al., 2014; Gioli et al., 2014a, b), with little focus on the immobility aspect. There is a general lack of knowledge on the climate mobilities in the mountain communities of the Eastern Hindu Kush region. Moreover, climate immobility is an understudied aspect in the growing global environment and migration literature (Blondin, 2021; Cundill et al., 2021).

Considering a recent review of migration theory in climate mobility research, which argues that empirical literature on climate migration has grown in isolation from the advances in migration theory (Sherbinin et al., 2022), our approach is shaped by the synthesis of several theoretical approaches since a single one cannot fully capture the non-linear relationship between environment, climate change, and human mobility: push-pull, NELM, aspirations and capability framework, livelihoods approach, and foresight framework. Accordingly, we define migration

aspirations as people's ambitions and preferences about life in their villages and their perceptions of opportunities in destinations (De Haas, 2021). Migration capabilities are the social and economic resources needed for people to move, depending on positive and negative liberties (De Haas, 2021). Negative liberty denotes the presence of external constraints, obstacles, or barriers that are often enforced by the macro context, such as government policies, and positive liberty means "the ability to take control of one's life and to realize one's fundamental purposes" (De Haas, 2021, p. 24).

We also acknowledge that even those without migration aspirations, but exposed to significant risk and in dire situations, may still be unable to move (Boas et al., 2019; Suckall et al., 2017). There could also be involuntary immobility of individuals due to a gap between aspiration (to move) and capability to do so (De Haas, 2021). In other cases, they are forcibly displaced by drivers such as floods. The forced displacement is generally a short-term and sudden involuntary movement of households and communities from their place of residence often triggered by extreme events (Adger et al., 2018). We understand migration capability (De Haas, 2021) as the social, cultural, and economic resources that enable a person to realize their move to a new place. Natural hazards and extreme events act as push factors affecting income, land, and other economic assets while better employment opportunities, family networks, and higher income at the destinations serve as pull factors. We regard climate change as an indirect driver of migration where it interacts with economic conditions leading to migration as an adaptive strategy by households or immobility for others, thus conforming with foresight and livelihoods frameworks (Black, Adger, et al., 2011; Scoones, 1998). We also consider human mobility and immobility to be interconnected and should be studied together as noted in the climate mobilities perspective (Boas et al., 2022; Wiegel et al., 2019). We placed the decision-making process of (im)mobility within the household context (as informed by NELM and livelihoods approach), considering it a collective decision influenced by the household head but also taking into account individual and household aspirations. To operationalize this, we employ the concepts of capital (including natural resources, financial resources, education, skills, and social networks) and livelihoods (skills, resources, and activities) from the sustainable livelihoods framework (Scoones, 1998). The livelihoods framework is criticized for its lack of attention to cultural and power relations within the households (Adato & Meinzen-Dick, 2002). While acknowledging these limitations, we use the livelihoods approach to explore the livelihoods and capitals of the households and the relationship between these assets and climate change and extreme events in our study area.

To investigate the relationships between environment, climate change, and human (im)mobility patterns, we focus on the Eastern Hindu Kush, especially the Lotkuh valley, in north Pakistan. Currently, Pakistan is ranked as the 8th most affected country over the last 20 years (Eckstein et al., 2021) and among the high-risk countries globally for humanitarian crises and natural disasters (Thow et al., 2022). Remote mountain communities in northern Pakistan are experiencing rapid socioeconomic, environmental, and demographic changes (Wester et al., 2019), heavily depend on agriculture for their food security and livelihoods, and face the depletion of natural resources, lack of access to the market, poor infrastructure, and a small local

economy (Rasul et al., 2019). The agriculture in mountain areas of northern Pakistan is fed by irrigation networks spanning long distances dependent on glacial meltwater and snow cover (Nüsser, 2001; Nüsser et al., 2019; Parveen et al., 2015). The agriculture-based livelihoods are susceptible to the impacts of climate change (Ajani & van der Geest, 2021). Fast-onset events such as glacial outburst floods, heavy rains, snow avalanches, and landslides disrupt the irrigation networks, erode agricultural land, damage the public infrastructure, and pose risks to the livestock, human settlements, and the local environment (Elalem & Pal, 2015; Khan et al., 2022; Nizami et al., 2019; Nüsser, 2001; Vaidya et al., 2019). The changes in precipitation and temperature result in water scarcity, affect crop growth, and result in low agricultural productivity (Ahmad et al., 2020; Ajani & van der Geest, 2021; Nizami & Ali, 2017).

Our study area—Lotkuh valley—is located in the Eastern Hindu Kush and is administratively part of the Lower Chitral district of Khyber Pakhtunkhwa province in Pakistan (Fig. 1). The semi-arid study area with the three subvalleys Arkari, Garum Chashma, and Karimabad has a complex topography and is exposed to multihazards. Migration from the remote villages of northern Pakistan, including Chitral, to the other cities, is not a new phenomenon (Rahman, 2007). However, it increasingly serves as an adaptation strategy to adjust to the decreasing agricultural productivity in the face of environmental changes and respond to extreme events (Gioli et al., 2014a, b; Gioli et al., 2014a, b). Previous research in the Eastern Hindu Kush included migration patterns in Lower Chitral and Upper Chitral (Holdschlag, 2000), seasonal migration of herders (Nüsser et al., 2012), and male out-migration from Melp valley (Rahman, 2007). However, scholarship on climate–environment–migration relationship in mountain communities in northern Pakistan is very limited. Climate (im)mobilities, particularly in Chitral and the Eastern Hindu Kush region, are largely not investigated.

Methods

In this study, a mixed method approach (Bazeley, 2017; Creswell & Clark, 2017) comprising quantitative and qualitative techniques was used to collect data from 13 villages in the Lotkuh valley (Table 1). Informed consent from all the participants in this research was received before collecting any data. Both the data collection and analytic methods are explained below.

Data collection

For our study, villages were selected using a purposeful sampling method guided by a set of carefully considered criteria. These criteria, which were deliberated upon with the local research teams and contacts in Lotkuh valley, encompassed various aspects, including the geographical setting, agroecological conditions, susceptibility to natural hazards, patterns of out-migration, logistical feasibility, and cost considerations. As a result, a total of 13 villages were selected, representing the diversity

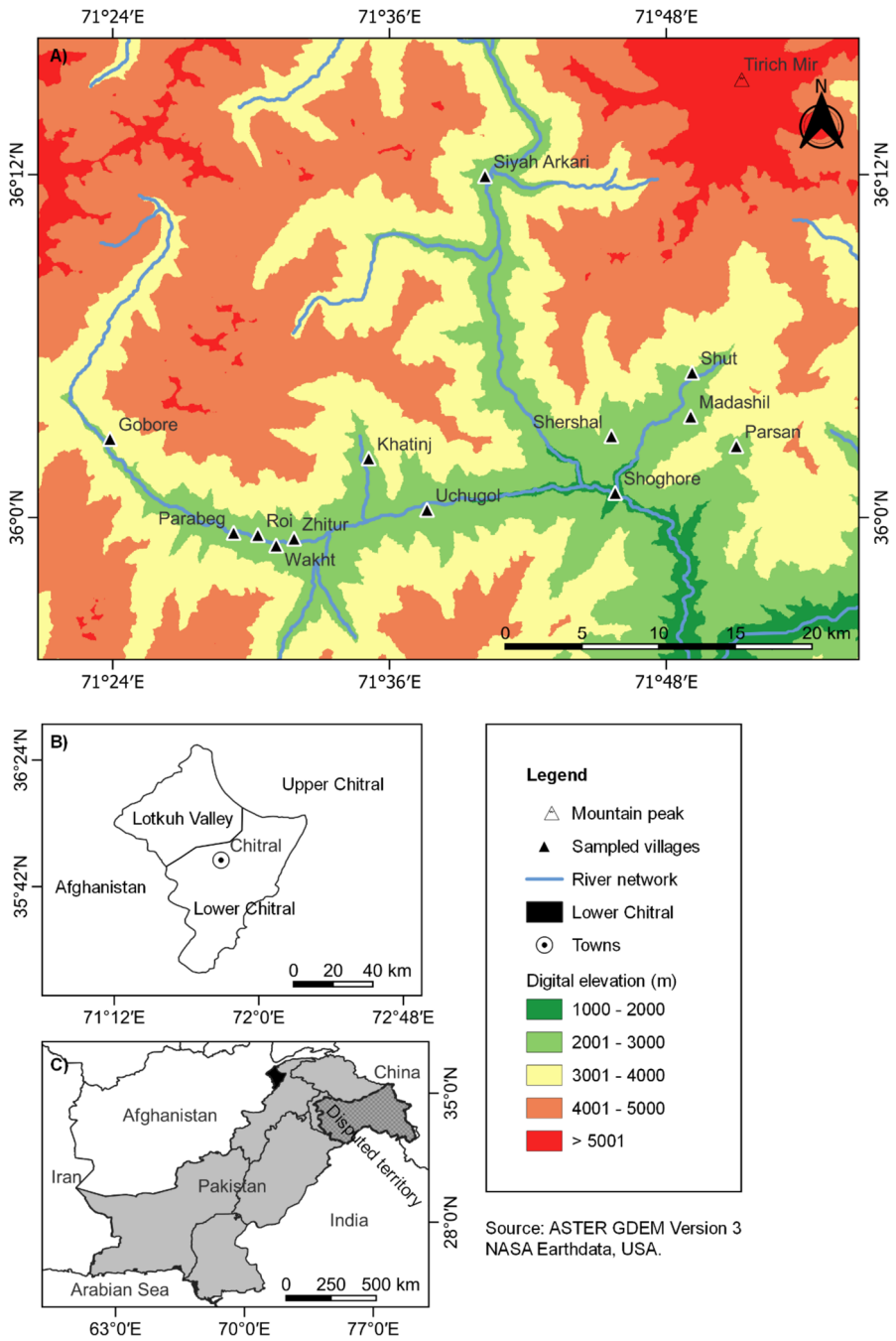


Fig. 1 Map of the study area. **A** Sampled villages in the Lotkuh valley. **B** The location of Lotkuh valley in the Lower Chitral district. **C** Lower Chitral in the northwest of Pakistan

Table 1 Summary statistics on the population, the number of total households, surveyed households, interviews and focus groups, and natural hazards in each village

Villages	Population (2017 census)	Households (2017 census)	Households surveyed	Interviews conducted	Focus groups conducted	Natural hazards
Gobore	1028	114	26 (23%)	2	1	Snow avalanche
Khatinj	206	30	11 (37%)	2		Landslide
Madashil	735	108	33 (31%)	4		Landslide, rockfall
Parabeg	1567	217	49 (23%)	3		River erosion
Parsan	716	93	29 (31%)	3		Rockfall, landslide, land subsidence
Roi	812	99	23 (23%)	4	1	Debris flow
Shershal	485	78	24 (31%)	2	1	Snow avalanche
Shoghore	491	69	26 (38%)	3	1	River erosion
Shut	481	82	27 (33%)	2		Landslide
Siyah Arkari	691	121	45 (37%)	5	1	Debris flow, glacial outburst
Uchugol	987	146	56 (38%)	3	1	Snow avalanche, rockfall
Wakht	410	58	14 (24%)	4		Snow avalanche
Zhitur	786	109	25 (23%)	4	1	Debris flow

Source: Population census (Government of Pakistan), fieldwork in 2020

present in the Lotkuh valley. These selected villages, shown in Fig. 1, represent a wide spectrum of characteristics, including varying altitudes, accessibility, community sizes, agroecological conditions encompassing both crops and livestock, exposure to diverse natural hazards, and divergent out-migration patterns.

The first part of our data collection methodology comprised a survey questionnaire that was administered to 388 households in sampled villages with the assistance of a locally trained research team. The sample size was calculated based on the population (approximately 45,000 inhabitants spread over 6,600 households) recorded in the national census in 2017. The sample size was distributed proportionally to the population and household units of the villages based on the latest census conducted by the government in 2017 (Table 1). Since the list of households did not exist for the villages, the households in each village were selected using the sampling interval starting from one end of the village and covering all the hamlets (locally called *mohalla*) within the village. Households were revisited in case the respondent was not available on the first visit. Overall, all the sampled households participated in the survey. It is worth noting that due to the purposive selection of the villages, the results from the sample may not be statistically generalizable to the region.

Summary statistics on respondents of this survey are provided in Table 2. The survey collected data on migration and immobility, including their drivers. Specific data was also collected on the migrants and involuntarily immobile persons (i.e., who have migration aspirations but lack the capabilities) including their gender, age, education, occupation, destination, and reasons for migration or immobility. Migration aspirations (education, healthcare, income opportunities, etc.) and capabilities (such as educational qualifications, economic resources to bear migration costs, and social networks) were covered together with other impacts of climate change and extreme events on their livelihoods.

To find out the relationship between mobility (migration and forced displacement), involuntary immobility, and climate change, we collected data on climate change and extreme events' impacts on livelihoods. Semi-structured interviews were carried out to explore the extreme events, their impacts, and coping strategies. Information was also collected on the perceived changes in precipitation and temperature and their effects on livelihoods. In interviews, we also gathered data on migration and immobility of household members including their drivers. The purposive sampling technique was used for the interviews. Forty-one interviews were conducted with individuals who are migrants or have migration experience in the past, are immobile or belong to a household with migrants or immobile persons, and engage in agriculture or livestock farming. Finally, to provide broader socioeconomic information on the area and to situate the data from the interviews and household survey, seven focus groups were organized in selected villages representing the overall diversity of the study area (Table 1). Data on livelihoods including agricultural practices, community experience of past natural extreme events, impacts of environmental change on agriculture, and (im)mobility and their drivers were collected. Participants in the focus groups included farmers, migrants, village elders, social workers, and persons representing different castes and hamlets within the village and their diverse experiences. Focus groups were organized in places usually where

Table 2 Descriptive statistics of the survey. This table provides information on the total surveyed households and the corresponding number of migrants and involuntarily immobile persons. It also summarizes the individual characteristics including age, gender, education, occupations, and migration destinations. Immobile persons are those individuals who want to migrate but could not realize it due to socio-economic, political, or environmental reasons

	Respondent	Migrants	Immobile persons
Households	388	301 (78%)	202 (52%)
Total count	388	561	273
Number of migrants/immobile per household			
Mean	–	1.86	1.35
Median		1.00	1.00
Mode		1	1
Std. deviation		1.232	0.607
Age			
N Valid	376	561	264
Missing	12	0	9
Mean	40.82	29.42	28.84
Median	38.50	27.00	26.00
Mode	35	25	25
Std. deviation	15.363	11.023	10.954
Gender			
Female	97 (25%)	111 (19.8%)	62 (22.7%)
Male	291 (75%)	450 (80.2%)	211 (77.3%)
Education			
Illiterate	145 (37.4%)	77 (13.7%)	53 (19.4%)
Primary	44 (11.3%)	72 (12.8%)	38 (13.9%)
Secondary	85 (21.9%)	177 (31.6%)	86 (31.5%)
Islamic education	1 (0.3%)	2 (0.4%)	–
Technical	5 (1.3%)	27 (4.8%)	1 (0.4%)
College/university	108 (27.8%)	206 (36.7%)	95 (34.8%)
Occupation			
Agriculture	10 (2.6%)	3 (0.5%)	5 (1.8%)
Government employee	26 (6.7%)	55 (9.8%)	12 (4.4%)
Housekeeping	67 (17.3%)	20 (3.6%)	37 (13.6%)
Labor	65 (16.8%)	173 (30.8%)	62 (22.7%)
Others	4 (1.0%)	5 (0.9%)	1 (0.4%)
Private employee	28 (7.2%)	63 (11.2%)	13 (4.8%)
Retired	6 (1.5%)	2 (0.4%)	–
Self-employed	33 (8.5%)	26 (4.6%)	18 (6.6%)
Student	42 (10.8%)	133 (23.7%)	75 (27.5%)
Unemployed	107 (27.6%)	81 (14.4%)	50 (18.3%)
Migration status			
Migrant	47 (12.1%)	–	–
Non-migrant	341 (87.9%)		
Respondent as head of household			
No	167 (43%)	–	–
Yes	221 (57%)		
Migration destination			
Another village in Chitral	–	24 (4.3%)	13 (4.8%)
Chitral city		55 (9.8%)	37 (13.6%)
Other districts		446 (79.5%)	150 (54.9%)
Other countries		36 (6.4%)	73 (26.7%)

community meetings or events are held. Open-ended questions and prompts were prepared that guided the discussion.

Data analysis

Our data analysis approach consisted of a separate analysis of quantitative and qualitative data. The household survey was analyzed using descriptive statistics calculated for each relevant variable. These statistics allowed us to summarize and present key features of the dataset, providing a clear overview of our findings. Survey data was analyzed using R and SPSS. To further explain and enrich our quantitative findings, we analyzed the qualitative data gathered using interviews and focus groups. Based on transcription guidelines, the interviews and focus groups were transcribed in the Urdu language and then checked and translated into English by the lead author. The translated transcripts were then analyzed using the Qualitative Content Analysis (QCA) approach described in Kuckartz (2019). This involved preparing data for analysis, formation of main categories based on research questions, and then coding qualitative data with the main categories. Subcategories were formed inductively on the passages compiled with main categories. Finally, category-based analyses were carried out to formulate key results. QCA was implemented in the computer-assisted qualitative data analysis environment of the MaxQDA software (Kuckartz & Rädiker, 2019). Qualitative results from interviews and focus groups were interpreted and synthesized using the identified themes and subthemes and using excerpts from the transcripts to illustrate key results. Moreover, findings from different focus groups and interviews were triangulated to increase the reliability and validity of the results. Finally, a complementary analysis of the various data sources involved analytic strategies such as producing a coherent picture using multiple data sources, comparing and contrasting different data to enrich interpretation, and merging sources to create a detailed description (Bazeley, 2017).

Results

Mobility characteristics

Descriptive statistics of the household survey are provided in Table 2. Out of 388 surveyed households, 78% ($n=301$) reported migration compared to 52% ($n=202$) involuntary immobility of at least one or more members between 2010 and 2020. A total of 561 migrants and 273 immobile persons were reported by surveyed households. The gender composition of the migrants is 20% female and 80% male and of immobile persons 23% female and 77% male.

Both male and female migrants are found in all villages except Shershal which has 100% male migrants. About 37% of migrants are college/university graduates (35% for similar education for immobile persons), 32% have secondary education (a similar number for immobile persons) and 14% are illiterate (19% of immobile persons). Among 5% of migrants have technical or professional education in contrast

to only 0.5% of immobile persons with such qualifications. The top occupation for migrants is labor work (31%) in contrast to immobile persons who are currently receiving education (27%). Migrants' destinations are other districts (80%) in the country or a foreign country (6%) in contrast to immobile persons' intended destinations are other districts (55%) followed by a foreign country (27%).

Migration trend in Lotkuh valley is from rural to urban areas. Labor migration is primarily undertaken to regional trade hubs such as Chitral town and Gilgit, as well as major cities, particularly Peshawar, Rawalpindi, Lahore, and Karachi. On the other hand, education-related migration is more concentrated in cities such as Peshawar, Islamabad, Rawalpindi, Lahore, and Karachi, while international destinations for migrants are predominantly Gulf countries. Temporally, migration in the Lotkuh valley can be classified into three categories: seasonal, temporary, and permanent. The most common type of migration is temporary, which is reported by 75% of migration households. Temporary migration involves people's movement to urban centers for a limited period to pursue education and employment opportunities, to eventually return to their villages. In addition to temporary migration, about 13% of migration households engage in seasonal labor migration, which takes place in the winter. Finally, 12% of migration households reported permanent migration of their members who settled permanently in urban centers.

Our findings suggest that there are similar age, gender, and educational level distributions between mobility and immobility groups. However, the importance of the destination differs significantly between the two groups. Specifically, a higher proportion of the immobility group intends to migrate internationally (27%) compared to the migrant group (6%). In contrast, a higher proportion of the migrant group moved to other districts or cities (80%) compared to the immobility group who wanted to move to other districts (55%). Qualitative data shows that aspirations to migrate internationally are not met due to lack of financial resources and networks and then alternatively migrants choose internal migration. The increased migration of young women in Lotkuh valley is a relatively new phenomenon, primarily driven by educational aspirations, particularly in nursing education. Many of these women are later employed in hospitals in cities such as Karachi and Peshawar.

Another form of mobility in the Lotkuh valley is the displacement caused by extreme natural events. A total of 83% of households ($n=321$) were affected by an extreme event during 2010–2020. During this period, 45% of surveyed households reported displacement due to an extreme event. The drivers of displacement, migration, and immobility are described in the next section.

Multiple drivers of migration, immobility, and displacement

The survey results (Fig. 2) show that there are multiple drivers of migration in the Lotkuh valley. Socioeconomic drivers are predominant. Access to better education (40%) and health facilities (75%) are considered important factors in migration decision-making by households. The younger migrants move to Chitral town, Peshawar, Karachi, and other cities to receive college and university education. Similarly, access to better health facilities in these cities is also perceived as an

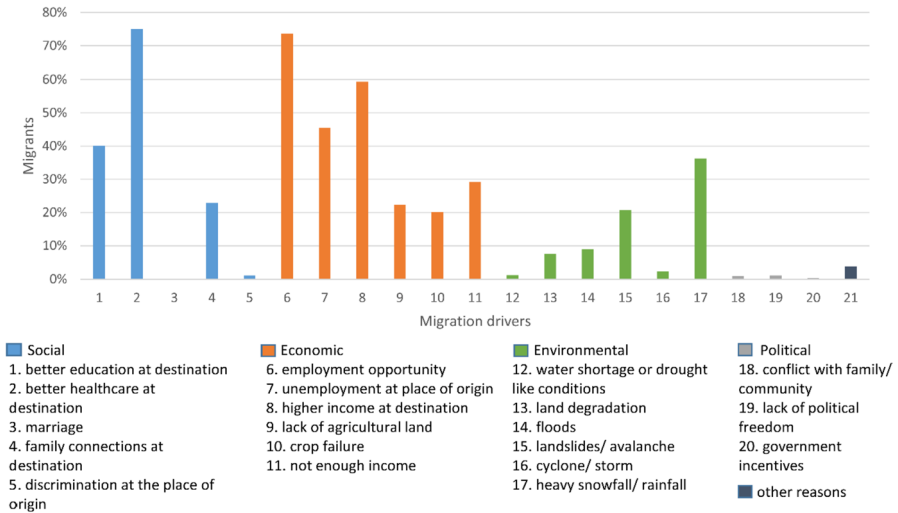


Fig. 2 Drivers of migration in the Lotkuh valley

important factor in migration decision-making. Health services are inaccessible particularly in the winter seasons due to snowfall and avalanches. Migrants sometimes relocate vulnerable family members to other locations for the winter seasons. The presence of migrants’ social networks and family connections (23%) in destinations also contributes to migration and the choice of these destinations. Political drivers such as conflict within the community (1%) and lack of political freedom (1%) are rare in the Lotkuh valley; we believe this rarity may be attributed, in part, to the absence of significant religious and ethnic tensions in the valley presently. However, focus group data revealed that such tensions existed before the merger of the Chitral state into Pakistan. Moreover, we identified the development of key infrastructure, specifically the Lowari pass and tunnel, as playing a role in increasing mobility to the lowlands. Furthermore, factors such as the visa process, availability of information, and social networks in other countries were highlighted as elements that can either drive mobility or their absence can contribute to immobility. The survey results revealed that discrimination did not play any role in (im)mobility decisions. Focus groups highlighted that destinations with the presence of religious communities (of Ismaili) are preferred for migrants to other places. However, these findings require further exploration to develop a nuanced understanding of the underlying dynamics at play.

It is also obvious from Fig. 2 that economic motives weigh heavily on migration decision-making. Migrants reported employment opportunities (74%) and higher income (59%) at the destinations as the main economic reasons for migration. Similarly, about 45% of migrants also cited unemployment at their place of origin. Moreover, one-fifth of migrants cited lack of agricultural land (22%) and crop failures (20%) as the motives while not enough income (29%) at the place of origin also contributed to their migration. To consider the interrelationships between climate change, environment, and human migration, we also asked about various

natural hazards and changes in climatic conditions. Heavy snowfall and rainfall (36%) related extreme events contributed significantly followed by landslides (21%), floods (9%), and cyclones and storms (2%). Water shortages and drought-like conditions were mentioned by a mere number of migrants (1%). Migration decision-making takes place at the household level and is often influenced by the head of household who is mostly a male member. Factors such as education, migration costs, social networks in places of destinations perceived likelihood of job, and income influence migration decisions.

About 52% of surveyed households ($n=202$) reported immobility of 273 members (211 males, 62 females). Figure 3 shows various factors of immobility for these persons. Overall economic barriers to migration are quite prominent such as a lack of financial resources (73%) that are used to meet basic household needs. Other environment-related drivers include the impact of extreme events on income (36%), loss of their economic assets (24%), the collapse of transportation networks (11%), and more manpower required for land rehabilitation (25%). Noticeable social reasons include lack of education (39%), health reasons (30%), and responsibility to take care of household work (59%).

In terms of displacement, it is triggered by several extreme events in the Lotkuh valley. Out of surveyed households ($n=388$), floods (28%), earthquakes (23%), and avalanches (16%) are the main drivers of displacement (Fig. 4). In addition, erratic rainfalls (11%), snowfall (6%), and landslides (56%) also caused the displacement of households. The displacements were forced by a multitude of factors such as the severity of the potential risk and the likelihood of loss of human life and precious assets such as houses and livestock. It is undertaken mostly in the aftermath of an event or some cases before the event if a warning is received. This escape mobility is short term, from a couple of days to a couple of weeks, and is over a short distance (such as a safe place in the village or nearby areas).

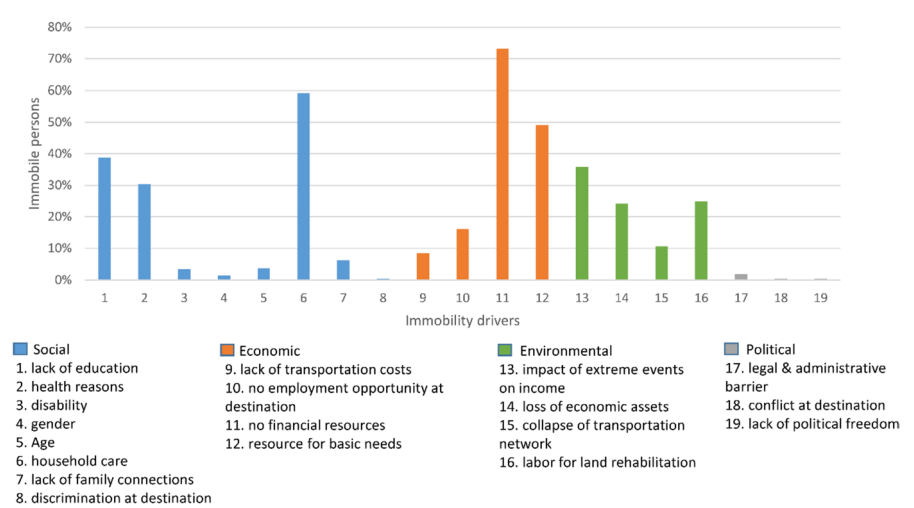


Fig. 3 Drivers of involuntary immobility in the Lotkuh valley

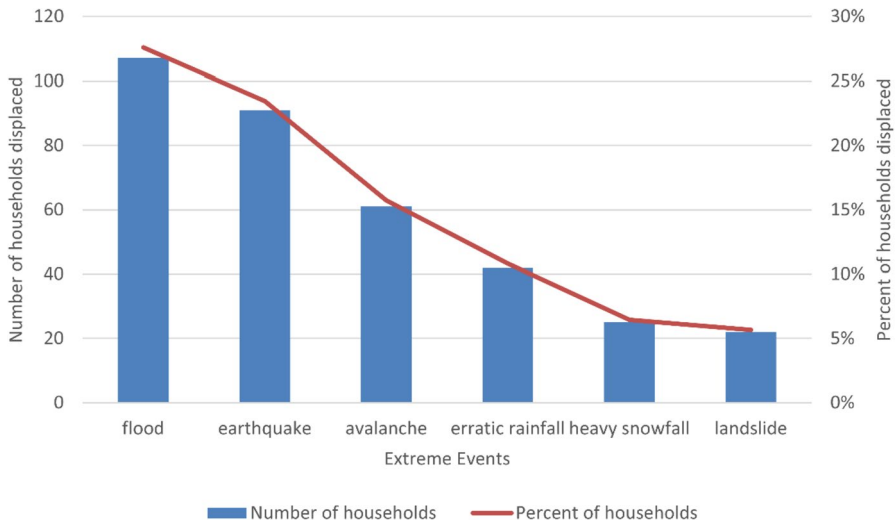


Fig. 4 Forced displacement triggered by extreme events

Communities organize the assistance of food rations and shelter, sometimes with the support of local organizations and the government to provide to the displaced families during this displacement period.

In the following section, we explore how extreme natural events and climatic changes affect their livelihoods leading to their migration or immobility outcomes.

Mountain livelihoods and climate (im)mobility

The livelihoods in the mountain communities of Lotkuh valley are based on subsistence agriculture and livestock farming coupled with income from labor migration. People consider land as an important resource that is susceptible to the impacts of climate change and associated extreme events. In the following, we explore the climate (im)mobilities in the local livelihoods context through the interaction of climate change and extreme events with land degradation, crop productivity, and livestock farming.

Land degradation

Natural hazards and associated extreme events, especially floods, landslides, rock-fall, and snow avalanches, cause erosion and degradation of the scarce land in mountain communities of Lotkuh valley. According to our survey, the foremost impact of these natural events is soil erosion in which land, both urban and farmland, is eroded by floods (45%), landslides (18%), and avalanches (18%). Similarly, these hazards (floods 12%, landslides 7%, and avalanches 6%) mostly triggered by heavy precipitation are devastating as they bring debris and sediments given the topography of the

area and cause land degradation in the floodplains. The situation in Arkari village which is frequently affected by floods is described below:

A lot [of agricultural land] from the lower side [of stream which connects it the river]. My large agricultural field was washed away by this flood in this stream. The floods from Dhirgol [a local tributary of Arkari river], there were 3 or 4 large floods. The large flood was in 1977, then in 2010, and then a very dangerous flood came in 2015. (Interview, Siyah Arkari village, August 2020)

As in the case of Arkari and similar to other villages, farmland lies mostly along the riverbanks and the recurring floodwater erodes them and causes them to collapse resulting in loss of land for the farmers. Flooding also erodes the fertile topsoil damaging the growth of crops and plants in the future. In addition, flash floods, avalanches, and landslides also bring down sediments such as sand, rocks, and boulders to the farmlands which degrade the farmlands. In some cases, farmers spend a lot of financial resources to rehabilitate the affected lands while some of these huge boulders cannot be removed from the lands. Moreover, farmers said that many such affected lands cannot be restored and are not cultivable anymore. This leads to the abandonment of land by some households.

A prime example of land degradation is the village of Shoghore, where it is a regular phenomenon for the farmers, due to its physical location at the confluence of three tributaries of the Lotkuh river. It is frequently affected by floods, sometimes simultaneously by more than one tributary in extreme flooding years of 2010, 2015, and 2016, as narrated below:

That one [river], which comes from Karimabad, causes erosion and destroys lands from the one side, and the other one which comes from another side brings sand and gravel. The lands are being degraded because of this. (Interview, Shoghore village, August 2020)

Another example is Parsan village in Karimabad valley which is experiencing the problem of landslips or land subsidence. The agricultural land is being lost or degraded as a result of the landslips. Moreover, farmers in Parsan face a lot of difficulty in irrigating their crops as the water seeps into the land and cannot reach the crop fields. The land subsidence is destabilizing the whole area and affecting the houses which require regular repair and maintenance, thus migration becoming a more suitable strategy for them. When a migrant was asked about his migration and its connection with the ongoing land subsidence in Parsan, he said:

Yes, it [migration] has a link with the land subsidence because you cannot construct a concrete house in the village, cannot invest. The house will survive for 5 years or a maximum of 10 years. Because of this [people] build ordinary houses. [We] go to grow crops in our fields, stay for two to four months. That's why we do not stay there and those who stay there have to rebuild their houses. (Interview, Parsan village, July 2020)

The above results show that soil erosion and land degradation are important factors in local livelihoods context, exerting strain on the income as well as food security of

households. To offset the losses incurred by land degradation, households engage mostly in a mixed strategy where some members undertake migration to urban centers and some stay in their villages to cultivate their agricultural lands. Those who remain in their villages are responsible for managing social relations as well as agricultural lands. There are also people who “lend their lands to others for farming” if they do not find it viable and move to other places for labor migration.

It was also mentioned that the availability of financial resources to cover the costs of migration is an important factor when considering mobility decisions. The extreme events amplify the lack of financial capacity of the household resulting in the immobility of its members as they do not have enough financial means for migration to their desired local (e.g., Karachi) and international destinations (e.g., Saudi Arabia). For some, the attachment to their land also plays a role in their immobility, and for others “living here [in their villages] is also a compulsion.”

Crop production

People engage in subsistence agriculture in the Lotkuh valley by growing various staple crops (such as wheat and maize) and cash crops (potatoes, tomatoes, peas, etc.). Natural extreme events reduce the agricultural yield through their adverse impacts on standing crops, irrigation, and other rural infrastructure. Floods (22%), heavy rainfalls (7%), and landslides (3%) which occur mostly in the spring and summer seasons destroy the standing crops. The crops are prone to these extreme events, particularly the wheat crop which serves as the main crop for household food security. Cash crops such as potatoes if affected by floods cause a lot of financial strain for the households as they are more labor and cost-intensive. Farmers' selected accounts of crops being affected by these natural events are given below:

The first flood which I remember occurred in 1977. It was a massive flood because of rain, in the Shah Galogh. This flood was caused by rain and it uprooted, we plant trees along the banks, all of them and took away. People [lives] were not affected and were safe during the flood. [It] washed away so many trees and plants. Then in 2010, again a flood occurred driven by rain ... The one [flood] which came in 2010, was massive and it washed plants and trees away. [The damage] was mainly along the riverbanks and mainly trees. Then after this, a very dangerous flood came in 2015. On the one side of my house, the trees which are not fruit trees which I planted myself, 7000 to 8000 plants. They were quite grown, all were uprooted and taken away [with the flood]. (Interview, Siyah Arkari village, August 2020)

Irrigation channels in the Lotkuh valley often span long distances. They are constructed from the upper part of the valleys to the cultivated areas and are very prone to disruption by landslides, avalanches, and floods. Similarly, floods (30%), landslides (12%), and avalanches (10%) cause damage to the irrigation infrastructure which includes both main irrigation channels from the water source and then water courses in the fields. The damage to the irrigation network affects the supply of irrigation water for crop cultivation. The affected channels are regularly, and sometimes urgently, repaired requiring a lot of communal effort and costs. In some

places that frequently experience these extreme events, farmers require restoration of the irrigation network at least annually, as stated below:

Water channels that are constructed [for irrigation] are disrupted by avalanches and floods. We rehabilitate them [water channels] every year. (Interview, Gobore village, July 2020)

Aside from the extreme events, climate change-induced changes in precipitation and temperature also negatively affect crop production in the area. The survey results suggest that 96% ($n = 372$) and 92% ($n = 356$) respondents perceive that temperature and precipitation have changed over the last 20 years, respectively. The hot summer season causes the crops to ripe earlier and often with less yield. Fruit crops are more vulnerable to heat stress. The harvesting period has also shifted from August to July with a difference from 10 to 20 days in different places. Moreover, erratic rainfalls, such as monsoon (47%) which is more intense, at the time of harvest combined with warmer summer (63%) result in either destruction of standing crops or a reduction in yield due to diseases. The snowfall in the previous year also influences the availability of water for the next crop season. Generally, participants felt snowfall (62%) is decreasing and glaciers as a result are on the decline. Selected perceptions on the impacts of climate change on crop production are in the following:

When the summers are warmer, the harvest of the crop is reduced. When the summer is intense and rainfall [occurs] then the crops are infected with a disease, then this causes crop loss. This year the crops have turned bad. (Interview, Siyah Arkari village, August 2020)

Few farmers contradict this, particularly those living in colder places, who attribute the rise in summer temperature to more production of fruits and crops in cold places, as described below:

It is hotter now [in summer]. Temperature is on the rise. In former times, there was a place on the upper side [at a higher elevation] where there were no crops and fruits grown. But now there are good crops and good fruits are grown which tells us that summers are becoming warmer. (Interview, Siyah Arkari village, August 2020)

When he is asked about the effect of warmer summers on agricultural yield, he responds “It does not affect much” instead “agriculture yields more in warmer summers.”

The interviews and focus group data showed that the failure of a wheat crop or a reduced yield leads to economic stress for the households for the whole year requiring them to procure wheat grain and flour from the market. Moreover, the households that face the failure of cash crops are severely stressed as they incur the loss of investment and potential. Some people find crop cultivation simply not worth the effort and rather “prefer employment and labor wages instead of plowing.” People also highlighted that forest depletion, caused by their over-exploitation for livestock and fuel wood, also stresses households’ economic burden as they have to purchase fuel wood. Many households find the income from subsistence agriculture marred by the impacts of extreme events

and changes in temperature and precipitation simply not enough to meet their expenditures. To cope with a deficit in on-farm income, households seek labor migration, either seasonal or temporary, as an adaptation strategy as voiced by the following interviewees:

I do farming. I am also a tailor. Apart from this, I also go to the city [for labor migration]. I go there thinking about how much money to give to my family and where to spend it. The income from the farmlands is not enough for the family. We have to purchase everything. (Interview, Roi village, August 2020)

Moreover, it was also observed that some households associated the effects of extreme events on crop productivity and labor migration more strongly than changes in precipitation and temperature. This is due to higher costs and effort required for land rehabilitation thus leading to more seasonal labor migration to generate revenue. There are also a few instances in which houses were relocated to other places due to frequent extreme events, but this could be due to the availability of land in relocation places.

The economic stress or lack of finances caused by extreme events and climate change is also perceived by households as a barrier to their mobility or a cause of immobility. For instance, the interviewee responds “How can we poor people migrate?” when asked about migration. Without sufficient money, the households cannot afford the costs associated with migration, as stated below:

If they do not have money, they cannot afford the cost of migration. So that’s why they cannot migrate. There are such reasons that people want to migrate but cannot. (Interview, Shershal village, June 2020)

In such cases, immobility is caused when economic assets and income are eroded by extreme events and climatic changes resulting in a lack of capabilities to migrate.

It was noted from the interviews and focus groups that the households prefer a mixed strategy where some members of the family engage in out-migration while others engage in agriculture including those who are immobile. This strategy enables them to generate food from agriculture and income from labor migration which is used to build household assets and also meet other needs, and those who stay in the village also fulfill their social obligations there.

Livestock farming

Interviews and focus groups show that livestock farming has been declining in the Lotkuh valley in the recent past. When asked about the reasons for this decline, local people associate this with several factors. Out of 81% of households ($n=321$) affected by an extreme event, the loss of livestock was reported when they were struck by floods (9%), avalanches (9%), landslides (4%), erratic rains (4%), and heavy snowfalls (3%). In recent years, more and more children are enrolled in schools. They also attributed the growth in literacy to the decline of

livestock farming as children are in schools and cannot help families in livestock raising. Young and educated people prefer to pursue off-farm jobs and occupations over livestock keeping and emigrate to urban centers within the country or in other countries.

In addition, the cultivation of cash crops (e.g., potatoes, peas, tomatoes) in Karimabad and Garam Chashma valleys has expanded, which have little fodder value for the livestock. Farmers cannot cope with the acute shortage of fodder for the animals during the winter season thus reducing their livestock. Similarly, the recent trend of young people moving to urban centers for education and labor work results in a shortage of manpower for livestock management. Most of the livestock is now raised to meet the basic daily dietary needs of the households, instead of earning income by selling it in the market although still practiced by some households. The selected views on livestock practices are the following:

Livestock is declining, it almost has ended because it requires human resources. Because of education, colleges, and universities, people are unable to continue it. That is why agriculture is also compromised ... If I recall my childhood or if I talk about 2000 or before, people used to have livestock, sheep, and goats. In our house, the elders who were illiterate used to take them for grazing on mountains and pastures there. But when it came to the new generation, schools were built and people started going to schools. Then there was a gap between the old and new generations. Then this work [livestock rearing] was not done, then all those were sold out. Livestock depleted. Now every household has one or two cows for milk, which people mostly use for tea. (Interview, Shershal village, June 2020)

The decline in livestock deprives households of cash income and also weakens household food security. Farmers also highlighted that alpine pastures are declining in the area because of their over-exploitation, and they are reducing livestock to “protect them and do planning for them” for their restoration. To reduce the risk of erosion and degradation of rangelands, a joint initiative is undertaken by several villages, especially in Garam Chashma valley, to reduce the number of animals so that less grazing land is destabilized. Such initiatives are advocated by development organizations to reduce the impact of floods and landslides on the rangelands. Despite a reduction in livestock farming, it still plays a significant role in the food security of local populations.

Discussion

Our study explores the relationship between climate change and human (im) mobilities in the Lotkuh valley in the Eastern Hindu Kush, using a mixed methods approach. We revealed that approximately two-thirds of surveyed households reported migration, while more than half reported involuntary immobility of at least one of their members. Both groups are predominantly men. However, the qualitative data showed that the migration of young women has been increasing recently in several villages of Lotkuh valley, primarily for educational aspirations and later

acquiring jobs in major urban centers. These findings are in line with the global trend of increased feminization of migration observed in recent years (Malhotra et al., 2016).

The primary drivers of both mobility and immobility are socioeconomic. However, the added burden of recurring extreme events results in specific manifestations of mobility and immobility, which is consistent with the foresight framework (Black, Adger, et al., 2011). These events, such as floods and earthquakes, often lead to forced displacement (Adger et al., 2018) which is short term and short distance and often unforeseen involuntary movement triggered by rapid onset events. In such scenarios, extreme events act as push factors causing forced displacement. Meanwhile, social networks in places of destination, coupled with higher income and employment opportunities, serve as the pull factors significantly influencing migration decisions (Sherbinin et al., 2022).

Furthermore, our research reveals that climate (im)mobilities manifest through the interplay of climate change and associated natural extreme events with livelihoods. This manifests in the form of land degradation, decreased crop productivity, and a decline in livestock farming. Extreme events exacerbate soil erosion and degrade the fertile farmlands along riverbanks through inundation and debris deposition (Khan et al., 2022). The land loss contributes to food insecurity among affected households, also observed in the HKH region (Gioli et al., 2019; Hussain et al., 2016). Additionally, another process that was noted by farmers in Parsan is the landslips or subsidence caused by the destabilization of the land triggered by the absorption of large quantities of water seeping into the land mass (Ali et al., 2017). When lands are severely affected and the restoration costs are not met, some households are compelled to abandon their lands, as also observed in the wider HKH region (Rasul et al., 2019).

In the context of our study, it is evident that extreme events exacerbate the financial constraints faced by households, thereby leading to the immobility of their members (Hoffmann et al., 2020). These individuals often lack migration capabilities (De Haas, 2021; Maharjan et al., 2021) such as the necessary financial resources to pursue migration to preferred destinations, whether within the country or internationally. Moreover, for certain households, a strong attachment to their land emerges as a contributing factor to voluntary immobility, a sentiment highlighted by Adams (2016). Additionally, some individuals express a sense of compulsion to remain in their villages—*involuntary immobility* (De Haas, 2021; Zickgraf, 2021b), emphasizing the multifaceted nature of factors influencing immobility in this region (Boas et al., 2022; De Haas, 2021).

Similarly, crop productivity in the Lotkuh valley experiences adverse impacts from a combination of extreme events and shifts in temperature and precipitation patterns. The impacts of extreme events include a reduction in agricultural yield due to the disruption of standing crops, irrigation, and other infrastructure which are also reported in other studies in the HKH region (Hussain et al., 2018; Nizami et al., 2019; Rasul et al., 2019). The restoration of irrigation channels requires a lot of community effort and costs (Nüsser, 2001) which further strains the household income. In addition to the extreme events, changes in precipitation and temperature patterns have negative consequences on crop yields

in the region, confirming the findings documented in various areas of the HKH (Hussain et al., 2016; Rasul et al., 2019). Furthermore, it was noted that certain households placed greater emphasis on the impact of extreme events on both crop yields and labor migration, showing a stronger association compared to shifts in precipitation and temperature. This observation aligns with the results of a study conducted in the HKH region (Banerjee et al., 2011). As a result, households turn to labor migration as an adaptive strategy to diversify their income and reduce the risk of food insecurity (Black, Bennett, et al., 2011; Call & Gray, 2020), which is consistent with NELM and livelihoods framework (Scoones, 1998; Stark & Bloom, 1985). In contrast, households facing severe income stress and erosion of economic assets find themselves in a situation where their members are compelled toward immobility despite aspiring to migrate, which reflects involuntary immobility due to high migration aspirations and low migration capabilities (De Haas, 2021).

Additionally, the decline in livestock farming in the Lotkuh valley can be attributed to a confluence of factors. These include the aspirations of young individuals seeking opportunities for education, off-farm employment in urban centers, an urban lifestyle, and a shift to cash crops, as well as the implementation of risk reduction measures aimed at addressing the degradation of rangelands and erosion stemming from flash floods and landslides. Finally, the decline in farming partially due to migration aspirations results in the loss of vital income and reduces household food security in the long-term often leading to further immobility and mobility of household members. Also, our results confirm the decline in livestock and its drivers noted in previous studies (Nüsser et al., 2012).

Largely, the households in the Lotkuh valley tend to adopt a mixed strategy, where certain members engage in out-migration as part of an adaptive approach by moving to various urban cities or other countries. Meanwhile, others opt to remain in their places of origin, continuing their engagement in agricultural activities and fulfilling their social roles. This strategy is a widely chosen livelihood diversification measure aimed at mitigating losses and alleviating economic stress, also noted in other studies in the neighboring regions (Maharjan et al., 2020; Banerjee et al., 2011). Migration as an adaptive strategy by the households in the face of land degradation, decreasing crop productivity, and declining livestock farming in Lotkuh valley is aligned with the foresight and livelihoods frameworks (Black, Adger, et al., 2011; Scoones, 1998). Moreover, migration decision-making is undertaken at the household level aimed at improving the socioeconomic status of the household in line with the NELM theory (Piguet, 2018; Stark & Bloom, 1985). However, the power and gender dynamics that influence (im)mobility as well as the effectiveness of migration as an adaptation strategy require further research.

Conclusions

This study sheds light on the intricate relationship between climate change, environmental factors, and human (im)mobility in the Lotkuh valley of the Eastern Hindu Kush. Our findings emphasize that while socioeconomic factors are primary drivers,

climate change and associated natural extreme events play a crucial role in shaping the specific manifestations of mobility and immobility outcomes. Extreme events such as floods trigger forced displacements in risk-prone areas (Adger et al., 2018).

Climate (im)mobilities are the result of a complex interplay between climate change, extreme events, and local livelihoods. We identified the impacts of climate change and extreme events on land resources, crop productivity, and livestock farming as the three aspects of livelihoods that influence mobility and immobility outcomes in the Lotkuh valley. Specifically, extreme events, such as flash floods and landslides, exacerbate soil erosion and loss of fertile farmlands, contributing to food insecurity and pushing households toward labor migration as an adaptation strategy. For those with severely stressed incomes and eroded economic assets, immobility is the outcome as they do not possess enough capabilities to undertake migration. It is also evident that some households pursue a mixed strategy (Gioli et al., 2014a, b; Maharjan et al., 2021) by sending member(s) of the household to other areas while others stay to pursue livelihoods in places of origins. With climate change and its influence on the frequency and intensity of natural hazards in the Hindu Kush Himalaya (Wester et al., 2019), the climatic and environmental conditions may further exert pressure on mountain livelihoods affecting existing mobility and immobility patterns in the region.

We contribute to the debate on the relationship between climate change and human movement by applying the concept of “climate mobilities” (Boas et al., 2019, 2022; Cundill et al., 2021) to the setting of Eastern Hindu Kush and addressed the gap in the understanding of how climate change is affecting human movement in the area. Our study provides a more nuanced and holistic understanding of the complex ways in which climate change is shaping patterns of human mobility and immobility. Moreover, the findings have practical implications for policymakers, government, and development organizations by informing their livelihood and disaster risk reduction strategies and programs to address the challenges of land degradation, reduction in crop productivity, and decline in livestock farming.

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Author contribution SAK carried out the study’s conception and design with contributions from co-authors. Material preparation, data collection, and analysis were performed by SAK. The first draft of the manuscript was written by SAK, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Declarations

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