IMPACTS OF CLIMATE CHANGE ON MIGRATION AND INTERNAL DISPLACEMENT: A STUDY OF SOUTHWESTERN PROVINCES OF AFGHANISTAN

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EXECUTIVE SUMMARY

Environmental changes are profoundly affecting human mobility and livelihoods in Afghanistan's southwestern provinces. This research examines the complex relationship between climate stressors and population movement across six provinces: Helmand, Kandahar, Zabul, Nimruz, Farah, and Urozgan. Through rigorous analysis of environmental data and community experiences, our study reveals the urgent challenges facing these regions.

Our mixed-methods approach combined quantitative and qualitative techniques to ensure comprehensive data collection and analysis. We conducted 675 household surveys across the six provinces, held six structured focus group discussions, and performed 30 in-depth interviews with key stakeholders.
Additionally, we employed advanced GIS-based multi-criteria decision analysis using the Analytic Hierarchy Process (AHP) to assess environmental factors driving migration.

The findings reveal severe environmental pressures affecting local communities. Groundwater levels have dropped dramatically, from 7 meters to 170 meters in some areas of Farah province. Temperature extremes range from -22°C in winter to +52°C in summer, significantly impacting agricultural productivity and human health. Our household survey data shows that 82% of families in Nimruz province have experienced displacement, while 93% of households in Urozgan report severe income decline. Water insecurity affects 64% of households in Nimruz, with many families reporting reduced access to clean drinking water.

The AHP analysis identified five critical environmental stressors: precipitation patterns, vegetation coverage, potential evapotranspiration, dust storms, and groundwater storage. These factors were weighted to create a comprehensive migration potential index, revealing that Farah, Nimruz, and parts of Helmand face the highest risk of climate-induced population movement.

Agricultural productivity has declined significantly, with 79% of households in Urozgan and 73% in Farah reporting substantial decreases in farm output. The research also documented concerning trends in public health, with high percentage of surveyed households in these provinces experiencing climate-related health issues. Additionally, 97% of these households required medical attention more than three times in the past year due to environmental factors.

Key recommendations from this research include:

1. Developing comprehensive water resource management systems that integrate traditional knowledge with modern technology to address declining groundwater levels and improve water security.
2. Implementing climate-smart agricultural practices and drought-resistant crop varieties to enhance food security and maintain agricultural livelihoods.
3. Establishing early warning systems for extreme weather events while strengthening community-based disaster preparedness and response mechanisms.

This research provides crucial evidence for policymakers and stakeholders to develop targeted interventions that address the complex challenges of environmental change and population movement in southwestern Afghanistan. The findings emphasize the urgent need for integrated approaches to building community resilience and adapting to changing environmental conditions.

LIST OF ACRONYMS

ACRONYM	FULL NAME
AHP	Analytic Hierarchy Process
ANDMA	Afghanistan National Disaster Management Authority
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station
CLSM	Catchment Land Surface Model
DRR	Disaster Risk Reduction
FGDs	Focus Group Discussions
GIS	Geographic Information System
GLDAS	Global Land Data Assimilation System
GRACE	Gravity Recovery and Climate Experiment
GWS	Groundwater Storage
HRB	Helmand River Basin
MCDA	Multi-Criteria Decision Analysis
MERRA-2	Modern-Era Retrospective Analysis for Research and Applications Version 2
MODIS	Moderate Resolution Imaging Spectroradiometer
NEPA	National Environment Protection Agency
NSIA	National Statistics and Information Authority
NOAA	National Oceanic and Atmospheric Administration
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
Power BI	Power Business Intelligence (software)
SPSS	Statistical Package for the Social Sciences
TLO	The Liaison Office
UNHCR	United Nations Refugee Agency
WASH	Water, Sanitation, and Hygiene
WLC	Weighted Linear Combination
YES	Yaran Yakdel Environmental Services Company

GLOSSARY[1]

Adaptation: Process of adjustment to actual or expected climate change and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities.

Biodiversity: The variety of all living species, including plants, animals, bacteria, and fungi.
Climate change: A change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

Climate risk: Potential for consequences from climate variability and change where something of value is at stake and the outcome is uncertain.

Climate-driven migration: Migration attributed largely to the slow-onset impacts of climate change on livelihoods owing to shifts in water availability and crop productivity, or to factors such as sea-level rise or storm surge.

Disaster: A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts that exceed the ability of the affected community or society to cope using its own resources.

Disaster risk reduction: The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters.

Drought: A prolonged period of abnormally low rainfall, resulting in soil moisture depletion and water scarcity.

Distress migration: Movements from the usual place of residence when an individual and/or their family perceive that there are no options open to them to survive with dignity, except to migrate.
Ecosystem: Complex of living organisms, their physical environment, and all their interrelationships in a particular unit of space.

Exposure: People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses.

Flood: A general and temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters.

Internally displaced people (IDPs): Internally displaced people, referred to as IDPs, have been forced to flee their homes by conflict, violence, persecution or disasters, however, they remain within the borders of their own country.

[1] The definitions in this section are adapted from the UNISDR publication Terminology of Disaster Risk Reduction, Groundswell Part 2: Acting on Internal Climate Migration and UNHCR

GIS (Geographic Information System): A system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data.

Migration: The movement of people from one place to another, either within a country or across international borders, for various reasons such as seeking better economic opportunities, education, or safety. Migration can be voluntary or forced and may be temporary or permanent.

Mitigation: The lessening or limitation of the adverse impacts of hazards and related disasters.
MCDA (Multi-Criteria Decision Analysis): A sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making.

Resilience: The ability of a system, community or society exposed to hazards to resist, absorb, adapt to and recover from the effects of a hazard in a timely and efficient manner.

Sustainability: Meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Vulnerability: The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.

Wetland: Land that is covered or saturated with water. For example, shallow lakes, swamps, bogs.

Wildlife: Living beings that are not human or domesticated, existing in their natural environment. Often restricted to vertebrate species

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INTRODUCTION

The impacts of climate change on human migration and displacement have invited serious attention globally, with Afghanistan standing out as one of the most vulnerable nations to these phenomena. The country's southwestern provinces, encompassing Helmand, Kandahar, and Nimroz, are particularly affected due to their arid and semi-arid climatic conditions and reliance on agriculture for livelihoods (Loodin et al., 2023). Over recent decades, recurrent droughts, desertification, and variable rainfall patterns have compounded the challenges of poverty, food insecurity, and conflict in these regions. These environmental stressors, exacerbated by limited adaptive capacity and governance challenges, have driven internal displacement and migration as households seek to mitigate the risks associated with climate change (Mayar, 2022; Loodin et al., 2024b).

Prolonged droughts, in particular, have put pressure on water availability and agricultural yields, leading to a surge in rural-to-urban migration (see Hanif et al., 2023; Hanif et al., 2024). This trend is observable in southwestern Afghanistan, where farmers and pastoralists face dwindling resources and are compelled to abandon traditional livelihoods (Přívara & Přívarová, 2019; Mayar, 2023). At the end of June 2024, there were 72.1 million internally displaced people. They accounted for the majority of the world's forcibly displaced population (59 per cent). IDPs are among the most vulnerable people in the world, and many are trapped in protracted displacement for years or even decades. Uprooted from their homes and livelihoods, they often face dangerous conditions and continue to face risks even after fleeing for safety. National governments have the primary responsibility to protect and assist their displaced citizens and residents, but they may be unable or unwilling to do so (UNHCR, 2024). A 2018 United Nations report highlighted that approximately 275,000 people were displaced by drought in the region, surpassing conflict-induced displacement figures for the same period (UNHCR, 2018). These movements have implications for urban centers, which are often ill-equipped to handle the influx, exacerbating socio-economic pressures and straining public services.

According to the United Nations Environment Program (UNEP), Afghanistan has experienced a temperature increase of approximately 1.8°C since the mid-20th century, significantly higher than the global average (Snyman, 2020). This warming trend has led to the accelerated melting of glaciers, reduced snowpack, and a shift in precipitation patterns, further straining the country's water resources. In a country where nearly 80% of the population depends on agriculture and livestock for their livelihoods, the consequences of climate change are particularly dire. Prolonged droughts have rendered vast tracts of farmland unproductive, while flash floods and soil erosion have destroyed crops and infrastructure. The loss of arable land and water scarcity have not only intensified food security but also triggered economic instability, leaving millions of Afghans with little choice but to migrate in search of better opportunities.

Understanding the interplay between climate change, governance, and migration in Afghanistan's southwestern provinces requires a multifaceted approach. It is crucial to explore how environmental degradation intersects with socio-political factors to drive displacement, particularly in regions heavily dependent on climate-sensitive livelihoods. By examining this nexus, policymakers and international organizations can identify pathways for intervention that address the root causes of displacement, build resilience among vulnerable populations, and support sustainable development in a region profoundly .affected by both human and environmental challenges

Problem Statement

The southwestern provinces of Afghanistan - Helmand, Kandahar, Zabul, Nimruz, Farah, and Urozgan - face a critical convergence of environmental challenges that threaten community stability and human security. Prolonged droughts, declining groundwater levels, and increasing frequency of extreme .weather events are disrupting traditional agricultural practices and forcing population movements Despite the scale of this crisis, there has been limited systematic research examining the relationship between environmental changes and human mobility in these regions. This knowledge gap hampers the development of effective interventions to support affected communities and build regional

resilience.

This study addresses this critical research gap by examining how environmental changes influence migration decisions across six provinces, representing diverse geographical and socio-economic contexts while sharing similar environmental challenges. Through comprehensive data collection and analysis, we seek to understand the complex interplay between environmental stressors and human mobility, ultimately informing more effective policy responses

Overview of Study Area

The research focuses on six provinces in south and southwestern Afghanistan: Helmand, Kandahar, Zabul, Nimruz, Farah, and Urozgan. These provinces represent diverse geographical and socio-economic contexts while sharing similar challenges related to climate change impacts and population displacement.

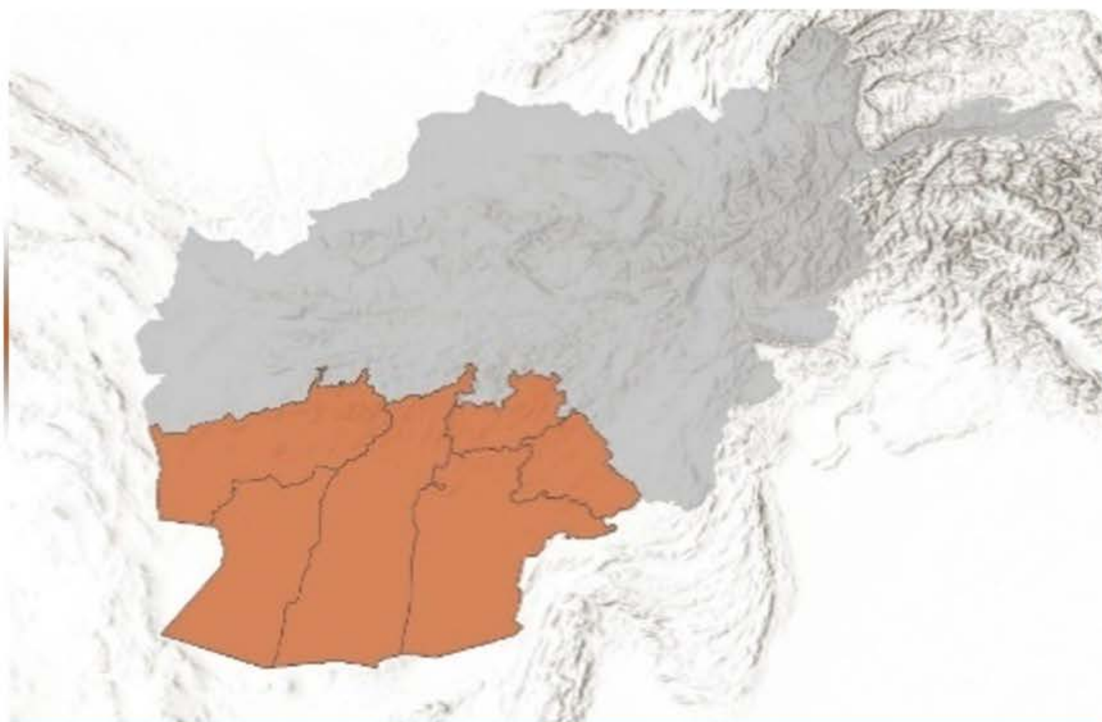


Fig 1: Study Area (Highlighted)

Research Questions

This study seeks to answer three primary research questions:

1. How do environmental changes (particularly droughts, floods, and dust storms) correlate with migration decisions in southwestern Afghanistan's six provinces during 2018-2024?
2. What are the primary socioeconomic impacts of climate-induced migration on household livelihoods and community resilience?
3. How do water scarcity and agricultural productivity changes influence displacement patterns across different people groups?

Research Objectives

1. Quantify the relationship between environmental changes and migration patterns across the study provinces
2. Map internal displacement potential in relation to changes in agricultural productivity, water availability, and extreme weather events
3. Assess the socio-economic consequences of climate-induced migration through household-level impacts
4. Formulate targeted policy recommendations based on comprehensive data analysis

LITERATURE REVIEW

The climate crisis and human displacement are increasingly interconnected. Not only did climate-related disasters trigger more than half of new reported displacements in 2022, but nearly 60 per cent of refugees and internally displaced people now live in countries that are among the most vulnerable to climate change (UNHCR, 2023). The interconnection between climate change and human migration is a pressing global challenge, particularly in South Asia, where the impacts of environmental stressors are intensifying. Afghanistan, already grappling with socio-political complexities, faces severe consequences from climate-induced disasters such as droughts, floods, sand and dust storms and environmental degradation. These events have compounded issues of internal displacement, food insecurity, and livelihood disruptions, which not only hinder the country's development but also exacerbate the vulnerability of communities already facing socio-economic hardships.
Recent studies, including those employing a mixed-methods approach, highlight the intricate relationships between climate change, migration, water resource management, and livelihoods in Afghanistan. This research integrates both quantitative methods, such as household surveys across six provinces, and qualitative methods, such as focus group discussions and in-depth interviews, to capture a comprehensive understanding of how climate-induced environmental changes affect migration patterns. Remote sensing data, including satellite imagery and climate models, further enrich the analysis by providing spatial and temporal context to the environmental stressors impacting the region.

The study revealed that environmental stressors, such as water scarcity, degraded agricultural land, and increasing frequency of extreme climatic events, are pivotal in shaping migration patterns. These findings emphasize the urgent need for adaptive measures in water resource management, agricultural practices, and community resilience programs to address the growing threat of displacement. This report synthesizes these findings to inform policy recommendations aimed at enhancing community resilience and reducing vulnerability to climate change in Afghanistan.

The subsequent sections of this literature review delve into key aspects of migration in the context of climate change, with particular focus on South Asia and Afghanistan. This review includes analyses of environmental stressors, such as droughts, floods, sand and dust storm, ground water storage, vegetation coverage, and the role of water scarcity in driving displacement. The methodologies employed in this study, including both spatial analysis through AHP-GIS and survey data, provide an evidence-based foundation for understanding the socio-economic drivers of migration in the region. These discussions are complemented by references to a broad range of studies, datasets, and policy frameworks, providing a comprehensive perspective on the issue.

Theoretical Frameworks of Climate-Induced Migration

In their comprehensive review of migration theories, de Sherbinin et al. (٢٠٢٢) outline several key theoretical frameworks that explain climate-induced migration. According to their analysis, push-pull theory provides a fundamental framework where environmental factors serve as both push factors driving people from origin locations and pull factors attracting them to new destinations. They note that recent developments include the "push-pull plus" model, which distinguishes between predisposing, proximate, precipitating, and mediating drivers of migration.

De Sherbinin et al. (2022) identify two significant frameworks for understanding migration decision-making. First, the New Economics of Labor Migration conceptualizes migration as a household-level strategy for risk minimization and income diversification in response to environmental constraints. Second, they discuss the Aspirations and Capabilities framework, which examines how environmental factors shape both migration desires and implementation abilities.

The authors highlight two additional important frameworks. The Foresight framework synthesizes multiple approaches and uniquely positions climate change as an indirect driver operating through existing economic, demographic, social, political, and environmental conditions. They also discuss the Livelihood Framework, which connects migration to five forms of capital—social, human, natural, physical, and financial—with environmental factors primarily influencing natural capital while potentially affecting all capital types.

Migration and Climate Change in South Asia:

Migration, or human movement from one place to another, is nothing new. Numerous studies have found that, due to climate change and various extreme weather events, relocation to other places is increasing, and experts often say that these events will have a significant impact on human migration in the future, especially in South Asia (Ahmed, 2024). Population mobility is a norm rather than an exception in human history. From the remote past, human beings have been in a constant state of movement over varying distances and for different reasons. Migration patterns are very complex and can be grouped as 'internal' and 'international' (Asfaw, 2010). Globally, the migration phenomenon encompasses over 1 billion individuals, with approximately 10 percent attributable to water scarcities and climate-related hazards (Hamzah, 2024)

Climate Change and Migration in Afghanistan:

Afghanistan, highly vulnerable to extreme weather conditions and natural disasters, faces significant challenges due to climate change. Severe droughts, floods, and environmental degradation are affecting the livelihoods of millions, particularly vulnerable groups such as female-headed households, internally displaced people, and those with disabilities. The ongoing climate crisis has exacerbated Afghanistan's humanitarian situation, making it one of the world's most severe crises. Immediate action is needed to protect the population from further harm and to build resilience against the escalating impacts of climate change (OCHA, 2023; INFORM Risk Index ,2023)

This climate vulnerability is reflected in the significant displacement patterns across the country. According to UNHCR data, Afghanistan currently hosts 3.22 million internally displaced persons (IDPs) as of June 2024, with only 19,750 IDPs having returned to their places of origin during 2024 (UNHCR, 2024b). The scale of displacement is expected to grow, with UNHCR's 2025 planning figures projecting approximately 9.2 million forcibly displaced people, including 5.9 million refugees and asylum-seekers, 3.1 million IDPs, and 160,000 refugee and IDP returnees (UNHCR, 2024b).

Impacts of Climate Change on Internal Displacement

Environmental degradation continues apace and climate-induced shocks have only expanded. In recent years, water shortages and irregular snow and rainfall patterns have had a major impact on livelihoods as over 60% of the population relies on rain-fed agriculture. Drought remains the most widely experienced shock across the country (Azizi, 2024), with 64% of households reporting that they have been affected by it, a 25-percentage- point increase from 2021. Deforestation, land and pasture degradation, and floods continue to have severe impacts on livelihoods, food security, and displacement, increasing the risk of local conflict (de Clerck et al., 2023). The compounded effects of extreme weather events and population displacement due to drought, floods, sand and dust storms, and conflict have rendered people vulnerable and led to a need for strong disaster mitigation and adaptive measures. Given the high vulnerability to environmental crises, the issue of migration is central, as Afghans affected by environmental impacts and their consequences, such as insufficient rainfall and unsuitable weather conditions, are likely to seek safety elsewhere.

Water Scarcity, Agriculture, and Livelihoods

The impact of unaddressed climate changes on water scarcity, agriculture, and livelihood practices, particularly in rural areas that heavily depend on rain-fed agriculture, has exacerbated food insecurity issues in Afghanistan (Gautam, 2023). Decreased access to water resources and the impact of warming temperatures on agriculture and livestock are also significant drivers of environmental migration within Afghanistan. The compounding effects of climate change and environmental degradation have led to negative coping strategies like child marriage, child labor, and internal and external migration, further impacting the lives of Afghans (Azizi, 2023).

Recent Climate Events and Their Impacts

Above-average precipitation and extreme rainfall events, mainly attributable to the combined effects of El Niño and climate change, have been triggering floods, flash floods, and mudslides in 25 of Afghanistan's 34 provinces since the end of February 2024. This has resulted in casualties, displacement, widespread housing and infrastructure damage, and significant crop and livestock losses (UN Climate Crisis Coordinator, 2024). By 12 May, floods had affected more than 30,000 people throughout the country within the year (OCHA, 2024). These events follow the end of an exceptionally dry winter season that delayed crop planting and threatened a fourth consecutive year of drought (FEWS NET, 2024). Floods are the most common natural hazard in Afghanistan. In 2024, soil aridity arising from previous droughts limited water absorption and increased run-off, resulting in worse flooding (WB 2021; AJ, 2024).

In April, heavy rainfalls triggered floods across Central, Central Highland, Northeastern, Northern, Southern, and Western regions (OCHA, 2024; IR, 2024). The most affected provinces included Badakhshan, Badghis, Farah, Ghazni, Ghor, Helmand, Herat, Kabul, Kandahar, Kunar, Laghman, Nimruz, Paktika, Parwan, Saripul, Takhar, Uruzgan, and Zabul. By 23 April, there were at least 90 fatalities and dozens of injuries reported across these provinces. The rainfall had also damaged more than 2,000 houses and killed thousands of livestock across the country (ECHO, 2024). In March, heavy rainfall particularly affected Faryab province in the Northern region, Nangarhar province in Eastern region, and Daykundi province in Central Highland region. By 30 March, the floods had destroyed more than 1,500 acres of agricultural land and severely damaged 540 homes (OCHA, 2024).

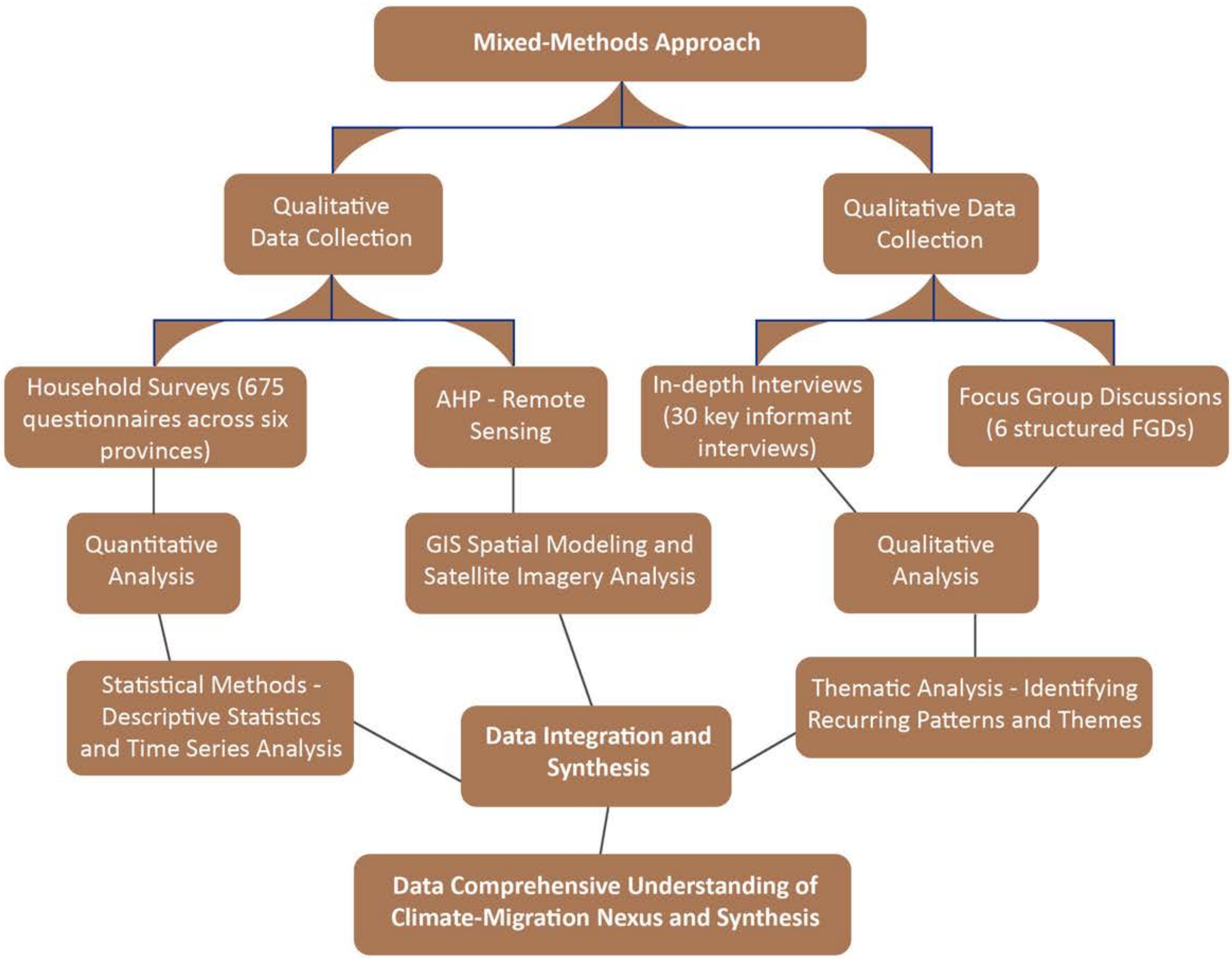
Helmand River Basin and Climatological Disasters

The Helmand River Basin (HRB) encompasses 12 provinces in Afghanistan, covering 40% of the country's territory. The focus of this proposed research includes the provinces of Helmand, Kandahar, Zabul, Nimrooz, Farah, and Urozgan, which constitute significant portions of the HRB. Since 2000, these regions have been severely affected by climatological disasters such as severe flooding and drought (Loodin et al., 2023, 2024). The HRB is classified climatologically as an arid hot desert region, where river flow has decreased due to the impacts of climate change. Following an unusually prolonged drought in the early 2000s, a cyclic pattern has emerged with periods of drought followed by floods and then normal years. The onset of droughts in the basin is believed to be triggered by occurrences of La Niña.

In conclusion, Afghanistan, specifically the targeted provinces, faces a complex crisis involving climate change, severe droughts, flash floods, internal displacement, environmental vulnerabilities, and critical food insecurity concerns. It warrants comprehensive attention and solutions that encompass the fundamental linkages between climate change, migration, water resources management, and sustainable human livelihoods. Afghanistan's history of migration spans decades and provides a crucial backdrop for understanding the current and future impacts of climate change on population movements. The interplay between climate change, socio-economic factors, and the historical context of migration in Afghanistan creates a unique and challenging environment for research and policy-making.

METHODOLOGY

This study employed a robust mixed-methods approach, combining quantitative and qualitative data collection and analysis techniques to provide a comprehensive understanding of climate-induced migration in Afghanistan. The methodology drew inspiration from successful approaches used in .similar studies, adapted to the specific context of the target provinces



Research Methodology Flowchart, (Source: Authors) :2 Figure

Quantitative Data Collection

Household Survey

A structured questionnaire was administered to 675 households across the six target provinces (Annex 1). The survey covered key topics such as demographics, livelihood and food security, WASH (Water, Sanitation, and Hygiene), health, migration history, climate impacts, biodiversity, and socio-economic conditions. The choice of household surveys was based on their ability to capture standardized, quantifiable data from a diverse range of respondents, ensuring comparability across provinces. These surveys were particularly appropriate for assessing community-level variations and providing statistically significant insights.

Survey Implementation:

- Method: Paper-based data collection was adopted due to restrictions on electronic devices in cer tain areas, ensuring inclusivity in data collection.
- Process: Manual data collection in the field, followed by data entry and digitization into Excel format.
- Languages: Surveys were administered in Pashto and Persian (Dari) to ensure comprehension and inclusivity.
- Duration: Average 20–35 minutes per household, designed to balance depth and participant en gagement.
- Data Verification: A double-entry verification system was implemented using trained data entry operators. Additionally, 20% of the entered data were cross-checked against the original survey ensure accuracy and reliability.
- Quality Control: Random spot checks of 10% of surveys were conducted during data collection to identify and rectify errors.

A pilot survey was conducted before the full rollout to test the consistency of the questionnaire, identify potential ambiguities, and refine the field implementation strategy. This process also ensured that enumerators were adequately trained and that the survey captured relevant and actionable information. On-the-spot monitoring during field data collection further ensured adherence to protocols and high-quality data collection.

Remote Sensing and GIS Data

Remote sensing and GIS data were integrated into the research to complement primary data collection. These methods were chosen for their ability to provide spatially explicit information on environmental factors. We incorporated satellite imagery data including Normalized difference vegetation index (NDVI) for vegetation health mapping, Gravity Recovery and Climate Experiment (GRACE) satellite images for groundwater mapping, Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data for precipitation, National Oceanic and Atmospheric Administration (NOAA) data for potential evapotranspiration, and MERRA-2 (Modern-Era Retrospective analysis for Research and Applications) dataset to assess sand and dust storm data. The incorporation of satellite data enhanced the study's ability to assess environmental stressors at a regional scale. Standardized criteria maps and the AHP were used as data processing to evaluate the relative importance of environmental factors. As a result, a migration spatial potential map was generated, focusing solely on environmental factors. This map highlights areas with high to low potential for out-migration based on environmental stressors.

Integration with Questionnaire Data:

To ensure holistic analysis, questionnaire responses were linked to the spatial model using districts and provincial administrative boundaries. This approach allowed for the validation and refinement of spatial predictions using primary data on economic, welfare, and socio-cultural dimensions.

Quantitative Data Collection

Focus Group Discussions (FGDs):

Six structured FGDs were conducted, including three during the National Dialogue Conference on Climate Change in Kabul. FGDs allowed for an in-depth exploration of complex and context-specific issues, such as environmental changes, migration, and community resilience, which are not easily captured through quantitative surveys. This method was chosen for its ability to foster diverse perspectives and enable dynamic discussions among participants.

Survey Implementation:

- **Structure:** Discussions were structured to cover key themes, such as environmental changes, agriculture, WASH, health impacts, migration, and community resilience. Each session lasted 90–120 minutes, with group sizes of 8–16 participants to encourage balanced participation.
- **Implementation:** Trained moderators fluent in local languages facilitated the discussions. Audio recordings and detailed notes ensured comprehensive documentation. Ice-breaker activities helped build rapport and enhance participant engagement.
- **Participant Selection:** Purposive sampling ensured diverse representation, capturing insights from various community members.

In-Depth Interviews:

Thirty key informant interviews were conducted with stakeholders, in international, national level and more focused across six targeted provinces, including academia, civil society, community leaders, local government officials, environmental experts, healthcare providers, and agricultural extension workers. This method provided detailed, expert-level insights that complemented broader survey and FGD data.

- Duration: Interviews ranged from 30–60 minutes, tailored to the depth of expertise and the participant's availability.
- Documentation: Interviews were audio-recorded with participant consent and fully transcribed in the original language, with translations into English for analysis.

Justification for Chosen Methods

The selected data collection methods were tailored to the research objectives, balancing breadth and depth. Household surveys provided standardized, generalizable insights across the study areas, while FGDs and in-depth interviews captured nuanced, context-specific information. Remote sensing and GIS techniques offered a spatial dimension to the research, enriching the analysis of environmental factors influencing migration. While the reliance on paper-based surveys and manual data entry posed potential limitations in terms of efficiency and error, these challenges were mitigated through rigorous quality assurance measures, including double-entry verification, random spot checks, and pilot testing. The combination of quantitative, qualitative, and spatial methods ensured a comprehensive and triangulated understanding of the research questions.

Sampling Strategy

To ensure robust and representative data collection, we used Cochran's formula for finite populations, a trusted method in survey research. This approach enabled us to determine an appropriate sample size that balances statistical validity and practical feasibility, while considering the unique vulnerabilities of certain regions.

Step 1: Population Estimation

We listed the estimated population of each target province as published by the National Statistics and Information Authority (NSIA) in July 2023.

Province	Population (2023 - 24)
Zabul	405050
Kandahar	1498666
Nimruz	193942
Hilmand	1525188
Farah	593841
Uruzgan	459593
Total	4,676,280 (Total estimated population)

Table 1: Estimated population of targeted provinces 2023 - 24

Step 2: Minimum Sample Size Calculation

Using Cochran's formula for finite populations: $n = \frac{N.z^2.p.(1-p)}{d^2.(N-1)+z^2.p.(1-p)}$

Where:

n = Sample size
N = 6,120,466 (total population)
z = 1.96 (z-score for 95% confidence level)
p = 0.5 (assumed population proportion, maximizing sample size)
d = 0.05 (5% margin of error)

Logic behind Cochran's formula:

- It accounts for the total population size (N), making it suitable for finite populations.
- It incorporates the desired level of precision (d) and confidence (z).
- The use of p(1-p) maximizes the sample size, ensuring we don't underestimate the required number of respondents.
- It provides a statistically valid minimum sample size for the given parameters.

Calculation: n = [4,676,280 * 1.96^2 * 0.5 * (1-0.5)] / [0.05^2 * (4,676,280 -1) + 1.96^2 * 0.5 * (1-0.5)]
n ≈ 384

Step 3: Sample Size Adjustment

While Cochran's formula suggested a minimum of 384 questionnaires, we decided to maintain our sample size of 675 questionnaires. This decision was made for several reasons:

1. Enhanced precision: A larger sample size reduces the margin of error, improving the overall precision of our results.
2. Provincial-level analysis: The increased sample size allows for more robust analysis at the provincial level.
3. Subgroup analysis: It provides better opportunities for meaningful analysis of various subgroups within each province.

Step 4: Proportional Allocation with Adjustment for Nimruz

We allocated the questionnaires proportionally based on the estimated 2023 -24 population of each province, with a special adjustment for Nimruz:

- Helmand: 190 questionnaires
- Kandahar: 220 questionnaires
- Farah: 97 questionnaires
- Uruzgan: 57 questionnaires
- Zabul: 51 questionnaires
- Nimruz: 60 questionnaires

This sampling strategy ensured that:

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2. Provincial-level analysis: The increased sample size allows for more robust analysis at the provincial level.
3. Subgroup analysis: It provides better opportunities for meaningful analysis of various subgroups within each province.
4. Non-response buffer: The larger sample accounts for potential non-responses or incomplete questionnaires.
5. Special consideration for vulnerable areas: It allows us to allocate more questionnaires to highly vulnerable regions like Nimruz.

Data Analysis

Quantitative Analysis

The quantitative analysis combines spatial and statistical approaches to examine environmental, social, and economic dimensions influencing migration patterns.

Spatial Analysis:

GIS-Based Multi-Criteria Decision Analysis (MCDA) was applied to assess environmental variables such as dust storms, drought, groundwater storage, potential evapotranspiration (PET), and precipitation. The environmental layer processing involved creation of standardized maps for each environmental factor, implementation of the AHP to assign relative weights to criteria based on expert consultations, and integration of weighted environmental factors using the Weighted Linear Combination (WLC) model to produce migration potential maps.

Analytic Hierarchy Process

In the present study, the AHP was adopted to establish the weight of each criterion based on a pairwise comparison matrix. The AHP is a well-known MCDA method that was proposed by Saaty (1980). It is a multi-objective, multi-criteria decision analysis approach that uses a pairwise comparison method to obtain values of preference among a set of parameters. It enables decision-makers to determine the weights of the criteria in the solution of a multi-criteria problem. The AHP consists of four steps (Mijani, 2022):

1. Construction of decision hierarchy: A hierarchy of the decision-making problem is drawn up in which the ultimate objective of the problem is at the top level, followed by criteria groups at the second level, individual criteria at subsequent levels, and alternatives at the lower levels.
2. Pairwise comparisons: A comparison matrix is formed by making a pairwise comparison between the criteria.

1. **Weights:** The weights for various criteria are determined based on pairwise comparisons. Values between 1 and 5 are assigned to different criteria, which are then compared in pairs to obtain a numerical weight for each criterion. Each of these numbers indicates the importance of criteria. In the modeling process, the greatest weight is assigned to the most effective criterion (Mijani, 2022).
2. **Verification of consistency:** The final step of the AHP is to check the consistency ratio (CR), defined as the consistency index (CI) divided by the random consistency index (RCI). The CI is calculated as follows: $CI=\frac{\lambda max-m}{m-1}$, where m is the number of criteria, and λmax represents the principal eigenvalue of the pair-wise comparison matrix. The CR should be less than 0.1.

Calculation Process and Results

The AHP analysis yielded precise weights for each environmental factor, supported by detailed classification ranges that reflect their impact on migration potential. This quantitative framework provides a nuanced understanding of how each factor contributes to migration pressure.

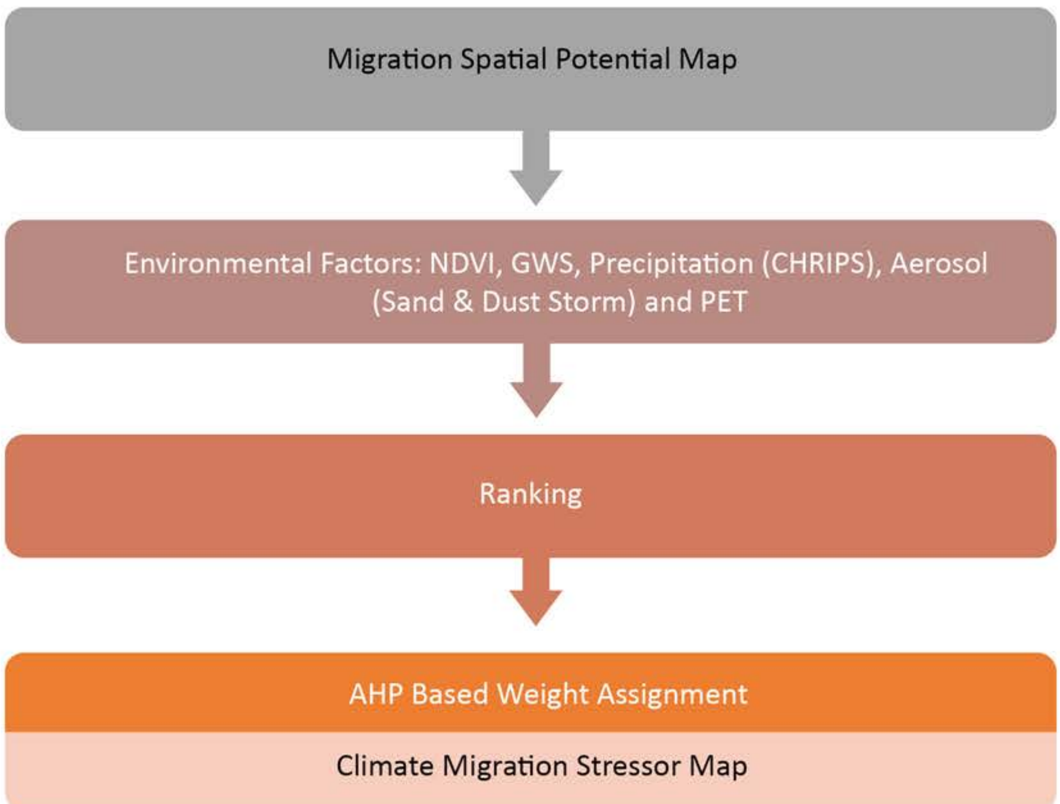

Chart 1: GIS-based Multi-Criteria Decision Analysis

Potential Evapotranspiration (PET) received a 25% weight, with values classified into five ranges from 0 to 21.8 mm. Lower PET values (0-2.56 mm) were assigned greater importance (scores of 4-5) as they indicate increased water stress, while higher values (12.65-21.8 mm) received lower scores (1-2), reflecting reduced migration pressure.

Vegetation status, measured through NDVI, also received a 25% weight, with classifications based on land cover types. Notably, bare ground (0-0.2) received the highest score of 5, indicating its strong correlation with migration pressure. Forest and agroforestry areas (0.3-0.84) received lower scores (1), suggesting their role in migration prevention through environmental stability.

Precipitation patterns (CHRIPS) were weighted at 20%, with ranges from 6.78 to 1283.14 mm. Areas with lowest precipitation (6.78-181.96 mm) received the highest score of 5, while regions with abundant rainfall (612.42-1283.14 mm) scored 1, reflecting the inverse relationship between rainfall and migration pressure.

Groundwater Storage (GWS) also received a 15% weight, with measurements in mm ranging from 1.04 to 14.31. Lower storage levels (1.04-4.17 mm) scored 5, reflecting critical water scarcity, while higher levels (9.32-14.31 mm) scored 1, indicating better water security.

These precisely defined ranges and their corresponding scores were integrated into the Weighted Linear Combination framework within GIS. The resulting spatial map effectively visualizes the combined impact of these environmental stressors, with each pixel's value representing the weighted sum of all factors.

This detailed classification system ensures that the migration potential map accurately reflects the complex interplay between environmental conditions and migration pressure across Afghanistan's diverse landscape.

The statistical validation of this framework through consistency checks (CR = 0.039 < 0.1) confirms that these weights and classifications provide a reliable basis for identifying areas at risk of environmentally induced migration. This comprehensive quantitative approach, grounded in precise measurements and carefully calibrated classification ranges, offers policymakers a robust tool for understanding and responding to environmental migration pressures.

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Table 2: Assigned weights of different thematic layers and their corresponding sub-classes (As Pushing factor of Internal displacement and migration)

Influencing Factor	Classes (range)		Material	Weight (Migration Pushing Factor)	Normalized Weight (W) %
PET	0	1.025882	mm	5	25%
	1.025882	2.564706	mm	4	
	2.564706	5.300392	mm	3	
	5.300392	12.652549	mm	2	
	12.652549	21.799999	mm	1	
NDVI	-0.07	0	Water body	1	25%
	0	0.2	Bare Ground	5	
	0.2	0.3	Crop, Grass	2	
	0.3	0.5	Agroforestry	1	
	0.5	0.84	Forest	1	
Precipitation (CHRIPS)	6.775526	181.96234	mm	1	20%
	181.96234	302.09044	mm	5	
	302.09044	432.229216	mm	4	
	432.22922	612.421367	mm	3	
	612.42137	1283.1366	mm	2	
Aerosol (Sand & Dust Storm)	6.775526	181.96234	0.5 x 0.625 degrees	1	15%
	181.96234	302.09044	0.5 x 0.625 degrees	2	
	302.09044	432.229216	0.5 x 0.625 degrees	3	
	432.22922	612.421367	0.5 x 0.625 degrees	4	
	612.42137	1283.1366	0.5 x 0.625 degrees	5	
GWS	1.044452	4.166507	mm	5	15%
	4.166507	5.779568	mm	4	
	5.779568	7.340596	mm	3	
	7.340596	9.317897	mm	2	
	9.317897	14.313185	mm	1	

Statistical Methods:

The analysis included descriptive statistics through computation of means, medians, standard deviations, and frequencies to summarize data trends, along with time series analysis that identified temporal patterns in climate-related variables and their linkage to migration behavior.

Data Processing: The process encompassed comprehensive data cleaning to address missing values, duplicates, and inconsistencies, coding of variables into primary categories (e.g., demographic, livelihood, health), and importation of questionnaire data into SPSS for analysis.

Visualization Techniques: The analysis involved development of interactive dashboards using Power BI to visualize key insights, and generation of graphs, heatmaps, and temporal trend charts to enhance interpretability.

Qualitative Analysis Derivation of Themes

The thematic analysis followed a systematic approach to ensure transparency and reliability in identifying and interpreting recurring patterns within the qualitative data. This process was conducted in three main stages, aligned with established qualitative research methodologies (Strauss & Corbin, 1990/1998; Moretti et al., 2011):

1. Data Familiarization and Initial Coding Data preparation involved transcribing FGDs and interviews verbatim to ensure the integrity of participants' responses. Transcripts were translated into English, with quality checks conducted to maintain accuracy in meaning. NVivo software was used to organize, code, and manage the qualitative data systematically. Open coding involved breaking down data into smaller units of meaning, generating initial codes to label these data segments, and adding annotations and memos to capture contextual nuances and preliminary thoughts about patterns or connections.

2. Identification and Organization of Categories Axial coding involved grouping codes into broader categories based on shared meanings or relationships, establishing subcategories to capture more specific aspects of these broader categories, and alternating between inductive and deductive approaches to refine and differentiate categories. Collaboration included peer debriefing sessions to compare coding interpretations and resolve discrepancies in categorization through iterative discussions.

3. Theme Development and Refinement Selective coding integrated categories and subcategories into overarching themes that encapsulated key findings and identified patterns within and across themes. Thematic saturation was achieved through continued data collection and coding until no new themes emerged. Validation involved cross-referencing themes with raw data and incorporating feedback from participants and external reviewers to enhance credibility.

Focus Group Discussions (FGDs):

Transcription and translation involved fully transcribing audio recordings of FGDs and translating them into English, ensuring linguistic accuracy through quality checks. Thematic analysis encompassed identifying recurring themes and subthemes using NVivo software, analyzing group dynamics and diverse perspectives, and comparatively integrating FGD findings with quantitative survey data.

Data Integration Methods

Mixed-Methods Approach: The approach incorporated triangulation through cross-validation of findings through integration of quantitative data and qualitative insights, combined environmental and social indicators with spatial and statistical outputs with community-level insights, and validated spatial migration potential maps using reported migration patterns from survey data.

Synthesis Across Data Sources: The integration of thematic insights from FGDs with statistical trends strengthened the overall interpretation of migration drivers, while AHP-weighted criteria and WLC model outputs were linked to survey responses for comprehensive analysis. This rigorous analysis framework ensures the reliability and validity of findings, addressing both the environmental and socio-economic dimensions of migration in the study regions.

Field Research Documentation

Focus Group Discussions Visual Documentation

FDG in Farah Province: Based on research team coordination in Farah, FDG conducted with participants of 10 members, they actively discussing main challenges in terms of environmental, migration, climatic issue, water resource management, economy, livelihood, agriculture, and livestock. The discussion

Figure 3: Conducting of FDG in Farah

revealed deep concerns about sever impact of climate change impacts, declining agricultural productivity, food security and its impact on local livelihoods and pattern of migration.

FDG in Helmand Province: Community members engaging in dialogue about climate change impacts on livestock and traditional farming practices. The session highlighted the increasing frequency of drought conditions and their impacts to migrations.

Figure 4: Conducting of FDG in Helmand

At the recent National Conference on Climate Change and its Impact on Society, hosted by TLO in Kabul, a series of four focused group discussions provided invaluable insights into the ways climate change affects Afghan communities. The conference, which gathered over 180 participants from Afghanistan's 34 provinces, featured the participation of national and international NGOs, international organizations, and relevant stakeholders. It aimed to amplify the voices of Afghan communities, addressing critical challenges and formulating actionable recommendations for adaptation and resilience in the face of climate change.

The research team leader, serving as the FGD moderator, facilitated discussions on two main themes. All main FDGs topics was as following:

1. Climate Change and Migration,
2. Social Resilience in Response to Climate Change Impacts,
3. Climate Change Impacts on Natural Resources and Resulting Societal Conflicts, and
4. Effects of Climate Change on Livelihoods and Job Security.

Figure 5; FDGs Conduct in Kabul and National Dialogue in Climate Change, TLO

These FGDs engaged a diverse panel of experts, each representing unique perspectives and firsthand knowledge of climate impacts in their regions. Participants collaboratively explored the specific challenges posed by climate change, examining its impact on resources, migration patterns, economic stability, and community resilience. The discussions culminated in a series of adaptation strategies and policy recommendations, which were shared in plenary sessions to foster broad, inclusive dialogue.

This collaborative effort underscored the power of collective action and highlighted the urgent need for climate adaptation policies tailored to Afghanistan's unique context. The discussions revealed a strong commitment among participants to advocate for effective climate solutions and resilience-building initiatives, reinforcing the importance of shared, community-led responses to the climate crisis.

Statistical Methods:
Community Engagement Through Household Surveys

A series of eight representative photographs showcasing our trained researchers and enumerators conducting household surveys across different regions:

Figure 6: Enumerator conducting interview with farming family in Farah Province

Figure 7: community which struggling with poor livelihood and migration due to war (Helmand)

Figure 8: Discussion with displaced individuals about environmental factors driving migration (Farah)

Figure 9: Survey process in rural community addressing livestock challenges (Nimruz at right and Zabul at left)

Figure 10: Documentation of agricultural impacts in drought-affected areas and job security, A family which are relied on other job due to worsen impact of climate change (Kandahar)

Figure 11: Community members sharing concerns about future environmental challenges (Kandahar, left and Urozgan right)

Key Observations from Household Surveys:

- Participants expressed significant concern about current environmental conditions
- Communities showed a sense of urgency regarding water resource management
- Many respondents requested their insights be shared with relevant authorities and organizations
- Clear correlation observed between environmental degradation and displacement decisions

In-Depth Interview Documentation

Expert interview with Dr. Najibullah Sadid water and environmental specialist discussing climate adaptation strategies and find solutions, and in-depth discussion with agriculture, migration and water resource management professional, Professor Fazal Akhtar, Bon University, Germany about regional impacts

Figure 12: In-depth Interview with Dr. Najib Sadid (Left) and Professor Fazal Akhtar (right)

Figure 13: Interview and discussion with provincial experts and academia in order to address assess climate change impacts, weather-related hazards, food security, health, and so on

Expert Profile Analysis

Multidisciplinary Expert Participation

The research benefited from a diverse range of expertise, ensuring comprehensive coverage of climate change impacts and their relationship to migration patterns. Key expertise areas included:

1. Environmental Science and Climate Change
   - Environmental experts from NEPA (National Environmental Protection Agency)
   - Climate specialists with focus on regional impacts
   - Biodiversity and ecosystem management professionals

2. Water Resource Management
   - Hydro metrology experts
   - Water diplomacy specialists
   - Transboundary water management professionals

3. Agricultural and Livestock Sciences
   - Agricultural experts from MAIL
   - Livestock management specialists
   - Plant breeding and agronomy professionals

4. Academic and Research
   - University professors and researchers
   - International academic contributors from Switzerland, Germany, USA, and Canada
   - Specialists in glacier studies, hydrology, and climate science

5. Social and Community Development
   - Civil society representatives
   - Community development experts
   - Public relations and journalism professionals

6. Policy and Administration
   - Government agency representatives
   - Sustainable development specialists
   - Environmental policy experts

Geographic Distribution of Expertise

The research incorporated experts from:

- Regional centers (Farah, Helmand, Kandahar, Nimruz, Urzgan and Zabul)
- National institutions (Kabul and, Herat)
- International academic institutions (Germany, Switzerland, USA, and Canada)

Interview Process Highlights

- Experts showed high engagement and commitment to the research
- Most participants consented to voice recording
- Detailed notes were maintained for non-recorded sessions
- Questions were tailored to each expert's specific field of expertise
- Interviews revealed complex interconnections between climate change, resource manage ment, and migration patterns

This diverse expert participation enabled a comprehensive understanding of climate change impacts on migration and internal displacement, incorporating local, national, and international perspectives.

Quality Assurance Measures

To ensure the accuracy and reliability of the collected data, comprehensive verification measures were implemented throughout the research process. Survey data were entered independently another team, data entry team, enabling the identification and correction of inconsistencies or discrepancies, such as mismatched participant details (e.g., differing ages or occupations). Additionally, 20% of the entered data were cross-checked against the original survey forms to verify that the data were entered accurately, further minimizing errors in the final dataset. Prior to the main data collection phase, a pilot survey was conducted to test the consistency and reliability of the questionnaire. Feedback from the pilot survey allowed the research team to refine ambiguous or unclear questions and assess the feasibility of the data collection process. This step also served as an opportunity to train field teams effectively. During the primary data collection phase, on-the-spot monitoring was conducted by field supervisors to ensure adherence to established protocols. Random checks of completed survey forms were performed, and immediate feedback was provided to address any issues or deviations.

Comprehensive training and monitoring measures were implemented to maintain the integrity and reliability of the data collection process. Field teams participated in extensive training sessions designed to familiarize them with research tools and protocols, including role-playing exercises and mock interviews to prepare for real-world scenarios. During data collection, supervisors conducted random checks to ensure adherence to established protocols and addressed discrepancies in real time. Additionally, real-time quality monitoring was performed using dashboards to periodically review collected data and identify missing or inconsistent data points. For instance, illogical responses, were flagged and corrected through prompt follow-ups. To further enhance data reliability, triangulation was employed by cross-validating multiple data sources, including surveys, interviews, and observations. For example, participant responses about household water access were verified through direct observation of water collection practices.

To ensure consistency, transparency, and ethical compliance in the research process, robust documentation standards and ethical measures were employed. All data collection tools, including surveys, interview guides, and observation checklists, were designed in standardized formats to ensure uniformity across all data collectors. Pre-coded response options were included to minimize variability and streamline data analysis. Field teams followed strict record-keeping protocols, such as labeling survey forms with unique identifiers and creating daily electronic backups to prevent data loss or corruption. Ethical considerations were integral to the process, with explicit permissions obtained for photographs using signed consent forms, ensuring participants were fully informed about the intended use of images and could opt out if desired. To protect participant privacy, all personally identifiable information (PII) was anonymized prior to analysis by replacing names with unique participant codes and restricting access to sensitive data to authorized personnel.

FINDINGS

Agriculture, Livelihood, and Food Security

The people of the southern and southwestern regions of Afghanistan— the most drought-stricken region in the country—primarily rely on agriculture and livestock for their livelihood, and thus are heavily dependent on water resources (Bhattacharya et al., 2004; Chen et al. 2023). However, the impacts of climate change have led to the expansion of phenomena such as droughts, dust storms, flash floods, and other environmental anomalies, significantly affecting their livelihoods and income (Sadid, 2024). Additionally, with the drying up and reduction of vegetation and water resources, livestock farming has also been severely impacted. In addition to wild rangelands, rain-fed crops have been a significant source of income for these residents, which have been severely disrupted by consecutive years of droughts, causing harm to both farmers and herders (Loodin et al. 2023; Loodin et al., 2 024). According to our findings, the residents of Nimruz and Urozgan provinces have experienced the greatest decline in household income over the past five years (see chart 2). In Urozgan, 93% and in Nimruz, 82% of households reported a "Greatly decrease" in their income. A notable decrease is also observed in Farah, where 66% of households reported a "Greatly decrease" in income, while only 15% reported a “No change" in income. In Helmand, 46% of households reported a "greatly decreased" in income, and 34% reported a "slightly decreased." Similarly, in Kandahar, 40% of households experienced a "greatly decreased" in income, 34% reported a "slightly decreased," and in Zabul, 22% of households reported a “greatly decreased” in income.

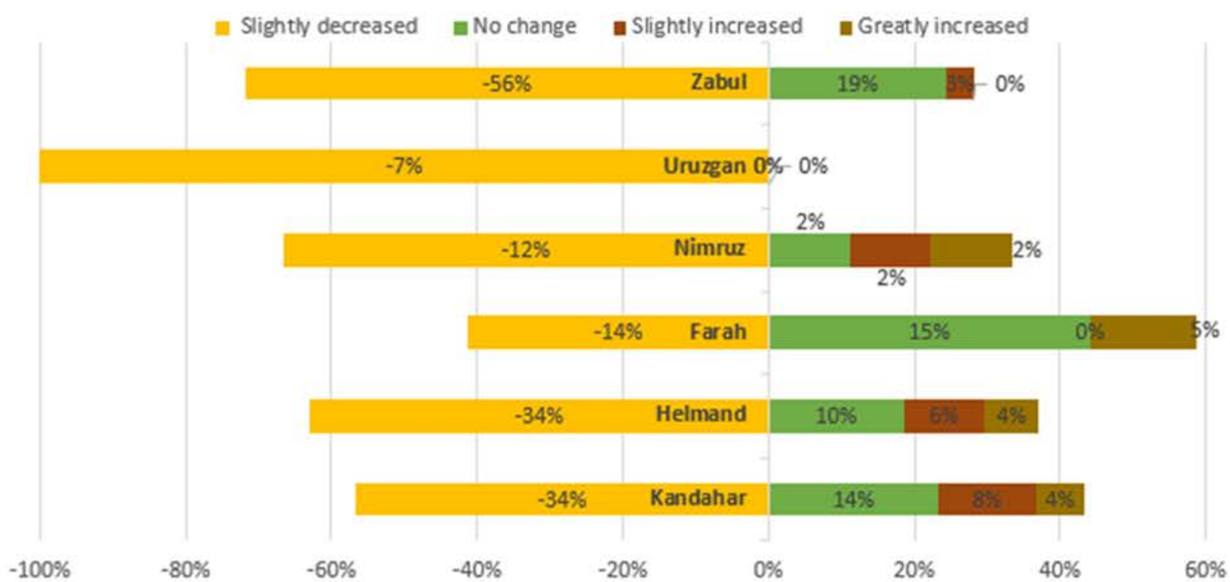

Chart 2: Fluctuation of household income in south and southwestern provinces of Afghanistan (source: authors)

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ve led to a decline in agricultural productivity and crop cultivation (Shokory et al., 2023). One respondent from Nimruz province stated, "The water shortage has increased so much in this province that there is no water even for irrigating basic crops like vegetables, and thus it has to be brought in from other provinces like Herat." In addition, extreme climatic events such as floods and dust storms have caused damage to infrastructure, agricultural products, and housing, increasing the vulnerability of communities. The costs of rebuilding and restoring agricultural lands damaged by environmental anomalies have placed a significant financial burden on residents. As one respondent said, "The repeated occurrence of droughts and floods has led to the destruction of rain-fed and irrigated crops and the death of livestock, which has forced many of us to seek safer areas." Furthermore, the decline in crop yields has severely challenged livelihood conditions and food security, with residents stating that climate change has harmed their income sources, particularly agricultural lands and water resources. This has resulted in severe food shortages for families, to the extent that many households are forced to reduce their food intake to ensure they have enough for all meals.
even enough for our own needs."

A large number of residents, especially from Nimruz, Farah, Urozgan, and Zabul, have claimed that they face difficulties in securing even one meal per day. According to nutrition standards, maintaining a diverse diet and adequate intake of vitamins, minerals, protein, water, and carbohydrates are crucial for human health. Given the current conditions in these provinces, worsened by climate change, obtaining clean drinking water and basic foodstuffs from local markets is increasingly difficult due to shortages, while purchasing from external markets is a challenge due to weak economies. As residents claim, "In the past, due to abundant water and favorable climatic conditions, we were exporters of animal products (meat, milk, yogurt, etc.) and plant products (rice, wheat, etc.), but now these products are not even enough for our own needs."

As a result, the residents of these areas, who mainly rely on agriculture and livestock for their livelihood, have seen significant impacts on their lives and income due to climate change. These climatic changes have created challenges for the agricultural sector, leading to reduced crop yields and insufficient grazing land for livestock, exposing local communities to increased economic vulnerability and food insecurity. The findings of this study indicate that Nimruz province has experienced the most severe food shortages, with 17% of households reporting that they "always" face food shortages. Similarly, about 26% and 32% of households in Kandahar and Helmand provinces, respectively, reported experiencing "Often" food shortages. Nimruz also had the highest percentage (61%) of households that reported "often" facing food shortages. Zabul province experienced the lowest level of food insecurity, with only 7% of households reporting "always" facing food shortages, and 37% reporting "sometimes" facing food shortages (see chart 3) (for information about water insecurity and its implication on agriculture see Loodin, 2024b).

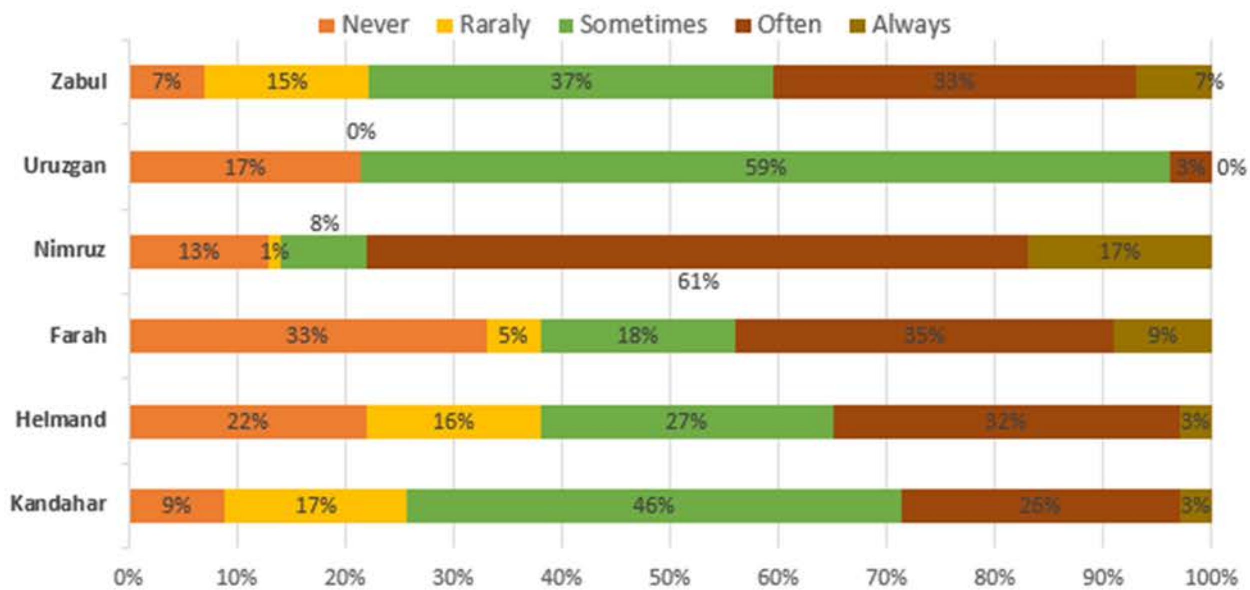


Chart 3: Household food insecurity in south and southwestern Afghanistan (source: authors)

The other adverse effect of climate changes on these under-served communities is that it has forced the majority of residents to seek water and food from other markets, which has led to additional costs. In critical situations, it has also resulted in migration to other areas for better livelihood seeking employment (Loodin et al. 2023).

WASH

Residents of the southern and southwestern regions of Afghanistan, especially in cities, suburbs, and villages, face significant challenges in accessing water. These regions, due to specific climatic conditions and recent environmental changes, have been impacted by severe and repeated droughts and unprecedented temperature increases (Hanif et al. 2024b).

It was documented that Zabul province has experienced the most severe shortages, with 11% of households reporting that their access to clean drinking water has been "completely disrupted," and 22% stating that it has been "severely affected." Meanwhile, 30% were "moderately affected," and 19% were "slightly affected." In Urozgan province, the majority of 59% of households reported being "severely affected," 21% "slightly affected," and 10% "moderately affected." In Nimruz province, a significant 64% of households reported being "severely affected," 15% "completely affected," 16% "moderately affected," and 4% experienced "slightly affected." Farah and Helmand provinces showed a mix of impacts, with households reporting "slightly affected," "moderately affected," and "severely affected" levels. In Farah, 9% of households reported "completely disrupted," while Helmand had 1% in this category. Kandahar province had the widest distribution, with 25% "not affected," 26% "slightly affected," 32% "moderately affected," 15% "severely affected," and 2% "completely disrupted" (see chart 4).

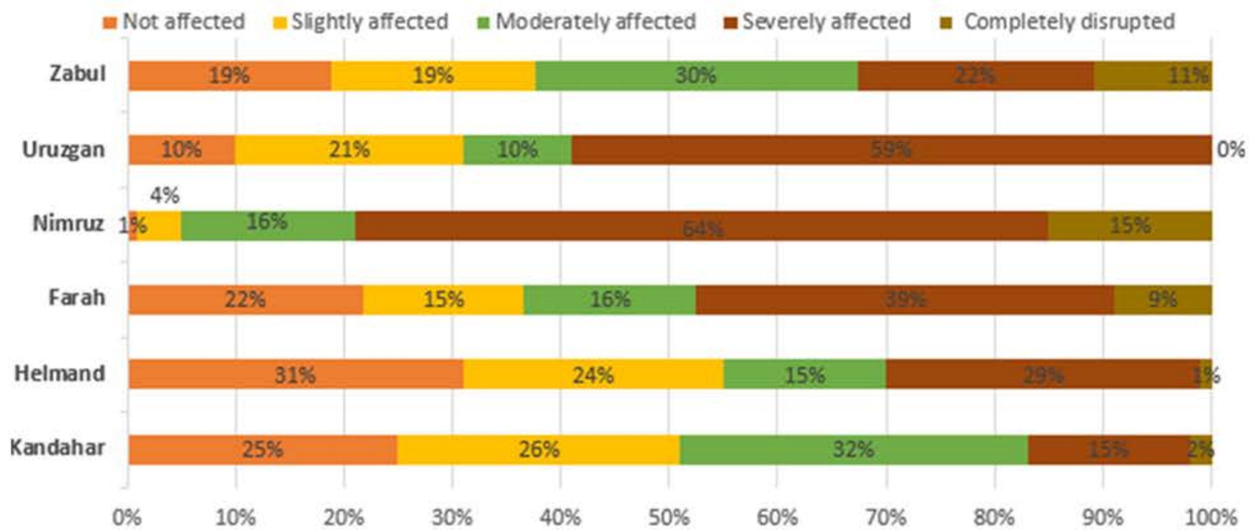


Chart 4: Impacts of climate changes on household access to drinking water (source: authors).

The prolonged droughts in recent years have significantly impacted access to drinking water, and reduced rainfall has led to the desiccation of springs and streams. Additionally, rising temperatures not only increase evaporation from water bodies but also alter rainfall patterns, which can result in heavy and sudden downpours, leading to dangerous flooding (Goes et al. 2016).

We will now explore how access to water varies within urban and rural areas.

Water Access in Urban Settings

Metropolitan areas are often considered the hubs of civilizations and economic growth in the region which general offers and provision services. According to the rule and policies of Afghanistan Urban Water Supply and Sewage Corporation (AUWSSC), each province has a division responsible for supplying water to the urban residents. However, due to economic challenges, widespread migration to cities, urban population growth, urbanization, water shortages, intermittent services (water rationing during the week), and insufficient infrastructure, these services are under pressure and unable to meet the needs of all areas (see Hanif et al. 2024a). As residents of Farah province reported, "The water supply department in the city center provides weak and inadequate services, with water available only two to three times a week for a few limited hours." As a result, in recent years, institutions, investors, and even city residents have resorted to various methods of water procurement. A significant portion of local residents have dug deep wells, which they consider a more reliable source compared to others, providing water for drinking, hygiene, and other uses. However, obtaining water from such sources comes with numerous challenges. In general, digging deep wells involves significant costs and is often done in areas where the water quality may not be suitable for drinking, as sewage is traditionally disposed of through absorption wells. Due to the lack of alternatives and the inability to afford bottled water, locals are forced to use the contaminated water source (Loodin, 2024a).

Another issue is public wells, such as bomb-like wells, where residents must wait in line, often spending several hours to collect water, which is a major challenge in provincial centers, districts, and villages, especially in more remote areas (Hanif et al., 2024b).

Water Access in Rural Areas

In the district centers and villages of southern and southwestern Afghanistan, the situation is even more insecure. These areas often lack sufficient infrastructure to support the growing population. Communities in these regions are heavily dependent on natural water resources such as rivers and streams, which are increasingly drying up or becoming polluted due to reduced rainfall and human activities (Mahmoodi, 2008; Akhtar & Shah, 2020). This has forced many families to travel long distances to fetch water, often making multiple trips a day and spending a significant amount of time gathering it. As residents of Nimruz stated, "Every day, we go in search of water several times, and the amount of water we manage to collect is not enough to meet our needs."

Overall, life in the villages and rural areas of the provinces studied faces deep and significant challenges due to a lack of economic and social development and the absence of basic infrastructure, especially regarding access to clean and safe drinking water. Every day, hospitals and health centers host numerous patients suffering from waterborne diseases. In many remote villages, securing drinking water is considered the most essential part of daily life. In fact, many people, unable to endure the water shortage and to escape various diseases caused by contaminated water, are forced to leave their homes and ancestral lands (Azizi, 2023; Rafat, 2024). These examples can be clearly seen in the districts of Chakhansur and Kang in Nimruz, Khak-e-Safid, Pusht Rod, Bala Buluk, Bakwa, Gulistan, and Lashkargah in Farah, as well as in the districts of Takht-e-Pul in Kandahar, Musa Qala, and Nawi in Helmand.

Sanitation and Hygiene

In recent years, with the decrease in rainfall and frequent droughts, families living in villages and cities have turned to groundwater sources for agricultural and domestic water needs. Over the past few years, the level of these water resources has significantly dropped, and in addition to agricultural needs, there is insufficient water available for drinking and household use. In many villages, families have moved closer to water sources due to the lack of water (Costello, 2013). In cities, water is extracted from deep wells and is bought and sold, leading to long lines for access in both urban and rural areas. People travel long distances to obtain water, and in the end, the amount of water available is still inadequate. As one respondent mentioned, "On Eid day, a private water service company was closed, and people in the city of Nimruz spent over a day searching for even the minimum amount of water to drink." However, many urban and rural residents who grapple with drinking water shortages no longer prioritize cleanliness and hygiene. Families have become stricter with their water usage, reducing the number of times they wash clothes or bathe during the week. As a result, there is less focus on cleanliness and hygiene, leading to an increase in health and sanitation-related diseases due to the insufficient amount of drinking water and neglect of proper hygiene (Mubarak et al., 2016). In areas without adequate health facilities, particularly in remote regions, mortality rates have also risen, as shown in Table 2 and chart 15.

As a result of climate change and major environmental challenges, many residents of cities and villages are seeking to move to areas with better facilities and health services. Higher-income individuals have migrated to district centers, neighboring provinces, and even to other countries to access better services and opportunities. However, lower-income individuals, who are more vulnerable, continue to live in these areas, often relocating to nearby regions and sending family members to work in neighboring countries such as Iran and Pakistan.

Health-related diseases

Climate change is recognized as a major factor contributing to the rise of various diseases worldwide. The effects of rising temperatures, floods, reduced rainfall, droughts, and stronger winds have significantly increased the prevalence of health problems. Long-lasting droughts, in particular, have led to an increase in harmful insects affecting both humans and plants, reduced pollination, a rise in waterborne diseases, and the expansion of desertification, which has contributed to respiratory diseases and allergies. Moreover, the productivity of both livestock and crops has decreased. The occurrence of floods has also resulted in the contamination of many water sources, rendering them unsafe for use without proper purification (Malik & Akhtar, 2020).

Furthermore, climatic anomalies have had a severe impact on agricultural productivity and food security, which in turn indirectly affects public health and leads to malnutrition and foodborne diseases. Sudden fluctuations in temperature over the past year in the southern and southwestern provinces of Afghanistan have played a prominent role in the rise and spread of diseases. Unprecedented winters with temperatures as low as -22°C and summers reaching +52°C have led to crop frost damage in winter and an increase in skin diseases, respiratory issues, allergies, heatstroke, fever, and nausea during the summer (Loodin et al., 2024b). Respondents have reported that "due to prolonged droughts and the increase in sandstorms, most families in Nimruz province are facing respiratory diseases and vision problems". In the provinces of Kandahar, Helmand, Farah, Zabul, and Urozgan, in addition to Nimruz, people complain about the rise in diseases and the lack of specialized medical facilities and minimal economic means for treatment. Public hospitals, whether in provincial centers, district offices, or villages, are facing severe shortages of facilities, specialized staff, laboratory equipment, and an efficient healthcare system (Sato, 2024).

Our findings that have unpacked the impacts of environmental anomalies on human health over the past five years highlight that the residents of Urozgan province have suffered the most, with 100% of households reporting health issues related to environmental changes. Zabul province was also heavily affected, with 97% of households facing such health problems. Similarly, Kandahar province showed a relatively lower but still significant rate, with 63% of households affected. Nimruz and Farah provinces had a similar rate, with 84% of households reporting health issues related to environmental changes (chart 5).

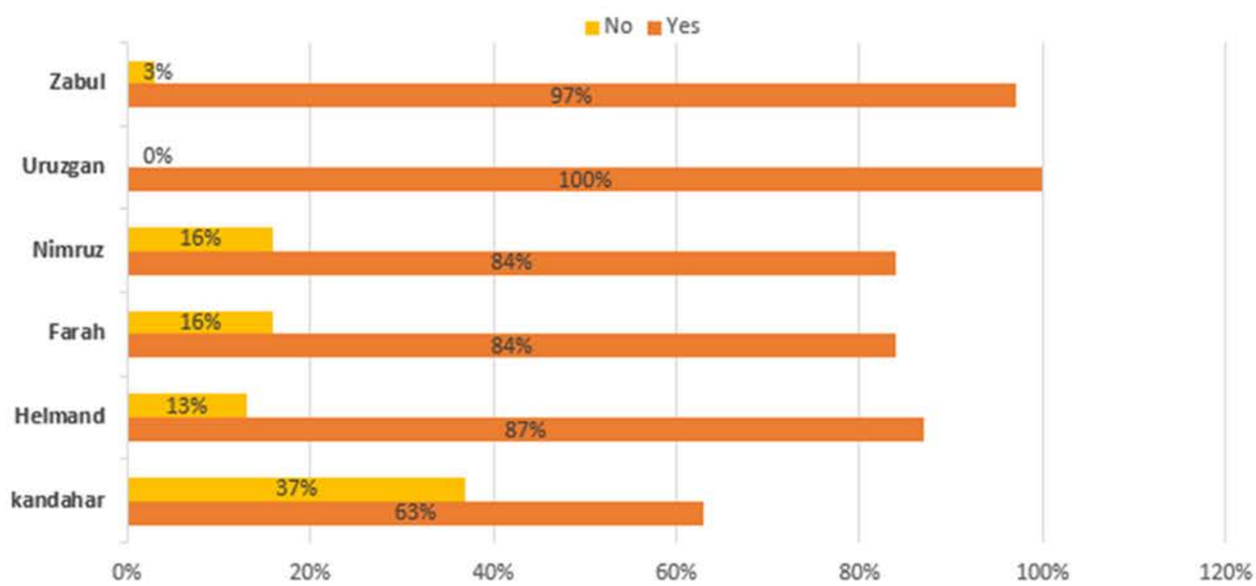


Chart 5: The spread of health-related diseases (source: authors)

In Table 3, data shows the number of disease cases recorded across southwestern provinces of Afghanistan that were attributed to climatic anomalies based on household survey participants. Respiratory issues (e.g., asthma, bronchitis) were most frequently documented with 399 total cases, predominantly in Helmand (140 cases) and Farah (96 cases). Heat-related illnesses ranked second with 62 total cases, mainly reported in Kandahar (44 cases) and Helmand (10 cases). Waterborne diseases like diarrhea and cholera accounted for 41 cases, with the highest numbers in Kandahar (30 cases) and Zabul (10 cases). The provincial distribution shows Helmand recording the highest number of cases, followed by Kandahar, Farah, Zabul, Nimruz, and Urozgan.

Table 3: Health condition of households under changing climate (source: authors).

Type of diseases	Farah	Helmand	Kandahar	Nimruz	Uruzgan	Zabul	Total
Vector-borne diseases (e.g., malaria, dengue)	3	1	2		1	2	4
Allergy		1		3		1	7
Blood pressure		37		1	1		1
body pain	1		1				1
Cancer	1	1					
Cold				1	2	2	1
Defective			1				1
Fever			1				1
flu			1				1
Heat-related illnesses (e.g., heatstroke, dehydration)	7	10	44			1	62
Kidney		1				2	1
Mental health issues (e.g., stress, anxiety)		2	2	1			6
Neck illnesses	1					2	1
None					14		7
Respiratory issues (e.g., asthma, bronchitis)	96	140	55	65	35	30	399
Skin illnesses				1			1
Stomached	1			1			2
Stone of Kidney				1			1
waist disk			1				1
Waterborne diseases (e.g., diarrhea, cholera)		5	30	1	1	10	41

Nevertheless, households have a significantly higher need for healthcare and services. The data shows that in Urozgan province, 97% of households reported that their members required healthcare more than three times due to health issues related to climate change. Zabul province also experienced very high rates, with 56% of households reporting similar needs. In Kandahar, 64% of households stated that their members needed medical care more than three times for such issues. Nimruz and Farah provinces had similarly high rates, with 88% and 87% of households, respectively, reporting that their members required healthcare more than three times due to climate-related health problems (see chart 6).

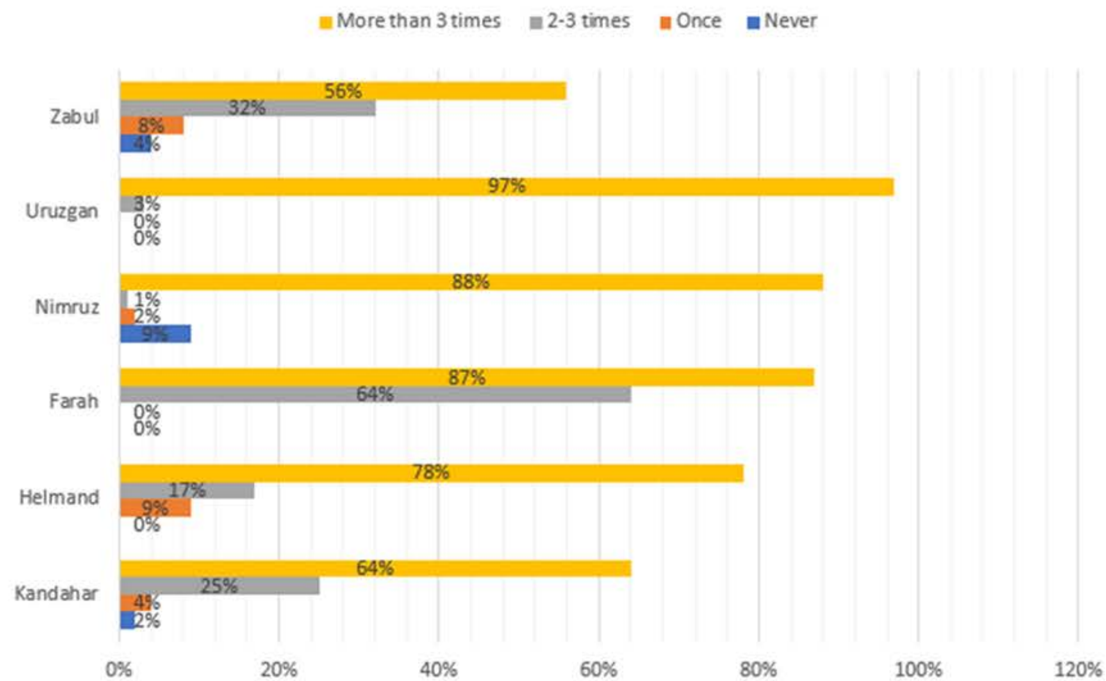


Chart 6: The frequency of health assistance under changing climate by the under-served communities (source: authors)

As a result of environmental and climatic changes in the region, access to resources has become a major challenge. This includes a shortage of drinking water, an increase in dust storms, and rising temperatures. Residents have witnessed the emergence of new plant and human diseases, locust attacks, reduced pollination leading to lower crop yields, seasonal allergies, increased exposure to ultraviolet rays, and vision loss. In addition, climate change has decreased their income and food security (Mayar, 2023), leading to less attention being paid to health and medical treatment. Despite these challenges, compared to previous years, there has been an increase in visits to healthcare centers for health problems and diseases. As residents and villagers in the area stated, "Respiratory, skin diseases, allergies, and vision problems have increased over the past few years.

Environment and Climate Changes

Climate change, as a global challenge, has had profound and concerning effects on the dry and desert regions of Afghanistan, particularly in the south and southwest of the country. These areas, which are already characterized by specific climatic conditions and limited water resources, have been severely impacted by climate changes and are facing significant challenges. On the other hand, floods, as another consequence of climate change, have caused widespread financial and human losses due to increased intensity of sudden rainfall (Aich et al., 2017; Azizi et al., 2024). The findings of this research highlight various phenomena resulting from climate change, which are discussed in detail below:

Drought

Climate change has had significant impacts on various regions of the world, and one of the most pressing issues in Afghanistan, particularly in the dry climate regions of the south (Helmand, Kandahar, Zabul, and Urozgan) and southwest (Farah and Nimruz), is the phenomenon of drought. Drought, often referred to as the dry season, denotes a prolonged period of low and abnormal rainfall, which leads to a shortage of water resources (Qutbudin et al., 2019). This has had profound effects on agriculture, water supply, household economies, social issues, and overall livelihoods in the affected regions.

Chart 7 shows the changes in the intensity and frequency of natural disasters within the study area over the past 5 years. A notable finding is the significant increase in natural disasters in Nimruz, where 38% of respondents reported a much more frequent of natural disasters, and 60% indicated that such disasters had slightly more frequent.

This highlights that Nimruz has been facing a growing challenge in coping with the effects of natural disasters compared to other provinces. The situation in Kandahar is also concerning, with 57% of the region reporting a slightly more frequent in natural disasters, and 15% reporting a much more frequent. In Helmand, 45% of respondents reported a slightly more frequent in natural disasters, while 43% in Farah experienced a much more frequent of disasters. In Urozgan, 14% and in Zabul, 19% witnessed a much more frequent in natural disasters.

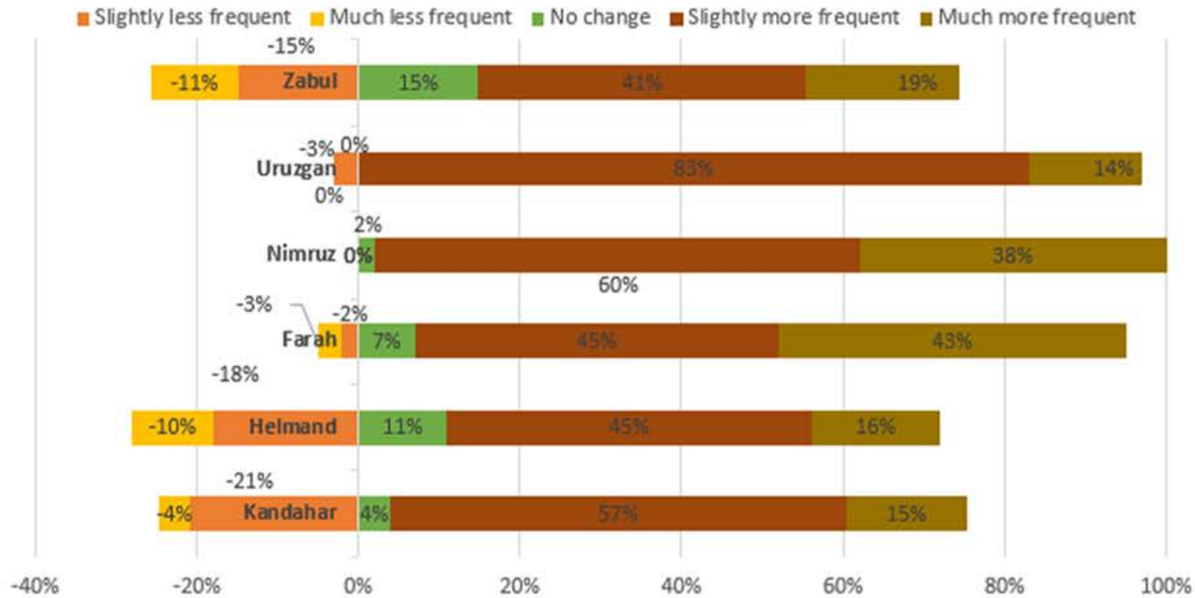
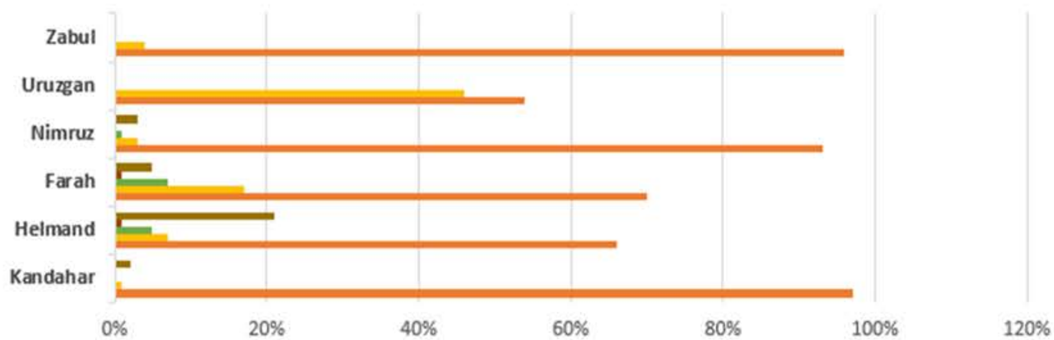


Chart 7: The frequency of natural disasters under changing climate (source: authors)

Given that these regions of Afghanistan have a dry and semi-dry climate, they are more vulnerable to the adverse effects of drought. The already limited water resources in these areas have come under pressure during prolonged droughts, exacerbating the challenges faced by local communities. One of the key challenges has been the increase in the number of days of unemployment in these regions, as shown in chart 8.



	Kandahar	Helmand	Farah	Nimruz	Uruzgan	Zabul
289-Above	2%	21%	5%	3%	0%	0%
217-288	0%	1%	1%	0%	0%	0%
145-216	0%	5%	7%	1%	0%	0%
73-144	1%	7%	17%	3%	46%	4%
72-Below	97%	66%	70%	93%	54%	96%

Chart 8: Impacts of extreme weather on the livelihood of farming communities (source: authors).

People in Afghanistan, especially in the southern and southwestern regions, have long been engaged in farming and livestock breeding, with their livelihoods relying on the cultivation of rain-fed crops, irrigation from canals or marshes, and animal husbandry. These communities are heavily dependent on rainwater for rain-fed agriculture and water from rivers or marshes for both drinking and irrigating crops. However, for the past decade, the increasing impacts of climate change, particularly prolonged droughts, have posed significant challenges to these communities, leading to the expansion of aridity and desertification (Loodin et al., 2023; Loodin, 2024b).

At the onset of the recent droughts, residents in these areas lost their rain-fed crops due to the lack of seasonal rainfall. This caused a series of negative effects, including the drying up of natural vegetation, reduced agricultural output, and lower productivity. The economic instability of households, desertification, soil degradation, and the reduction in crop yields all worsened. These changes have led to a decline in food security, as well as the social and economic well-being of these communities. With the loss of vital resources on which their livelihoods depend, their resilience has been severely impacted, and many have been forced to migrate in search of better opportunities and more secure living conditions (Hanif et al., 2022; Hanif et al., 2023).

The impact of drought on agricultural and livestock production in Kandahar, Helmand, Farah, Nimruz, Urozgan, and Zabul is illustrated in chart 9. The most significant finding is the severe impact of drought in Urozgan, where 90% of households reported substantial effects on their agricultural and livestock production. This indicates that Urozgan has been severely affected by the drought, causing major disruptions and challenges for the local population.

The impact of drought on agricultural and livestock production in Kandahar, Helmand, Farah, Nimruz, Urozgan, and Zabul is illustrated in chart 9. The most significant finding is the severe impact of drought in Urozgan, where 90% of households reported substantial effects on their agricultural and livestock production. This indicates that Urozgan has been severely affected by the drought, causing major disruptions and challenges for the local population.

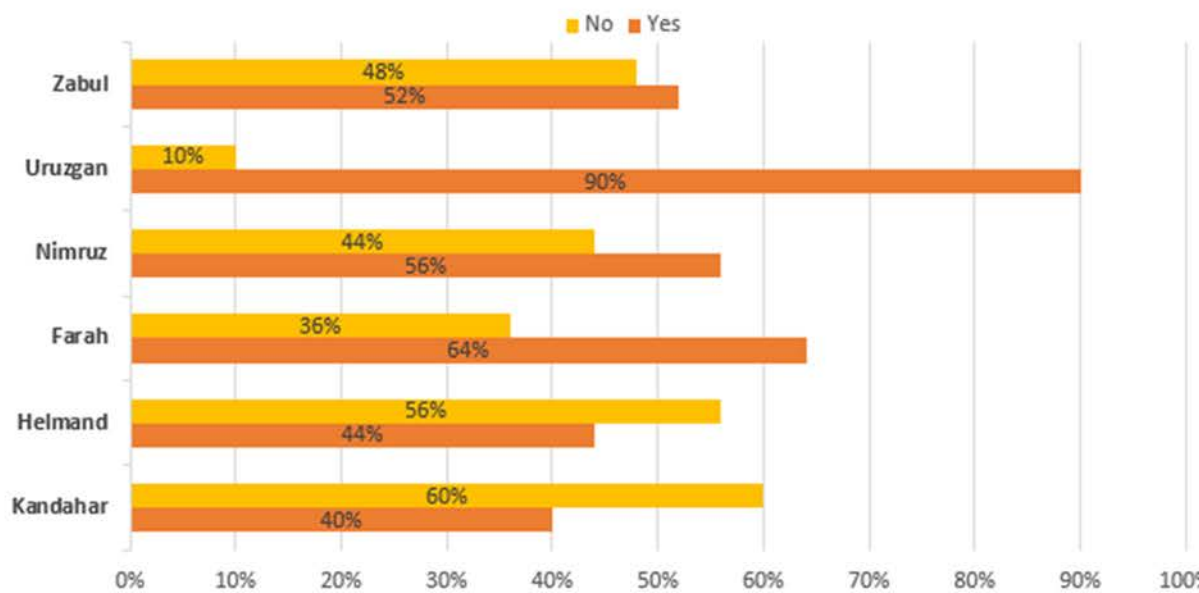


Chart 9: Agricultural productivity under climate-induced drought (source: authors).

In Farah, 64% of households reported significant impacts on their agricultural and livestock production. Similarly, in Kandahar, drought has also had a considerable effect, with 40% of households experiencing noticeable impacts on their farming and livestock. This shows that Kandahar has faced substantial challenges due to drought, which has affected the local population. In Helmand, 43% of households repored a significant impact, while 54% of households in Nimruz and 48% in Zabul also experienced considerable effects due to drought.

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Chart 10 reflects changes in agricultural land productivity in the southern and southwestern regions of Afghanistan over the past five years. The most concerning finding is the significant decline in land productivity in Urozgan and Farah, with 79% of households in Urozgan and 73% in Farah reporting a substantial decrease. This indicates that both Urozgan and Farah have experienced severe reductions in agricultural productivity, which can have serious consequences for the livelihoods and food security of the local populations.

In Nimruz, the situation is also alarming, with 65% of households reporting a greatly decreased in agricultural productivity. This shows that Nimruz has been facing significant challenges in maintaining agricultural productivity. The data from Kandahar, Helmand, and Zabul presents a mixed picture, with a combination of declines, increases, and no change in land productivity. In Kandahar, 15% of households reported a greatly decreased, while 31% of households in Helmand experienced a large decrease in productivity.

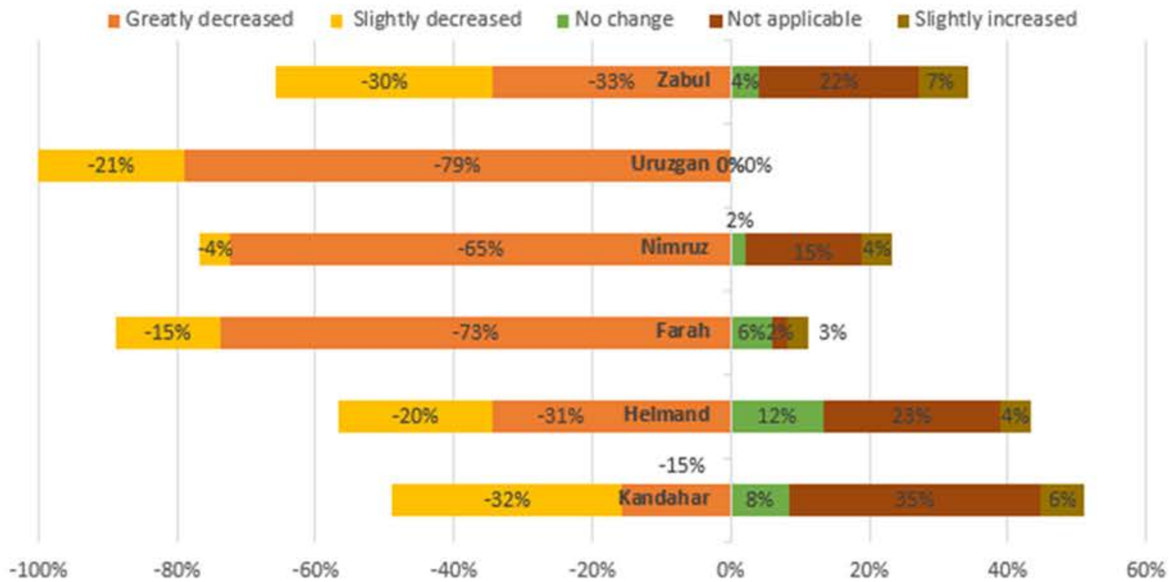

Chart 10: Farmland productivity under evolving changing climate (source: authors)

Over many years, a major portion of the income and livelihoods of farmers and herders in southern and southwestern Afghanistan has been dependent on rain-fed agriculture and livestock, particularly in mountainous and desert areas. However, due to prolonged droughts and decreasing rainfall over the past decade, these resources have significantly diminished. As a result, local residents have increasingly turned to irrigated agriculture to sustain their livelihoods, relying more heavily on underground water sources. Yet, the prolonged droughts and over-extraction of groundwater, as well as the drying up of rivers and wetlands, have led to a significant drop in groundwater levels.

As shown in chart 11, residents in Farah—one of the southwestern provinces—have observed a dramatic decline in groundwater levels over the last decade. For instance, in Dashte Bakwa, the groundwater depth has increased from 7 meters to 170 meters. In Kandahar, along the course of the Kajaki Dam, the water table has dropped from 8 meters to 80 meters. According to residents of Kandahar, "People are now gathering in areas where the water table is higher. Many desert areas have been turned into agricultural lands, and as a result, agriculture in such areas has increased." They continue to extract groundwater at significant depths using solar-powered pumps to water their crops, despite the steep decline in the water table (Mayar, 2022).

The ongoing droughts and falling groundwater levels have significantly impacted agricultural productivity. Previously, farmers could produce three harvests per year from the same land, but now this has been reduced to only one harvest annually (Nazari et al., 2023). Additionally, the rising temperatures and winds, which reduce moisture and cause soil dehydration, have further hampered crop growth. With irregular irrigation (once frequent, now reduced to a single irrigation session per week), the productivity of the land has dropped, and farmers are struggling to obtain sufficient quality crops.

Farmers, who traditionally relied on rainfall and natural water sources, have been severely affected by the over-exploitation of groundwater. One local resident mentioned in an interview: "At the beginning of the year, we borrow seeds, supplies, and other resources, hoping for rain to ease the drought. But the droughts always return, damaging our crops and land. Sometimes, we are forced to leave our area due to these conditions."

Moreover, prolonged droughts have put immense pressure on natural resources such as forests, wildlife, and local flora and fauna. The reduction in biodiversity, including native and migratory birds, reptiles, and wild animals, has disrupted the food chain and the local ecosystem. For instance, respondents from Kandahar mentioned that in Shah Wali Kot District, there were once forests and wildlife, including mountain goats, wolves, hyenas, and wild fruit trees, but these have significantly diminished due to drought and environmental degradation.

The depletion of water resources and the adverse effects of droughts have also led to a severe shortage of drinking water and basic sanitation. In the past 20 years, the increasing frequency of droughts and rising temperatures have created favorable conditions for the spread of skin and respiratory diseases, further exacerbating the challenges faced by these communities. The deepening impacts of droughts have led to food shortages, the destruction of green and forested areas, the loss of biodiversity, economic distress, and increased competition over natural resources (Nazari et al., 2023). These challenges have triggered social unrest, with residents competing for access to and ownership of dwindling resources. Consequently, many have sought alternative opportunities and resources to sustain their livelihoods, often migrating to neighboring districts, provinces, or even neighboring countries.

The rising migration due to droughts has intensified the over-exploitation of natural resources and put immense pressure on the infrastructure of host regions. This situation has fueled tensions, heightened crime rates, and contributed to internal conflicts, further destabilizing the affected areas (see Loodin et al., 2024b).

Flooding

Disruption of rainfall patterns and irregularities in the water cycle have become one of the most significant impacts of climate change in Afghanistan. Over the past two decades, the southern and western regions of the country have faced severe droughts and devastating floods. Flooding in these areas has notably increased in recent years, with flash floods and riverine floods becoming more frequent. In the past five years, these regions have experienced some of the worst flooding in their history, causing significant casualties, particularly in Kandahar, Farah, and Nimruz. These areas, which have low resilience and high vulnerability due to the loss of vegetation, desertification, the encroachment of riverbeds, and low public awareness, face both human and economic disasters every year. The impacts are felt not only by humans but also by ecosystems, agricultural land, infrastructure, and social services (Sefat & Tsubaki, 2024).

The people of southern and southwestern Afghanistan have traditionally relied on seasonal rainfall for their agriculture and livestock. However, over the last thirty years, there have been significant changes in climate patterns and rainfall distribution, which have resulted in decreased rainfall and a shift from steady, gentle rainfall to sudden, intense bursts. These changes have led to seasonal rain being replaced by heavy, sporadic rainfall during harvest seasons, which are often untimely.

The volume of rainfall and the accumulation of runoff from dry, low-lying watershed areas, which lack moisture, cause large volumes of water to accumulate, resulting in flash floods (Shokory et al., 2024).

Severe droughts and increasing temperatures have reduced soil moisture in these areas. In addition, human activities, such as deforestation and the destruction of native vegetation for heating purposes, have decreased the permeability of the soil and increased the speed of runoff. The frequent flash floods in such arid regions lead to the destruction of crops, homes, soil erosion, and loss of livestock and human lives. These floods also create enormous financial losses that are hard to recover from.

As reported in Farah province, one respondent noted, "The floods of 1990 and 1993 caused significant human and financial losses, completely destroying the farmers' crops. After those years, droughts have occurred regularly, leading to the displacement of many residents." Flash floods have also severely damaged crops during the harvest season, as one resident from Kandahar explained: "The harvests of fruit farmers, such as grapes and figs in Panjwai and Shah Wali Kot districts, were destroyed by flash floods that were completely unexpected, and now, due to these floods and continuous droughts, farmers are losing their interest in continuing agriculture."

In recent years, flash floods with heavy rainfall have become more common as a response to prolonged droughts. These floods, occurring unexpectedly during planting seasons (late in the first season and early in the second season), bring significant damage to crops, which are vital for the livelihood of the residents. Higher temperatures also enhance the atmosphere's capacity to hold moisture, which can potentially increase rainfall intensity. The combination of droughts, dust storms, and soil erosion (which reduces the ability of the soil to absorb water) has further reduced agricultural productivity, leading to lower household incomes and unsuitable living conditions.

Due to these factors, the residents of these areas seek safer and more stable living conditions, often resulting in internal displacement or transnational migration. The role of floods in migration is multifaceted: in some cases, individuals and communities are directly forced to leave their homes due to immediate flooding and seek refuge in other regions or countries. In other cases, the gradual and repeated occurrence of floods makes certain areas uninhabitable over time, causing a slow but steady migration of residents (Loodin, 2020).

Water level depletion

One of the significant impacts of climate change on the environment is the severe and deep reduction of water resources, which are the key source of life and the livelihood of residents in the dry and desert areas of Afghanistan (Mayar et al., 2024). Afghanistan is divided into five natural water basin regions. The Helmand River Basin is the largest in terms of area, but it is also considered one of the driest and most water-scarce basins in Afghanistan. Precipitation varies across different parts of the basin, especially in the upper and lower reaches. In the upper reaches, the annual rainfall exceeds 500 mm, while in the lower reaches, it is even less than 45 mm. The provinces of Zabul, Urozgan, Kandahar, and Helmand are in the central part of this river basin, while the provinces of Farah and Nimruz are in the lower or southern basins. A limited amount of the base flow of the Helmand River originates from the glaciers and highlands of the Hindu Kush, but with the increase in melting rates and changes in precipitation patterns, significant changes have occurred in the river and lake flows of the basin. However, the main water crisis, according to research findings, is in the provinces of Nimruz and Farah. These provinces, as downstream regions, are experiencing harsher conditions due to their dry climate, lack of hydrotechnical development, and natural position in the watershed. The absence of river flow and the drying up of qanats and surface water sources has led the people to unsustainable extraction of groundwater resources (Loodin et al., 2023).

Agriculture and livestock are the main occupations of the majority of people in these provinces, and water resources, both surface and groundwater, are essential for their livelihood and work. Provinces like Kandahar, Helmand, Zabul, and Urozgan, which have relatively better water resources, still maintain the capacity for agriculture and livestock compared to Farah and Nimruz. They produce a variety of crops such as pomegranates, grapes, and sorghum, which are exported to neighboring provinces and even abroad during different seasons.

Significant changes in rainfall patterns have occurred in these regions over the past five years. According to chart 11, the rainfall patterns have changed significantly, with some areas experiencing much less rainfall, while others have seen a slight increase. According to survey findings from the people: the residents of Kandahar have experienced a 20% much less in rainfall, with a slightly more 42% in the total rainfall. Helmand has seen a 21% much less in rainfall, but with a 35% slightly more in the amount of rainfall. Farah has experienced a 64% much less in rainfall, with a slightly more 13% increase in total rainfall. Nimruz has seen a 72% decrease in rainfall, with a slight 15% increase. Urozgan has faced a 24% decrease in rainfall, with a 7% increase in total rainfall. Zabul has experienced a 56% decrease in rainfall, with a slight 15% increase.

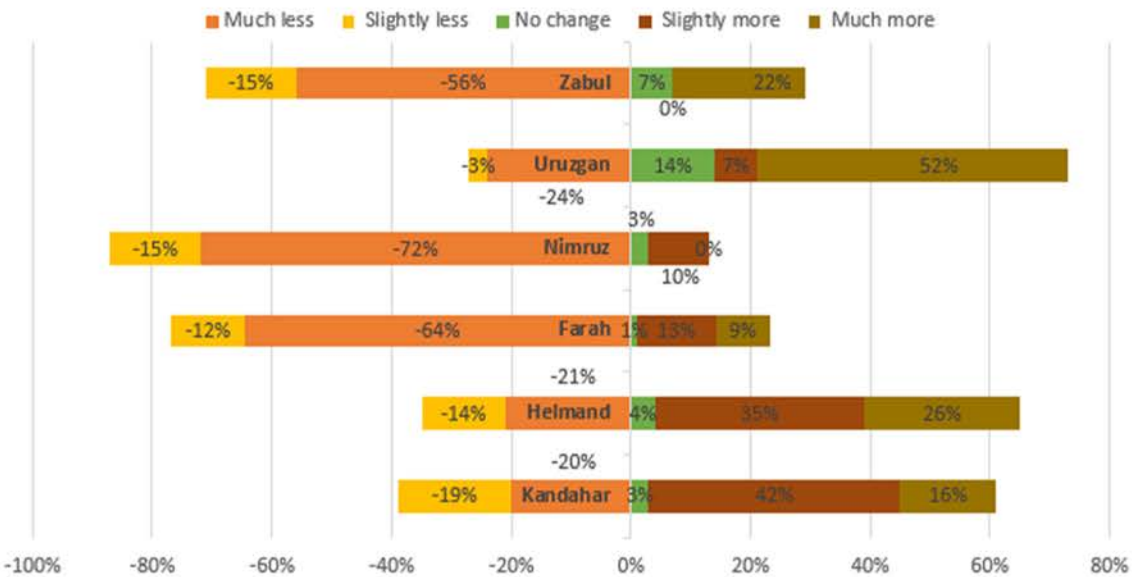

Chart 11: Change in rainfall patterns in south and southwestern Afghanistan in the last five years (source: authors).

As a result of decreased rainfall, prolonged droughts over the past several decades, rising temperatures, high evaporation rates, and the drying up of rivers, streams, and wetlands, many farmers have abandoned this industry. However, most people, faced with reduced surface water, have turned to digging deep wells with solar systems, which are considered a free resource (groundwater and solar energy). Since these provinces have the sunniest days of the year, people extract water using solar energy, sometimes at alarming rates, from deep underground for agricultural, drinking, hygiene, and other uses. There is ongoing competition among people to use groundwater resources for high-consumption, traditional farming. Excessive and unregulated use of groundwater, combined with ongoing droughts over the years, has severely reduced access to this resource. As a result, the residents of these provinces have identified water scarcity as the primary challenge resulting from these changes, affecting their livelihoods (Nazari et al., 2023; Loodin et al., 2024b).

Chart 12 shows the experiences of households with water shortages in the past year in the southern (Helmand, Kandahar, Zabul, and Urozgan) and southwestern (Farah and Nimruz) regions of the study area. Nimruz, in particular, has faced the most severe water scarcity challenges, with 64% of households occasionally facing this problem and 31% always experiencing it. In contrast, only 5% rarely or often encounter water shortages. Farah also faced significant water scarcity, with 56% of households occasionally facing this challenge and 14% always experiencing water shortages.

In Helmand, 24% encountered water shortages occasionally, while another 24% faced them rarely or often In the provinces of Kandahar (3%), Helmand (2%), Zabul (4%), and Urozgan (3%), the situation was slightly better, but it remains concerning.

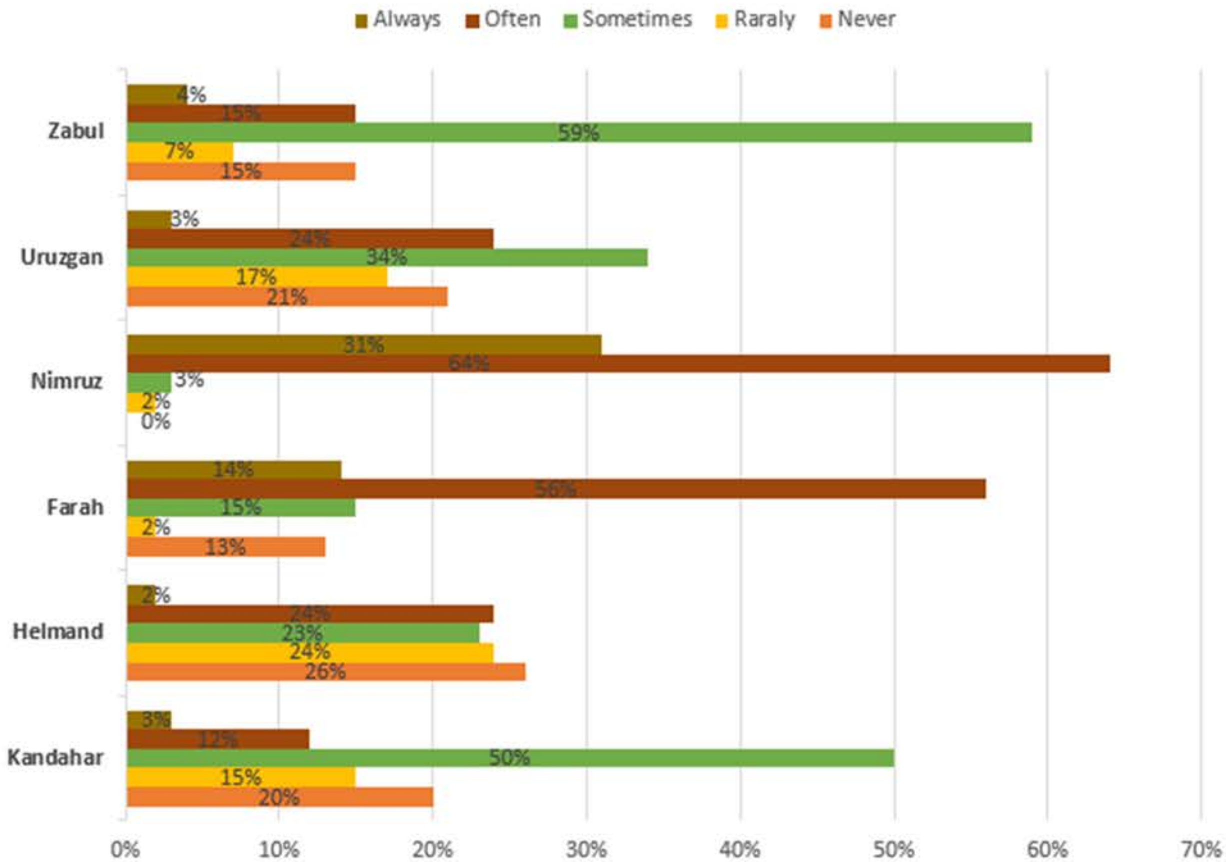

Chart 12: Water insecurity at the household level (source: authors).

If access to drinking water is provided through household deep wells, families without access to this resource spend a significant amount of time and effort to obtain it. As shown in chart 13, in Kandahar province, 81% of people, in Helmand province 72%, in Farah province 89%, in Urozgan province 83%, and in Zabul province 70% obtain drinking water from deep wells. However, in Nimruz province, most of the drinking water is purchased or obtained from pipes.

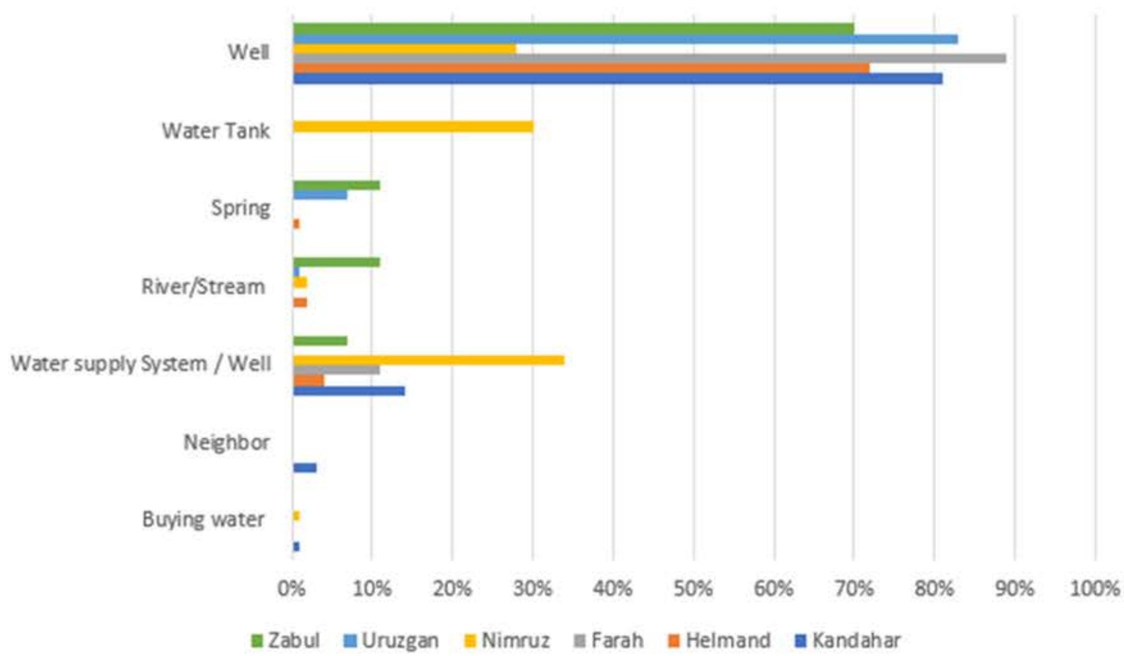

Chart 13: Primary source of drinking water in south and southwestern Afghanistan (source: authors).

Respondents in the Khak Safid district of Farah province stated, "In this province, the depth of groundwater has increased on average from 7 meters to 70 meters over the past decade, indicating a tenfold drop in the water level." In some areas, farmers have drilled deep wells up to approximately 170 meters to continue irrigating their fields for a longer period due to the rapid decrease in groundwater levels. However, many farmers cannot afford such investments and are forced to reduce their crops or even abandon their areas. A notable example is the districts of Beka and Gulistan, where the water level has reached 170 meters. In the center of Farah province, drinking water is purchased, and residents spend long periods traveling to the source and waiting in water queues.

Chart 14 shows changes in groundwater levels in the southern (Helmand, Kandahar, Zabul, and Urozgan) and southwestern (Farah and Nimruz) regions over the past 5 years. Farah experienced the most drastic decrease, with 91% of the area reporting a significant decrease in groundwater levels, reflecting a severe reduction in local water levels. Nimruz also faced a significant decrease, with 74% of the area reporting considerable groundwater level decrease, indicating a concerning trend of water scarcity. In Urozgan, 66% of the area reported a significant decline in groundwater levels. Similarly, in Kandahar, 48% of the areas experienced a significant reduction, while Helmand and Zabul reported 34% each with a noticeable decrease in groundwater levels.

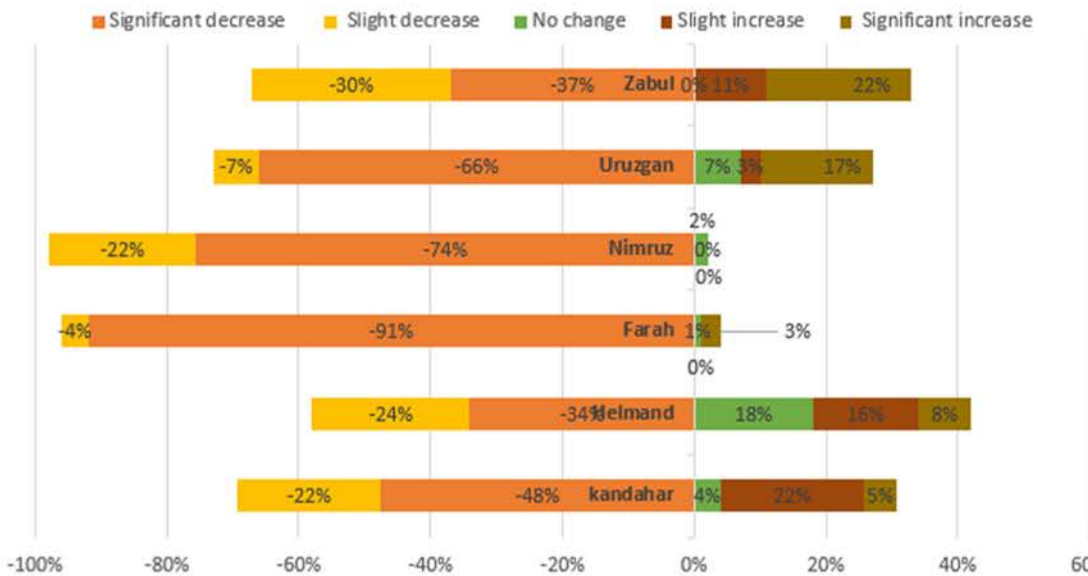

Chart 14: Fluctuation in groundwater level in south and southwestern Afghanistan (source: authors).

With the reduction in surface and groundwater, attention to hygiene in households has reached its lowest point. Due to inadequate and insufficient access to water, its use for hygiene purposes and the consumption of enough water for health has drastically decreased, leading to various diseases caused by insufficient water usage. As one respondent stated, "With reduced access to sufficient water, daily needs for drinking, bathing, washing clothes, and other hygiene matters have significantly decreased." As we can see chart 15, the impacts of climate change on household hygiene practices in the southern and southwestern regions of Afghanistan are presented. The data shows that Nimruz and Zabul are the most severely affected areas, with 28% of households in Nimruz and 22% in Zabul reporting disruption in their hygiene practices due to climate change. Additionally, 57% of households in Nimruz were heavily impacted, indicating a significant challenge in maintaining proper hygiene standards. In Helmand, 39% of households were severely impacted, and 31% were moderately affected. Similarly, in Kandahar, 11% of households, and in Urozgan, 59% of households were severely affected, showing a considerable impact on hygiene practices in these regions.

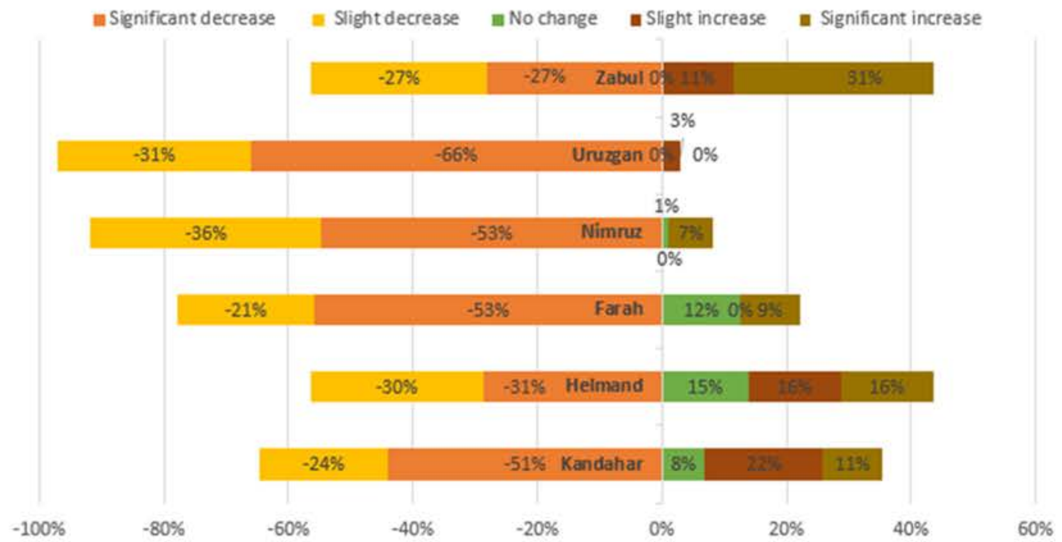

Chart 15: Adverse effects of climate changes on hygiene practices of communities (source: authors).

In addition to hygiene issues, the reduction in groundwater and the drying up of surface water, combined with the occurrence of severe dust storms, has led to soil erosion, significantly reduced soil moisture, and the destruction of many trees, wild grass, and vegetation in the natural plains and mountains. This has impacted wildlife and bird migration, contributing to a significant decline in their numbers.

Chart 16 indicates that Zabul province has experienced the most severe disruptions, with 11% of households reporting that their access to clean drinking water was "completely disrupted," and 22% stating that they were "severely affected." However, 30% experienced only "moderate impact," and 19% were "slightly affected." In Urozgan province, the majority (59%) of households reported a "moderate" impact, 21% were "slightly affected," and 10% were "severely affected." In Nimruz province, a significant portion (64%) of households reported a "moderate" impact, 15% were "severely affected," and 16% were "slightly affected," with 4% experiencing "complete disruption." Farah and Helmand provinces showed a mix of impacts, with families reporting "slightly affected," "moderately affected," and "severely affected" levels. Farah had 9% of households with "complete disruption," while Helmand had 1%. In Kandahar province, 25% of households were "not affected," 26% were "slightly affected," 32% were "moderately affected," 15% were "severely affected," and 2% experienced "complete disruption," reflecting the widest distribution of impacts.

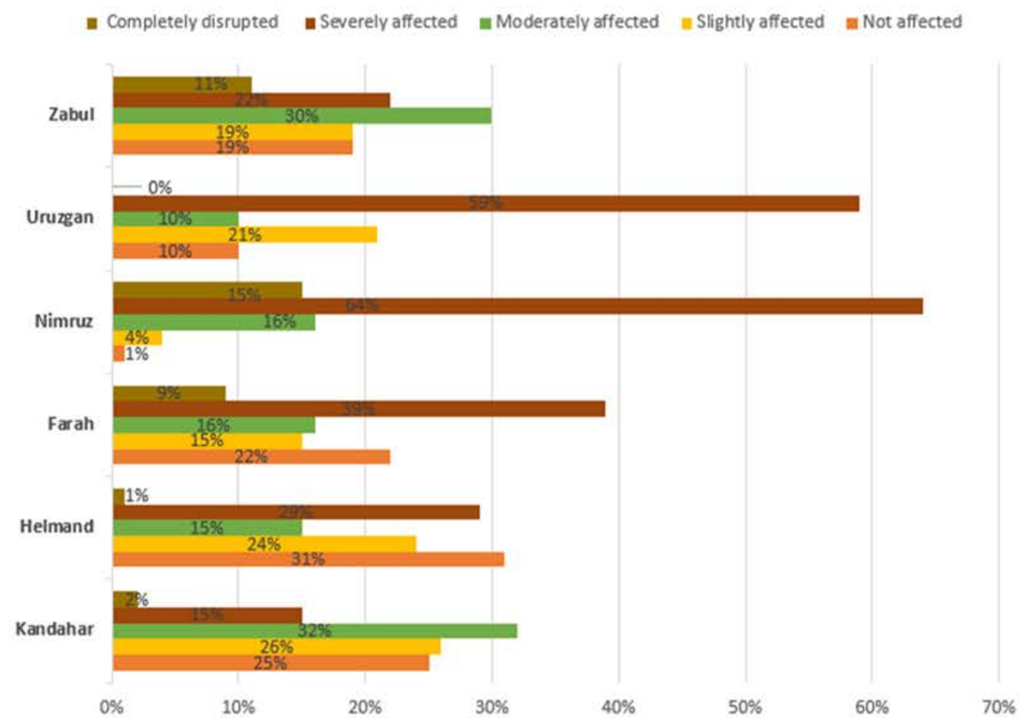

Chart 16: Impacts of climate changes on household access to drinking water (source: authors).

With the decrease in groundwater levels and the reduction or seasonal availability of surface water in the arid desert climate regions of Afghanistan, where agriculture is the only source of income, livelihoods face a serious challenge. This directly affects the productivity of crops, which in turn impacts the income and financial stability of families. As a result, in the face of water scarcity, people strive to preserve their livelihoods by seeking better opportunities and are often forced to migrate to other areas in search of job opportunities and alternative sources of income.

Temperature Variability

The industrialization of the world, driven by the use of fossil fuels, has been effective in promoting economic, social, and technological growth. However, it has had a severely negative, and even irreversible, impact on the environment, particularly in disrupting the global climate system. Global warming, or the increase in temperature, is considered the key factor driving climate change worldwide. Even small changes in this phenomenon can significantly affect other climatic parameters such as humidity, wind, air pressure, evaporation, and transpiration. The southwestern regions of Afghanistan, as very dry and desert areas, have been more impacted than other parts of the world. According to research findings based on interviews with water and environmental specialists, for the past 70 years, the climate in the southern and western provinces of Afghanistan has been influenced by the Indian monsoon climate, receiving a large amount of moisture. This meant that areas such as the Sistan region received considerable and effective rainfall. However, over time, with the increase in global temperatures, the climate of this region has shifted toward a drier and more desert-like condition.

The unprecedented rise in temperatures in the southern and southwestern regions of Afghanistan has created numerous challenges for the residents, including widespread consequences for human health, agriculture, the economy, and environmental conditions.

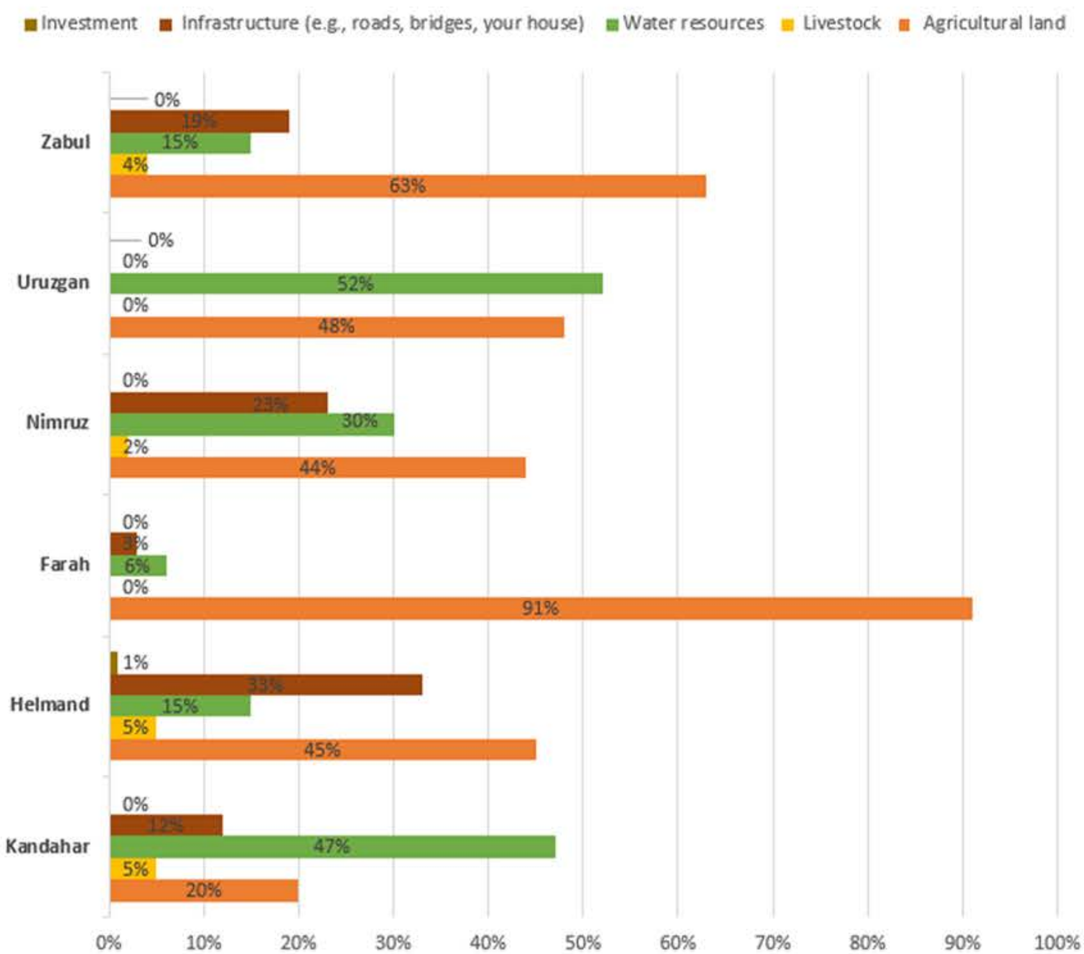

Chart 17: Household assets under changing climate (source: authors).

The most prominent finding is the significant impact on agricultural lands. As chart 17 indicates, the effects of climate change on various assets of households in the southern and southwestern regions of Afghanistan are demonstrated. In Farah, 91% of households reported that their agricultural lands have been affected by climate change. In Zabul, 63% of agricultural lands have been affected, while in Helmand and Nimruz, these charts are 45% and 44%, respectively. This indicates that climate change is a major threat to the agricultural livelihoods of these regions. The chart also shows that climate change has had a significant impact on infrastructure, such as roads and bridges, in these areas. In Helmand, 33% of households reported damage to infrastructure, 12% in Kandahar, 23% in Nimruz, and 19% in Zabul. Water resources have also been significantly affected. In Urozgan, 52% of households reported issues related to water resources, while 47% in Kandahar, 30% in Nimruz, 15% in Zabul, 15% in Helmand, and 6% in Farah faced challenges.

The residents of these regions, who are among the low-income groups and whose livelihoods primarily depend on agriculture and livestock, live with minimal basic resources. Recently, the effects of climate change, such as prolonged droughts, declining groundwater levels, and the drying up of rivers and lakes, have compounded their problems. In addition to these challenges, changes in temperature (heat and cold) have become another obstacle due to their vulnerability. Increased temperatures and changing weather patterns have had both direct and indirect effects on their health. Heatwaves and extreme temperatures have led to an increase in heat-related diseases and mortality. Furthermore, changing temperature patterns have caused the spread of infectious diseases, respiratory problems, heatstroke, fever, dizziness, dry skin, reduced eyesight, and severe seasonal allergies during the hot season. In some cases, fatalities due to ultraviolet radiation have also been reported. As one respondent mentioned, "In recent years, temperatures of 52°C in Farah have been unprecedented, and water shortages, along with increasing winds, have led to a rise in diseases." In addition to the heat, the cold weather during seasons has also been unprecedented, with temperature increases of 6 to 12 degrees above average in these areas according to climate models. This has altered both cold and warm seasons, with recent years witnessing dry and mild winters and heavy rains during the spring with cold temperatures. In the winter, farmers are affected by the lack of rainfall and absence of cold temperatures that would allow worms to go dormant and die, while in spring, they face unexpected cold and severe flooding, which damages their crops. As one local resident stated, "The sudden cold weather in a season we did not expect caused our crops to freeze and many flowers on our trees to die."

In addition to the widespread health consequences of temperature changes, this climatic factor has significantly impacted the agricultural environment and the economy of the residents in these areas. As previously highlighted, most residents rely on agriculture and livestock for their livelihood, making access to water crucial. However, rising temperatures have adversely affected both agriculture and livestock farming (Hajihosseini et al., 2020). Since 1950, Afghanistan's mean annual temperature has increased significantly and considerably by 1.8°C. This warming is most pronounced in the South, which experienced a temperature increase of 2.4°C, as well as the Central Highlands and North that experienced increases of 1.6°C and 1.7°C, respectively. In terms of future projections, under an optimistic (RCP 4.5) scenario, Afghanistan shows a trend of warming by approximately 1.5°C until 2050, followed by a period of stabilization and then additional warming up to approximately 2.5°C above current temperatures by 2100. In contrast, a pessimistic (RCP 8.5) scenario shows extreme warming across the whole country of approximately 3°C until 2050, with further warming up to 7°C above current temperatures by 2100. Under both scenarios, there are regional differences, with higher temperature increases expected at higher altitudes than in the lowlands. This prolonged warming trend has exacerbated challenges by intensifying water shortages, which directly affect soil moisture levels, agricultural productivity, and food security (SNC, 2017). A one-degree increase in temperature causes 7% more water to evaporate, and this heat, in the form of intense heatwaves, has led to higher evaporation of water on the surface and even in the underground moisture of the soil.

In general, the increase in temperature in the areas under study has led to water shortages, increased agricultural diseases and pests, growth of harmful insects, reduced pollination, decreased agricultural productivity, rising human diseases, and food insecurity (Nabavi, 2024). Consequently, these anomalies have triggered higher unemployment rates and diminished incomes for residents. This reality was further emphasized by respondents who noted, the scorching heatwaves and unprecedented water scarcity in the districts of Bakva and Khak Safid in Farah have caused many areas to become deserted. Such findings underscore the interconnected effects of rising temperatures on livelihoods, migration patterns, and the socio-economic fabric of these vulnerable regions.

The combination of environmental challenges, economic difficulties, food insecurity, and climate change—particularly increasing temperatures and changing weather patterns—has significantly impacted the lives of people in southern and southwestern Afghanistan, disrupting their livelihoods and migration patterns in these areas. As shown in chart 4, a decrease in agricultural productivity has also been reported.

Chart 4 illustrates the changes in agricultural land productivity in the southern and southwestern regions of Afghanistan over the past five years. The most notable finding is the significant decrease in agricultural productivity in Urozgan and Farah, where 79% of households in Urozgan and 73% in Farah reported a significant decline. This indicates that both Urozgan and Farah have experienced severe reductions in agricultural productivity, which could have serious consequences for the livelihoods and food security of the local population.

The situation in Nimruz is also concerning, with 65% of households in the region reporting a significant decline in agricultural land productivity. This suggests that Nimruz is facing significant challenges in maintaining agricultural productivity as well.

In contrast, the data from Kandahar, Helmand, and Zabul presents a more mixed picture, showing a combination of decreases, increases, and no changes in agricultural productivity. In Kandahar, 15% of households reported a significant decrease, while in Helmand, 30% reported a considerable decline in productivity.

The increase in sand and dust storms

Climate change has brought various environmental challenges, including increased occurrences of drought and water scarcity. These changes have led to an increase in wind patterns in many parts of the world, and the arid desert climate of southern and southwestern Afghanistan is no exception. The impacts have been significant on agricultural lands, water resources, the spread of diseases, soil erosion, reduced productivity, household livelihoods, and consequently on migration (Sadid, 2024).

Winds are caused by significant changes in air pressure resulting from sudden temperature shifts. Regions with more active meteorological dynamics to balance air pressure are more prone to winds. However, the issue of dust and particulate matter in the air, leading to dust storms and sandstorms in the studied regions, is a major environmental challenge. The drying up of the Aral Sea in Central Asia, due to the promotion of cotton cultivation and agricultural land expansion by the Soviet Union in Central Asian countries, as well as the drying of marshes and wetlands in neighboring countries of Afghanistan and the desiccation of the Hamouns in Farah and Nimruz, are major causes of increased dust storms and particulate matter in the region. Airborne particles can travel thousands of kilometers from one region to another. Therefore, to study the origin of these dust particles affecting the southern and western provinces of Afghanistan, highly specialized research is needed (see Sadid, 2024).

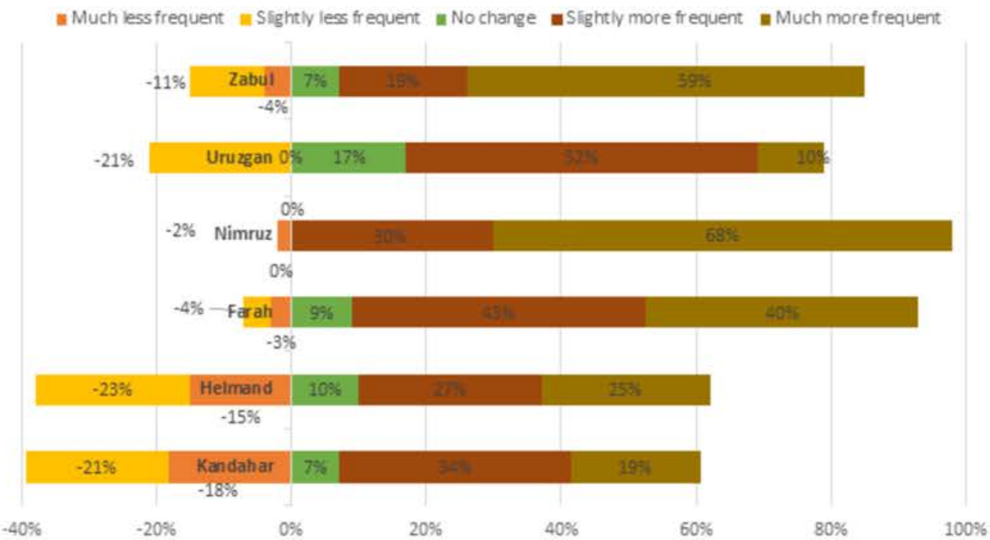

Chart 18: Dust storm occurrences in south and southwestern Afghanistan (source: authors).

Agricultural lands have also experienced reduced crop productivity due to decreased soil moisture and increased soil erosion caused by dust storms, to the point where many trees and crops have perished in various seasons due to lack of water and increased winds. As one respondent stated, "Many trees along the streams, forests, and orchards of jujube, pomegranate, and grapes have dried up unprecedentedly in Farah province due to severe dust storms." In addition to crop losses, sandy winds have caused vision problems, increased skin diseases, and heightened sensitivities (Salehi et al., 2024).

Overall, the increase in storms and dust has harmed public health, polluted natural resources, and disrupted transportation systems, including highways and agricultural lands in the provinces of Nimruz and Farah. This has also become a push factor for migration to neighboring provinces or districts. The consequences of this migration and displacement include increased competition for natural resources in the areas where people have settled, as well as potential conflicts with local communities. Additionally, the loss of traditional livelihoods and cultural practices exacerbates the challenges faced by these marginalized groups.

Biodiversity

Afghanistan's rich natural environment is under increasing threat of degradation and loss resulting from 45 years of instability and a rapidly increasing human population. Protecting biodiversity is critical to maintaining the capability of the land to support human livelihoods and sustain ecosystem integrity (NBSAP, 2024).

Afghanistan's varied topography has created a number of diverse habitat types, with temperature and precipitation changing considerably at different elevations. The species that occupy these habitats are uniquely adapted to their ecosystems and, therefore, vulnerable to the impacts of climate change. Afghanistan is home to more than 700 species of animals and 3,500-4,000 native vascular plant species. Human activity, especially habitat fragmentation, is the primary cause of biodiversity loss, though climate change is expected to become the single largest global cause of biodiversity loss before the end of the century (SNC, 2017).

The three major threats to Afghanistan's biodiversity are loss and degradation of natural ecosystems, the effects of climate change and overexploitation of living resources. Lesser, but still significant, threats are environmental pollution, invasive species, the diversion and unsustainable use of water, and the loss of genetic diversity in wild and domesticated species. Afghanistan's 45 years of instability and rapidly increasing human population have amplified each of these threats (NBSAP, 2024)

The southwestern provinces of the country, compared to other regions of Afghanistan, have a lower number of forests and rangelands. Findings from this study, based on interviews with respondents, indicate that the lack of energy for heating and cooking, as well as the inability of people to afford materials like iron or rebar for construction, have contributed to the destruction of forests and loss of biodiversity in recent decades, alongside the effects of climate change as human factors (Breckle et al., 2018).

In recent years, the dry climate and severe droughts in desert areas, coupled with scattered and insufficient rainfall, have had very negative effects on various environmental elements in the region. These sudden climate patterns have significantly impacted the biodiversity of these areas, leading to changes in ecosystems that have affected various plant and animal species. As residents of Farah province stated, "Most of the native animals, migratory reptiles, or extinct species, shrubs, and field fodder have generally dried up and disappeared. Animals and birds have mostly migrated, and field fodder has not been observed due to repeated droughts over the years."

The excessive water stress in the region, along with sudden flooding, has disrupted the natural growth cycle, reduced vegetation cover, and endangered vital habitats for wildlife in these areas. As residents of Nimruz province stated, "We have always witnessed desert birds such as Por, Chers, Lugo, and animals like rabbits and jackals," but with the impacts of climate change, the food chain in these ecosystems has been disrupted. As a result, these animals and birds have significantly decreased; some have migrated, while others have perished. However, in recent years, due to the damage to the region's food chain, various types of pests, such as marmots, have increased, causing damage to agricultural lands and crops. Additionally, the number of insect attacks, such as locusts, has also risen in recent years.

Chart 19 illustrates the changes in local biodiversity over the past 5 years in the provinces of Kandahar, Helmand, Nimruz, Farah, Urozgan, and Zabul. In Urozgan, 66%, in Nimruz and Farah 53%, and in Kandahar 51% of the areas have experienced a significant decrease in biodiversity. This indicates that biodiversity in these regions is under severe pressure. Helmand and Zabul show a similar pattern, with 31% and 27% of their areas reporting a significant reduction in biodiversity.

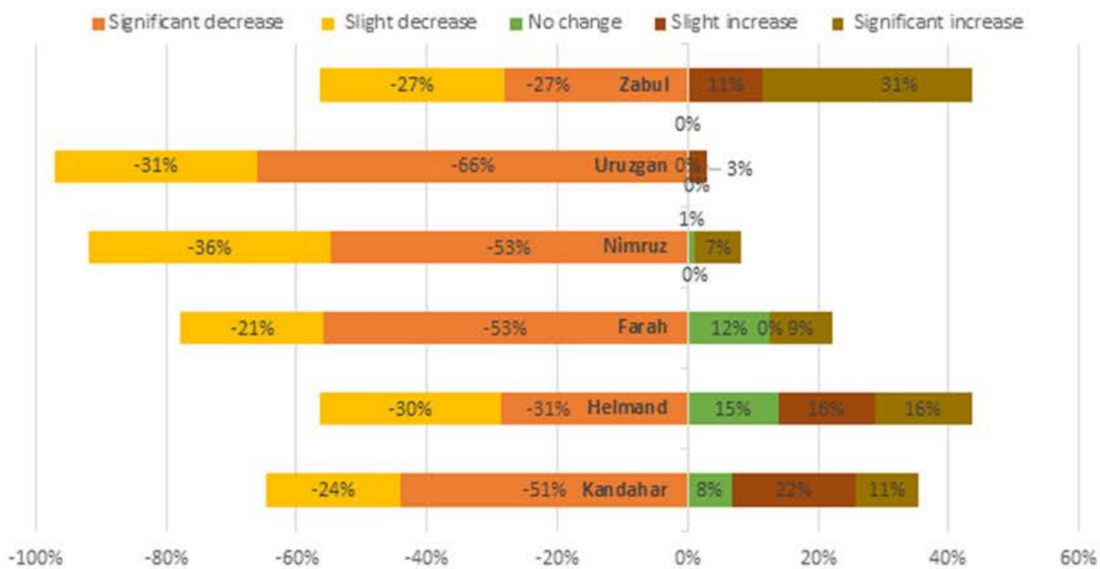

Chart 19: Biodiversity changes in south and southwestern Afghanistan (source: authors).

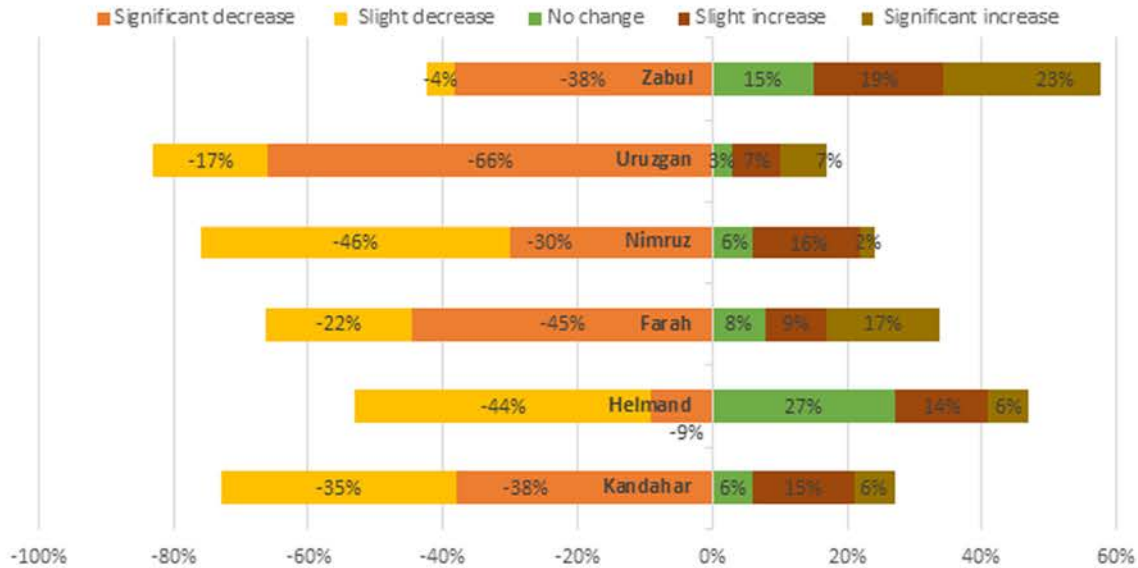

Chart 20: Animal population changes in south and southwestern Afghanistan (source: authors).

Chart 20 highlights a deep overview of the changes in the local animal population sizes in the southern and southwestern regions of the country over the past 5 years. In Kandahar and Zabul, this chart clearly shows that 38% of the area has experienced a significant decrease in animal populations, while only 6% in Kandahar and 7% in Zabul have seen a notable increase. This indicates that the animal populations in Kandahar are heavily impacted by factors such as drought, disease, or human-wildlife conflict. Similarly, Helmand and Farah also show significant reductions. Nimruz, as a region, has the most concerning statistics, with 46% of the area experiencing a significant decrease in animal populations, while only 16% saw a slight increase.

AHP Analysis

AHP serves as the core methodological framework for this research, enabling a systematic approach to multi-criteria decision-making and environmental analysis. This method allows for the structured quantification of complex environmental interactions by decomposing the research problem into a hierarchical structure of goals, criteria, and alternatives. In our study, five primary environmental layers were carefully selected and weighted: Precipitation (CHIRPS), Normalized Difference Vegetation Index (NDVI), Potential Evapotranspiration (PET), Sand and Dust Storm intensity, and Groundwater Storage (GWS). Each layer was assigned a specific weight reflecting its relative importance in driving internal displacement: NDVI and PET at 25% each, Precipitation at 20%, Sand and Dust Storm at 15%, and Groundwater Storage at 15%. By applying a WLC model within a GIS framework, we transformed these weighted environmental factors into a spatially explicit assessment of migration potential, providing a nuanced understanding of climate-induced population movements in Afghanistan.

Precipitation

The Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) is a 35+ year quasi-global rainfall dataset designed to address gaps in precipitation monitoring. Spanning latitudes 50°S to 50°N and covering the period from 1981 to the near-present, CHIRPS combines high-resolution (0.05°) satellite imagery, in-situ rain gauge data, and climatological models to produce reliable, gridded rainfall time series. Developed collaboratively by USGS, CHC scientists, and partners like NASA and NOAA, CHIRPS supports early warning systems for drought and environmental monitoring, particularly in regions with sparse surface data.

Key features include:

- Integration of satellite and ground-based rainfall data.
- Correction of biases due to complex terrains.
- Applicability for trend analysis, drought monitoring, and climate studies.
- Public domain accessibility to support research and humanitarian initiatives.

CHIRPS has been instrumental in initiatives like USAID's Famine Early Warning Systems Network (FEWS NET), helping place current rainfall variations in a historical context for effective decision-making.

Spatial Analysis

The spatial distribution of mean rainfall across Afghanistan from 2018 to 2023 was analyzed using CHIRPS monthly rainfall data. This data was processed and analyzed through GIS to produce the map below, which highlights significant regional variability in precipitation. Higher rainfall concentrations are observed in the northeastern and eastern regions, while the western and southern areas experience considerably lower rainfall.

This analysis provides critical insights into Afghanistan's precipitation patterns, which are essential for understanding the impacts of climate change. The spatial variability in rainfall plays a crucial role in drought occurrences, water resource distribution, and agricultural productivity. Furthermore, this data serves as a key input for AHP-GIS modeling to assess climate-induced challenges, such as internal displacement and migration trends.

Northern Zone

- Rainfall: 250–500 mm, some areas >500 mm.
- Features: Supports seasonal agriculture; drought-prone.

Eastern Zone

- Rainfall: 500–1,283 mm (highest in the country).
- Features: Orographic rainfall ensures water availability for agriculture.

Central Zone

- Rainfall: 100–250 mm.
- Features: Rain-fed agriculture; water scarcity due to limited storage and high population.

Western Zone

- Rainfall: 50–100 mm, some areas <50 mm.
- Features: Arid with high evapotranspiration; prone to desertification and water shortages.

Study Area (Southwest)

- Rainfall: 6.8–50 mm (driest region).
- Features: Severe aridity, drought-driven displacement, high climate vulnerability.

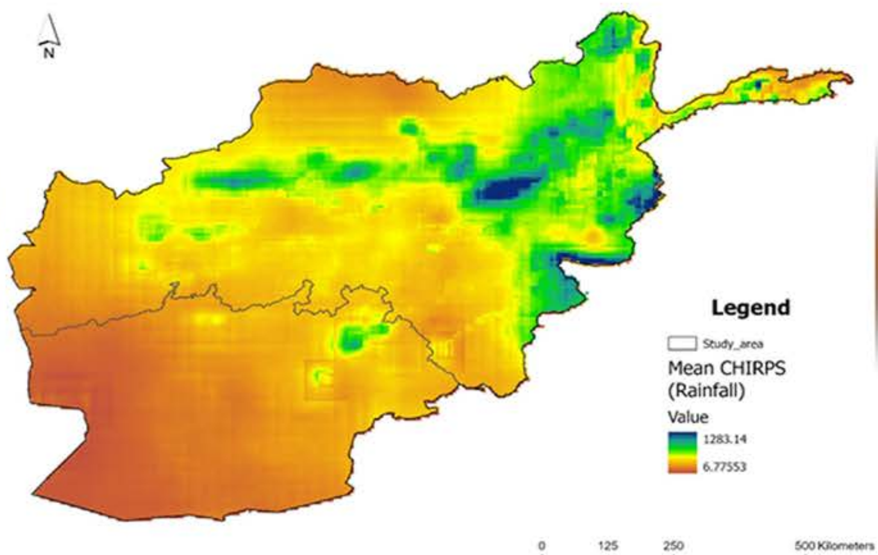

Figure 14: Average Rainfall (CHIRPS), Afghanistan, 2018 -2023, (source: authors)

Rainfall Analysis by Province and District in the Study Area:

Farah Province:

- Rainfall: Predominantly low, ranging from 48 to 220 mm annually.
- Key Districts:
  - o Pur Chaman and Gulistan: Receives marginally higher rainfall compared to surrounding districts.
  - o Lash-e-Juwayn and some parts of Shib Koh: Extremely low precipitation, highlighting severe aridity.

Helmand Province:

- Rainfall: Mostly arid, ranging between 50 and 220 mm annually, with slight variability.
- Key Districts:
  - o Baghran, Nawzad, and Nawai-i-mesh: Slightly better conditions compared to the other dis tricts.
  - o Reg-e-khan Nishani, and Deshu: Among the driest, receiving rainfall closer to the Char Burjan districts of Nimruz.

Nimruz Province:

- Rainfall: Severely arid, with most districts receiving rainfall below 35 mm annually.
- Key Districts:
  - o Zaranj, Kang, Asl-e-Chakhansur and Char Burjak: Faces extreme aridity with negligible rainfall.
  - o All districts except Dilaram: Persistently dry conditions, exacerbating desertification risks.

Kandahar Province:

- Rainfall: Ranges between 70 and 350 mm in northern districts, while southern areas fall below 70 mm.
- Key Districts:
  - o Shah Wali kot, Khakrez, and Kandahar City: Relatively better rainfall, supporting agricultural activities.
  - o Reg, Takhta Pul, Panjwayee, and Miwand, Dan: Drier conditions, affecting water availability.

Zabul Province:

- Rainfall: Receives moderate rainfall in comparison, ranging from 250 to 490 mm.
- Key Districts:
  - o Daichopan, and Qalat: Experiences better precipitation due to elevation and geographic position.
  - o Shah Joy, Tarank-wa-Jaldak: low rainfall supports limited agricultural practices.

Urozgan Province:

- Rainfall: The highest rainfall across the study area, ranging from 300 to 590 mm annually.
- Key Districts:
  - o Chinarto, and Khas Urozghan: Receives the highest precipitation due to proximity to high-alti tude regions.
  - o Trinkot, and Gizab: Also benefits from enhanced rainfall, supporting agriculture and local liveli hoods.

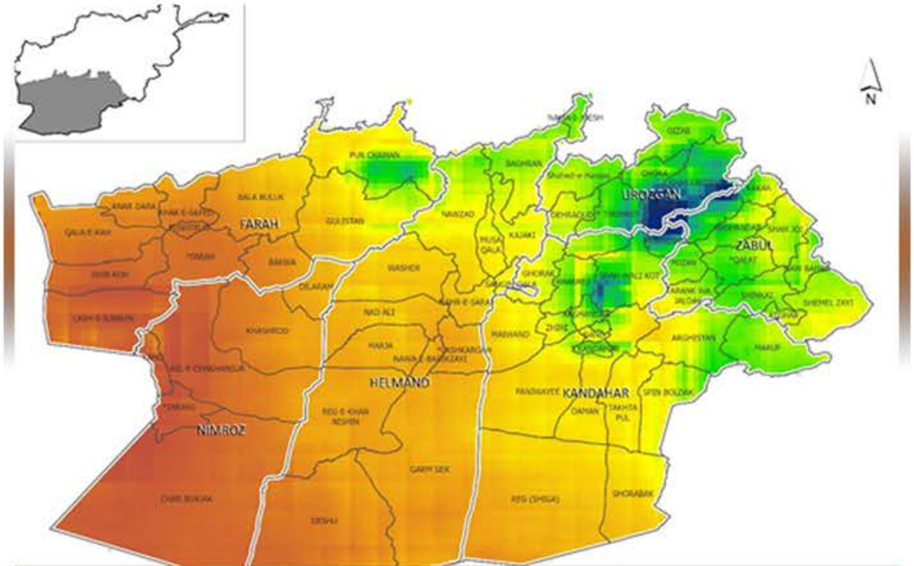

Figure 15: Average Rainfall (CHIRPS), Research area, 2018 -2023, (source: authors)

PET

The PET data used in the maps is from the Global Potential Evapotranspiration (PET) dataset, which is updated monthly and available at a 1-degree spatial resolution. This dataset is generated by the National Oceanic and Atmospheric Administration (NOAA) using the Penman-Monteith equation, which takes into account various climatic factors such as air temperature, atmospheric pressure, wind speed, relative humidity, and solar radiation.

The maps show the spatial distribution of Potential Evapotranspiration (PET) across Afghanistan from 2018 to 2023. The PET values are represented using a color gradient, with higher values (shown in orange/red) indicating higher evapotranspiration and lower values (shown in green) indicating lower evapotranspiration.

At the national level, the maps reveal significant regional variations in PET across Afghanistan:

1. Northern Zone:
    - PET values range from 8-20 mm.
    - This region supports seasonal agriculture but is also prone to drought.
2. Eastern Zone:
    - PET values are the highest in the country, ranging from 12-22 mm.
    - The high precipitation in this region, driven by orographic effects, ensures water availability for agriculture.
3. Central Zone:
    - PET values range from 13-20 mm.
    - Faces water scarcity due to limited storage and high population.
4. Western Zone:
    - PET values are generally low, ranging from 5-13 mm
    - This arid region is prone to high evapotranspiration and desertification, This region relies on rain-fed agriculture, leading to water shortages.
5. Southwest (Study Area):
    - This is the driest region, with PET values ranging from 0 – 10 mm.
    - The severe aridity in this area contributes to drought-driven displacement and high climate vulnerability.

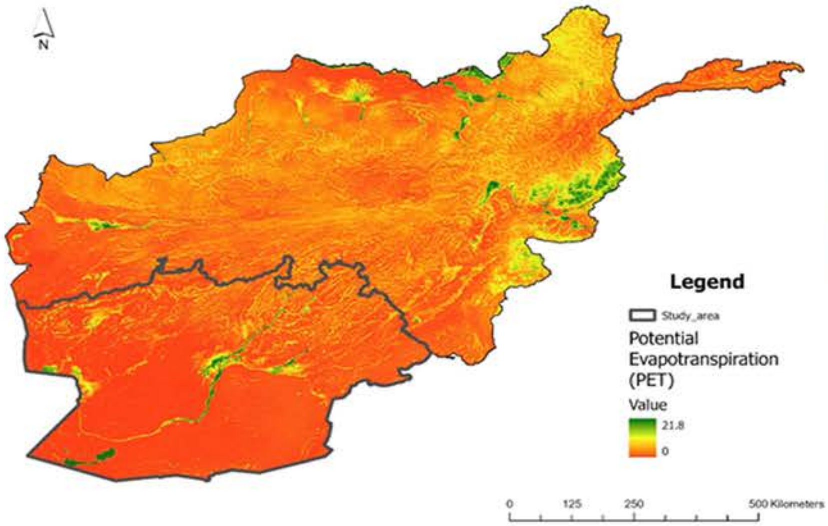

Figure 16: Potential Evapotranspiration, Afghanistan, 2018 - 2023, (source: authors)

Focusing on the study area in the southwest, the analysis at the province and district levels provides more detailed insights:

- Farah Province:
    - Predominantly low PET, ranging from 0 to 14 mm.
    - The Pur Chaman and Gulistan districts receive marginally higher rainfall compared to the surrounding areas, while Lash-e-Juwayn and parts of Shib Koh have extremely low PET.
- Helmand Province:
    - Mostly arid, with PET values ranging between 5 and 20 mm annually, with slight variability.
    - The Baghran, Nawzad, and Nawai-i-mesh districts have slightly better conditions compared to the other districts, while Reg-e-khan Nishani and Deshu are among the driest.
- Nimruz Province:
    - Severely arid, with most districts receiving rainfall below 35 mm annually.
    - The Zaranj, Kang, Asl-e-Chakhansur, and Char Burjak districts face extreme aridity with negligible rainfall.
- Kandahar Province:
    - PET values range between 10 and 22 mm in the northern districts, while the southern areas fall below 10 mm.
    - The Shah Wali kot, Khakrez, and Kandahar City districts have relatively better PET, supporting agricultural activities, while the Reg, Takhta Pul, Panjwayee, and Daman districts experience drier conditions.
- Zabul Province:
    - Receives moderate PET compared to the other regions, ranging from 7 to 14 mm.
    - The Kakar, Mizan, Arghandab and Qalat districts experience better PET due to their elevated position and geographic location, while the Shah Joy and Tarank-wa-Jaldak districts have lower PET, limiting agricultural practices.
- Urozgan Province:
    - The highest PET across the study area, ranging from 14 to 22 mm annually.
    - The Dehraoud, Trinkot, Chinarto and Sahed-e-Hassas districts experiencing the most PET due to their proximity to high-altitude regions.

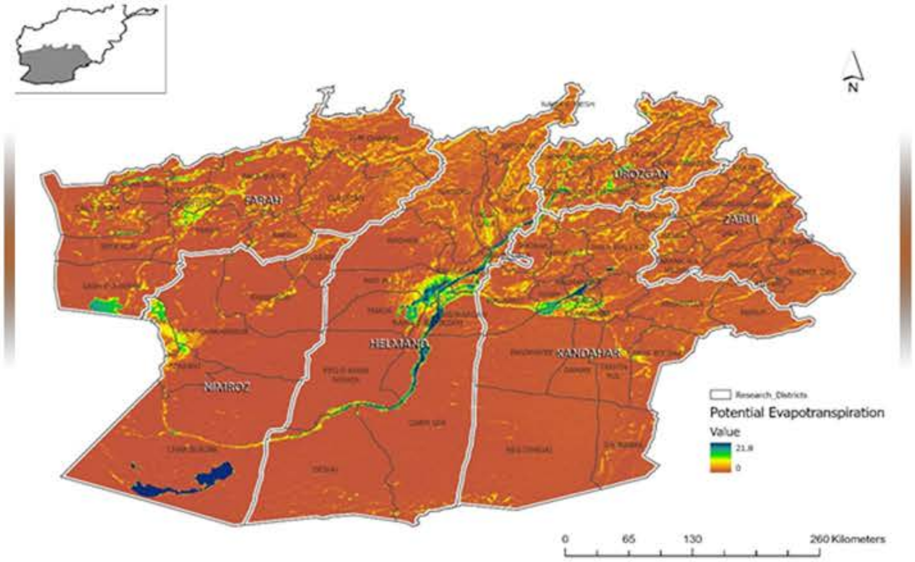

Figure 17: Potential Evapotranspiration, Research Area, 2018 - 2023, (source: authors)

NDVI

The maps provided show the Normalized Difference Vegetation Index (NDVI) data for Afghanistan. NDVI is a widely used remote sensing-based index that measures the density of green vegetation. It is calculated as the normalized difference between the near-infrared (NIR) and red (RED) spectral bands, and it ranges from -1 to 1, with higher values indicating more vigorous vegetation.

National-level NDVI Analysis: The NDVI map of Afghanistan reveals the spatial distribution of vegetation conditions across the country. The key observations are:

1. Northern and Eastern Regions: These areas show relatively higher NDVI values, indicating the presence of more dense and healthy vegetation. This is likely due to the higher precipitation and more favorable climatic conditions in these regions.
2. Central and Western Regions: The central and western parts of Afghanistan display lower NDVI values, suggesting sparser and less vigorous vegetation. This is consistent with the arid and semi-arid climate in these regions.
3. Riparian Areas: The river valleys and floodplains show higher NDVI values, as the availability of water supports more lush vegetation growth.
4. Mountainous Areas: The high-altitude mountainous regions in the northeast and central parts of the country exhibit a mix of NDVI values, likely due to the presence of different vegetation types, from alpine meadows to sparse shrublands.

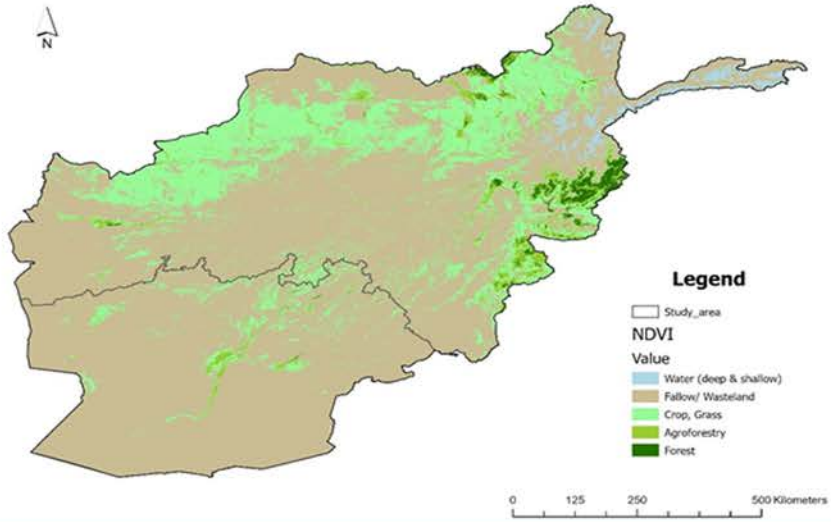

Figure 18: NDVI, Afghanistan, 2018 – 2023, , (source: authors)

Study Area (Southwest) NDVI Analysis:
Focusing on the study area in the southwestern part of Afghanistan, the NDVI map provides the following insights:

1. Farah Province: The NDVI values in Farah province are generally low, with some slightly higher values in the Pusht-Rud, Farah Center, and Pur Chaman districts. This indicates more sparse and less vigorous vegetation, likely due to the arid climate and limited water availability.
2. Helmand Province: The NDVI values in Helmand province are also relatively low, with a few pockets of higher values in the Baghran, Kajaki, Nawzad, Nahar-e-Saraj, Nad Ali, and Nawa-e-Barikzayi districts. The majority of the province exhibits sparse vegetation conditions.
3. Nimruz Province: This province shows the lowest NDVI values in the study area, with most districts experiencing highly arid conditions and minimal vegetation cover.
4. Kandahar Province: The northern districts of Kandahar province display higher NDVI values compared to the southern. The Zhire, Arghandab, Shah Wali kot, Khakrez, and Kandahar City districts have relatively better vegetation conditions.
5. Zabul Province: This province exhibits moderate NDVI values, with the Daichopan and Mizan, and Kakar districts showing relatively higher vegetation density, likely due to their elevated position and more favorable climate.
6. Urozgan Province: This province emerges as the most vegetated area within the study region, with the Chinarto and Khas Urozghan districts experiencing the highest NDVI values. The Trinkot, Saheed-e-Hassas, Dehradou and Gizab districts also benefit from enhanced vegetation cover.

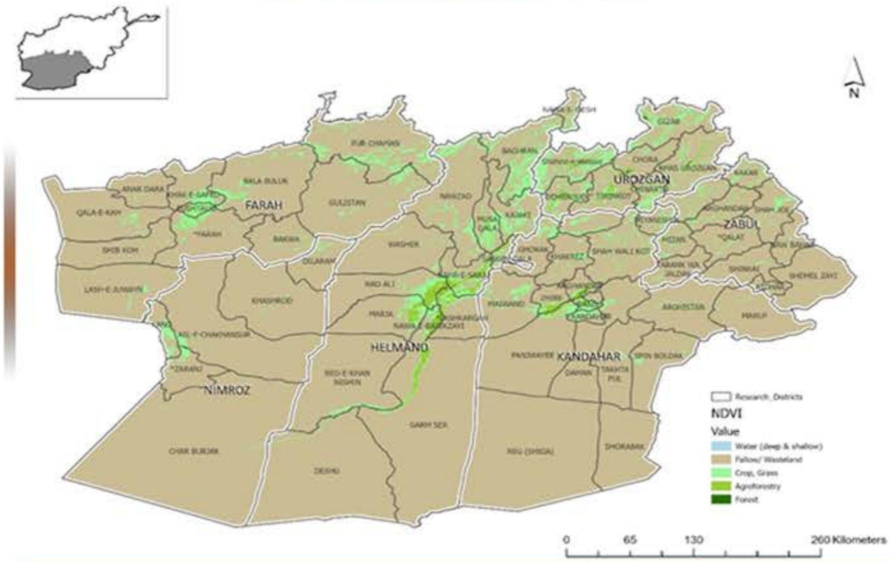

Figure 19: NDVI, Research Area, 2018 – 2023, (source: authors)

This NDVI analysis from 2018 to 2023provides valuable insights into the spatial distribution of vegetation conditions across Afghanistan, particularly in the study area. This information can be used to better understand the environmental and agricultural dynamics in the region, as well as support decision-making processes related to resource management and climate change adaptation.

Sand and Dust Storm

This analysis utilizes the MERRA-2 (Modern-Era Retrospective analysis for Research and Applications version 2) dataset to assess the sand and dust storm conditions across Afghanistan, particularly in the southwestern study area. The MERRA-2 dataset is a global atmospheric reanalysis produced by the NASA Global Modeling and Assimilation Office (GMAO), providing a comprehensive set of aerosol diagnostics, including a parameter called "Sand and Dust Storm Value."

The "Sand and Dust Storm Value" in the MERRA-2 dataset represents the intensity of sand and dust storm activity, with higher values indicating more severe dust-related events. This parameter is derived from the assimilation of various satellite and ground-based observations, allowing for a detailed spatial and temporal understanding of dust conditions in the region.

The MERRA-2 data shows the spatial distribution of the sand and dust storm intensity across Afghanistan, as represented by the "Sand and Dust Storm Value" parameter presented for the:

National-Level Sand and Dust Storm Analysis:

1. Northen, southern and Western Regions: These areas of Afghanistan display higher Sand and Dust Storm Values, indicating more intense sand and dust storm activity. This is consistent with the arid and semi-arid climate prevalent in the Northen and western parts of the country.

2. Central and Eastern Regions: The central and eastern regions of Afghanistan show relatively lower Sand and Dust Storm Values, suggesting less severe dust-related events in these areas. This is likely due to the more favorable climatic conditions and higher precipitation levels.

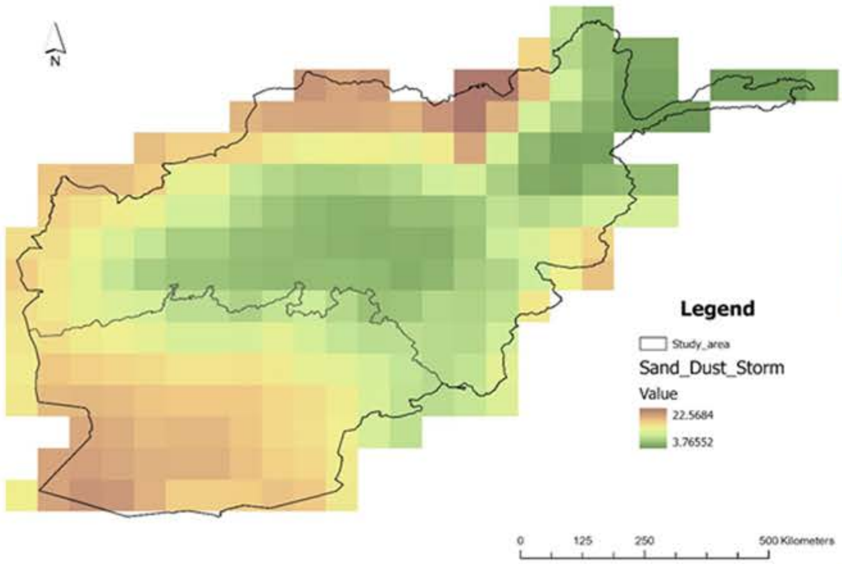

Figure 20: Sand and Dust Storms, Afghanistan, 2018 -2023, (source: authors)

Study Area (Southwest) Sand and Dust Storm Analysis:

1. Farah, Helmand, and Nimruz Provinces: These provinces in the southwestern study area display the highest Sand and Dust Storm Values, indicating the most intense sand and dust storm conditions. The arid climate and limited vegetation cover in these regions contribute to the elevated dust activity.

2. Kandahar Province: The northern districts of Kandahar province experience relatively lower Sand and Dust Storm Values compared to the southern areas, suggesting less severe dust-related events in these northern parts.

3. Zabul Province: This province exhibits moderate Sand and Dust Storm Values, with the Daichopan and Qalat districts showing slightly lower dust intensity levels.

4. Urozgan Province: The Urozgan province emerges as the study area with the lowest Sand and Dust Storm Values, especially in the Chinarto and Khas Urozghan districts. This indicates more favorable environmental conditions and relatively less severe dust-related challenges in these parts of the province.

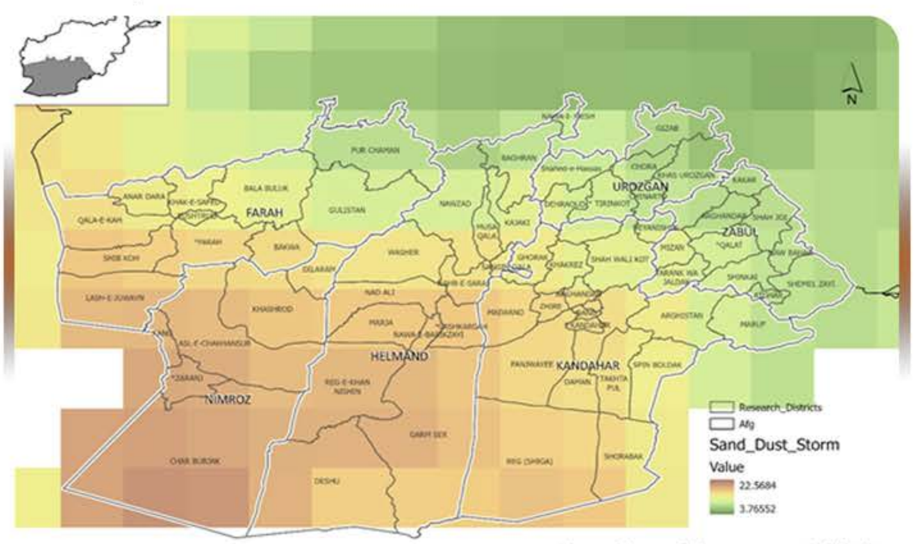

Figure 21: Sand and Dust Storms, Study Area, 2018 -2023, (source: authors)

This analysis of the sand and dust storm conditions, based on the MERRA-2 Sand and Dust Storm Value parameter from 2018 to 2023 provides valuable insights into the spatial distribution and intensity of dust-related events in Afghanistan, particularly in the southwestern study area. This information can support decision-making processes related to environmental management, disaster risk reduction, and climate change adaptation strategies in the region.

Groundwater

This analysis utilizes the Groundwater Storage (GWS) dataset, which is derived from the Global Land Data Assimilation System (GLDAS) Catchment Land Surface Model (CLSM). The GLDAS dataset provides a comprehensive set of land surface parameters, including the GWS variable, which represents the water stored below the root zone and above the bedrock.

The GWS data is particularly useful for understanding the groundwater dynamics in Afghanistan, as it offers a spatial and temporal perspective on the subsurface water resources in the region. This information can provide valuable insights into the availability and distribution of groundwater, which is a critical resource for various sectors, including agriculture, domestic use, and industrial activities.

National-Level Groundwater Analysis: The GWS map of Afghanistan reveals the spatial distribution of groundwater storage across the country. Some key observations from the national-level analysis:

1. Western, and eastern regions: These areas generally exhibit higher GWS values, indicating relatively greater groundwater storage capacities.

2. Central, Southwest, and northern regions: The central and western parts of Afghanistan display lower GWS values, suggesting less abundant groundwater resources in these areas.

   The arid and semi-arid climate, combined with limited surface water availability, may contribute to the lower groundwater storage in these regions.

3. Mountainous Areas: The high-altitude mountainous regions in the northeast and central Afghanistan exhibit a mix of GWS values, potentially influenced by the complex hydrogeological
conditions and local climate variations.

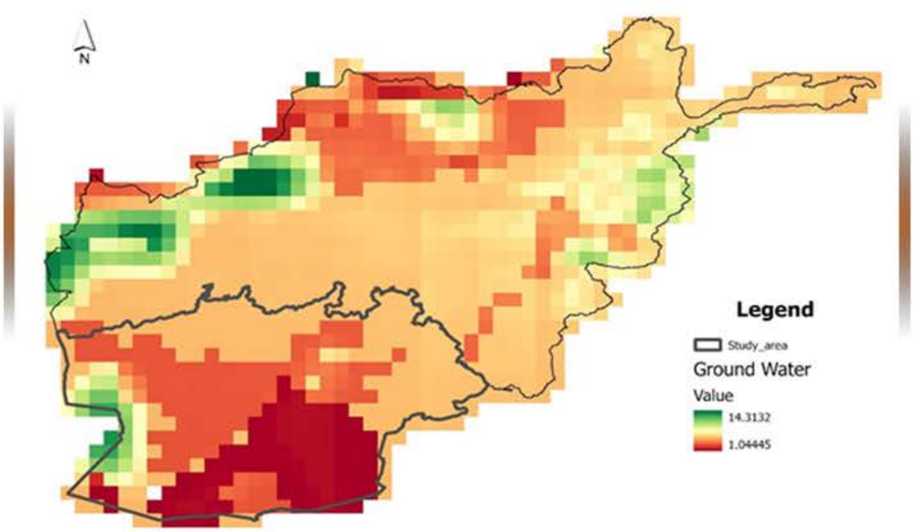

Figure 22: Ground Water Storage, Afghanistan, 2018 -2023, (source: authors)

Study Area (Southwest) Groundwater Analysis Focusing on the southwestern study area, the GWS map provides the following insights:

1. Kandahar and Helmand Provinces: These provinces display the lowest GWS values in the study area, indicating limited groundwater resources. The arid climate and lack of significant surface water bodies in these regions contribute to the reduced groundwater storage.

2. Farah & Nimruz Provinces: The western districts of Nimruz and Farah provinces experience relatively higher GWS values compared to the other parts, suggesting more favorable groundwater conditions in the western areas.

3. Urzgan Province: This province exhibits moderate GWS values, with the Gizab and Khas Urozgan districts showing slightly higher groundwater storage capacities.

4. Zabul Province: The Urozgan province emerges as the study area with the highest GWS values, particularly in the Sheml Zayi and Shah Joi districts. This indicates more abundant groundwater resources in these parts of the province, which may be attributed to the local hydrogeological and climatic factors.

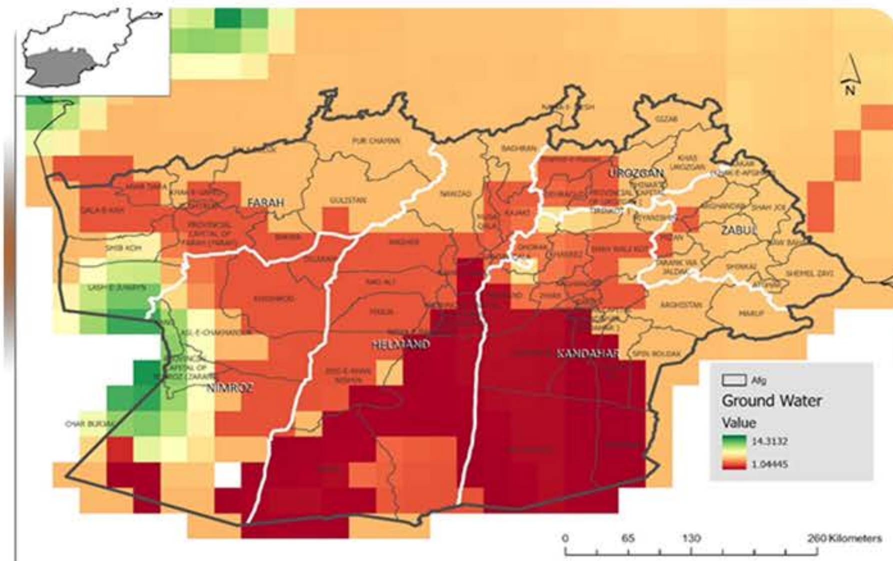

Figure 23: Ground Water Storage, Research Area, 2018 -2023, (source: authors)

Country-Level Analysis

At the national level, the AHP analysis has categorized Afghanistan's 34 provinces into different zones based on their overall migration potential score:

High Migration Potential Zone (AHP Value >= 4): This zone covers the southwestern provinces of Farah, Nimruz, Helmand, Kandahar, south districts of Herat, Jawzjan, Balkh, Kunduz and parts of Urozgan. These areas are characterized by severe aridity, low precipitation, sparse vegetation, high potential evapotranspiration, and low groundwater storage - all of which contribute to a high migration potential.

Moderate Migration Potential Zone (AHP Value 2-4): The central and northern provinces, such as Ghor, Bamyan, Daykundi, Ghazni, Zabul, and parts of Urozgan, fall into this zone. While still facing climate-related challenges, these areas tend to have relatively better access to water resources and vegetation cover compared to the high potential zone.

Low Migration Potential Zone (AHP Value < 2): The northeastern and eastern provinces, including Badakhshan, Takhar, Kunduz, Baghlan, Badghis, Faryab, Nangarhar, Khost, Paktya, Kapisa, Saer-e-Pul, Kabul, Parwan, Panjshir, Kunar, Laghman, and Nuristan, comprise this zone. These regions generally experience higher and more reliable precipitation, better vegetation cover, lower potential evapotranspiration, and higher groundwater storage, resulting in a lower migration potential.

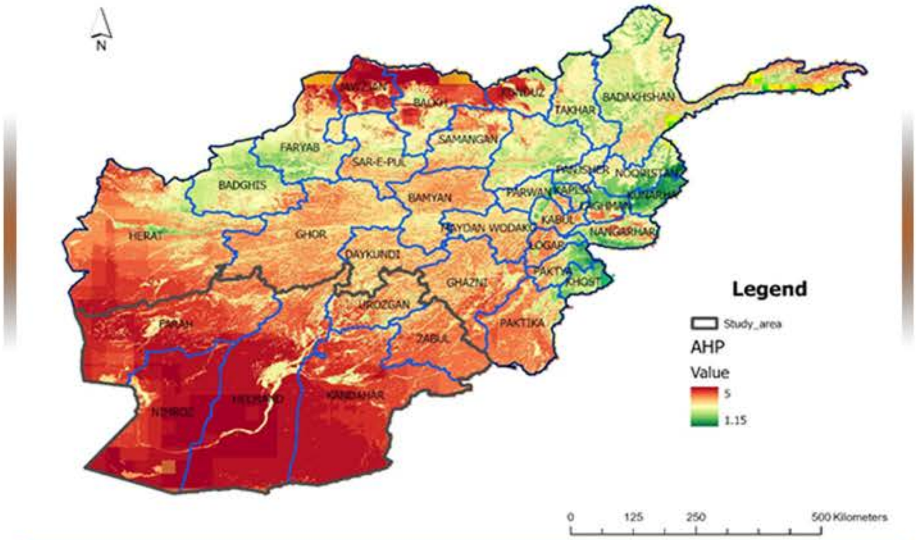

Figure 24: AHP - Afghanistan, 2018 – 2023, (source: authors)

Study Area Analysis (Southwest Afghanistan)

The primary study area in southwest Afghanistan, covering the provinces of Farah, Nimruz, Helmand, and parts of Kandahar, Zabul and Urozgan, is characterized by the most severe climate-induced migration potential in the country.

Farah Province:

- Predominantly low rainfall, ranging from 48 to 220 mm annually, with the districts of Lash-e-Juwayn and parts of Shib Koh experiencing extremely low precipitation.
- The high PET and low GWS values contribute to the overall high AHP value across the province, indicating a severe migration potential.
- Key districts like Pur Chaman and Gulistan receive marginally higher rainfall compared to the surrounding areas but still face significant aridity challenges.

Nimruz Province:

- Experiences the most severe aridity in the study area, with most districts receiving less than 35 mm of rainfall annually, coupled with high PET and low GWS.
- The AHP value is extremely high (5.0) across the province, reflecting the dire climate conditions and high migration potential.
- Zaranj city, Kang, Asl-e-Chakhansur, and Char Burjak districts face extreme aridity and are at the greatest risk of desertification and population displacement.

Helmand Province:

- Rainfall ranges between 50 and 250 mm annually, with slight variability across the province, but high PET and low GWS values.
- The AHP value is consistently high, indicating a substantial migration potential.
- Districts like Baghran, Nawzad, and Nawai-i-mesh experience relatively better conditions compared to the rest of the province, but still face significant water scarcity challenges.

Kandahar Province:

- Rainfall ranges from 70 to 350 mm in the northern districts, while the southern areas receive less than 70 mm, with high PET and low GWS.
- The AHP value varies, with the northern districts like Shah Wali Kot, Khakrez, and Kandahar City experiencing relatively better conditions, supporting agricultural activities.

- The southern districts of Reg, Takhta Pul, Panjwayee, and Miwand face drier conditions, affecting water availability and livelihoods.

Urozgan Province:

- Receives the highest rainfall across the study area, ranging from 300 to 590 mm annually, but still has moderate PET and GWS values.
- The AHP value is moderate, with the districts of Chinarto and Khas Urozghan benefiting from the higher precipitation due to their proximity to high-altitude regions.
- The districts of Trinkot and Gizab also experience enhanced rainfall, supporting agriculture and local livelihoods.

Zabul Province:

- Receives moderate rainfall in comparison to the rest of the study area, ranging from 250 to 490 mm.
- The AHP value is in the moderate range, with the districts of Daichopan and Qalat experiencing better precipitation due to their elevation and geographic position.
- The districts of Shah Joy and Tarank-wa-Jaldak have lower rainfall, supporting only limited agricultural practices.

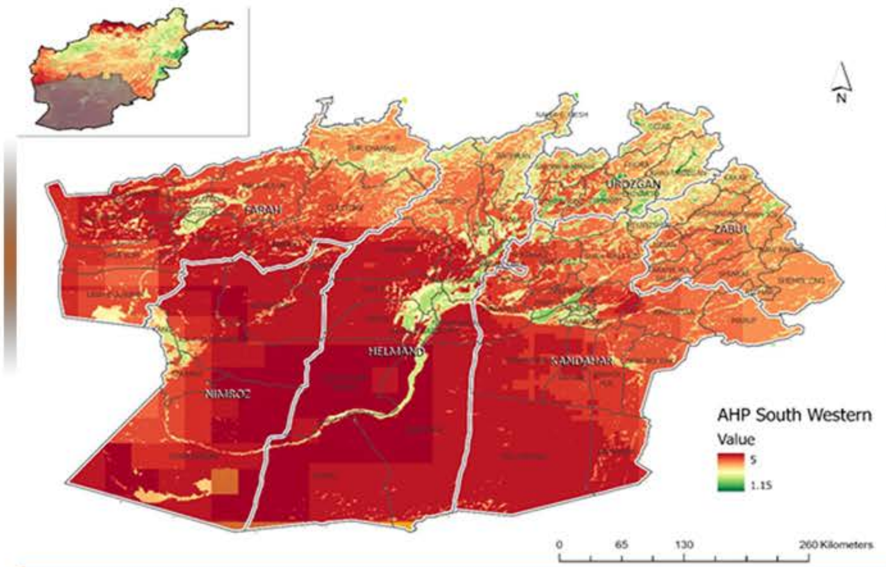

Figure 25: AHP - Research area, 2018 – 2023, (source: authors)

In conclusion, the southwestern region of Afghanistan, particularly the provinces of Farah, Nimruz, Helmand, and parts of Zabul, Kandahar, and Urozgan faces the most severe climate-induced migration potential in the country. The combination of low precipitation, sparse vegetation, high potential evapotranspiration, and low groundwater storage creates an environment that is highly vulnerable to desertification, water scarcity, and displacement of local populations. Targeted interventions and adaptation strategies will be crucial to mitigate the impact of these climate-related challenges in the region

Immigration and Displacement

Climate change and the resulting environmental anomalies have been identified as one of the main factors behind both internal and external migration in Afghanistan. Over the past few decades, the effects of climate change have affected the majority of the residents of the country, particularly those in the southern and southwestern regions of Afghanistan (Hanif et al., 2024a). While dryness and desertification have traditionally been characteristics of these areas, global warming and climate change have exacerbated these conditions, to the point that many residents have become disillusioned and hopeless about continuing life there. Agriculture and animal husbandry, deeply rooted in the traditions of past generations, remain the primary occupation for the current generation. Farmers in these areas, with their vast and extensive lands, engage in both rain-fed and irrigated agriculture.

Frequent droughts in recent years have reduced livelihoods and food security. Many rain-fed crops in the mountainous areas have been destroyed due to lack of rainfall, soil erosion, and the drying of land. Wild grasses in the plains and mountains, which were a vital source of livelihood for livestock herders relying on natural pastures, have also dried up. Additionally, the drying up of springs, streams, and wetlands, seasonal fluctuations in water bodies, increased evaporation, reduced seasonal rainfall, desertification, and the drying up of forests are some of the other effects of prolonged droughts in this region, all of which have forced many residents to migrate to other areas for survival (Shokory et al., 2024). As respondents in Nimruz province stated, "Repeated droughts have led to a reduction in agriculture and unemployment, and most residents have migrated to other areas in search of work." In most interviews, the main reason cited for the repeated droughts was the lack of water for agriculture, which in turn caused unemployment (Hayat & Baba, 2017).

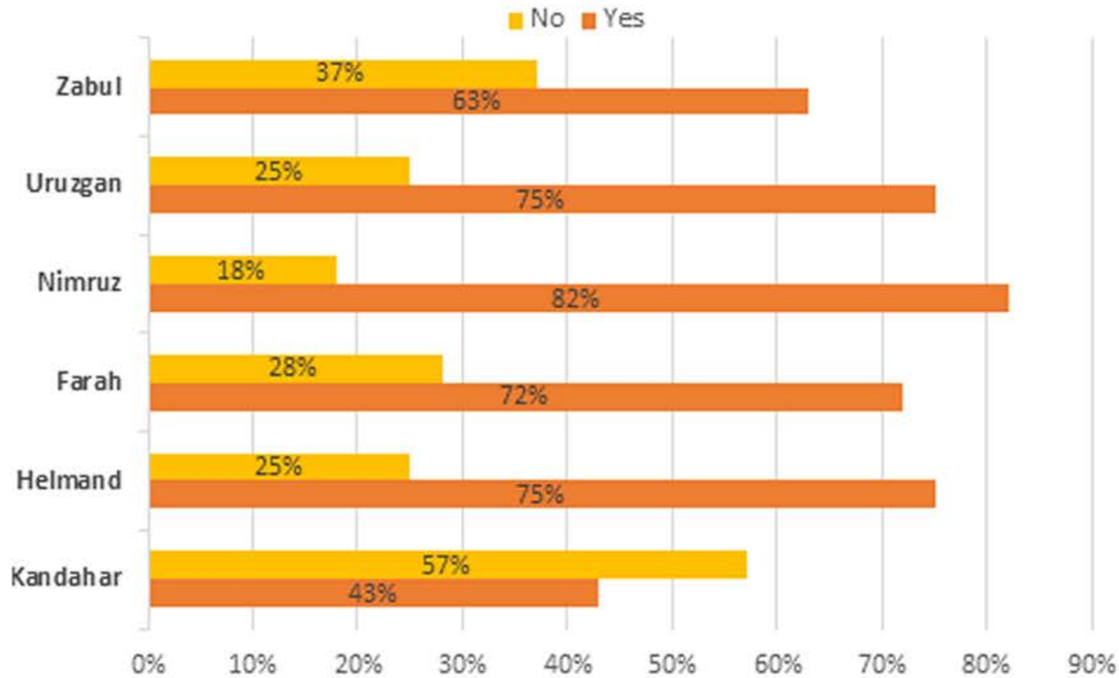

Chart 21: Immigration and Displacement pattern in south and southwestern Afghanistan (source: authors).

The findings of this study show that in Nimruz province, 82%, in Helmand and Urozgan provinces, 75%, in Farah province, 72%, in Zabul province, 63%, and in Kandahar province, 43% of households have experienced displacement (see chart 21). These migrations have occurred for various reasons, with the lack of sufficient livelihood resources being one of the primary factors, as shown in chart 22. In Nimruz, 84%, in Urozgan 73%, and in Farah, 72% of households were forced to migrate due to a lack of livelihood resources. However, according to interviews and FGD in Table 4, drought has been one of the major factors contributing to migration in these areas.

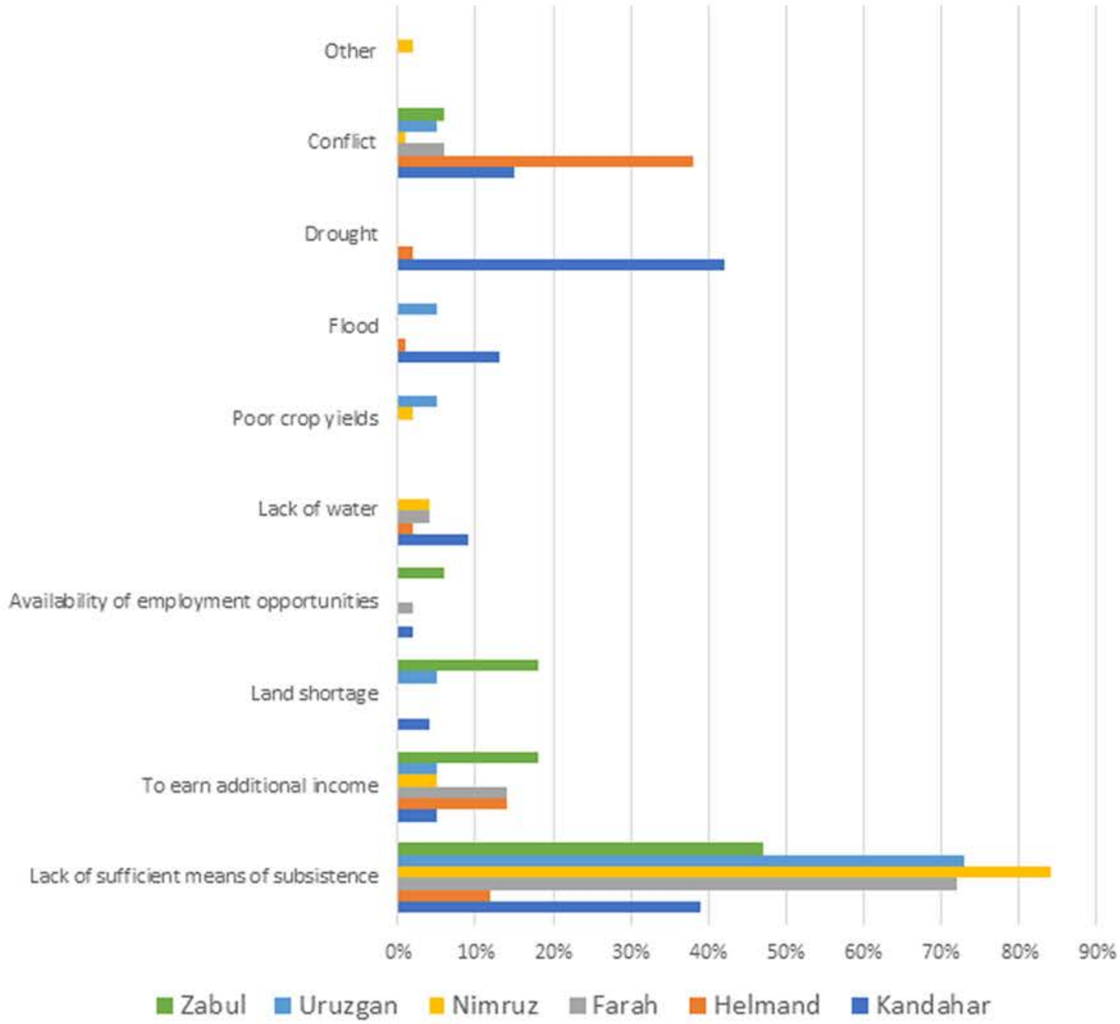

Chart 22: Reasons for the immigration of local communities (source: authors).

In addition to drought, the reduction of groundwater, which has led to a lack of sufficient surface water, has become another major challenge for access to clean drinking water, hygiene, and sanitation. As a result of water shortages, the daily water usage for drinking has decreased, and even the washing of clothes and bathing for family members has been reduced (Doherty & Scannell-Desch, 2012). Respondents also stated that "with the reduction of water, attention to hygiene and health issues has become much less important."

Table 4: The adverse effects of climate changes on immigration and displacement (source: authors).

IMPACT LEVEL	FACTOR	DETAILS OF INFLUENTIAL FACTORS
More than 50% of interviews and FGDs	Drought	• Reduction of rainfed farming • Decrease in seasonal rainfall • Loss of natural pastures • Increase in desertification • Soil degradation • Loss of crops • Forest destruction • Decrease in soil moisture • Creation of social and economic challenges • Early marriages
More than 50% of interviews and FGDs	Water resources depletion	• Decrease in groundwater levels • Drying up of streams and lakes • Low access to clean and safe drinking water

20%-50% interviews and FGDs	Temperature variability	• Intense heat and cold – heatwaves • Drying of land surface • Increase in diseases • Loss of crops • Growth of harmful insects
20%-50% interviews and FGDs	Poverty	• Loss of income sources • Decrease in household income • Loss of hope in life
20%-50% interviews and FGDs	Flooding	• Loss of agricultural products • Destruction of residential houses • Environmental degradation • Destruction of infrastructure • Financial and human losses
Less than 20% of the interviews and FGDs	Increase in wind and dust storm	• Loss of soil moisture • Low productivity of crops • Evaporation and transpiration • Increase in respiratory and eye diseases
Less than 20% of the interviews and FGDs	Widespread diseases	• Poor hygiene • Increase in harmful insects • Pollution of water sources
Less than 20% of the interviews and FGDs	External factors	• War and internal conflicts • Family problems • Mental and psychological issues • Regional tensions • Lack of adequate and timely services • Low educational standards • Lack of jobs and sufficient income • Lack of electricity

Other major issues caused by climate change that have created challenges for livelihoods in these areas include extreme heat and cold during different seasons, increased diseases, stronger winds, crop destruction, increased flash floods during harvest seasons, the rise of harmful insects, destruction of homes and agricultural lands due to floods, deep reduction of soil moisture for continued farming, and low crop yields. All of these factors stem from climate change and have led to a reduced crop range, lower productivity, decreased family income, and the loss of food security. As a result, the residents of these areas, whose primary skills are in agriculture and animal husbandry, have been forced to seek other locations for survival, migrating to district centers, neighboring provinces, and even other countries (Hanif et al., 2024b).

In desert regions, where survival relies on access to water, migration is influenced not only by environmental factors affecting water availability, agriculture, and livelihoods but also by external issues such as conflicts over water sources and fertile land, disputes over water distribution, land inheritance divisions, competition for natural resources, economic hardships, crime, psychological and social challenges, cultural tensions, ethnic, religious, and regional conflicts, and decades of war and instability. These factors have been less emphasized in the research. As shown in Table 4, each factor that has had a greater impact on the environment and residents due to climate change has been identified as a major cause of migration in these areas.

The findings of this study show that people still have the intention to migrate for various reasons. Based on chart 23, farmers (60%), day laborers (42%), small businesses (45%), and unemployed individuals (30%) represent some of the highest migration rates in the southern and southwestern regions.

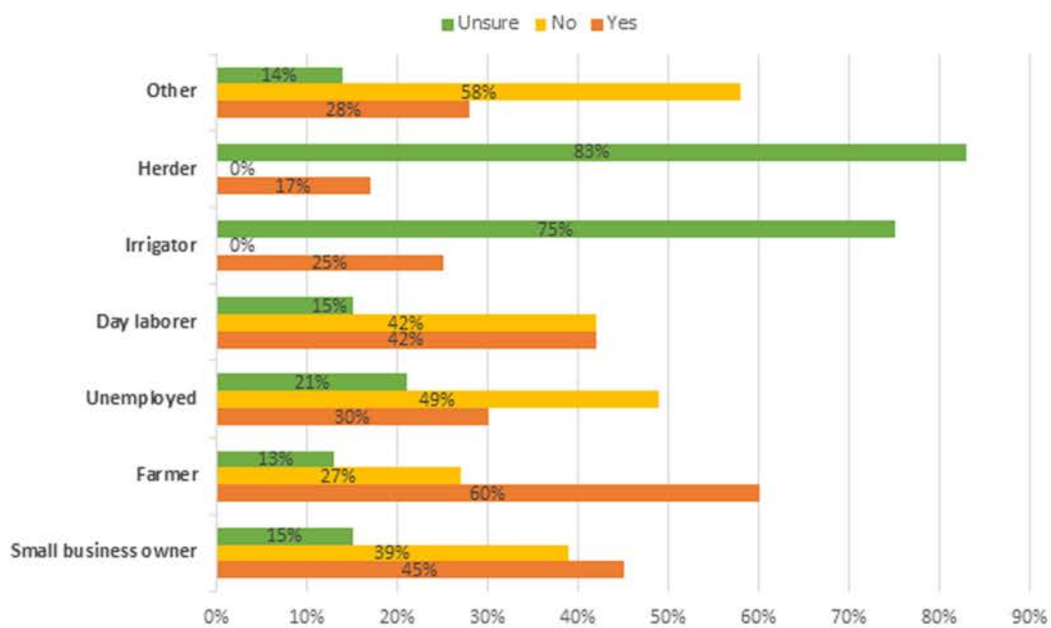

Chart 23: Displacement trend in local communities (source: authors).

As indicated in chart 24, multiple factors have influenced migration in these areas, including lack of livelihood resources, drought, floods, land shortages, etc. Among these, the lack of sufficient livelihood resources accounts for 66%, which is the main reason for migration in these regions. According to the findings of this study, 54% of these households intend to migrate abroad, 24% plan to migrate to another region within the same province, 19% to another province, and 3% intend to migrate within the same region (see charts 25 and 26).

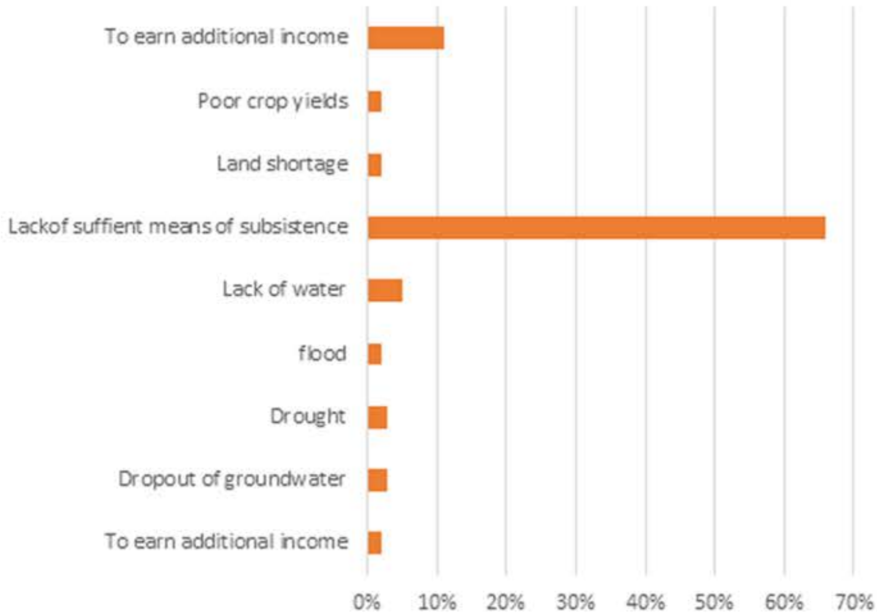

Chart 24: Reasons for people's displacement to other provinces and abroad (source: authors).

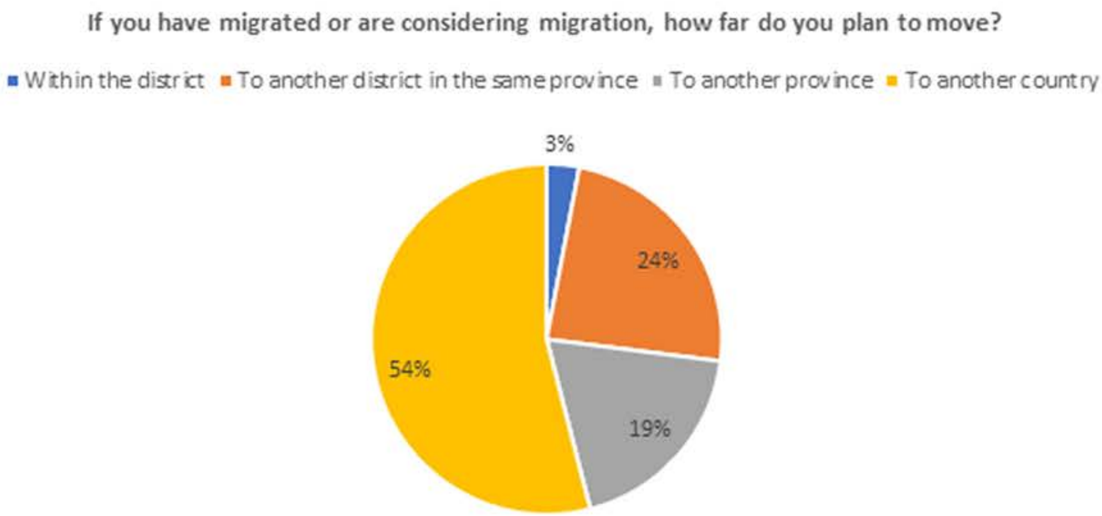

Chart 25: Immigration trend in south and southwestern Afghanistan (source: authors).

The findings of this study indicate that in Nimruz, 99% and in Urozgan, 90% of households have been displaced due to environmental changes in the past 5 years. Similarly, in Helmand and Farah, 86% of households, and in Kandahar, 43% of households have been displaced due to environmental changes that have occurred in their regions (see chart 26).

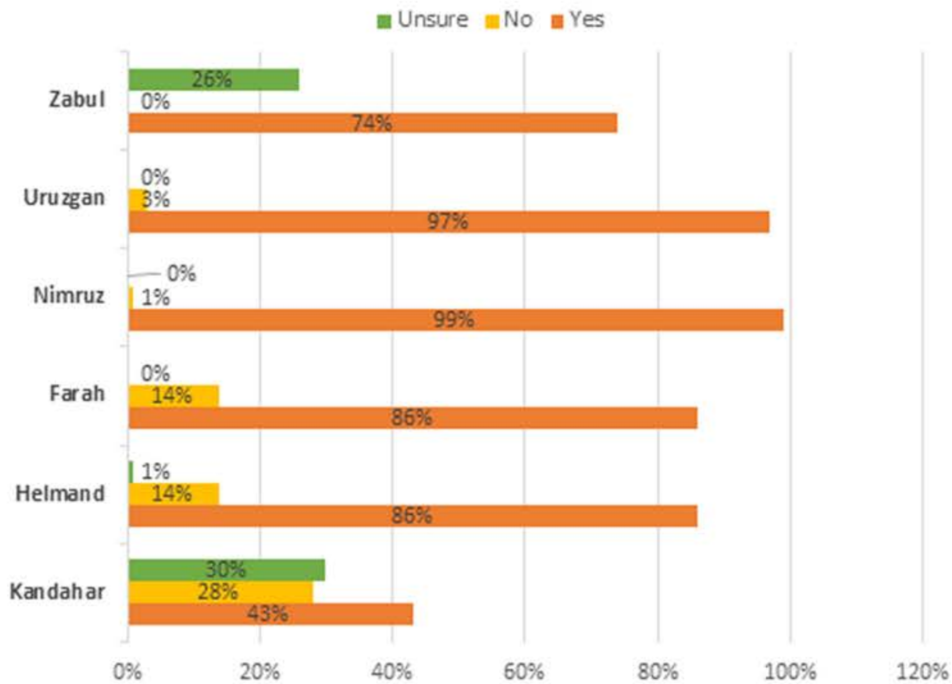

Chart 26: Displacement due to environmental disruption (source: authors).

POLICY IMPLICATIONS

In the face of changing climate and political turmoil in Afghanistan, the following several critical policy implications emerge that require urgent attention from policymakers, international organizations, and local authorities:

Water Resource Management

Given the extreme aridity in southwestern provinces like Farah, Nimruz, Helmand, and parts of Kandahar:

- Prioritize water resource management in high AHP value zones (provinces with AHP Value >= 4)
- Develop targeted groundwater recharge programs for provinces with low GWS
- Create specialized water conservation strategies for districts with less than 70 mm annual rainfall
- Implement precision water management in districts like Lash Jawain, Zaranj, Takhta-pul, Kang, and Char Burjak with extreme water scarcity

Agricultural Adaptation

Focusing on provinces with moderate to high migration potential:

- Develop crop varieties specifically adapted to regions with 50-250 mm annual rainfall
- Create agricultural support programs for districts in Farah, Nimruz, Kandahar, and Helmand provinces
- Provide targeted support for agricultural transitions in areas with high potential evapotranspiration
- Design agricultural interventions specific to each AHP migration potential zone
- Provide farmers with technical training on climate-smart agricultural practices
- Establish early warning systems for extreme weather events
- Develop insurance mechanisms to protect farmers against climate-related losses
- Create agricultural extension services focused on climate adaptation

Public Health Response

- Strengthen healthcare infrastructure to address climate-related health impacts
- Develop heat action plans for extreme temperature events
- Implement air quality monitoring systems in areas affected by dust storms
- Establish mobile health units to serve displaced populations
- Create public health education programs focused on climate-related diseases

Migration Management

Tailored to AHP migration potential zones:

- Develop province-specific internal displacement response frameworks
- Create targeted economic opportunities in high migration potential zones (southwestern provinces)
- Establish priority relocation support for districts in Nimruz and Farah provinces
- Establish climate refugee support systems in urban areas
- Implement planned relocation programs for communities in high-risk areas
- Develop cross-border cooperation mechanisms for managing climate-induced migration

Environmental Protection

- Implement strict measures to protect the remaining forest cover and vegetation
- Develop soil conservation programs to combat desertification
- Create protected areas to preserve biodiversity
- Establish dust storm mitigation programs
- Implement watershed management programs

Economic Diversification

- Develop non-agricultural employment opportunities in vulnerable regions
- Invest in renewable energy infrastructure to create new job sectors
- Establish vocational training programs focused on climate-resilient industries
- Create microfinance programs for climate-adaptive businesses
- Develop sustainable tourism initiatives where feasible

Infrastructure Development

- Climate-proof essential infrastructure including roads, bridges, and water systems
- Develop renewable energy systems to reduce reliance on limited resources
- Create emergency shelters and evacuation routes in flood-prone areas
- Implement urban planning measures that account for climate risks
- Develop sustainable housing solutions for displaced populations

Institutional Capacity Building

- Strengthen local governance structures for climate response
- Develop climate change monitoring and evaluation systems
- Create coordination mechanisms between different government agencies
- Build capacity for climate-related disaster response
- Establish research institutions focused on climate adaptation

International Cooperation

- Strengthen regional cooperation on transboundary water management
- Develop international funding mechanisms for climate adaptation
- Create knowledge-sharing platforms with other arid regions
- Establish cross-border early warning systems
- Develop joint research programs on climate impacts

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- Strengthen regional cooperation on transboundary water management
- Develop international funding mechanisms for climate adaptation
- Create knowledge-sharing platforms with other arid regions
- Establish cross-border early warning systems
- Develop joint research programs on climate impacts

Community Engagement

- Implement community-based adaptation programs
- Create public awareness campaigns about climate change
- Establish local climate action committees
- Develop indigenous knowledge preservation programs
- Create participatory decision-making processes for climate initiatives

Implementation Priority Matrix

i. Immediate Priority (0-2 years):
   - Water resource management systems
   - Emergency health response capacity
   - Migration support systems
   - Basic infrastructure protection
   - Early warning systems

ii. Medium-term Priority (2-5 years)
  - Agricultural adaptation programs
  - Economic diversification initiatives
  - Environmental protection measures
  - Institutional capacity building
  - Community engagement programs

iii. Long-term Priority (5+ years)
  - Advanced infrastructure development
  - Research institution establishment
  - Regional cooperation frameworks
  - Comprehensive biodiversity protection
  - Sustainable urban development

These policy implications require substantial financial investment, technical expertise, and coordinated effort from multiple stakeholders. Thus, we argue that success will depend on strong political will, community participation, and international support. Implementation should be routed based on urgency and resource availability, with regular monitoring and evaluation to ensure effectiveness.

RECOMMENDATIONS AND CONCLUDING REMARKS

Climate change is one of the major challenges facing the southern and southwestern provinces of Afghanistan, profoundly impacting not only the environment but also the economic, social, and political aspects of communities. Rising temperatures, changes in rainfall patterns, sudden floods, prolonged droughts, and increasing sand and dust storms are clear signs of climate change that demand immediate and effective responses.

These challenges are especially critical in regions that rely heavily on natural resources, agriculture, and livestock. The increasing frequency of droughts, floods, and storms poses serious threats to food security, health, natural resources, and the livelihoods of millions. Addressing these challenges requires a comprehensive and multi-faceted approach that includes international cooperation, local policymaking, and community empowerment. Experts, researchers, officials, and educators involved in this research have provided valuable insights, which are outlined below.

To effectively tackle these crises, modern technologies must be employed, natural resource management improved, and sustainable lifestyles promoted. Increasing public awareness and fostering community participation in decision-making processes are also crucial for strengthening climate change mitigation efforts. Given the widespread impacts of climate change, swift and effective action is essential to achieve a sustainable and resilient future (Loodin et al., 2024b).
The following are suggested based on the findings of our research:

1. Develop Comprehensive Climate-Resilient Migration Policies
We recommend the formulation of policies that integrate climate resilience into migration management, ensuring that displaced populations have access to basic services such as housing, education, healthcare, and employment. In our view, the inter-ministerial committee can play a vital role in drafting climate-resilient migration policies ensuring that each individual Afghan family are informed and benefited from these policies.
Action Steps:

- Designate areas prone to climate-induced displacement and prioritize investments in adaptation strategies
- Collaborate with international partners to align policies with global climate adaptation frameworks (e.g., the Paris Agreement)
- Ensure that internal migrants are included in national disaster management plans

2. Strengthen Early Warning Systems and Disaster Preparedness
We suggest the improvement of early warning systems to predict extreme weather events (e.g., droughts, floods) and enable proactive migration strategies, particularly during the heat waves of summer and cold weather in winter where families, especially the under-served farming communities in south and southwestern Afghanistan grappling with socio-economic challenges.

Action Steps:

- Invest in meteorological infrastructure for real-time data and forecasting
- Establish localized communication systems to alert vulnerable communities in rural and remote areas
- Provide training for community leaders on how to act during climate-related events to prevent forced migration

3. Promote Sustainable Livelihood Programs in Vulnerable Areas
We recommend the formation or establishment of sustainable livelihood programs in areas vulnerable to climate change, reducing the need for migration due to resource depletion.
Action Steps:

- Introduce climate-smart agricultural practices to help farmers in drought-prone areas improve yields and conserve water
- Develop alternative income-generating activities (e.g., agroforestry, handicrafts) to diversify the economy in vulnerable regions
- Strengthen local infrastructure to facilitate trade and access to markets for displaced people who may settle in rural areas

4. Invest in the Resettlement of Climate-Displaced Populations
Additionally, the establishment of resettlement programs for internally displaced persons (IDPs) that are climate-sensitive, ensuring they can build new, sustainable livelihoods in their new locations.
Action Steps:

- Create temporary housing solutions that can be expanded into permanent settlements
- Facilitate skills training and educational opportunities for IDPs to integrate into new communities and economies
- Involve local communities in the planning and integration of displaced populations to minimize social friction and ensure smooth transitions

5. Encourage Climate-Smart Urbanization and Infrastructure Development
While building climate-resilient cities and urban areas to accommodate growing populations due to migration, with a focus on environmental sustainability is challenging given the political constraints that our government is facing, the current growing population will eventually trigger the Afghan government to consider sustainability in the development of urbanity in Afghanistan.
Action Steps:

- Incorporate green infrastructure (e.g., parks, water management systems) into urban planning to reduce the impacts of floods and heatwaves
- Ensure that affordable housing options are available in urban areas where climate migrants are likely to settle
- Establish migration hubs or zones where displaced people can temporarily reside while seeking permanent solutions

6. Enhance Local Capacity to Address Migration and Displacement
One of the effective policies tackling the adverse effects of climate changes on internal migration is the enhancement of the capacity of local governments, community leaders, and NGOs to manage climate-induced migration at the grassroots level.
Action Steps:

- Train local officials on climate adaptation and migration issues to ensure informed decision-making
- Support community-based organizations that are directly involved with displaced populations and have a deep understanding of local needs
- Create forums for cross-sectoral dialogue (involving government, NGOs, and the private sector) to ensure a coordinated response to migration and displacement

7. Increase International Cooperation and Funding

Added to the abovementioned policies are the advocation for international support in addressing climate-induced displacement through funding, technology transfer, and knowledge exchange.
Action Steps:

- Engage in regional climate adaptation initiatives and partnerships with neighboring countries to share best practices and resources
- Mobilize international financial support for climate adaptation and resilience projects targeted at vulnerable populations
- Seek technical assistance from international bodies (e.g., UNHCR, UNDP) to build robust climate resilience and displacement response systems

8. Monitor and Collect Data on Climate Migration Trends

We also suggest the establishment of systems to monitor, assess, and forecast the trends in climate-induced migration and displacement within Afghanistan.
Action Steps:

- Develop a national database for tracking displaced populations, including reasons for displacement and demographics
- Conduct regular assessments of climate impacts on rural and urban populations to inform future planning
- Use data to continuously refine policies and programs, ensuring that responses remain effective and relevant

9. Promote Public Awareness and Community Engagement

Raising awareness about the links between climate change and migration, promoting community-based responses to reduce displacement pressures is also proved to be effective in addressing the adverse impacts of climate changes on internal migration.
Action Steps:

- Organize educational campaigns that highlight climate change's impact on livelihoods, migration patterns, and community health
- Empower local leaders and influencers to act as climate ambassadors, advocating for sustainable practices and migration preparedness
- Facilitate community dialogue platforms where people can discuss climate risks, adaptation strategies, and migration options

Additional Technical and Resource Management Recommendations

In arid and desert regions, a range of measures can enhance resilience and sustainability. Establishing renewable energy systems, such as wind and solar power, offers significant potential. These systems not only provide sustainable electricity but also mitigate the environmental impacts of conventional energy sources. Afghanistan's exceptional wind and solar energy potential, estimated at 66,726 MW and 222,852 MW respectively, presents a promising avenue for long-term energy sustainability, especially in rural areas (SNC, 2019). By leveraging this vast renewable energy potential, Afghanistan can reduce its dependence on non-renewable resources, ensure energy access for underserved rural communities, and address some root causes of climate vulnerability.

Improved water resource management is also critical. Actions such as constructing dams and check dams, digging wells along rivers to recharge groundwater reserves, and storing water in remote areas can bolster water security. Transitioning to drought-resistant crops, such as jujube, figs, and saffron, alongside adopting drip irrigation and greenhouse techniques, can enhance agricultural productivity while minimizing water use. Furthermore, fostering non-agricultural job opportunities and shifting from agriculture to industry in desert and border provinces can reduce pressure on natural resources and create sustainable livelihoods.

Conclusion

We thus believe that the implementation of these actionable steps, policymakers, community leaders, and stakeholders can mitigate the adverse effects of climate change on internal migration and displacement in Afghanistan. This would not only improve the resilience of vulnerable populations but also contribute to sustainable development across the country.

Lastly, implementing measures such as establishing absorption wells, modernizing irrigation systems, and optimizing water resource management can significantly strengthen local capacities for addressing climate challenges. These actions aim to mitigate the adverse effects of climate change, enhance the living conditions of residents in vulnerable areas, and increase the resilience and adaptability of communities, thereby reducing the drivers of migration and internal displacement.

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Data Sources

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58. GWS: https://giovanni.gsfc.nasa.gov/giovanni

ANNEXES

Annex.1: Household Questionnaire

ENUMERATOR INSTRUCTIONS: Read each question aloud. For multiple choice questions, read all options before recording the answer. Allow multiple responses where indicated.

A. Demographics

1. Respondent ID: _____ (pre-filled by enumerator)
2. Province: _____
3. District: _____
4. Age of respondent: _____
5. Gender of respondent: 1□ Male 2□ Female
6. How many people live in your household? _____

7. What is the highest level of education you have completed? 1□ No formal education 2□ Primary 3□ Secondary 4□ University 5□ Other (specify): _______

B. Livelihood and Food Security

8. What is your primary occupation? 1□ Farmer 2□ Herder 3□ Irrigator 4□ Day laborer 5□ Small business owner 6□ Unemployed 7□ Other
9. How has your household income changed in the last 5 years? 1□ Greatly decreased 2□ Slightly decreased 3□ No change 4□ Slightly increased 5□ Greatly increased
10. How often has your household experienced food shortages in the last year? 1□ Never 2□ Rarely 3□ Sometimes 4□ Often 5□ Always
11. Has the productivity of your farmland changed in the last 10 years? (If applicable) 1□ Greatly decreased 2□ Slightly decreased 3□ No change 4□ Slightly increased 5□ Greatly increased 6□ Not applicable
12. Which of the following assets of your household have been most affected by climate change? □ Agricultural land □ Livestock □ Water resources □ Infrastructure (e.g., roads, bridges, your house)
13. By how much has your household's monthly income changed due to climate-related events in the past year? (Amount in Afghanis): _____________ AFN
14. How many days of work have been lost due to extreme weather events in the last 12 months? _______________
15. Has your household experienced any loss in agricultural yield or livestock due to drought in the past year? □ Yes □ No; If yes determine Agricultural yield loss: _______________ Number of livestock lost: _______________

C. WASH (Water, Sanitation, and Hygiene)

16. What is your primary source of drinking water? 1□ Piped water 2□ Well 3□ Spring 4□ River/stream 5□ Other (specify): _______

17. How often have you experienced water shortages in the last year? 1□ Never 2□ Rarely 3□ Sometimes 4□ Often 5□ Always
18. Has your household's access to clean drinking water been affected by climate-related events in the past 12 months? 1□ Not affected 2□ Slightly affected 3□ Moderately affected 4□ Severely affected 5□ Completely disrupted

19. Has your household's ability to maintain good hygiene practices been compromised due to the adverse effects of climate change? 1□ Not affected 2□ Slightly affected 3□ Moderately affected 4□ Severely affected 5□ Completely disrupted

D. Health

20. Has anyone in your household experienced health issues related to environmental changes in the last 5 years? 1□ Yes 2□ No
21. Which of the following health conditions has anyone in your household experienced due to climate-related events? (Select all that apply) □ Respiratory issues (e.g., asthma, bronchitis) □ Waterborne diseases (e.g., diarrhea, cholera) □ Heat-related illnesses (e.g., heatstroke, dehydration) □ Vector-borne diseases (e.g., malaria, dengue) □ Mental health issues (e.g., stress, anxiety) □ None
22. How often have members of your household needed medical attention due to climate-related health issues in the past year? 1□ Never 2□ Once 3□ 2-3 times 4□ More than 3 times
23. What is the total amount of money you spent on healthcare due to climate-related illnesses in the past 12 months? (in Afghanis) _____________ AFN

E. Environmental and Climate Change

24. How has the amount of rainfall changed in your area over the last 5 years? 1□ Much less 2□ Slightly less 3□ No change 4□ Slightly more 5□ Much more
25. Have you noticed any changes in the frequency of natural disasters in your area over the last 5? 1□ Much less frequent 2□ Slightly less frequent 3□ No change 4□ Slightly more frequent 5□ Much more frequent
26. What environmental changes have you noticed in your local area over the last 5 years? (Multiple responses allowed) □ Reduced water availability □ Increased temperatures □ More frequent droughts □ More frequent floods □ Soil degradation □ Deforestation □ Other (specify): _______

27. Have you noticed any changes in the occurrence of dust storms in your area over the last 5 years? 1□ Much less frequent 2□ Slightly less frequent 3□ No change 4□ Slightly more frequent 5□ Much more frequent
28. Have you noticed any changes in groundwater levels in your area over the last 5 years? 1□ Significant decrease 2□ Slight decrease 3□ No change 4□ Slight increase 5□ Significant increase

F. Biodiversity

29. Have you noticed any changes in the diversity of plant and animal species in your local area over the last 5 years? 1□ Significant decrease 2□ Slight decrease 3□ No change 4□ Slight increase 5□ Significant increase
30. Have you observed any changes in the population sizes of key animal species (such as pollinators, predators, or endangered species) in your local area over the last 5 years? 1□ Significant decrease 2□ Slight decrease 3□ No change 4□ Slight increase 5□ Significant increase
31. Have you noticed any changes in the health or condition of forests, rangelands, or other natural habitats in your local area over the last 5 years? 1□ Significant degradation 2□ Slight degradation 3□ No change 4□ Slight improvement 5□

G. Migration and Displacement

32. Have you or any member of your family moved to a different place in the last 5 years?
1□ Yes 2 □ No
33. What were the reasons for migration? (Multiple responses allowed) □ Lack of sufficient means of subsistence □ To earn additional income □ Land shortage □ Availability of employment opportunities □ Indebtedness □ To education □ Increase in household size □ Lack of water □ Poor crop yields □ Dropout of groundwater □ Flood □ Drought □ Sand and dust storm □ Conflict □ Other (specify): _______

34. Are you considering moving to another place in the next year? 1□ Yes 2□ No 3□ Unsure
35. If yes, what are the reasons you are considering moving? (Multiple responses allowed) □ Lack of sufficient means of subsistence □ To earn additional income □ Land shortage □ Availability of employment opportunities □ Indebtedness □ Education □ Dropout of groundwater level □ Increase in household size □ Lack of water □ Poor crop yields □ Flood □ Drought □ Sand and dust storms □ Conflict □ Land degradation □ Deforestation □ Other (specify): _______

36. If you have migrated or are considering migration, how far do you plan to move? 1□ Within the district 2□ To another district in the same province 3□ To another province 4□ To another country
37. Has anyone in your community been displaced due to environmental changes in the last 5 years? 1□ Yes 2□ No 3□ Don't know
38. What kind of support do you think will help you cope with environmental changes in your area? (Multiple responses allowed) □ Improved irrigation systems □ Drought-resistant crops □ Alternative livelihood training □ Access to credit □ Better weather forecasting □ Improved healthcare □ Other (specify): ______

Annex.2: In-Depth Interview Questionnaire

INTRODUCTION (for interviewer)

- Introduce the purpose of the research and the interview
- Obtain informed consent from the participant
- Clarify the participant's role, level of expertise, and relevant background

PARTICIPANT BACKGROUND

1. Can you please tell us about your educational, experiences and professional background?
   - o *Probe for their academic qualifications, areas of study, and relevant work experiences*

2. Based on your expertise and involvement in the community, what are the key environmental, social, and economic issues facing in Afghanistan and specifically study area (Kandahar, Helmand, Farah, Nimruz, Zabul and Urzgan)?
   - o *Explore their deep understanding of the main challenges and concerns*

ENVIRONMENTAL CHANGES AND IMPACTS

3. From your observations and experiences, what are the most significant environmental changes that have occurred in this region over the past 15-20 years?
   - o *Probe for changes in rainfall patterns, temperature, heat wave, water availability (surface and groundwater), land degradation, natural disasters (flood, drought, landslides, and dust storms, earthquakes),, desertification, declining of agriculture production etc.*

4. How have these environmental changes impacted the lives and livelihoods of the people in this community?
   - o *Explore impacts on agriculture, livestock, access to resources, food security, health, etc.*

5. What are some of the coping strategies or adaptation measures that community members have adopted in response to these environmental changes?
   - o *Discuss changes in livelihood practices, migration patterns, use of new technologies, etc.*

BIODIVERSITY
6. Have you observed any changes in the local biodiversity (e.g. plant and animal species) in this region over the past 15-20 years? o *Probe for specific examples of species that may have declined, disappeared, or emerged in the area.*
7. How have these changes in biodiversity impacted the livelihoods and food security of the local community? o *Explore how shifts in available plant, animal, and other natural resources have affected the community's ability to sustain themselves.*
AGRICULTURE AND FOOD SECURITY
1. How have environmental changes affected agricultural practices and crop yields in this region? 2. What specific challenges are farmers facing due to climate change? 3. How has food security in the community been impacted by these environmental changes? 4. What strategies have been implemented or have you adopted to improve agricultural resilience and food security? 5. How have livestock management practices changed in response to environmental shifts?
WATER, SANITATION, AND HYGIENE (WASH)
8. How has access to clean water changed in recent years, and what are the main causes? 9. What are the primary challenges in maintaining adequate sanitation practices in the community? 10. How have water scarcity issues affected hygiene practices? 11. What measures have been taken to improve water management and conservation? 12. How have changes in water availability impacted women and children specifically?
HEALTH
13. What are the most significant health issues in the community that you believe are linked to environmental changes? 14. How have changes in temperature and precipitation patterns affected the prevalence of certain diseases? 15. What impacts have you observed on maternal and child health due to environmental stressors? 16. How has access to healthcare been affected by environmental changes or related to migration? 17. What health-related adaptation strategies have been implemented in response to these challenges?
MIGRATION AND DISPLACEMENT
18. In your experience, how have environmental factors such as water scarcity, ground water dropdown, droughts, flood, sand and dust storms or other natural disasters influenced migration and displacement in this region? o *Probe for specific examples and trends* 19. What are the primary drivers of migration and displacement in this community? o Discuss the relative importance of environmental, economic, conflict-related, and other factors 20. How do these migration patterns differ between various demographic groups (e.g., gender, age, socioeconomic status)? o *Explore the unique vulnerabilities and experiences of different population segments*

POLICY AND INTERVENTIONS

21. What kind of support or assistance did the government, NGOs, or any other organizations provide you in adapting to environmental changes and their impacts?
    - *Assess the effectiveness and gaps in existing programs and initiatives*
22. From your perspective, what policies, programs, or interventions would be most helpful in enabling communities to better cope with and adapt to climate-induced changes and migration?
    - *Gather insights on potential solutions, including infrastructure, livelihood support, social services, etc.*

CONCLUDING QUESTIONS

23. Is there anything else you would like to share about the relationship between climate change, environmental issues, and migration in this region?
24. Do you have any final thoughts or recommendations for our research project?

Dear respected interviewee!
Thank you for your time and valuable insights. This information will be extremely helpful for our research on climate-induced migration in Afghanistan.