Article

Farmers' Perception of Climate Change and ITS Impacts: A Case Study of Baba Mountain Valleys, Center of Bamyan Province, Afghanistan

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Abstract: Climate change affects both human and natural systems. Afghanistan ranked globally on the top of highly vulnerable countries to the adverse effects of climate change. The agricultural communities of Afghanistan is highly affected by climate change. Understanding farmers' real experiences on changing climate become crucial in planning the future adaptation strategies. This study assessed the farmers' perception of climate change and its impacts on farming communities. Primary data were collected through face-to-face interviews conducted with 120 household heads. Additional qualitative data were collected by conducting 4 Focus Group Discussions (FGDs), 4 Historical Timeline Calendars (HTCs), 18 Key Informant Interviews (KII), and sketches of 4 Crop Calendars. The study reveals that climate indicators have varied and changed. The farmers express their experiences of decreasing snowfall in winter and annual rainfall in spring and summer, which led to the intensity and frequency of 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. These changes affected both positively and negatively. There is a half-month new opportunity for cultivation and increased earlier animal ranching in the rangelands. These findings can be valuable inputs for developing effective and efficient adaptation strategies.

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

1. Introduction

Climate change is affecting human life, society, and the global ecological system through adverse impact on the food production system, infrastructure, coastal areas, cities, rural areas, human health, and livelihood capitals (IPCC, 2014). It also undermines global progress toward poverty alleviation, food security, and sustainable development. It increases the vulnerability of people dependent on agriculture for their livelihoods, which includes most of the world's poor (Lipper et al., 2014). Climate models project more increase in global temperature, precipitation change, and sea level rise and further impact in future. This is having 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. According to the 2022 report of Afghanistan National Statistics and Information Authority (NSIA), the share of agriculture sector in total GDP was

33.6 % in 2021. Major crops are wheat (rainfed and irrigated), rice, barley, maize, onion, potato, almond, grape, mulberry, apricot, pomegranate and apple (NSIA, 2022). About 80% of the Afghan population lives in rural areas, and their livelihood is directly or indirectly related to agricultural activities. Afghanistan has an arid and semi-arid continental climate with cold winters and hot summers. The water sources for irrigation are mainly surface water and groundwater, and 86% of the irrigation water supply comes from surface water (Hussainzada & Lee, 2022). Crops are cultivated during the summer and winter seasons. The summer cropping season starts in May and finishes in November. The main crops grown during summer are rice and corn. The main cultivated crops in winter (October to June) are wheat and barley. Arable land is only 12 %, and about half of them are currently cultivated. Rangeland covers about half of the country (Najmuddin et al., 2017). Surface water is the primary water source for irrigation. Afghanistan is the 6th top vulnerable country in the world (Eckstein et al., 2021).

A study on precipitation and its extremes across Afghanistan (1951–2010) 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. It leads to intensifying drought events affecting water availability and agricultural production. Also, it shows 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)

The mean annual temperature, the number of cold days and nights, and heat wave frequency are increasing in most Asian countries (Hijioka, et al., 2014). Afghanistan's average annual temperature has risen by 0.6 °C until 1960 (Savage, Dougherty, Hamza, Butterfield, & Bharwani, 2009; Hijioka, et al., 2014). Average annual temperature in most parts of Afghanistan from 1981-2010 and 1951-1980 has increased significantly to 1.2 degrees Celsius. The temperature from 1951 to 2010 for all of Afghanistan shows an increase of 1.8 °C. The highest temperature is 2.4 °C in the east, and the lowest is 0.6 °C in the Hindu Kush region (Aich, et al., 2017). It is projected that Afghanistan's temperature trend will increase from 2006 to 2050 by 1.7 to 2.3 ◦C and, based on the RCP 4.5/8.5, from 2006–2099 to 2.7-6.4 ◦C. Increasing temperatures, decreasing precipitation, and untimely rainfall has led to higher drought frequency negatively affecting food production. (Qutbudin et al., 2019) An analysis of the impact of climate change in the 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% that led to a strong decrease in river discharge (Qutbudin et al., 2019). The increasing glacier melt compensates the decreases and leads to increased runoff only in the highland parts of the upper catchment. 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). The studies also indicate that more severe droughts in the future are expected due to increased temperature and reduced precipitation (Akhundzadah et al., 2020; Qutbudin et al., 2019)

Climate change is expected to decrease agricultural production, adversely affecting food security. An increase in temperature and change in precipitation patterns could change the growing season, crop duration, and soil moisture regime, inducing drought in the crop plants, thereby negatively affecting crop yield. More frequent and heavy precipitation increases the risk of crop damage from flooding, soil erosion, and landslides (Dahal et al., 2023).

A study in northern part of Afghanistan found that people perceived the impacts of climate change by loss of agricultural land in low elevation area due to water level rises, changing river course due to high degradation of the riverside lands and snow melting, reduction of rangeland productivity, loss of crops such as potatoes productivity, and increasing number of avalanches and rockslides due to rains. The study also found the prevalence of insect infestations that reduced their apricots fruit trees production. Also, the ecological calendar has changed due to the changes in temperature. For example, the grandfather of today's farmers consumed more barley due to not being able to harvest the wheat successfully, but now they can harvest wheat. Moreover, the farmers reported 15 to 20 days longing the cropping time. That is, they now cultivate earlier than a decade ago (Kassam, 2009). A study relates climate change impacts to the conflict in Afghanistan and warns of possible escalation if no action is taken (Price, 2019)

Understanding farmers' perceptions of climate change impacts on agriculture are important to design location-specific community-based adaptation strategies. We assessed the farmers' perception of climate change indicators, broadly temperature change, rainfall change and seasonality change via perception-based approach. Downscaling methods are not always reliable at regional and local scales (Salick and Ross, 2009; Kassam, 2018). 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, 2018). There are a few studies conducted in Afghanistan using the limited national and broad global climate data. However, there is a knowledge gap on what have been observed by farmers in the field. Downscaling studies at the national level indicates the changing climatic condition (Aich, et al., 2017), (Aliyar et al., 2021), it is not validated whether those findings match with local experiences of the farmers. On this premise, this study was conducted to understand farmers' local knowledge of climate change and its impacts on agriculture, especially there is a need on ground-truthing climate studies using people's perceptions and ecological knowledge to find the local changes and impacts for creating better local, regional, and national planning and policies and better preparation can be done to minimize impact through several means. 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, observe and experience the trend of climate indicators, ii) how do agricultural communities observe the impacts, and iii) how are the farmers affected by climate change.

2. Methodology

This research uses both quantitative and qualitative research designs. The quantitative design collects data through survey and questionnaires and analyses the data through descriptive and inferential statistics. The qualitative method for this research is used to understand the perception of the people about the changing of the climate, its impacts on agriculture of the study area. This research used the structured questionnaire to survey the households, focus group discussion, field observation, key informant interview, crop calendar and historical timeline calendar for information gathering.

2.1. Study Area

The study was conducted in two valleys: Foladi and Khushkak. Foladi valley is located at coordinates of 34.76° N and 67. 72° and Khuskak valley of 34°44'25.71" N and longitude 67°48'20.78" E in Bamyan District of Bamyan Province of Afghanistan (**Error! Reference source not found.**). Bamyan district is highly mountainous with deep valleys in 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 basic feature of these villages is the high dependence on agriculture, which is of mixed type with crops, livestock, and forestry.

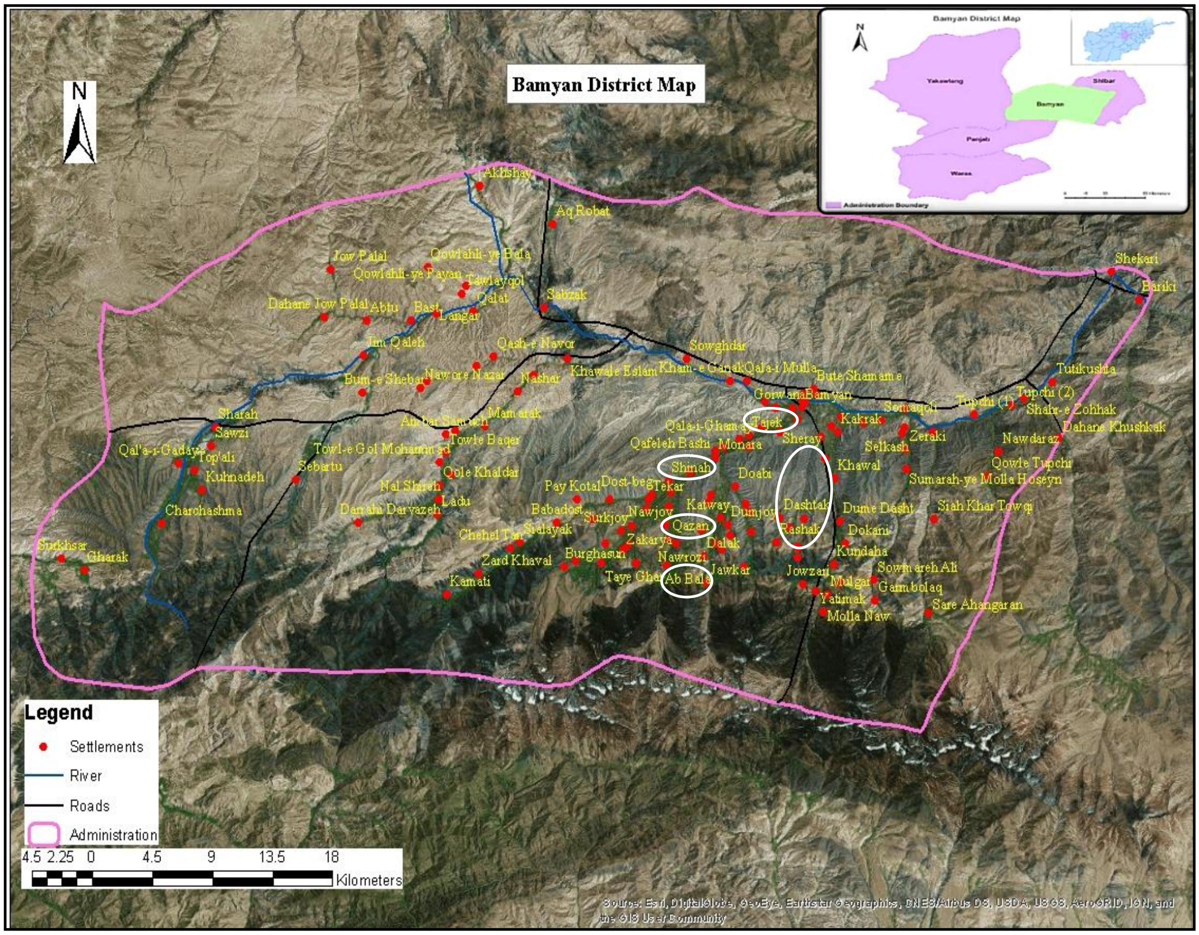

Figure 1. Map of the study Sites. White circles show the villages the study conducted in Bamyan District of Bamyan Province.

The climate is arid and the lowest temperature with six months of winter drops to -20⁰ C. The highest precipitation happens 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 Cº. Farming and livestock are the primary sources of household's income. In Bamyan province, the rangeland accounts for 1.3 million hectares (92.4%), while irrigated land makes up only about 33790 ha (2%). Shah-Foladi valleys irrigated land reported lesser than the provincial level (UNEP, 2016). Most households' members are dependent and involved in agriculture activities. Agriculture area is about six percent and mainly irrigated still about 2 percent is rain fed agriculture (Aich, et al., 2017). Rangelands provide a significant plant species for fuel, food, medicine and the means for livestock production, such as sheep, goat, and cow. Wheat and potato are the main crops. The total population in Bamyan province is 454633, of which 13218 are living in Bamyan district at the centre of Bamyan and 441415 are living in the rural area (Central Statistics Organization, 2016). In the studied villages 322 households are living. The average household size is seven. Socially setting of the studied households are composed of three different ethnicities Hazara, Sayeed and Tajik (60%, 14 %, and 26%) **Error! Reference source not found.**.

Table 1. Socio-economic profile of the surveyed farmers in the studied households.

Variable	Description	Respondents (%)	Variable	Description	Response (%)
Ethnicity	Hazara	60		Illiterate	29

	Sayeed	14	Educational Qualification	Primary	52
	Tajik	26		Tertiary	14
Gender	Male	61		Two-year professional	3
	Female	39		University	2
Female-headed HH	Yes	8			
Having land	Yes	99	The age group of respondents (Years)	22-32	2
Female land ownership	Yes	10		33-42	20
Source of income	Agriculture	58		43-52	28
	Employment	7		53-62	23
	Remittance	12		63-72	21
	Enterprise	1		73-81	8
	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		Private rangeland	0.30
	Not having profitable productivity	6		Forest	0.31
	Coldness	78	Total land (ha)	0.2-06 ha	45
	Other (Chemical Fertilizer)	3		08-1.2 ha	40
Irrigation facility	Yes	80		1.4-1.8 ha	5
	No	20		2-3 ha	10
Access to irrigation water	Year-round	63	Irrigated land by ha	0.2-06 ha	92
	Only the spring and summer seasons	11		08-1.2 ha	8
	Only for one season	26	Source of drinking water	Hand pump	10
				Spring/well	78
				River	12

Source: Field survey, 2017.

The studied area's mountains are covered with snow throughout most of the year. They are a nationally significant watershed from which major rivers like Kabul, Helmand and Arghandab originated. Snowmelt is the primary source of water for communities living in the valleys. The flood irrigation is the irrigation type. Khushkak valley's main water source is the nearby hills' snowmelt and is not connected to the mountains. Due to that, the dwellers only have water access for agriculture for one season. People in Foladi valley collect their drinking water from wells and in Khushkak valley from wells and streams.

After four days of village-based survey and talking with the community development councils' heads and local and international organisations working in the area, the study sites are selected. There are three reasons, elevation from the sea level, access to water and social settings, or ethnicities. The villages are located in the valleys' upper, middle and lower, and their elevation is from 2600-3100 masl.

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Khushkak valley is not connected to the mountains, but Foladi does. Moreover, there are three different social groups, Hazara, Sayed and Tajik.

2.2. Method

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

2.2.1. Data collection and analysis

A face-to-face household survey was conducted using a structured questionnaire to collect data on socio-economic profiles, agriculture practices, perceptions of climate change, and its impacts. Respondents were randomly selected from lists prepared by Community Development Council representatives and age was an important criteria to assess past changes in the climate condition and their experiences of the impacts. The survey included 120 respondents from nine villages and used both open-ended and closed-ended questions for qualitative and quantitative data collection. The data on household-level characteristics, socio-economic profile, livelihood assets, income, and the perception of climate change its impacts were collected quantitatively Prior to the survey, a pre-survey session was conducted to test the questionnaire for clarity and relevance. The qualitative data based on the understanding and view of the respondent were coded as other question for 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, and the collected data supported HH survey data. 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 first author conducted four Focus Group Discussions (FGDs) in four main villages, namely Khushkak, Ab Bala, Jaroob, 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 FGDs were conducted in various locations, including villagers' homes, mosques, and a community development council's room.

The Historical Timeline Calendar (HTC) was used to encourage local people to talk about the past climatic hazard events, their trends, and associated impacts. Many scholars used this method (Pandey & Bardsley, 2015), (Tshuma & Mathuthu, 2014). Four HTCs with 7-10 farmers were conducted The HTC guideline was framed using the Drivers→Pressures→State→Impacts→Response (DPSIR) framework.

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.

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2.3. Sample Size

The study valley's villages' total population was 322 households, and a total of 120 households (61 % Male and 39 % female) were interviewed; in this, 8 % of the women were heads of their households. The respondents' ages range from 22 years of minimum to 81 years of maximum with a median of 47 years; to represent the whole social and ecological systems of area, two main valleys, namely Khushkak and Foladi, were chosen purposively.

The respondents for the household questionnaire were selected according to random sampling (1 out of 3 or 4 households. The accuracy of selecting the household was considered 93 %, with a 7 % error. Accordingly, 120 respondents were interviewed out of 322 households in nine villages (five in Khushkak and four in Foladi valleys).

For conducting Focus Group Discussions, sketching crop calendars, drawing historical timeline calendar, conducting key informant interviews the respondents were invited and coordinated by phone calling in consultation and coordination of community development councils. The participants were called and invited by the researcher. Gender, roles in community-based organisations, types of activities, age, experience, and ethnicity were the issues considered for inviting as participants.

For specifying the sample size, the following formula is used:

$$n = \frac{N}{1+Ne^2} \text{.........................} (1)$$

Where, n=sample size, N=Population, e=error limit (7%) at Confidence level=93 %.

The sampling method for this study is both representative and non-representative sampling techniques. A representative sample size has been used to collect quantitative data from households. The size of the sample for each village is provided randomly and purposively. The research sample is considered according to the total population of each village.

Both qualitative and quantitative techniques were used to analyse the data. The household survey was analysed quantitatively using basic descriptive statistics, while Historical Timeline Calendar, Key Informant Interview and Crop Calendar was analysed qualitatively. This study used SPSS (Statistical Package for the Social Sciences) 24 version and MS Excel Applications to understand the perception of climate change and its associated impacts, the Guttmann Scale and Score were used. This method is modified by the Likert Scale (Pandey & Bardsley, 2015). The scale ranges from (1=Yes, Clearly Observed, 2=Often observed, 3=Occasionally observed (it seems like that), 4=Cannot Evaluate/Do not know, 5=Non observed no changes). Different level of responses (1-5) is changed into a single category to get the normalised response by using;

Normalised response (%) = (Total score of the actual responses ÷Total of the highest possible score) *100............................. (2)

Here, the total score of actual response refers to the cumulative score of the specific level of response from all the respondents (number of the respondents*level of response); the total of the highest possible score means the overall score of all the respondents. If the respondents scale their response to '5' in a particular question (Total respondents multiplied by the highest score 5); while 100 is the constant applied to calculate the percentile. Qualitative data were analysed using qualitative stories of the research participants to recognise the past changes and present issues from an agricultural perspective. The statements were coded and analysed to support and clarify the quantitative data.

3. Results

3.1. Profile of respondents

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 HHs source of income. Both male and female participated in the research 61 % Male and 39 % female which 8 % of the women were head of their households. The education level of the studied village's household members is low; about 1/3 is male, and 2/3 is female. The survey result shows that almost 1/3 of the household's members are illiterate (Table 1). Moreover, about half of the HH members are in primary or just literate. Tertiary level, two-year professional, and university levels are (14 %, 3 %, and 2%, respectively). 99 % of the households have land. Only 10 % of women reported land ownership, and 90 % of men.

There are five types of lands; terrace, sloping, homestead, private rangeland, and forest 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 respondents reported the coldness, lack of irrigation, not having profitable productivity, and lack of chemical fertiliser, respectively (78%, 13 %, 6%, and 3 %) as 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 a whole 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 having lease land. Share of irrigated land is very low 92 % of the farmers own only 0.2 to 0.6 hactares and 8 % own 0.8-1.2 % hactares of irrigated land. Therefore, having access to less area of irrigated land and being highly sensitive to the weather events might lead to insecure livelihood only from farm activities. Respondents (16%) reported that their land remained uncultivated due to drought and the locking of the ditches due to landslide respectively (94 % and 6%).

Source of drinking water is one of the important aspects of having good health. Respondents replied that 78 percent of them use spring or wells water, 12 percent river water and 10 percent hand pump water. People in the villages of study area depend on the available resources. Respondent replied that 80 % of them collect their firewood and bushes from their agricultural lands, private forest, public rangeland and private forest and agricultural land respectively (8%, 19%, 48% and 5%), while only 20 percent buy. The respondents also reported that 63 percent of their building material wood comes from their private forest while only 37 % buy their building material wood

All respondents bring their animals to the agricultural lands and public rangeland (38% and 62 %), respectively and about one-third of respondents collect medicinal plants from agricultural land and public rangelands, respectively (38% and 62%). 85 % collect fodder from agricultural land, private forest and public rangeland (48%, 8%, and 29%), respectively, while 15 % buy from others or the market. Findings show that 13 percent of the respondents collect medicinal plants for the purpose of household consumption and selling (63% and 37%), respectively. The firewood and bushes have decreased compared to decade ago, 26% of the respondents replied "not at all changed" option of changes, but others replied change a little bit, notably, significantly and completely (10 %, 17%, 26% and 30%, respectively). The building material wood, according to 72 % of 108 respondents replied "Not at all" option and 14%, 4%, 9%, and 1% replied, respectively (a little bit, notably, significantly and completely). It shows that 28 percent confirmed the changes. The rangeland fodder, according to 57% of 111 farmers not change, while on the other hand, 13%, 11%, 7%, and 13%, respectively, replied (a little bit, notably, significantly and completely).

Regarding grazing area, 65 % replied the "Not at all" option. While 19%, 6%, 5%, 8% replied, respectively (a little bit, notably, significantly and completely). It shows that 35 confirmed the changes. The participants of the FGDs replied that households used to keep more livestock but recently decreased due to changing the area.

The medicinal plants, according to 65% of 60 respondents not changed but and replied "Not at all" option. While 18%, 10%, 3% and 3% replied (a little bit, notably, significantly and completely), respectively, changes in the availability of medicinal plants.

3.2. Farmers' Perception of Climate Change and Its Associated Impacts on Agriculture

The farmers reported a decrease in annual rainy days. Normalised proportion of 88 % of respondents reported a decrease in annual rainy days, while other 67.8, 18 and 8% of respondents evaluated the status as being clearly, often and occasionally observed.

Farmers observed a decrease in annual snowfall and an increase in heavy snowfall. The normalised proportion of 94 % of respondents reported decrease in annual snowfall, while other 78, 17 and 3 % of respondents evaluated the status as being clearly, often and occasionally observed. The snowfall starts from the last of October to the last of April months. The study area has six months winter. Farmers also 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 observed changes in annual rainy days. However, on the contrary, most respondents agreed that there was an increasing number of extreme rainfall events. A high proportion of the normalised response (56%) expressed that extreme erratic rainfall in the spring and summer seasons has increased It shows that most of them perceived erratic rainfalls. Farmers in the FGDs reported experiences of unseasonal rainfall in multi years, including 2005, 2009, 2012 and 2013, which caused considerable damages to agricultural products. Farmers also noted that unexpected rain showers occur suddenly, washing away crops and causing flash floods.

Farmers face recurrent challenges with flash floods, as recent years have witnessed decreased rainfall that occurs rapidly and in short durations. The proportion of the respondents who felt that summer floods have increased clearly (8%), often (11%) and occasionally (31 %). The proportion of the respondents who stated intensified and frequent summer flood normalised response shows (46%). Farmers reported a change in the rainfall pattern. Farmers reported that hailstone is not a common phenomenon in the area, but it occurs sometimes. The normalised response of the studied households shows that 48 percent of interviewees agree that hailstone timing and occurrence has increased and changed.

The seasonal calendar has changed. The overall proportion of the normalised response shows that 89 % of interviewees agree that the seasonal calendar has changed. Spring is the starting time of working on agricultural land. Farmers start cultivation after a long-time winter in the studied area. Thus, it plays an important role in securing livelihood. The respondents replied that, on average, the spring season arrives 16 days earlier than before. It shows that there are sixteen days of new opportunities for the farmers to grow new crops and start their work earlier. Farmers look happy now with these changes and can grow wheat and harvest it in a timely manner. It was difficult in the past for them to harvest it timely; thus, they were growing barley.

To understand trend of temperature changes, the questions were asked about changes in summer temperature, the temperature during the day and night, and the temperature in the winter.

Farmers perceived an increase in summer temperature. The normalised response shows that 88 percent of the farmers felt hotter summer than before. 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 normalised response for the studied communities shows that 71 percent of respondents feel minimum and maximum temperature changes. About 42 percent of the interviewee replied and increased temperature range.

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The winter is called "death of the poor season" 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. The proportion of the normalised response indicates that 88 percent of the respondents agree that the winter has changed, and it has become hotter and shorter than before.

3.3. Impacts of Climate Change on Agriculture

Drought is one of the main impacts of climate change in the region. Farmers reported that droughts have extremely affected agriculture. Of the total, the normalised proportion of 79 % of respondents has perceived intensity and frequency of increased drought and its impacts have put severe pressure on agriculture (**Error! Reference source not found.**). Farmers in FGDs stated that they experienced severe drought from 1998-2001, 2013, and from 2011-2016 years. The participants expressed the impacts very severely.

Farmers reported that droughts from 1998-2001 and 2011-2016 resulted in dried river water, loss of agricultural productivity, livestock loss, food insecurity, increased poverty, and pest and disease outbreaks. Drought impacted water resources, rangelands, agriculture, and livestock, causing decreased water levels, dried water bodies, wells, springs and low agricultural productivity, exacerbating poverty and food insecurity. Drought led to increased livestock mortality rate, decreased land cultivation area and pest and disease outbreaks which consequently decreased the land productivity. In addition, rangelands overgrazed and dried because of the drought and livestock holders lost their livestock. On the social aspect, children left the schools as the bushes were collecting from far areas even time of the collection doubled due to that the school students decreased, and indebtedness, food insecurity, and poverty became a common phenomenon among the people. Due to scare resources drought increased the social conflict.

Farmers observed water shortages and it is getting worsen every year, which affects agriculture. Of the total, the normalised proportion of 72 % of respondents has perceived water shortages and its impacts on the agriculture of the study area. Respondents observed water shortages in the summer season. However, the irrigation has been scheduled and thus led to lesser land cultivation. The low land areas of the valley observed severe water shortages as the water used much more in the upper land areas of the valley. Farmers stated that the annual life of water or water availability is decreasing, which negatively affected agriculture in the study area. Of the total, the normalised proportion of 67 % of respondents has perceived water shortages and agreed on decreasing water sources and its impacts on the agriculture of the study area. Shorten annual life of water is decreasing and has put more pressure on the households.

Respondents reported that windstorm has become stronger and more violent recently. The proportion of the normalised response shows that about 49 percent of the people agreed. Farmers in the four FGDs sketched the impacts of extreme windstorms based on the years. They indicated the occurrence of extreme wind/cyclones in 2003, 2012, 2016, and every three years, which negatively impacted the agriculture. The respondents also stated that the frequency of extreme winds has increased in recent years.

Farmers stated that the spring is coming earlier than before. The normalised response shows that 91 percent of the respondents agree with the springtime changes. Among the respondents, 82 % mentioned clearly observed earlier coming of the spring season. The crop calendar also confirms that farmers cultivate earlier than before. The average changes in earlier arrival days of spring are shown in **Error! Reference source not found.**. The farmers used to start ploughing the lands on the 15th of Sawr (05 May) but now they are starting on the 1st of Sawr (20 April). It shows that the weather has changed.

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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 species of plants in rangelands	15	4	8	13	59	41

Source: Field survey, 2017.

Table 3. Earlier arrival of spring.

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

Source: Field survey, 2017.

Because of the warmer temperature, the flowering and fruiting season has changed. Farmers observed earlier flowering and fruiting of trees, crops, and plants. The normalised response shows that 84 percent of the farmers replied positively and agreed on the changes. Farmers observed the habitat changes of plants. The normalised responses show that a proportion of 48 percent agreed and confirmed the changes in habitat of the plant's species.

Farmers observed new diseases and insects. The normalised proportion of respondents, respectively 58 % and 49 %, who stated that increased insects and new diseases led to decreased production and burdened economic pressure. Farmers observed an extreme increase in the grasshopper insect population and changed habitats (some years). Farmers in the FGDs reported severe damage to crops due to rust disease of wheat and pest in potatoes. In wheat, the seed size remains small but also changes its colour to red, which later needs washing and has increased the workload for both men and women. In addition, the insects eat the potato leaf and prevent growth. Due to that, the production of the potato decreased up to 60 %. Farmer added that every household gets 2800-3500 kg potato less than before from the same land size. Farmers stated that Alfalfa lands are attacked yearly by insects and cause damage. Farmers also reported new diseases to animals which led to economic losses. Sia Qayak and Amro (Local Names) are the examples.

Farmers stated that rangeland grasses and bushes grow earlier because of the warm temperature. The proportion of the normalised responses shows that 89 percent of the farmers agree and confirm it. Moreover, the farmers perceived and related this phenomenon to the winter's declining snow and its earlier and sooner melting in the spring.

Farmers observed new plant species in higher elevations of the rangeland, and 41% agreed on the appearance of new species. Rangeland area changes toward mountains were reported by 59% of farmers, exacerbating issues for households. The younger member of the farmer's family is responsible for borrowing the animals to rangeland areas. This causes them to get busier and negatively affects their health and education.

The study found rangeland habitat changes. Farmers borrow the animals for long distances and take time to reach a good area for ranching. This causes weight loss in livestock, low milk production, and economic losses. However, the farmers relate these changes to the overutilisation of the resources, bush collection, severe drought, hotter temperatures than before, lower rainfall in the spring and summer seasons and quicker melting of the snow.

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 earlier 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 interviewee 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 have to go long distances for

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ranching. This issue may increase overutilisation along with the bush collection which will lead to desertification and loss of biodiversity.

Farmers observed high unpredictable rainfalls. The proportion of the normalised responses of respondent's show that 54 % agreed on changes. Farmers in the FGDs confirmed sudden rainfall and reported its negative impacts on the agriculture and livestock for examples, lessening the quality of dried alfalfa, decreasing the yield and quality of wheat as it grows on the spike, flooded the potato lands, wheat lands damaged, an increased disease in potato, land nearby waterways damaged due to flash flood.

Farmers observed changes in the number of snow days and a decrease in annual snowfall and number of snow days. The proportion of the normalised response shows that 89 % agree that the number of snow days reduced. Farmers observed faster and heavy snows recent years. Water shortages threaten them and lead to water scarcity. On the other hand, based on the respondents, the soil is not wet these years except for the spring season, leading to decreased rangeland productivity. Farmers also relate this issue to snow avalanches in the area as well.

Farmers also observed that snow avalanches had become a common phenomenon every year and relate it to heavy snowy and decreased snow days. There is no vegetation on the hilly slopes to prevent it thus comes down and brings much snow on the agricultural lands, cuts trees, damages the houses, and blocks the ways and water channels. Respondents reported avalanched brought snow as an obstacle in the spring, making the soil compact, and leading to low productivity. It also cut trees and caused economic losses.

Farmers stated that the snow is melted sooner and relate it the warmer temperature in the winter and summer. The maximum and minimum temperature ranges have increased with high-normalised responses (88 %, 88 %, and 73 %, respectively), affecting snow melting. The proportion of the normalised responses shows that 95 percent confirmed quicker snow melting. Among the respondents, 89 % of them reported the "Yes, clearly observed" option. In the studied area, mountains feed the main rivers like Kabul, Helmand and Kunduz rivers of Afghanistan. In this regard, considers the natural freezer of Afghanistan. This issue reported one of the challenges in the study area as the water flow increases when they do not need water. However, when they need water, there is not enough water. (Maharjan et al., 2018)

Farmers leave their lands uncultivated and reduce their land productivity because they mow or harvest sooner, as there is no hope for water. Farmers have scheduled the water for irrigation based on land size. However, water demand increased in the summer and decreased, which caused water shortages and led to conflict on water use, which is now a familiar story. Famers observed changes of snowing time toward winter, and it used to snow earlier, but now it snows later. The proportion of the normalised responses of the farmers shows that 80 percent agreed and confirmed changes in the snowing time.

Changing the snow's time is an advantage in the mountainous community. When farmers harvested the wheat, it was snowing, and they could not harvest it properly. When they separated the hay and seeds, it took a long time to be dried and processed. Farmers in the past could not take the hay to the home to feed livestock, which faced difficulties in the winter. The women of the households happier and expressed their happiness in the FGDs. They can collect enough fuel for the winter, dry it, and take more readiness. Delaying the winter gives them the chance to take care of the children well, learn new skills and create more opportunities, as they collect less bush for fuel. Farmers also reported that the winters come late, we could delay selling potatoes at a low price because when the supply is more, the price comes down. They delay selling and use the time for their beneficial. This increases their benefit and can evaluate the market and give them the ability to sell more expensive and to the right marketer. Moreover, farmers reported that they now have enough opportunity to prepare new lands and provide organic matter to their lands, clean ditches, and find new opportunities inside the villages as a labour force.

Farmers reported changes in snow time and quicker melting patterns, resulting in decreased water discharge, spring water availability, and increased pressure on rangelands. Respondents observed reduced spring water in summer and fall, impacting household water consumption. Longer rangeland time may lead to degradation, soil erosion, and consequently flash floods in case of rainfalls. While delayed snow time presents new opportunities, careful resource management is crucial.

The farmers observed the disappearance of snow from the nearby mountains. Because of their cold weather, mountains play an important role as a natural freezer; the snow is melted slowly and lasts longer. However, melting speed has increased and has changed recently. The proportion of the normalised response of the respondents shows that 89 per cent agreed that snow covers from a particular location on the mountain have disappeared. Among the respondents, 74 per cent replied with "Yes, clearly observed" options. Farmers noted decreased snow presence during specific times compared to the past in previously snow-covered areas.

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 river banks 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.

3.4. The Overall Perception of Climate Change

The overall indicators for understanding the changes in precipitation, temperature, and drought are discussed here: the findings show that the precipitation has decreased and its patterns have changed. Of the total, the normalised proportion of 94 %, 88 % of respondents perceived decreased snowfall in winter and annual rainfall, respectively. Simultaneously, the normalised proportion of 56% of the respondents perceived increased erratic rainfall in the spring and summer seasons. Furthermore, the normalised proportion of 48 % of respondents perceived increased hailstone occurrence.

Drought is reported as one of the indicators of climate change. According to the perception of the research participants, the normalised proportion of the respondents, 79 %, 72 %, and 67 %, respectively, show the increase in intensity and frequency of drought, water shortages and decrease in annual life or availability of water. FGDs and HTC participants supported these issues.

Temperature shows an increase in the study area. Of the total, the normalised proportion of the respondent's responses shows that 88%, 88%, 71 % and 89 % perceived changes in the increased winter temperature, increased summer temperature, changed the range of minimum and maximum daily and night temperature, and earlier arriving of spring season respectively. Therefore, based on the research participant's perception, the temperature in the study area differed and increased

Table 4. The overall farmers' perceptions on changing climate of Bamyan 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: Field survey, 2017.

3.5. The Overall Perception of Climate Change Impacts on Agriculture

Farmers perceived and experienced the impact of climate change. The overall perception of climate change impacts profoundly affects the household of the farmer's community. The respondents in the studied area perceived and experienced the impacts of earlier melting on snow cover, reduced amount of snowfall, disappearing snow cover from specific places, changing the flowering season, changing the time of the snowing toward winter, and earlier borrowed animals to the rangeland. The normalised proportion of respondents showed, respectively, 95 %, 94 %, 89 %, 89 %, 84 %, 80 %, and 63 %. The primary impacts resulted in the secondary impacts. According to the respondents, all these changes relate to the changes in temperature. Moreover, the normalised proportion of 89 and 54 per cent of the respondents perceived the changes in reducing the number of snow days and occurrence of unpredictable rainfall. According to people's perception, these changes are related to the decrease in precipitation. People perceived changes in the increased number of new insects and pests, increased diseases in agriculture, increased windstorms, migrated the plant species into the upper areas, decreased the production capacity of the rangelands, and shifted up rangeland zones. The normalised responses of the respondents are, respectively, 49 %, 58 %, 49 %, 48 %, 79 %, and 59 %. According to the respondents, these changes affected them negatively.

Table 5. Farmers' perceptions on changing climate impacts in Bamyan 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: Field survey, 2017.

4. Conclusion

Understanding farmers' perceptions of climate change is critical for designing community-based adaptation strategies and building climate resilience. The study concludes that farmers perceived, observed and experienced climate indicators trends, changes and impacts in agriculture in the study area. The study's results confirm the regional and limited national climate data studies (Savage, Dougherty, Hamza, Butterfield, & Bharwani, 2009; Aliyar et al., 2022; Aich et al., 2017). The study found that major elements of the climate indicators, such as snowfall in winter and the amount and annual rainfall in spring and summer seasons, have decreased, leading to water shortages for agriculture in the middle and lower parts of the valleys. This study (Maharjan 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. Thus, this study confirms warming temperature and increased snow melt.

Moreover, the study revealed that temperatures in winter and summer have increased, leading to earlier snow melting, blooming, flowering, and greening of the plants. These changes affected both people and agriculture positively and negatively. There is a half-month new opportunity for cultivation and the earlier ranches of animals in the rangeland. Kassam, 2009b study findings in the northern part of Afghanistan show a similar impact to the central part of Afghanistan, for example, 15 to 20 days longing the cropping time. But on the contrary, increased insect infestation, loss of rangelands productivity and higher land degradation, and increased avalanches and rockslides due to heavy snow and rainfalls.

The farmers cultivate earlier, harvest on time, consume less wood fuel for warming the houses in the winter, and the families have enough time to manage the wood fuel from their lands. 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 fertiliser demand which is more chemical, and increased inputs 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 social-ecological system. 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 expected more droughts in the future.

Local knowledge is a source of knowledge. Bottom-up research methods and participatory action research among the farmers by starting with current problems will help better understand the situation and policy development. This study based on farmer's local experience and perception, support the findings of downscaling studies as the climate has changed, and farmers are aware of its impacts. Farmers are affected by climate change impact and trying to adapt to. Identification of major impacts such as in this study can be an important basis to formulate the adaptation strategies by involving them for enhancing adaptation.

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