

Assessing Farmers' Perception on Climate Change and its Consequences: A Case Study in the Baba Mountain Valleys of Bamyan, Afghanistan

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ABSTRACT

Climate change poses significant challenges in the vulnerable regions like Afghanistan, where agriculture is main source of peoples' livelihoods. This study examines the farmers' perspectives and their experiential insights into changing climate indicators and its impacts on agriculture. Through a combination of quantitative and qualitative data collection methods, including household surveys, focus group discussions, historical timeline calendars, crop calendars, and key informant interviews, the study identifies changes in climate indicators as perceived by farmers. The study's findings highlight a range of changes in climate indicators. The farmers have experienced decreasing snowfall in winter and annual rainfall in spring and summer, consequently the intense frequent drought and water shortages for agriculture and rangelands in the upper and lower part of the valleys. The temperatures in winter and summer have increased and led to earlier snow melting, earlier blooming, flowering, and greening of the plants. Both positive and negative impacts, brought by the shift in climate indicators, have presented new cultivation opportunities but also led to droughts, water shortages and reduced productivity. These findings can be valuable inputs for effective ecosystem and community-based adaptation strategies at local level, guiding for a resilient planning and policies for addressing current and future climate impacts on agriculture.

Keywords: climate change, perception, impacts, temperature, precipitation, agricultural community, Bamyan, Afghanistan.

INTRODUCTION

Climate change adversely affects coupled ecosystems and human systems including water security, food security, infrastructure, health, and well-being. In the near term (2021-2040), 1.5°C global warming increases climate hazards, posing risks. In the mid to long-term (2041-2100), risks intensify, surpassing current observations for numerous identified key risks (IPCC, 2022). Climate change vulnerability varies across regions and Asia will face adverse impacts to agricultural and food security in many parts. The potential of total fisheries

production in South and Southeast Asia is also projected to decrease. However, in southeast and south Asia including Afghanistan, agriculture and food systems will be mainly affected by drought and precipitation regime shifts (Shaw, et al., 2022). The impacts also include increasingly severe social and economic consequences, especially in low and lower-middle-income nations, which tend to be most vulnerable to the impacts of climate change (IPCC, 2021).

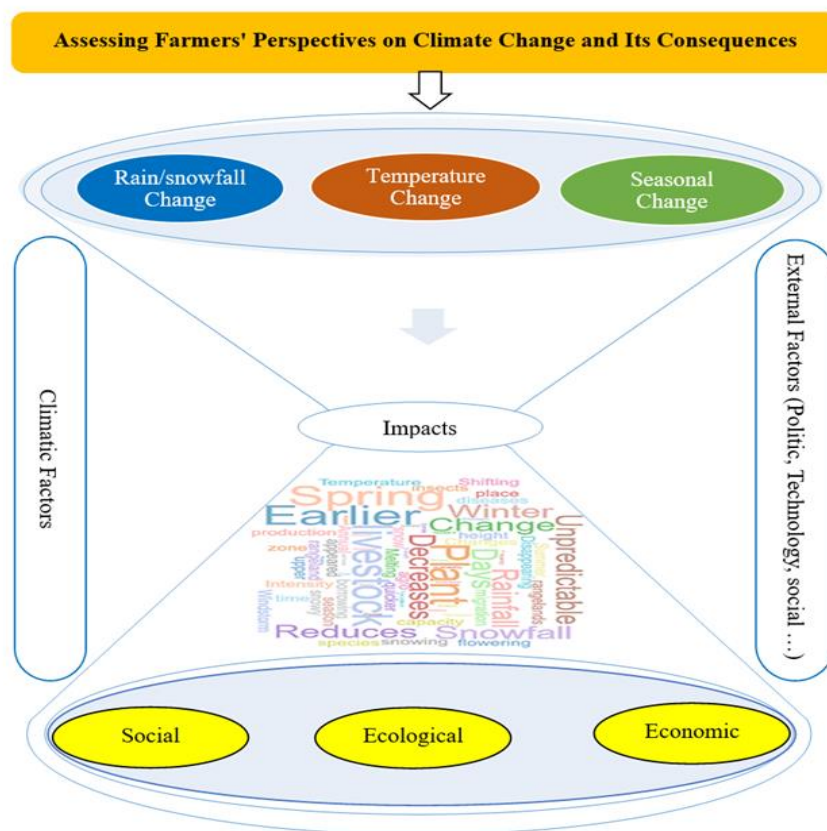
Afghanistan is a landlocked, less developed, and agrarian country with an estimated population of 34.3 million people, mostly dependent on agriculture, with a share of total GDP of 33.6 % in 2021 (NSIA, 2022), with an arid and semi-arid continental climate with cold winters and hot summers and using surface water (86%) and groundwater for irrigations (Hussainzada & Lee, 2022), is the 6th top vulnerable country in the world, experiences severe flash floods, droughts and landslides and lead to life and economic losses (Eckstein et al., 2021). A study on precipitation and its extremes across Afghanistan (1951–2010) using global climate data shows a decrease in precipitation and an increase in the number of consecutive dry days in north-eastern and southwestern agroclimatic regions, especially in the spring season, whereas there is an increasing trend of summer precipitation and the frequency of very heavy and extremely heavy precipitation in the central, eastern, and southern agroclimatic regions, leading to increased flooding events (Aliyar et al., 2022). Intensifying and higher drought frequency events affecting water availability and agricultural production are also reported in the country (Aliyar et al., 2022).

A study on the perception of farmers using meteorological data in the Bamyan area found an increase in average temperature and a decline in average precipitation from 1998–2017. The temperature from 1951 to 2010 for all of Afghanistan shows a rise of 1.8 °C, with the highest temperature of 2.4 °C in the east, and the lowest of 0.6 °C in the Hindu Kush region (Aich et al., 2017). Kunduz River basin shows an extreme warming trend, partly above 2 °C since the 1960s and a dramatic decline in precipitation by more than –30%, leading to a strong decrease in river discharge. Increasing temperatures, decreasing precipitation, and untimely rainfall have led to higher drought frequency negatively affecting food production (Qutbudin et al., 2019). The reduction of water availability and the additional stress on the land leads to a strong increase of barren land and a decrease of vegetation cover (Akhundzadah et al., 2020).

Afghanistan will be experiencing higher rates of warming compared to the global average, with potential temperature rise ranging from 1.4°C to 5.4°C by the 2080s and 2090s (WBG & ADB, 2021). More severe droughts in the future are expected due to increased temperature and reduced precipitation (Aich et al., 2017; Qutbudin et al., 2019). Climate change presents significant challenges for agriculture in Afghanistan (WBG & ADB, 2021) with the expected decrease agricultural production, adversely affecting food security due to change in growing season, crop duration, soil moisture regime, and yield decline. More frequent and heavy precipitation increases the risk of crop damage from flooding, soil erosion, and landslides (Dahal et al., 2023). The negative impacts are much ramified, for instance, loss of glaciers due to increasing temperature threatens water supply while increased frequency of floods (Hashmi et al., 2020), climate-induced migration (Přívvara & Přívarová, 2019), possible

escalation conflicts (Price, 2019) but the limited data and research impede effective climate risk understanding and adaptation in agriculture (WBG & ADB, 2021).

Assessing farmers' perspectives on climate change and its consequences on agriculture is important to designing location-specific ecosystem and community-based adaptation strategies as climate change can vary from location to location and eventual impacts on location specific farming systems and livelihood resource systems (Shrestha et al., 2017). Downscaling studies at the national level indicate the changing climatic condition (Aich et al., 2017; Aliyar et al., 2022; WBG & ADB, 2021). Ground-truthing climate models with indigenous ecological knowledge refine downscaling methods, and synergies between people's perceptions and climate science are more beneficial for better local, regional, and national planning and policies (Kassam et al., 2018) but most often it is hard to obtain appropriate data regarding temporal and spatial resolution in developing countries (Imran et al., 2018). There are a few studies conducted in Afghanistan using the scarce and limited national and broad global climate data. Validating what farmers have experienced in real-world situations will further enhance the robustness of results from climate change models. On this premise, this study was conducted to understand farmers' local knowledge of climate change and its impacts on agriculture. The study objective was to assess farmers' perception of climate change and its impacts on agricultural communities of Baba Mountain valleys, Bamyan province of Afghanistan to understand about i) how do farmers perceive about climate indicators trend and its impacts on agriculture? and ii) how are the farmers affected by climate change?



MATERIALS AND METHODS

Study Area

The study was conducted in two valleys of Bamyan district: Foladi and Khushkak. Foladi valley is located at coordinates of 34.76° N and 67.72° E and Khushkak valley of 34°44'25.71" N and longitude 67°48'20.78" E in Bamyan District of Bamyan Province of Afghanistan (Figure 1).

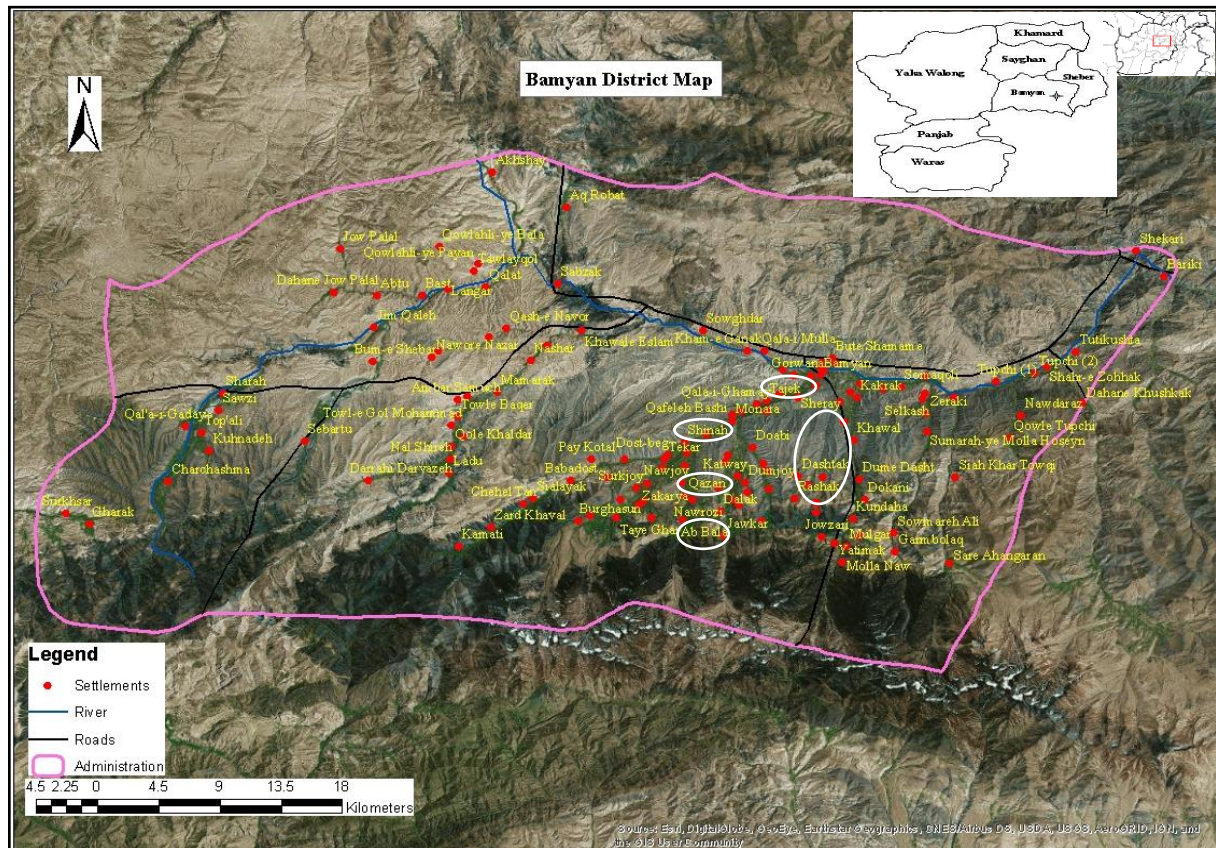


Figure 1: Map of the study Sites. White circles show the villages the study conducted in Bamyan District of Bamyan Province

Bamyan district is highly mountainous with deep valleys and an elevation of about 2,800 meters from the sea level (MASL). The studied villages are located from 2600-3100 masl and are parts of Koh- E-Baba region in the western Hindu Kush, the Central Highlands or Hazarajat region of Afghanistan. The climate is arid and the lowest temperature with six months of winter drops to -20 C. The highest precipitation occurs from March to April at 25 to 30 mm. The mean annual precipitation is 332 mm/year, and the mean yearly temperature is 5.2°C.

The total population in Bamyan province is 504,312, 97% as rural population (NSIA, 2022). Farming and livestock are the primary sources of households' income and hence livelihood is highly dependent on crops, livestock, and forestry. The agricultural area is about six percent and mainly irrigated still about 2 percent is rain fed agriculture (Aich et al., 2017). Shah-Foladi valleys irrigated land is less than the provincial average (UNEP, 2016). Wheat and potato are

the main crops. 1.3 million hectares (92%) of Bamyan province area is rangeland and hence provides major source for fuel, food, medicine, and the means for livestock production, such as sheep, goat, and cow.

Of 322 households (with 2,260 people, 61 % Male and 39 % female) in the study area at elevation of 2,600-3,100 masl, the average household size is seven. The social setting of the studied households is composed of three different ethnicities Hazara, Sayeed and Tajik (60%, 14 %, and 26%) given in Table 1. Snowy mountains in the area form a nationally significant watershed from which major rivers like Kabul, Helmand and Arghandab originated. Water is, however, scarce and the dwellers only have water access for agriculture for one season, while people in Folangi valley collect their drinking water from wells and in Khushkak valley from wells and streams.

Method

For this research, both primary and secondary data were collected. The primary data were gathered through social learning using different methods like household questionnaires survey and Participatory Rural Appraisal (PRA), the Key Informant Interview (KII), Focus Group Discussions (FGD), preparing Historical Timeline Calendar (HTC), and Crop Calendars tools as these were important in understanding the institutional context of environmental changes and participatory risk hazard assessment in the lack of locally recorded quantitative climate data.

Data Collection and Analysis:

The key informant's interviews were conducted to collect descriptive data, understand the perception and experiences, and promote greater accuracy in responses through cross-questioning. 18 KII were conducted. The key informant interviewees were the community-based councils (CBO's) heads, head of directorates like, agriculture, environment, rural development, disaster management and women affairs.

The major source of data came from a face-to-face household survey conducted using a structured questionnaire containing both close- and open-ended questions to collect data on socio-economic profiles, agriculture practices, perceptions of climate change, and its impacts. Of 322 total households in the study area, 120 respondents from nine villages were randomly selected from lists prepared by Community Development Council representatives and age was an important criterion to assess past changes in the climate condition and their experiences of the impacts. The data on household-level characteristics, socio-economic profile, livelihood assets, income, and the perception of climate change and its impacts were collected quantitatively. Prior to the survey, a pre-survey session was conducted to test the questionnaire for clarity and relevance.

Four Focus Group Discussions (FGDs) in four main villages, namely Khushkak, Ab Bala, Jarob, and Tajik, with 7-10 participants in each group. The purpose of the FGDs was to collect detailed information and discuss the perceptions of climate change, its impacts, climate trends in the valley, and changes in the climate system. A prepared questionnaire was used to guide the discussions. The FGDs also helped to validate and confirm important information collected during the household survey. In two of the FGDs, the participation of women was 50%, while

in the other two, no women participated due to cultural issues and the distance of the mosques and villages.

The Historical Timeline Calendar (HTC) is a commonly used tool and method in environmental policy and management that facilitates the organization and synthesis of multidisciplinary evidence (Pandey, 2019). It provides a structured approach for analyzing and addressing complex environmental issues (Moss et al., 2021). In this study, HTC was used to encourage local people to talk about past climatic hazard events, their trends, and associated impacts. Four HTCs with 7-10 farmers were conducted. The HTC guideline was framed using the Drivers-Pressures-State-Impacts-Response (DPSIR) framework. By examining the driving forces (such as temperature rise and changing precipitation patterns), pressures (such as drought and arid land expansion), state (current condition of agriculture and water resources), impacts (crop yield decline and water scarcity), and responses (adaptation strategies and policies), we gained a comprehensive understanding of the complex dynamics and identified potential solutions to address the challenges faced by the agricultural sector in the context of climate change.

Sketching the Crop Calendars was used to identify the changes in agriculture activities over time. Before conducting the FGDs, the farmers were asked to share their activities times of two main crops, spring wheat, and potato, within the villages. Four sets of crop calendars were drawn in four main villages from three past decades up to the present. The changes over time from the crop calendar are interpreted to understand changes in climate. Observation, photographs, and field notes were also used to collect qualitative data and observe the farmer's activities, nearby land and rangelands, and livestock herders.

The data were analyzed using Statistical Package for the Social Sciences (SPSS version 24). To analyze the perception and experiences of farmers on climate change and its impacts, the Guttman Scale and Score also known as scalograms (Pandey, 2019) was used. The perceived impacts of climate change over the past decade were assessed using a unipolar scalogram. The level of impacts was recorded and scored on a scale ranging from 1 to 5 (1=Yes, Clearly Observed, 2=Often observed, 3=Occasionally observed, 4=Cannot Evaluate/Do not know, 5=Non-observed no changes), which was converted to a single category to get the normalized response using the following formula:

$$\text{Normalized response (\%)} = \frac{\text{Total score of the actual responses}}{\text{Total of the highest possible score}} * 100$$

RESULTS

Profile of Respondents

The table 1 presents demographic, socioeconomic, and agricultural characteristics of respondents, highlighting key variables and their respective percentages. The demographic characteristics of the surveyed population reveal a primarily Hazara majority at 60%, with Tajiks comprising 26% and Sayeed 14%. Gender distribution shows a predominance of males at 61%, contrasting with females at 39% which 8% of female are their household's heads. Educational attainment is varied, with a significant portion lacking formal education (29%) or

holding only primary education (52%), while 14% have tertiary qualifications, and smaller percentages possess professional certifications or university degrees.

Agriculture is the major backbone of the household's economy. Agriculture, remittance, employment, enterprise, ecotourism industry and other activities, respectively (58%, 12 %, 7%, 1%, 1%, and 1%) are the HH's source of income. In terms of land ownership, 99% of respondents own land, with a notable 10% of females among them. There are five types of lands according to its use; terrace (currently used agricultural lands with levelled surface), sloping (limited to use for agriculture purpose and mainly used as a rainfed agriculture for one season), homestead (lands located nearby the house and mainly used for horticultural purposes), private rangeland (lands have private ownership and due to water shortages do not used for cultivation), and private forested area lands. The mean size for each type is respectively (0.64, 0.41, 0.17, 0.3 and 0.31 ha) with standard deviations of (0.78, 0.52, 0.17, 0.61 and 0.60) ha, respectively.

The coldness, irrigation limitation, productivity issues, and lack of chemical fertilizer, respectively (78%, 13 %, 6%, and 3 %) are the main limitation of cropping intensity. In addition, highly rugged topography, high rate of soil erosion, and low productive soil increased water demand for a higher level of efforts for farm-management and maintenance of irrigation facilities are the reasons to secure their livelihood. About 80 percent of farmers have access to irrigation facilities. 63 % of respondents have access to water for an entire year, 11 % only for two seasons (spring and summer) and 26 % have access to water only for one season. Based on the interviewee and FGDs water is getting scarcer and negatively affecting their social and economic issues. 85 % of the respondents have leased land. The share of irrigated land is very low 92 % of the farmers own only 0.2 to 0.6 hectares and 8 % own 0.8-1.2 % hectares of irrigated land. Respondents (16%) reported that their land remained uncultivated due to drought and the locking of the ditches due to landslides respectively (94 % and 6%).

Table 1: Socio-economic profile of the surveyed farmers households' head in the studied area

Variable	Description	Respondents (%)	Variable	Description	Response (%)
Ethnicity	Hazara	60	Educational Qualification	Illiterate	29
	Sayeed	14		Primary	52
	Tajik	26		Tertiary	14
Gender	Male	61		Two-year professional	3
	Female	39		University	2
Female-headed HH	Yes	8	The age group of respondents (Years)	22-32	2
Having land	Yes	99		33-42	20
Female land ownership	Yes	10		43-52	28
Source of income	Agriculture	58		53-62	23
	Employment	7		63-72	21
	Remittance	12		73-81	8
	Enterprise	1			

	Wage-labour	20	Type and area of land (Mean Hectare)	Terrace land	0.64
	Ecotourism	1		Sloping land	0.41
	other sources	1		Homestead land	0.17
The reason for the limited intensity	Lack of irrigation	13	Total land (ha)	Private rangeland	0.30
	Not having profitable productivity	6		Forest	0.31
	Coldness	78		0.2-06 ha	45
	Other (Chemical Fertilizer)	3		08-1.2 ha	40
				1.4-1.8 ha	5
Irrigation facility	Yes	80	Irrigated by ha	2-3 ha	10
	No	20		0.2-06 ha	92
Access to irrigation water	Year-round	63		08-1.2 ha	8
	Only the spring and summer seasons	11			
	Only for one season	26			

Source: Researchers.

Farmers' Perspectives on Climate Change and Its Consequences on Agriculture

The analysis reveals significant changes in environmental conditions, particularly related to seasonal patterns and climatic variables. Notably, 95% of respondents observed quicker melting of winter snow, and 94% noted a decrease in winter snowfall, reinforcing perceptions of warmer winters. An earlier start to spring is reported by 91%, corroborating the overall shift in the seasonal calendar acknowledged by 89%. Additionally, 89% observed earlier greening of rangeland and a reduction in the number of snow days, along with the disappearance of snow cover in specific mountainous locations. Regarding precipitation, 88% noted a decrease in annual rainy days, while 56% observed increased rain intensity in spring and summer. Temperature changes are evident, with 88% reporting increases in both summer and winter temperatures. A shift in snow timing toward winter is observed by 80%, affecting seasonal predictability. Drought conditions have intensified, with 79% reporting increased intensity and frequency of drought, 72% noting water shortages, and 67% observing a decrease in the annual lifespan of water sources. Further impacts include a perceived decrease in rangeland production capacity by 79% and earlier borrowing times for animals noted by 63%, affecting grazing schedules. Ecological shifts are indicated by 59% noting upward migration of rangeland zones and plant species, and 41% observing new plant species in rangelands. Increased vulnerability to biotic stress is suggested by 58% reporting new diseases in crops and livestock. Weather variability is highlighted by 54% noting unpredictable rainfall patterns, 49% reporting increased windstorms and new insect species, and 48% and 46% observing unpredictable hailstorms and frequent summer floods, respectively. This comprehensive analysis underscores broad perceptions of climate change impacts among respondents (Table 2).

In the FGDs farmers acknowledge the changes in environmental condition particularly relevant to climatic variables. The snowfall starts from the last of October to the last of April

months. Farmers in the FGDs reported that they recently experienced heavy snowfall, like in the 2017 winter, it snowed for 24 hours but very heavy and brought considerable social, health, physical, economic, and environmental losses to the people, lands, livestock, and properties. Due to that, pneumonia among the children was increased, trees were cut, fodder prices were doubled, roads were blocked for twenty days, and no one had access to the doctor and city. Moreover, it increased the workload of cleaning, damaging the houses, killing livestock, and increasing snow avalanches. Farmers in the FGDs reported changes in annual rainy days and increasing number of extreme rainfall events, experiences of unseasonal rainfall in multi years, including 2005, 2009, 2012 and 2013, which caused considerable damage to agricultural products. Farmers also noted that unexpected rain showers occur suddenly, washing away crops and causing flash floods. Farmers in the FGDs and HTC confirm changes in the increase in intensity and frequency of drought, water shortages and decrease in annual life or availability of water.

Farmers perceived an increase in summer temperature. Beekeepers in the area and livestock keepers felt these changes very clearly. Farmers also reported that the spring comes earlier, plants start growing, trees blossom and flower, and farmers start working on their land accordingly. However, in the spring season, frost affects negatively and causes damage to the products and rangeland. In general, the farmers in the studied villages perceived an increase in the minimum and maximum temperatures. The winter is called "death of the poor people" in the research area due to its coldness. The respondents replied that the temperature is increasing, and the weather is not as cold as it was in the past.

Table 2: Farmers' Perception on Climate Changes in the last ten years (2007-2017)

Farmers' perception (% respondents) N=120						
Variable	Clearly observed	Often observed	Occasionally observed	Cannot evaluate/ Do not know	Not observed/ No change	Normalized Response (%)
Melting of winter snow quicker	88	13	23	1	2	95
Decrease in winter snowfall	78	17	3	1	2	94
Earlier start of the spring season	82	7	3	3	7	91
Change in the seasonal calendar	79	8	2	3	9	89
Earlier greening of rangeland	28	8	26	4	34	89
Reduce in number of snow days	73	14	3	3	8	89
Disappear of snow cover at particular locations in the mountains	74	9	10	1	6	89
Decrease in annual rainy days	67	18	8	2	6	88

Increase in summer temperature	80	2	7	0	11	88
Increase in winter temperature	73	9	9	2	7	88
Change of snowing time toward winter	54	13	23	1	10	80
Increase in intensity and frequency of drought	59	10	13	1	17	79
Decrease in rangeland production capacity	59	13	7	5	17	79
Increase in water shortages	45	17	14	1	23	72
Increase in minimum and maximum temperature	42	16	16	11	16	71
Decrease in the annual life of water sources	36	15	21	3	26	67
Change in borrowing time of the animals earlier for grazing in rangeland	40	6	15	7	33	63
Shift up in or migration of plant species upward	18	8	13	14	47	59
Shift up of rangeland zones toward higher elevation	33	9	6	21	31	59
New disease in crops and or livestock	28	8	26	4	34	58
Increase in intensity of rain (spring and summer)	15	17	35	2	1	56
Become the rainfall unpredictable	14	12	33	10	31	54
Increase and stronger windstorms	16	5	32	3	45	49
New insects are identified	19	5	1	16	42	49
Unpredictable pattern of rainfall (Hailstorm)	3	18	34	5	40	48
Intense/frequent summer flood	8	11	31	3	47	46
Appear of new	15	4	8	13	59	41

species of plants in rangelands						
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Source: Researchers

The data analysis indicates a significant shift in the seasonal calendar, with 89% of respondents acknowledging this change. Spring, which marks the onset of agricultural activities, now arrives 16 days earlier on average. This advancement is crucial for the studied area's agricultural sector, providing farmers with additional opportunities for crop cultivation. The earlier onset of spring allows for timely wheat planting and harvesting, a practice previously hindered by late seasonal transitions, necessitating barley cultivation. Farmers express increased satisfaction with these changes, attributing improved agricultural productivity to the earlier spring.

Table 3

Number of days	Respondents (%)	Mean	St. Deviation
0-5	15	16	8.7
6-10	9		
11-15	26		
16-20	34		
21-25	3		
26-30	12		
31-35	1		

Source: Researchers

Table 4: The farmers' perceptions on changing climate of Bamyan district in the last ten years (2007-2017)

Local Experience of Change	Indicators	Normalized Response (%)
Precipitation	Decreases in winter snowfall	94
	Decreases in annual rainy days	88
	Increase in intensity of rain in spring and summer	56
Temperature	Increases in temperature in winter	88
	Increases temperature in summer	88
	Earlier arrival of spring	89
Drought	Increase in intensity and frequency of drought	79
	Increases in annual water shortages	72
	Decreases annual water availability	67
Weather events	Hailstone (Unpredictable pattern of rainfall)	48
	Increase in intensity and frequency of summer floods	46

Source: Researchers

Impacts of Climate Change on Agriculture

Drought is one of the main impacts of climate change in the region, extremely affected agriculture. Farmers (79 %) perceived intensity and frequency of drought and its impacts

have put severe pressure on agriculture (Table 2). Farmers in FGDs reported experiencing severe drought from 1998-2001, 2013, and 2011-2016 which had profound impacts.

The droughts during 1998-2001 and 2011-2016 led to dried river, reduced agricultural productivity, livestock loss, food insecurity, increased poverty, and outbreaks of pest and diseases. Water resources, rangelands, agriculture, and livestock were severely impacted, with decreased water levels, dried water bodies, wells, springs, and low agricultural productivity exacerbating poverty and food insecurity. Drought also increased livestock mortality rates, decreased land cultivation areas, and led to pest and disease outbreaks, further reducing land productivity. Rangelands were overgrazed and dried out, resulting in livestock losses. Socially, children left school as they had to travel farther to collect bushes, which doubled collection times and decreased school attendance. Indebtedness, food insecurity, and poverty became widespread, and scarce resources increased social conflict. Farmers observed worsening annual water shortages, especially in the summer, which affected agriculture. A normalized proportion of 72% of respondents perceived these water shortages, and 67% agreed that decreasing water sources negatively impacted agriculture. The decreasing annual water availability has added pressure on households.

Respondents also reported that windstorms have become stronger and more violent recently, with about 49 percent of the people agreeing. Farmers in the four FGDs noted extreme windstorms in 2003, 2012, 2016, and every three years, negatively affecting agriculture. The frequency of extreme winds has increased in recent years.

Farmers reported that spring season is arriving earlier than before, with 91 percent of the respondents agreeing. Of these, 82 % specifically noted the earlier arrival of spring season, confirmed by the crop calendar, which shows that farmers now start ploughing lands on April 20 instead of May 5. The warmer temperatures have altered the flowering and fruiting seasons, with 84% of farmers observing earlier flowering and fruiting. Habitat changes in plants were also noted, with 48% agreeing.

New diseases and insects were observed, with 58% and 49% of respondents, respectively, stating that these increases have decreased production and increased economic pressure. Grasshopper populations and habitat changes were particularly noted, causing severe crop damage. Wheat crops were damaged by rust disease, reducing seed size and necessitating additional washing, increasing the workload. In potatoes, insects damaged leaves, reducing production by up to 60%, with each household losing 2800-3500 kg of potatoes annually. Alfalfa lands were also attacked yearly by insects. New animal diseases, such as Sia Qayak and Amro (local names), have also led to economic losses.

Farmers stated that rangeland grasses and bushes grow earlier due to warmer temperatures, with 89% agreeing. This phenomenon was linked to declining winter snow and earlier melting in the spring. New plant species in higher rangeland elevations were observed by 41%, and 59% reported changes in rangeland areas toward mountains, exacerbating household issues. Younger family members now spend more time borrowing animals to rangelands, affecting their health and education. The study found decreased rangeland productivity, with 79% agreeing. Farmers now take animals to rangelands earlier, linked to

earlier greening and quicker snow melting. Although this reduces winter fodder needs, it increases overutilization and could lead to desertification and biodiversity loss.

Farmers observed a decrease in rangeland productive capacity, affecting the livestock herds. The proportion of the normalised responses of the respondents shows that 79 % agree that the productive capacity of rangeland has decreased. Among the respondents, 59 % reported that the capacity of the rangelands has decreased clearly. Farmers observed that the time of taking animals to the rangeland has changed. People observed early greening of rangelands that spring come earlier, snow melted quicker; and the weather has become hotter, which caused them to borrow their animals to the rangelands earlier. The proportion of normalised responses of the interviewees shows that 63 percent agreed with the changes. Farmers reported that this is good for them because they can keep less fodder for the winter and use nature. However, on the other hand, they must go long distances for ranching. This issue may increase overutilization along with the bush collection which will lead to desertification and loss of biodiversity.

Unpredictable rainfall has also increased, with 54% agreeing. Sudden rain negatively impacts agriculture and livestock, reducing dried alfalfa quality, wheat yield, and quality, flooding potato lands, and damaging nearby waterways. Reduced snowfall and snow days were noted by 89%, with faster and heavier snow in recent years leading to water shortages and rangeland productivity decline. Snow avalanches have become common, linked to heavy snow and decreased snow days, causing agricultural damage, tree loss, and economic impacts.

Farmers observed quicker snow melting due to warmer winter and summer temperatures, with 95% confirming this trend. Mountains in the area, which feed major rivers like Kabul, Helmand, and Kunduz, are losing their natural freezer function, leading to water shortages during critical agricultural periods. The disappearance of snow from specific mountain locations was observed by 89%, with 74% noting a clear decrease. Changes in snowing time toward winter were seen as advantageous, allowing better preparation for winter and more economic opportunities, although quicker melting reduces water discharge and increases rangeland pressure. Increased river water levels in spring, due to earlier snow melting, lead to summer water shortages, low production, and economic losses. Conversely, in Foladi Valley, increased river levels cause riverbank erosion and threaten agricultural lands. Livestock herders reported dried-up mountain pools, longer water access times, and increased water demand due to rising temperatures, negatively affecting livestock.

Farmers are leaving their lands uncultivated and reducing land productivity due to the necessity of early harvesting, driven by water scarcity. Water for irrigation is scheduled based on land size, but increased summer demand has led to shortages and conflicts over water use, especially in Foladi valley, which is now a common issue. Observations indicate changes in snowing patterns, with snow occurring later in the year. A normalized proportion of 80% of farmers confirmed these changes. The shift in snowing time benefits the mountainous community, as it alleviates difficulties faced when harvesting wheat during snowfall, which previously impeded proper harvest and extended the drying process for hay and seeds. Historically, transporting hay home to feed livestock during winter was challenging.

Women in the households expressed satisfaction with the delayed winter during focus group discussions (FGDs), as it allows them to collect sufficient bush fuel for winter, dry it, and be better prepared. This delay provides them with more time to care for children, learn new skills, and pursue additional opportunities, as less bush collection is required for fuel. The later onset of winter also benefits farmers economically. By delaying the sale of potatoes, they can avoid low prices during periods of high supply, thereby maximizing profits by targeting optimal market conditions. Additionally, farmers now have more time to prepare new lands, enrich their soil with organic matter, clean ditches, and find new labor opportunities within their villages. However, these changes in snow timing and quicker melting patterns result in decreased water discharge and spring water availability, increasing pressure on rangelands. Respondents observed that reduced spring water in summer and fall impacts household water consumption. Prolonged use of rangelands may lead to degradation, soil erosion, and flash floods during rainfall. While the delayed onset of winter offers new opportunities, it necessitates careful resource management to mitigate adverse effects.

Respondents reported increased river water levels during the spring season and experienced adverse effects. Farmers in Khushkak Valley in the FGD reported that because of the earlier snow melting, they faced water shortages in the summer season for irrigation, which resulted in low production and economic losses. It also decreased their wells and springs' water levels. While in Foladi Valley, the river water level in the spring and summer seasons increases, resulting in water erosion of riverbanks and threatening their agricultural lands. Livestock herders say that they could access small natural pools in the mountains to use for drinking livestock. Livestock herders reported dried-up mountain pools, longer water access time, and increased water demand due to rising temperatures, negatively affecting livestock.

Overall, the perception and experience of climate change impacts profoundly affect households in the farmer community. Respondents noted earlier snowmelt, reduced snowfall, disappearing snow cover, earlier flowering seasons, and changes in snowing time toward winter. These primary impacts result in secondary effects such as new pests and diseases, increased windstorms, and migration of plant species to higher elevations. These changes have negatively affected agricultural productivity and household livelihoods.

Table 5: Farmers' perceptions on changing climate impacts in Bamyan district in the last ten years (2007-2017)

	Indicators	Normalized Response (%)
Local Experiences of Climate change Impacts	Reduces the amount of snowfall	94
	Changes in time of snowing toward winter	80
	Reduces the number of snowy days	89
	Melting snow quicker	95
	Earlier spring than before	91
	Changes flowering season	84
	Disappearing of snow from a particular place	89
	Decreases production capacity of rangelands	79
	Earlier borrowing of livestock to rangeland	63
	Shifting up the rangeland zone	59
	New diseases in agro livestock	58

	Unpredictable rainfall	54
	New insects appeared	49
	Windstorm	49
	Plant migration in upper height	48
	Appears new plant species	41

Source: Researchers

DISCUSSION

The observed changes in climate indicators, including decreased snowfall accompanied with heavy snowfall events, and increased temperatures, align with studies using regional and global climate data in Afghanistan such as (Aich et al., 2017), (Aliyar et al., 2022); (WBG & ADB, 2021), regional (Shaw, et al., 2022) and global trends (IPCC, 2022) associated with climate change. However, there are an uncertainty and variations regarding precipitation. Two key observations from this study are the reported decrease in snowfall during winter seasons and increase in heavy snowfall events and decrease in annual rainfall during spring and summer seasons. This first one has important implications for water availability and irrigation practices, as snowmelt serves as a critical water source for agricultural activities. The decrease in snowfall, coupled with the earlier melting of snow, has led to water shortages and increased pressure on farmers to manage their water resources effectively. The second one is a significant concern for farmers because the decrease in rainfall resulted in the intensity and frequency of drought events, impacting agricultural productivity and exacerbating water shortages. Droughts have led to decreased water levels, dried water bodies, and low agricultural productivity, further contributing to food insecurity and poverty among farming communities. Aliyar et al., found a decline in overall precipitation and an increase in consecutive dry periods from 1951 to 2010 in Afghanistan, particularly in the northeastern and southwestern regions. The study also identifies an increase in summer precipitation and an increased frequency of heavy rainfall events, posing a heightened risk of flooding in the central, eastern, and southern regions (Aliyar et al., 2022). Aich et al, found that precipitation levels decreased across all regions of Afghanistan during 1951–2010, except for the South, during the months of March to May. Furthermore, the study reported a slight increase in precipitation from June to February. The study also found a slight shift in the timing of seasons, with an earlier onset of precipitation. This trend is particularly noticeable in the North and Central regions of the country (Aich et al., 2017) Aliyar and Esamilnejad found that there are varies on trend of precipitation across Afghanistan and revealed that from 1979–2019 period, the mean annual rainfall in the central regions indicates a raise of 37.5 mm per decade in Kabul, while in Vardak, the precipitation increases up to 9.21 mm per year (Aliyar & Esmailnejad, 2022). The observed increase in temperatures is consistent with global warming trends associated with climate change. Higher temperatures have led to earlier blooming, flowering, and greening of plants, increased water demand, impacting the timing of agricultural activities, increased snowmelts, and consequently flooding and hydrological drought in summer. While the earlier arrival of spring presents new cultivation opportunities, the changing temperature patterns also bring challenges such as frost damage during the growing season. Aich et al., found that the average annual temperature in the majority of Afghanistan has risen significantly by 1.2 degrees Celsius during the periods of 1981-2010 and 1951-1980 (Aich et al., 2017). Akhundzadah et al., 2020 found that in the Kunduz River basin, an analysis of climate change impacts reveals an alarming trend of

extreme warming, with temperatures exceeding 2°C since the 1960s in combination with a dramatic precipitation decrease by more than -30% lead to a strong decrease in river discharge (Akhundzadah et al., 2020). Additionally, the World Bank Group (WBG) and the Asian Development Bank (ADB) indicates that Afghanistan is experiencing higher rates of warming compared to the global average. The studies projected that temperatures in Afghanistan could potentially increase by 1.4°C to 5.4°C by the 2080s and 2090s (WBG & ADB, 2021), Hashmi et al., 2020 in a study on climate change impacts during the first half of 21st century on the flow regime of the Kabul River found that the temperature increases by a range of 3-5 °C, precipitation increases within the range of 1.3-1.7 for the entire watershed and floods increase (18-40%) under both RCP 4.5 and RCP 8.5 scenarios (Hashmi et al., 2020).

Drought in the study area was reported as a common problem and it has worsened recently. Farmers, affected by increase in intensity and frequency of drought, increase in annual water shortages, and decreases in annual water availability. Maharajan et al., 2018 found that the number and total area of glaciers in the Hindukush mountains between 1990 and 2015 decreased 13.4% with an average loss of 5.4% per decade (Maharjan et al., 2018). Thus, this study confirms warming temperature and increased snowmelt and water shortages. A study on farmers perception on drought in Herat province in western part of Afghanistan found that drought has resulted in severe economic impacts, including job losses and reduced crop yield and livestock production, migration, feelings of hopelessness and loss, water conflicts, health issues, disruptions in children's education, malnutrition, and limited food choices. (Iqbal et al., 2018) Furthermore, studies indicate that future projections anticipate more severe droughts due to rising temperatures and diminished precipitation (Aich et al., 2017), (WBG & ADB, 2021), (Qutbudin et al., 2019). The warming temperature has positive impacts as well. A study also found that warming temperatures have had a positive economic benefit for the mountain area of the central part of Afghanistan (Jawid, 2020) While on the contrary, due to the increase in the temperature, the water demand and prevalence of pests and diseases increased. Water demand for agricultural purposes has increased and led to water shortages in the lower part of the valley. At the same time caused social problems (conflicts) among the households on using the water and rangeland and reduced the land use in the study area. It has also increased fertilizer demand, which is more chemical, and increased input costs, which finally decreased the economic output of the land. Aich et al., 2017 findings confirm the increase in temperature and its consequences. Additionally, the warming temperature has led to increasing snowmelt, which increases the water for a short time in the spring season and causes river stream erosion. As the lands are in the lower part of the valleys, increasing river water levels threaten nearby lands. Moreover, it has not only caused an increase in workload but also negatively affected the farmers and their family members. In addition, the drought incidence and changes in rainfall patterns also threatened the study area. An increased drought intensity and frequency led to economic losses and social issues. At the same time, it has affected the women and children, as they are the bush and water collectors of the households. It negatively affected the households' overall status and children's education (Aich et al., 2017).

The study highlights the importance of incorporating local knowledge and perceptions into climate change adaptation strategies. The experiences and observations of farmers provide valuable information for developing context-specific, ecosystem-based adaptation measures

at the local level. Building resilience in agriculture requires the integration of adaptive practices, such as water management techniques, crop diversification, and improved pest and disease management strategies. Furthermore, the findings emphasize the need for collaborative efforts among farmers, policymakers, researchers, and local communities to address the challenges posed by climate change. Long-term monitoring and data collection initiatives can enhance our understanding of climate dynamics in the region and inform evidence-based decision-making and climate-smart agricultural practices and support the resilience of farming communities.

CONCLUSIONS

Understanding farmers' perceptions of climate change is critical for designing and building climate resilience agriculture. The study sheds light on farmers perceived change on climate indicators and its impacts on agriculture in Bamyan of Afghanistan. The farmers have observed significant changes and impacts related to climate change. These include a decrease in annual snowfall, increased heavy snowfall events, decreased annual rainy days, and increased extreme rainfall events. There is also changes in the timing and duration of seasons, with an earlier arrival of spring by an average of 16 days. Summer temperatures have increased, leading to frost damage during spring, and there has been a perceived increase in winter temperatures. Increased frequency and intensity of drought has emerged as a major concern of farmers as it causes water scarcity, agricultural productivity loss, livestock mortality, food insecurity, increased poverty, and outbreaks of pests and diseases. Livestock holders have suffered significant losses due to overgrazed and dried rangelands, and social impacts such as increased indebtedness, food insecurity, poverty, and conflicts have compounded the challenges faced by farmers. The impacts of climate change on agriculture in the study area extend beyond water shortages. Extreme windstorms have caused substantial damage. Changes in seasons have not only affected crop cultivation, but also the agro-ecosystem with incidence of emergence of new diseases and insects. Rangeland habitats have transformed, leading to decreased productivity, and longer grazing journeys. Adapting to these changes and developing resilience strategies are crucial for sustaining agricultural livelihoods in the face of ongoing climate change. Hence, local experiences and knowledge become invaluable to hold the key to gaining comprehensive insights and shaping informed policies. Grounded in the localized perceptions and experiences, the study findings corroborate and reinforce the evidence from downscaling studies.

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