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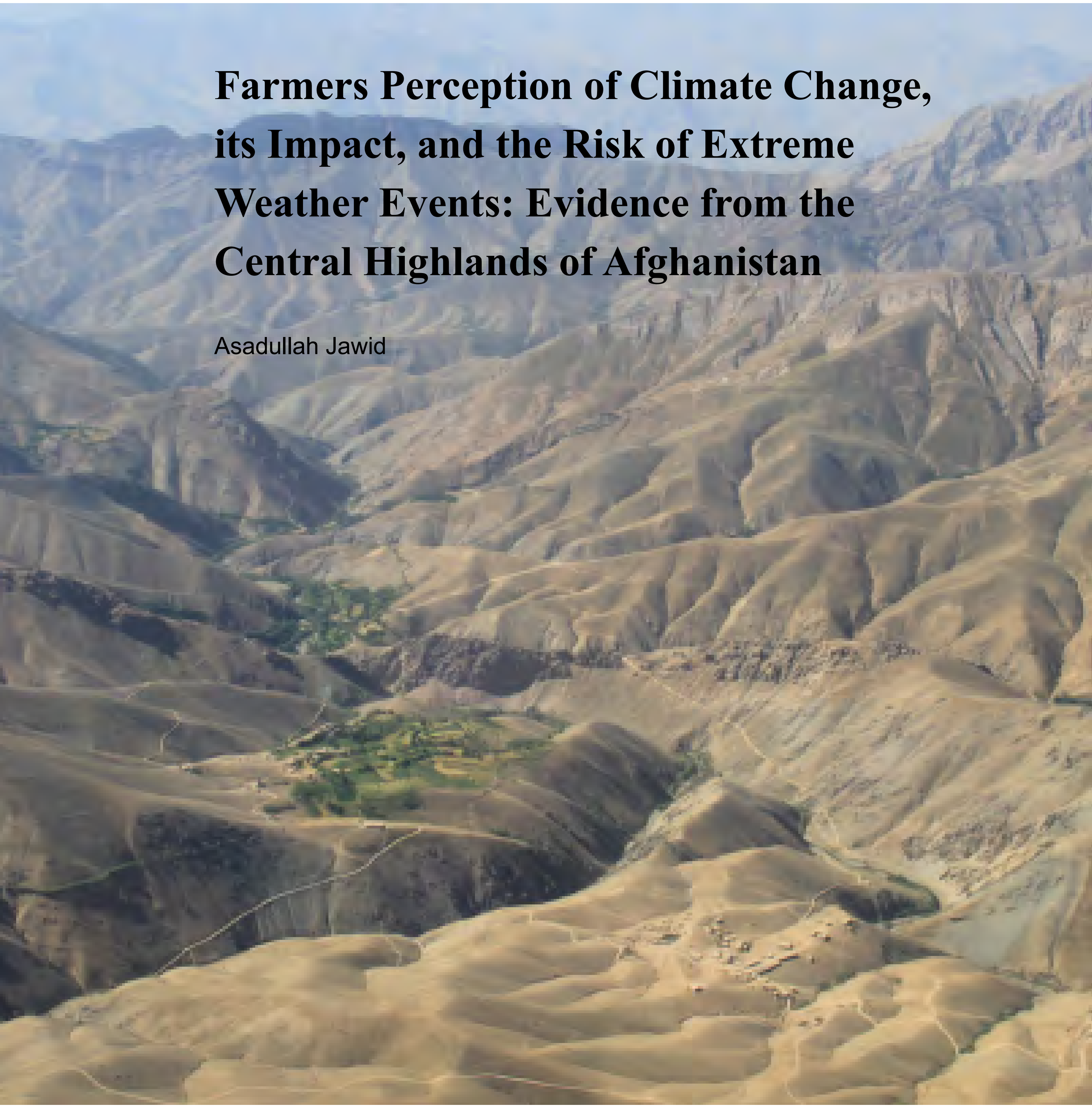
GRADUATE SCHOOL OF DEVELOPMENT
Institute of Public Policy and Administration

Farmers Perception of Climate Change, its Impact, and the Risk of Extreme Weather Events: Evidence from the Central Highlands of Afghanistan

Asadullah Jawid



Working Paper #60, 2021

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Abstract: This paper provides evidence on the farmers' perception of climate change, climate change impacts, climate change vulnerability, and the risk of extreme weather events. A novel dataset of 1,502 farmers from three central provinces of Afghanistan and different statistical and econometric methods have been used to study the research questions. The results suggest that farmers have perceived the changes in the climate and have tried to adopt the adaptation options available to them. Due to limited resources, the famers view themselves as vulnerable to the impacts of climate change and extreme weather events.

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About the author: Dr Asadullah Jawid is a full time faculty at the American University of Afghanistan and a research fellow at the University of Central Asia. His research interest includes quantitative analysis of climate change, climate change impacts, climate change adaptation, climate change perception, and extreme weather events. Dr Jawid has published in peer reviewed international journals.

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Table of Contents

Figures

Tables

List of Acronyms

GDP	Gross domestic product
UNEP	United Nation Environmental Programme

1. Introduction

The literature agrees that global climate change has been accompanied by a steady increase in the number and severity of climate-related extreme events, such as drought and flood (Jayatilleke, 2014). Agriculture is particularly susceptible to climate change (Mendelsohn & Dinar, 2009), the impacts from which include higher temperatures, reduced rainfall and increased rainfall variability, reduced crop yield, and threatened food security in low income and agriculture-based economies (Mendelsohn et al., 2006).

Afghanistan is continuously ranked as one of the most vulnerable countries in the world to the impacts of climate change and extreme weather events (Aich et al., 2017). It is both because of its very limited adaptation capacity (at all levels) and high dependency on agriculture for its income and employment.

Traditionally, Afghanistan is an agrarian country. And even though the contribution of agriculture to the national GDP is only around 22% (World Bank, 2019), it remains a particularly important sector as a source of livelihood for the poor rural population[1]. It is estimated that approximately 79% of the population is engaged in farming, herding, or both (Baizayee et al., 2014). Furthermore, agriculture is seen as central to Afghanistan's growth and development (Pain & Shah, 2009). Agriculture by nature is a risky activity and agricultural enterprises, especially in developing countries, operate under situations of uncertainty. Risk and uncertainty are, therefore, pervasive characteristics of agriculture production (Akcaoz & Ozkan, 2005). With the changing climate and increased risk of extreme weather events, the risks associated with agriculture have also increased.

For agriculture to survive the consequences of climate change and related extreme events, adaptation is key, including at the household level. The literature suggests that farmers' perception of climate change and associated extreme events is an essential factor in their decision to adapt (Sen et al., 2017). Farmers' perception may not be in alignment with scientific evidence on climate change; however, it still plays a vital role in the way farmers react to the changing environment (Nyanga et al., 2011). With this in mind, exploring farmers' understanding of these relevant matters is important in dealing with the consequences of the current and expected climatic changes. Such studies, however, are scarce in the context of Afghanistan.

This study uses a novel dataset of farmers from Afghanistan's Central Highlands to explore their understanding of climate change-related issues. In particular, we try to explore the farmers' perception of climate change, climate change-related impacts, and risks of extreme weather events.

We use data collected from 1,502 farmers in three central provinces of Afghanistan, namely, Bamiyan, Diakundi, and Ghazni. In addition, we use 34 years of daily weather information to analyze the changes over time in the region's climate.

Our results suggest that almost all farmers have perceived changes in the climate, largely in the form of further warming and a decrease in the amount of precipitation. Furthermore, the risk of drought, flooding, and cold and heatwaves are perceived to be high. The perceived risk, however, varies considerably across space. The impacts of climate change are mostly perceived to be harmful to farming, even though some positive effects are also noted. In the meantime, the majority of farmers think that their farms are vulnerable to further warming.

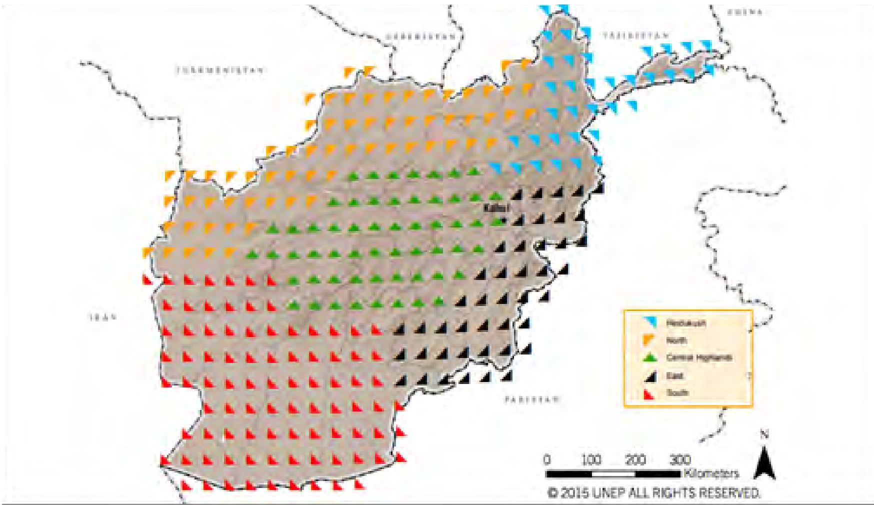
[1] https://openknowledge.worldbank.org/handle/10986/32144

The rest of the paper is organized as follows. Section 2 summarizes climate change and related extreme events in Afghanistan. Section 3 discusses the methodology. Results and discussions are presented in Section 4. Section 5 concludes.

2. Climate Change and Related Extreme Events in Afghanistan

Afghanistan, located in the southernmost part of Central Asia, is a mountainous country with generally cold winters and hot summers (Savage et al., 2011). The country has an extreme continental arid climate that is characterized by desert, steppe, and highland temperature regimes (Shroder, 2014). With respect to climate, Afghanistan is divided into five regions (Aich et al., 2017): (1) The Hindukush region; (2) Northern Plains; (3) Central Highlands; (4) the eastern slopes; and (5) the southern plateau. Figure 1 depicts the climate zones in Afghanistan.

Figure 1. Climate Zones in Afghanistan



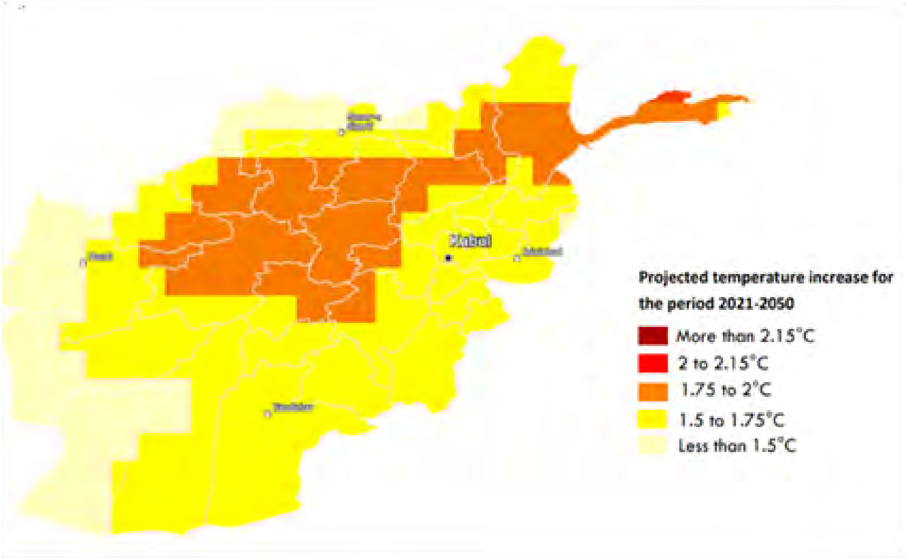
Source: UNEP Afghanistan

A recent analysis by Aich and Khoshbeen (2016) shows a significant change in Afghanistan's climate since the 1950s. For instance, the average annual temperature has increased by about 1.8 degree Celsius, the average annual precipitation has decreased (with higher variation across seasons and space), and extreme weather events have become more frequent. However, Savage et al. (2009) reported a warming of 0.6 degree Celsius and a decrease of 0.2mm in average monthly precipitation since 1960. Projections suggest that by 2050, Afghanistan's average temperature would have increased by up to 2 degrees Celsius compared to the base year of 2010 (Savage et al., 2009). Figure 2 depicts the spatial heterogeneity of the change in average annual temperature in the country.

Projections further suggest that the country would have generally drier conditions as precipitation during the main precipitation seasons—winter and spring—is predicted to decrease. In particular, spring rainfall would be significantly reduced. It is estimated that rainfall during March, April, and May would decrease by 10-40mm. Figure 3 depicts the spatial heterogeneity of predicted changes in average spring rainfall over Afghanistan.

Spring rainfall is vital for water availability during cultivation seasons (both spring and fall). This is because the absorption capacity of the soil peaks in spring. This has two key implications. First, most of the rainfall water is absorbed and does not turn to flush flooding, which can damage properties and farms, and kill livestock.

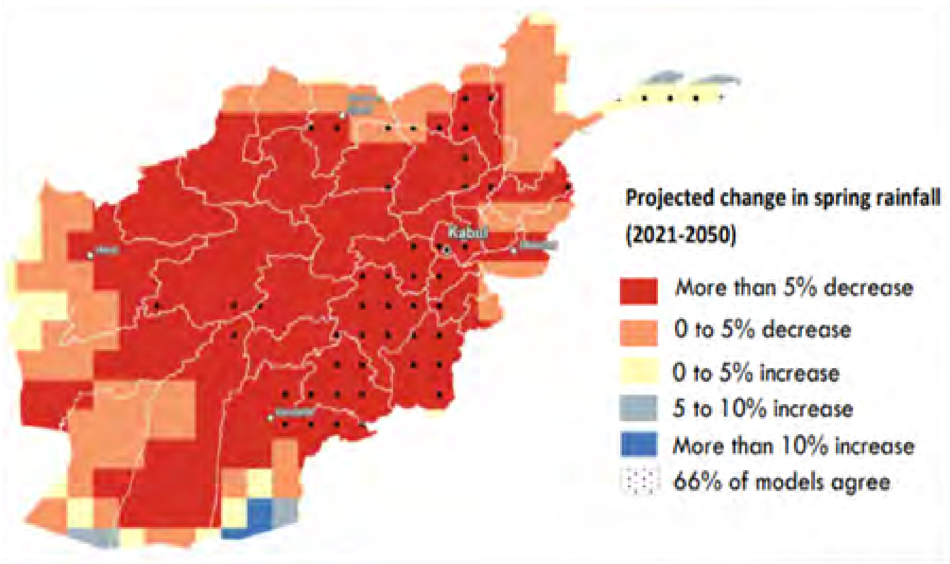
Figure 2. Projected average annual temperature change



Source: UNEP Afghanistan

Second, with most of the rainfall absorbed, the underground water reservoir is further enhanced. With rainfall expected to reduce in spring, the impact on water resources can be huge. Hence, if actions to mitigate this are not taken, its effect on agriculture could be enormous.

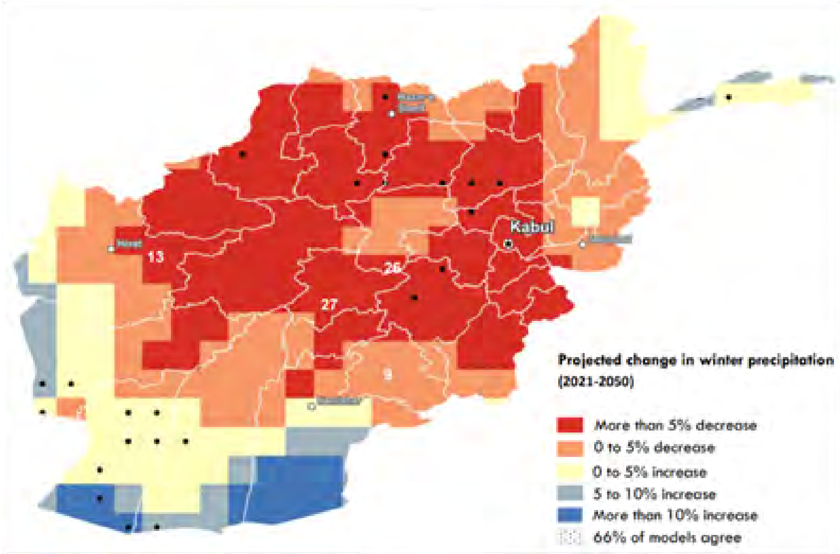
Figure 3. Changes in spring rainfall by 2050



Source: UNEP Afghanistan

Likewise, winter precipitation is also predicted to decrease. Figure 4 depicts the anticipated changes in winter snowfall over Afghanistan by 2050.

Figure 4. Changes in winter precipitation by 2050



Source: UNEP Afghanistan

As we can see in figures 2-4, the climate over the Central Highlands is also predicted to witness some significant changes by 2050. In particular, the average annual temperature is set to increase by 1.5-2 degree Celsius. Meanwhile, a decrease of more than 5% in spring rainfall is predicted for all districts in the Central Highlands. However, the decrease in winter snowfall is smaller in most parts of Bamiyan province (less than 5%).

Although climate change and related extreme events are crucial developmental matters in Afghanistan (especially in rural areas), only a limited number of scientific studies have touched upon this subject to date. Studies done on farmers' understanding and perception of climate change and related events are even more limited.

3. Methodology

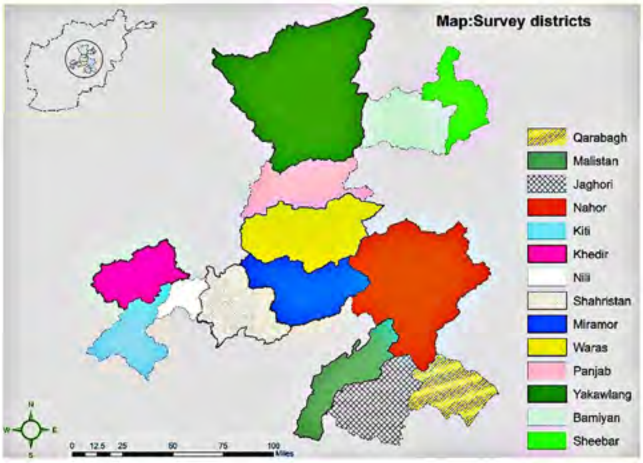
In this section, we discuss the methods used to study the questions concerned.
We start by introducing the study area, followed by a brief note on data and instruments.

3.1. Study Area

The study area for the current research includes 14 districts in three central provinces of Afghanistan, as depicted in Figure 5. The Central Highlands is one of the country's five distinct climate zones (Aich et al., 2017) and traditionally home to the Hazaras, an ethnic minority in Afghanistan. The region is widely characterized by deep valleys and mountain ranges that reach up to 6400m above the sea level (Aich et al., 2017). The Baba Mountain range is extended from the northeast to the southwest of the region providing a source for many of the country's major rivers, such as Helmand, Kabul, Harirood, and Baghlan. The reasons why we chose the Central Highlands are threefold: First, there has been no research done to our knowledge on climate change issues in the whole of this region; second, the region holds great importance as a water resource for the whole of the country; and third, the Central Highlands is one of the most marginalized regions in Afghanistan with limited arable land and high dependency of its inhabitants on agriculture.

The geographical boundaries of the Central Highlands—known also as Hazarajat—are not clear cut. Until the 1880s, the Central Highlands (Hazarajat) used to be an autonomous region and covered a large area extended from northwest of Kabul to the east of Herat; and from Balkh to north of Kandahar.

Figure 5. Study districts in the Central Highlands of Afghanistan



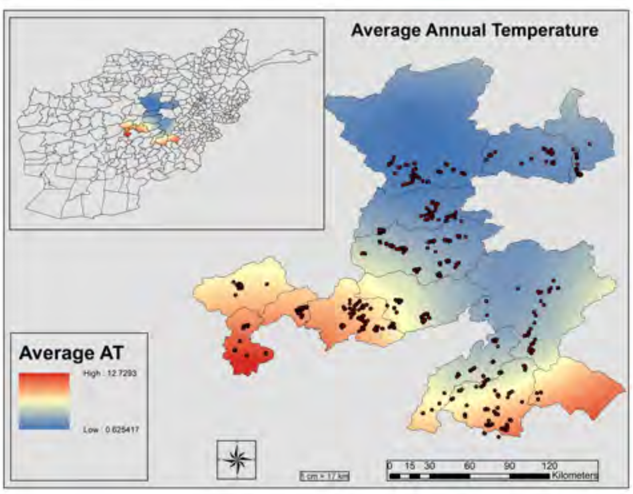
Source: Produced by the author

Even though the post-1880s developments dramatically affected the way the Hazaras were used to living since 300 BC (see Mousavi (1997) for more details), agriculture including farming and animal husbandry has nevertheless remained the primary employment and source of income for the inhabitants of the region.

Potatoes, wheat, beans, alfalfa, and almonds are the primary products in the study area. Meanwhile, sheep/goat, chicken, and cow are the primary livestock kept by households.

Concerning average temperature[2], we can divide the region into three distinct climate zones—relatively warm, moderate and cold (Jawid (2020) provides a detailed explnation of the climate dataset). Figure 6 depicts the heterogeneity of average annual temperature across the study area.

Figure 6. Average annual temperature in the Central Highlands of Afghanistan



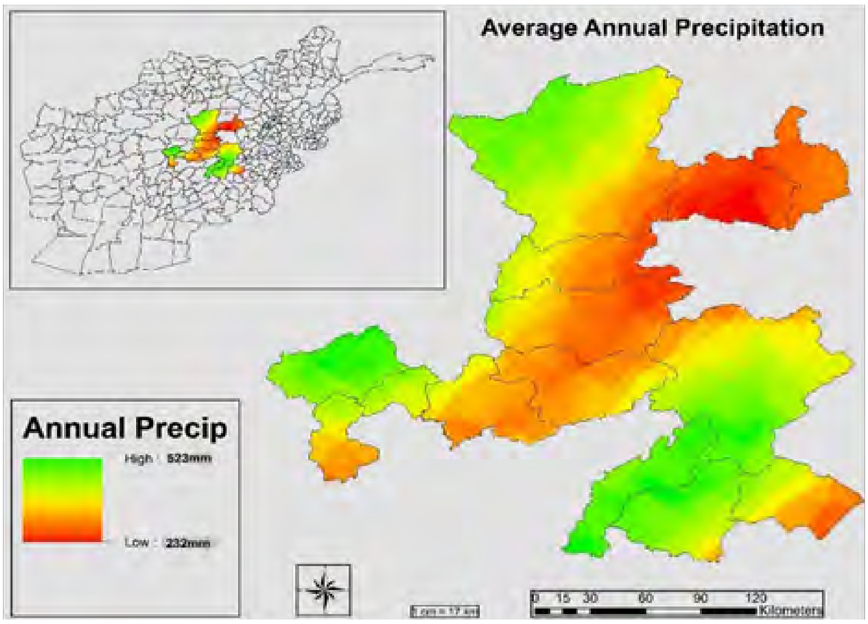
Source: Produced by the author

[2] The raw climate data used to analyze the climate of the region are obtained from the following online database: https://globalweather.tamu.edu/

As seen in Figure 6, the average annual temperature is around 0-4 degree Celsius in Shibar, Bamiyan Center, Yakawlang, Panjab, most parts of Waras and Nahoor, northeast of Miramor, and northeast of Malistan districts—which we classify under cold climate regime. The average annual temperature is around 4-7 degree Celsius in the west part of Miramor, east of Shahristan, north of Khedir, south of Malistan, north of Jaghori, and north Qarabagh districts—these fall under moderate climate regime. In areas such as Kiti, Nili, south of Jaghori, and south of Kiti, the average annual temperature can be as high as 8-13 degree Celsius—which are classified under warm climate regime.

Similar heterogeneities exist in terms of average annual precipitation. Figure 7 below depicts the variation of average annual precipitation in the study area and suggests two distinct climate zones. Areas such as the south part of Kiti, most parts of Nili, Shahristan, Miramor, and Waras, east of Panjab, southeast of Yakawlang, Bamiyan Center, Shibar, and southeast of Qarabagh receive on average about 200-380mm of precipitation per year. The rest—Jaghori, Malistan, southwest of Nahoor, Khedir, and most parts Yakawlang—receives on average between 400-550mm precipitation per year.

Figure 7. Average annual precipitation in the Central Highlands of Afghanistan

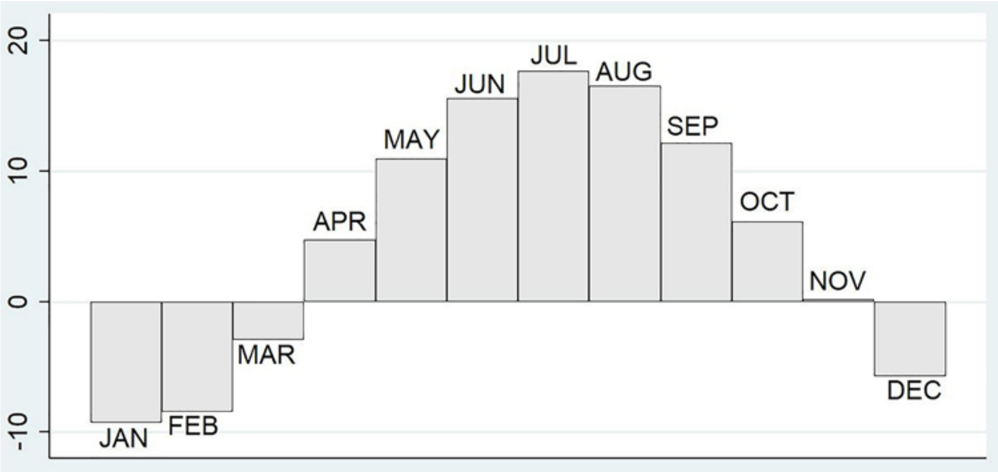


Source: Produced by the author

Such variation does not only exist across space, but also during different months. The variation of temperature and precipitation throughout the year has created distinct seasons in the study area. However, the onset and offset of seasons are being altered by climate change. For instance, the onset of winter is happening much later now compared to three decades ago. In addition, spring now starts much earlier than before. Figure 8[3] depicts the variation of average monthly temperature across 12 months and suggests that we have a negative average (averaged across space) temperature in December, January, February, and March—with January being the coldest. The average temperature attains its maximum value in July—with the average temperature being around 18 degrees Celsius.

[3] We have used weather information for 34 years (1979-2014) to calculate the averages displayed in Figures 7 and 8.

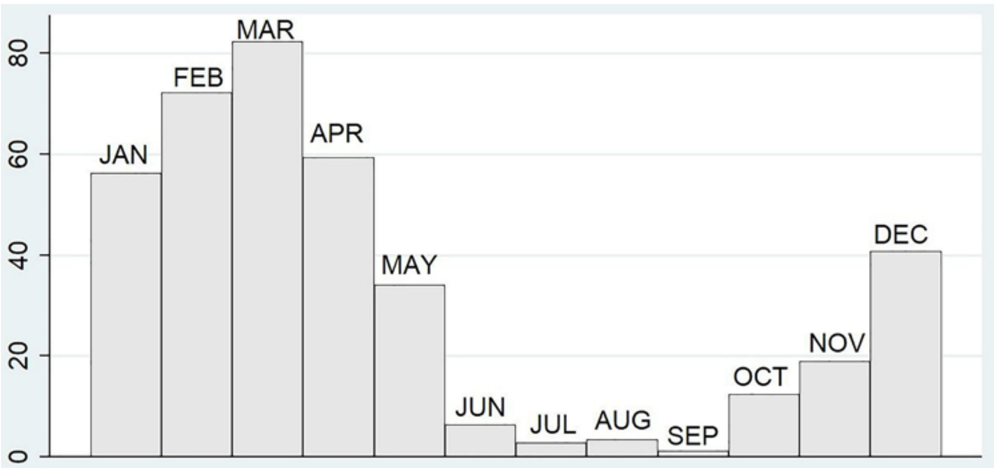
Figure 8. Variation of temperature across 12 months



Source: Produced by the author

The amount of precipitation also varies across time. Figure 9 shows that the main precipitation season starts in December and runs through to May. If we couple figures 8 and 9, we see that precipitation in December, January, February, and partly in March comes as snowfall. Meanwhile, precipitation during the rest of the months mostly comes as rainfall.

Figure 9. Variation of precipitation (in mm) across 12 months



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3.2. Data and Instruments

The primary data for the current research were collected by the author directly from a sample of 1,502 farmers in the Central Highlands of Afghanistan from May to July 2017. Multistage systematic random sampling was applied to select the subjects. A structured questionnaire and the World Bank's Survey Solution Application[4] were used to conduct face-to-face interviews with the heads of the farming household.

In addition to the data on farmers' perception on climate change, its related impact on agriculture, and the risk of extreme weather events, we also collected data on farmers' adaptation, characteristics of households, and implications of climate change for farm production.

[4] https://mysurvey.solutions/

The description and summary statistics of the instruments are reported in Table A.1 in Appendix A.

3.3. Analysis Approach

Descriptive statistics techniques are applied to summarize the related variables. A combination of different inferential analysis techniques (chi-square test, t-test, ANOVA, and logistic regression) has been applied to explore the various associations.

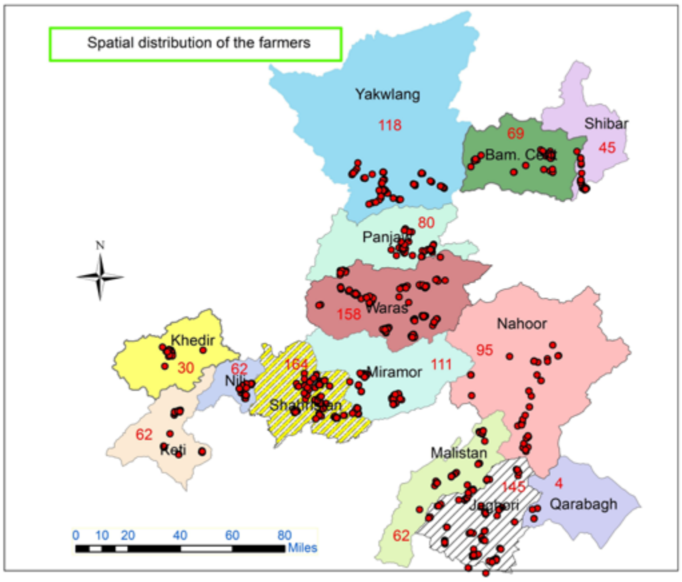
4. Results and Discussions

This section outlines the results starting with a presentation of sample characteristics. The statistics and econometrics results are then elaborated and discussed.

4.1. Sample Characteristics

Our sample consists of 1,502 farmers from 14 districts in Bamiyan (37%), Ghazni (33%), and Diakundi provinces (30%). The spatial distribution of farmers across the study area is depicted in Figure 10.

Figure 10. Spatial distribution of the sample across the study area

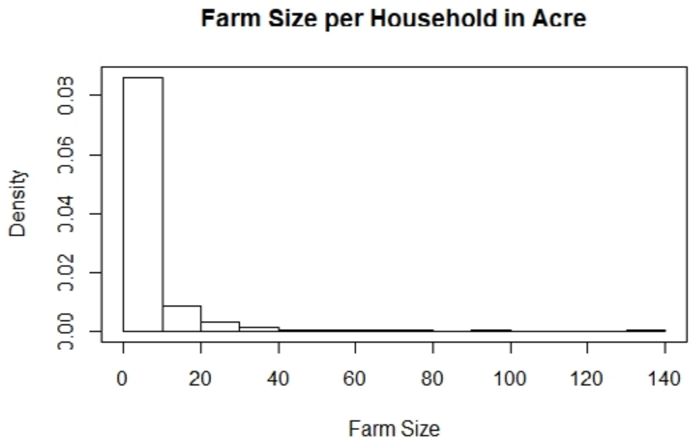


Source: Produced by the author

Women-headed households are very rare (3%) in our sample. Meanwhile, farming is the primary employment for 80% of the farmers in the sample, 37% of whom work exclusively on their own farms. The average household size is nine persons with almost equal distribution across gender. Including work on the farm, on average 60% of household members is out of which 75% work on the farm (68% male and 32% female household members).

On average, school attendance is 2.8 persons per household, while 3.7 members are literate. About 64% of the respondents spent some time abroad (mainly in Pakistan or Iran), and 65% of our subjects can at least read and write. The average age in our sample is 47 years, and the average time spent working on their farms is 22 years. Most of the farmers (78%) do not own a car, but many (63%), own a motorbike. Because the farmers are mostly poor and the region is predominantly mountainous, the motorbike seems to be the most practical means of transportation. Computer use is very uncommon—only 29% have one or more computers at home. Likewise, internet use is low (16%). About 67% have at least one TV at home and mobile phone use is prevalent (nearly 100%). About 72% have access (on average about five hours a day) to electricity. The use of solar panels is still not common, and only 7% of the households use them to generate electricity.

Figure 11. Per household farm size distribution (in acres)



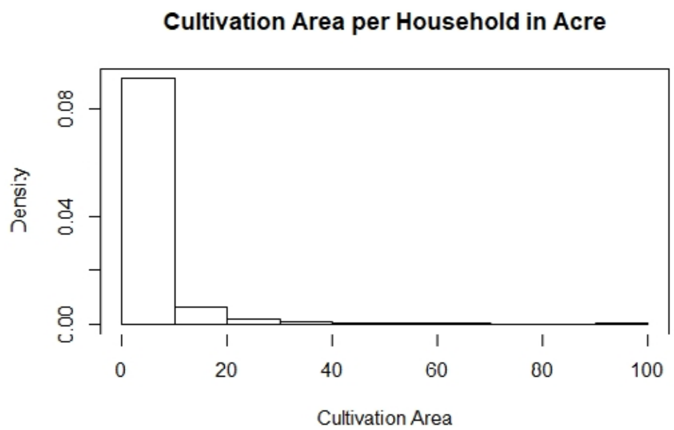
Source: Produced by the author

Due to the particular topology of the region, arable land is scarce. The average farm size per household is 7 acres (2.8 hectares), and again on average 5.5 acres (2.3 hectares) of it is under cultivation. The distribution of farm size and cultivation area [per household] are presented below. Figure 11 provides the distribution of farm size in acres per household and as it clearly shows, per household farm size is largely right skewed, where a total of 55 households own 30 acres or more of farmland.

However, nearly 90% of the farmers in our sample own 15 acres or less of farmland. Hence the median, 4 acers, provides a better measure for the center of farm size distribution.

Due to poor soil quality and increased water scarcity as a result of climate change, farmers cannot cultivate all of their farmland. The mean of the cultivation area per household is 5.1 acres (2.1 hectares). Below, Figure 12 depicts the distribution of the cultivation area.

Figure 12. Per household cultivation area density plot (in acres)



Source: Produced by the author

Similar to farm size, the distribution of cultivation is also highly right skewed disqualifying the mean to represent the true center of the overall sample. Hence we use the median, 3 acres per household, as a better measure for the center of distribution.

The median of annual crop net revenue per acre is estimated to be around AFN 30,000 (~USD 400). The net revenue is the difference between gross farm revenue and total cost (including seeds, external labor, and fertilizer). The market prices at the time of the survey were considered for both revenue and cost. Meanwhile, the portion of products consumed by the household was counted in gross revenue.

Livestock husbandry is another aspect of agriculture in the study area. The mean of annual net livestock income per household is about AFN 44,000 (~ USD 580).

Despite the small income farmers get from farming and livestock husbandry, agriculture plays a fundamental role in the economy of households, and is the primary source of income for 71% of the farmers in our sample. Most of the farms are subsistence in nature as only 21% of them sell on a portion of their agriculture products.

Remittances are the primary source of income for about 8% of the farmers, the majority of whom live in Ghazni province.

Three systems of irrigation are prevalent in the area. The first is to channel water from a river that passes through the villages (which services 18% of the farms in the survey). The second is a chain of underground canals (known as Karez) used to supply farmlands with water for about 41% of the households. The third is to channel water from a stream that flows in a nearby valley (41% of the households).

4.2. Farmers' perception of climate change

Referring to Table 1, in order to study farmers' perception of climate change, we have collected data on farmers' perception of climate change, the change in average annual temperature, average annual precipitation, and the main cause of climate change.

The data collected on variables measuring farmers' perception of climate change suggest that the majority perceive climate change mainly in terms of further warming and less annual precipitation. The main cause of climate change is perceived to be God's will.

Table 1. Farmer's perception of climate change

Variable	Values		
Perceived Climate Change	1,436 (yes)	66 (no)	
Change in Temperature	92 (No change)	1,294 (warmer)	116 (colder)
Change in Precipitation	57 (no change)	1,356 (decreased)	89 (increased)
Main Cause of Climate Change	975 (God's will)	163 (natural process)	364 (human)

Source: Produced by the author

It seems that farmers perceive climate change in terms of warming and/or a reduction in the average annual precipitation. To test this, we run a binomial logit regression of farmers' perception of climate change in terms of change in average temperature and average precipitation.

In Model 0, we run the regression using the change in temperature and precipitation and their interaction as our right-hand-side variables. In Model 1, we add other control variables, such as literacy and occupation. Table 2 below presents the results.

Table 2. Binomial logistic regression of farmers' perception of climate change

Dependent variables	Model 0	Model 1
Change in temperature (TEM)	3.5***	3.5***
Change in precipitation (PRE)	2.5***	2.5***
TEM*PRE	-2.3***	-2.4***
Literate		1.03***
Main occupation (farming)		.37
Main source of income (farming)		.08
Farming experience		.007
Sale farming products		.29
Constant	-0.39	-1.5*

Notes: *: p-value<0.01; ***: p-value<0.001

Source: Produced by the author

Model 0 suggests that farmers' perception of climate change is due to the warming and reduction in the amount of precipitation. In other words, farmers regard the evident change in average temperature and precipitation (throughout different seasons) as climate change. The significance of the interaction term suggests that the effect of one of the variables depends on the level of the other variables. Controlling for the effect of the other variables in Model 1, the conclusion remains the same. Moreover, among the control variables in Model 1, the effect of farmer literacy is significant. That is, the farmer's literacy increases the chance of the farmer perceiving climate change.

In order to explore the association of the perception variables with demographic and socio-economic variables—such as education, farming experience, the main source of income, crops net revenue, and occupation—we apply the chi-square test of independence and one-way ANOVA. In the chi-square test of independence and ANOVA, *H0* and *H1* are formulated as follows:

H0: The two variables of interest are not associated (in the population)

H1: The two variables are associated (in the population)

The results are presented in Table 3.

The chi-square test of independence suggests a significant association between the farmers' perception of the main cause of climate change and their main occupation being farming. That is, the perception (of the main cause of climate change) of those whose main occupation is farming differs from those whose main occupation is not farming. As expected, the null hypothesis of independence of farmers' occupation and their perception of climate change, the change in average annual temperature and precipitation cannot be rejected. The reason might be the significant change in normal temperature and precipitation, which has been very evident to everybody regardless of them being engaged (mainly) in farming.

Table 3. Chi-square test of independence for farmers' perception of climate change

Relevant variables	PCC	TEM	PRE	CCC
Main occupation	0.38	5.2	6.4*	36***
Literate	11***	23***	1.3	52***
Main source of income	.96	3.7	8**	4.4
Sale agriculture products	1.2	9**	24***	6.3*
Farming experience	0.03++	0++	0.2++	29++***
Crops net income	1.3++	1.62++	12.86++***	1.73++

Notes: PCC: perceived climate change, TEM: change in temperature, PER: change in precipitation, CCC: main cause of climate change; *": p-value<0.1, **: p-value<0.05, ***: p-value<0.01; ++ the value of F-statistic in ANOVA

Source: Produced by the author

The association of literacy and the perception variables (perceiving climate change, change in temperature and the main cause of climate change) is significant. It means that farmers who are literate have a (statistically) significantly different perception regarding the change in the climate, changes in mean temperature, and the main cause of climate change versus those who are illiterate5. In the case of farmers' literacy and their perception of change of the mean precipitation, we cannot reject the null hypothesis of no association.

In the case of the main source of income, we find a significant association between this variable and farmers' perception of change in the mean precipitation (p-value<0.05). In other words, farmers whose main source of income is farming perceived changes in precipitation differently from the rest.

The perception variables have a rather significant association with farmers selling a part of their produces, the farmers' perception of climate change being an exception.

In terms of farming experience, we expect that the more time a farmer has spent farming, the more they have perceived changes in the climate. However, our results suggest that the null hypothesis of no association between farmers' perception of climate change, changes in temperature and precipitation with their farming experience cannot be rejected. The association of farmers' experience and their perception of the cause of climate change, however, is significant (p-value<0.001).

The literature on the impact of climate change on crops revenue is rich (see Jawid (2020) for an analysis on the economic impact of climate change on agriculture in Afghanistan's Central Highlands). In the study area, it has been shown that changes in both (seasonal/annual) temperature and precipitation have a significant effect on crops revenue. Our results in Table 3, however, suggest a significant association between only change in precipitation and crop net revenue (p-value<0.001). Meanwhile, the association of change in temperature and crops net revenue is not statistically significant. A reason for this might be the endogeneity problem. Farmers' perception is an endogenous variable, while climate variables are exogenous. Like the change in temperature, the null hypothesis of an association between crop net revenue and farmers' perception of the main cause of climate change cannot be rejected.

4.3. Farmers' perception of the impacts of climate change

5 It should be emphasized that we are not talking about causation here. The significant association between variables here can have several sources, such as a common cause.

As our target population consists of farmers, it is natural to investigate their perception of the impacts climate change has on their main business. To this end, we have collected data on farmers' perception of the impact of climate change on farm production, the overall impact of climate change, and their farm vulnerability to climate change. We apply a chi-square test of goodness of fit to test a research hypothesis of unequal frequency distribution across all categories of the perception variables. Table 4 presents the results.

The results in Table 4 suggest that most of the farmers think that farm production has decreased, the overall impact of climate change has been negative, and their farming business is vulnerable to the impacts of climate change.

The chi-square test of goodness of fit (presented in the last column of Table 4) suggests that the number of farmers who think that farm production (as a result of climate change) has decreased, increased, and has seen no changes are different (p-value<0.001). This observation implies that the type of impact of climate change on farm production is heterogeneous among the farmers.

Table 4. Farmers' perception of the impact of climate change

Variable	Values			Chi-Sq Stat
Change in farm production compared to 25 years ago	935 (decreased)	225 (no change)	342 (increased)	576***
The overall impact of climate change	921 (negative)	160 (no impact)	421 (positive)	597***
Farm vulnerability to climate change	108 (not vulnerable)	750 (vulnerable)	644 (very vulnerable)	473***

Note: ***, p-value<0.01

Source: Produced by the author

The chi-square test of goodness of fit for the farmers' perception of the overall impact of climate change and their farm vulnerability also rejects the null hypothesis of equal frequencies (p-value<0.001). Hence, the degree of the overall effect of climate change and farm vulnerability to climate change vary among the farmers in the study area.

Following the results in Table 4, we know that the impact variables are unevenly distributed across their categories. To explore the geographical heterogeneity of these variables, we analyze the association of these variables with the variable province—a categorical variable measuring the province the farmer lives and farms in. For that, we apply a chi-square test of independence to study the association between the province variable and the impact variables. The results are presented in Table 5.

The results in Table 5 show a significant association between the impact variables and the province variable (p-value<0.001).

Table 5. Climate change impact across space

	Values	Bamiyan	Ghazni	Diakundi	Chi-Sq Test
Change in farm production compared to 25 years ago	DEC	282	350	303	169***
	NoCH	66	116	43	
	INC	207	29	106	
The overall impact of climate change	NEE	256	423	242	213***
	NoE	56	38	66	
	POE	243	34	144	
Farm vulnerability to climate change	NV	76	17	15	229***
	V	318	142	290	
	VV	161	336	147	

Notes: INC: Increased, NoCH: No change, DEC: Decreased, NEE: Negative effect, NoE: No effect, POE: Positive effect, NV: Not vulnerable, V: Vulnerable, VV: Very vulnerable, ***, p-value<0.001

Source: Produced by the author

The chi-square test of independence rejects the null hypothesis of no association between the province and the impact of climate change on farm production (p-value<0.001). Hence, at the population level, the impact of climate change on a farm's production is significantly different across three provinces. The results in Table 5 suggest that a negative impact is the most perceived option in Ghazni province followed by Diakundi province, while a positive impact is highest recorded in Bamiyan province.

Similar results can be observed in the case of the overall impact of climate change and a farm's vulnerability to climate change. The impact of climate change is largely negative in Ghazni province and partially positive in Bamiyan province. Moreover, the majority of farmers in all three provinces stated that their farming is vulnerable to the impacts of climate change (this also includes extreme weather events)—which is an indication of the low adaptive capacity of farmers in the study area.

4.4. Farmers' perception of the risks of extreme weather events

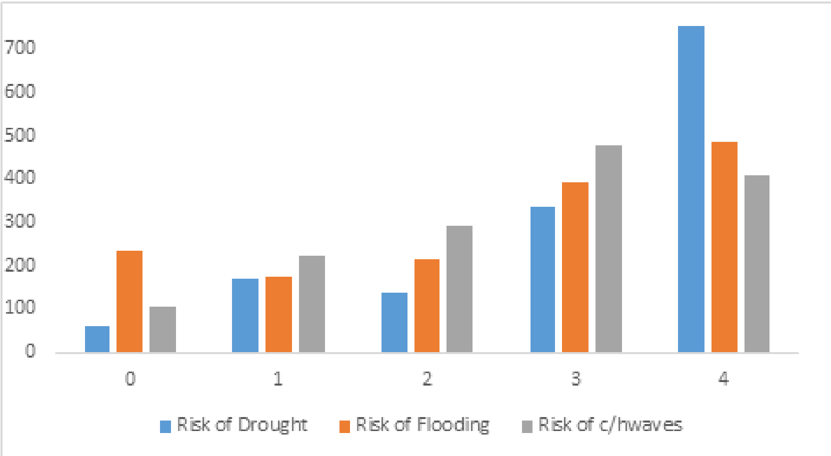
Extreme events, such as drought, flooding, and cold/heatwaves, are among the factors that have affected agriculture, farming, and rural livelihood throughout the history of humankind. Evidence suggests that both the frequency and intensity of these events have increased with recent climactic changes (Jayatilleke, 2014), putting them at the front line of discussions around climate change and agriculture.

In Afghanistan, drought and flood are viewed as the two most prevailing extreme weather events (UNEP et al., 2016). Following UNEP et al. (2016), there are two types of droughts: one that is caused by a significant reduction in rain/snowfall, and the second caused by reduced river discharge due to reduced snowmelt in the upland areas in spring and summer. Similar to drought, two types of floods have been identified: the first is caused by heavy rainfall during a short period of time and the second is caused by rapid snowfall.

The Central Highlands is prone to the first type of drought (due to a significant reduction in precipitation) and the second type of floodings (due to rapid snowmelt) (UNEP et al., 2016).

In order to study the effect of extreme weather events in the study area, we explore the farmers' perception of the risks of these events. To this end, we have collected data on their perception of the risk of drought, risk of flood, and risk of cold/heatwaves6. Figure 13 depicts the farmers' perception of these events. As evident in Figure 13, the risk of drought was rated as "very high" by the highest number of farmers. In general, the risks of all three events are rated as "high" or "very high" by the majority of the farmers.

Figure 13. Farmers' perception of the risk of extreme weather events



Source: Produced by the author

Table 6 presents the median as well as the distribution of the risk variables. The results suggest that farmers perceive the risk of drought to be the highest (also evident in Figure 13). Despite the mountainous topology of the region, water scarcity continues to be a major challenge for most of the farmers in the study area. This is mainly due to an acute reduction in the amount of precipitation and partly due to basic and traditional irrigation systems. That is why a drought of any kind immediately affects farming and farmers' income and employment. Moreover, the high risk of drought can be an indication of low adaptive capacity. This, considering the fact that climate change exacerbates the risk of drought, is becoming a key policy issue.

Flooding is an extreme event that causes huge destruction around the world and in less developed parts of the world in particular due to weak defensive measures. In the Central Highlands of Afghanistan, due to steep valleys, even moderate flooding can cause huge losses. The farmers in our sample have rated the risk of flooding second highest after drought. Like drought, the risk of flooding, in particular flush flooding, is expected to increase with climate change.

Table 6. Farmers' perception of extreme weather events

Variable	**Median**	**0**	**1**	**2**	**3**	**4**
Risk of drought	4	60	169	137	338	798
Risk of flooding	3	235	174	215	394	484
Risk of cold/heatwaves	3	104	223	290	477	408

Notes: 0: not serious at all; 1: not serious; 2: somehow serious; 3: serious; 4: extremely serious. ***, p-value<0.001

Source: Produced by the author

6 We have used an ordinal variable (with 5 categories) to measure the perception of farmers of the risk of extreme weather events. 0: very low; 1: low; 2: moderate; 3: high; 4: very high

In addition to the two primary extreme weather events (drought and flooding), cold/heatwaves are also harmful and can damage agricultural products. The farmers in our sample perceived the risk of these events as high as the risk of flooding. Due to climate change, the intensity and frequency of cold/heatwaves have increased (Ali & Erenstein, 2017). Considering the extreme nature of these events, considerable losses in a farm's production can occur. A cold wave in spring when most of the products blossom, for instance, can freeze premature seeds. In the same way, a heat spell in the summer, when water scarcity is at its peak, can damage products.

Like the climate change, the effect of extreme weather events varies across space. Hence, it is a relevant research and policy concern to explore the distribution of the risk of these events across space. Thus, we exercise the chi-square test of independence to assess the variation of these events between Bamiyan, Ghazni, and Diakundi provinces. Table 7 below presents the results.

The results in Table 7 suggest a significant variation of the risk of extreme events across space. In other words, the risk variables and province are significantly associated (p-value<0.001). While the risks of all three events are high in all three provinces, Ghazni province is most vulnerable to these events. This means that farmers in Ghazni province are more prone to the impacts of climate change which exacerbates the risks of extreme weather events. Such an understanding is key in designing adaptation measures and interventions. Underlying that, the risk of these events is high also in Diakundi and Bamiyan provinces.

Table 7. Risk of extreme weather events across space

Variable	Values	Bamiyan	Ghazni	Diakundi	Chi-Square Test
Risk of Drought	0	32	13	15	210***
	1	75	24	70	
	2	71	13	53	
	3	156	53	129	
	4	221	392	185	
Risk of flooding	0	62	110	63	131***
	1	72	28	74	
	2	105	29	81	
	3	159	105	130	
	4	157	223	104	
Risk of cold/heatwaves	0	46	34	24	38***
	1	73	85	65	
	2	97	75	118	
	3	193	137	147	
	4	146	164	98	

Notes: ***: p-value<0.001

Source: Produced by the author

5. Conclusion and policy recommendations

With a more robust understanding of the impacts of climate change on different sectors, adaptation has become a central issue in climate change discourse. Among other sectors, adaptation in agriculture, especially in the least developed agriculture-dependent countries, has become a key developmental matter. Adaptation in agriculture takes place at various levels, starting from farming households, to the community, and to the country level. Household-level adaptation is the base for the success of the process in a larger setting. The literature agrees that farmers' perception of climate change plays a significant role in their decision to adopt adaptation measures. In other words, the decision to adopt such measures to some degree depends on farmers' understanding the changes happening around them. In light of this argument, the current paper uses a novel dataset to study farmers' perception of climate change, causes of climate change, the impacts of climate change, and the risks of extreme weather events in the Central Highlands of Afghanistan.

The results suggest that almost all the farmers have perceived changes in the climate. Regression analysis suggests that the farmers' perception of climate change is mainly in the form of a further warming and/or decrease in the average annual precipitation. Nearly all the farmers in our sample agree that their region has become warmer and receives less precipitation compared to 25 years ago. The majority of the farmers think that the main cause of climate change is God's will, which is an observation that goes against scientific evidence stating that the main cause of climate change is the exceeding emission of greenhouse gases, motivated by economic activities. Such perception can affect the farmers' decision to adopt adaptation measures.

A mixture of climate change impacts is observed. While there are farmers in Bamiyan province who think that climate change has been beneficial to them, the majority of farmers believe that these changes have brought about negative impacts on their farming business. Along the same line, the vast majority of farmers think that their farming is vulnerable to the impacts of climate change and extreme weather events. This indicates that farmers in the study area view their farming business as vulnerable to the impacts of climate change (which also includes extreme weather events).

Extreme weather events have long affected farming and rural livelihoods. Extreme weather events, such as drought and flooding, due to their extreme nature, can cause huge losses to farmers. The Central Highlands of Afghanistan has a long history of experiencing extreme weather events, such as drought, flooding, and cold/heatwaves. But due to limited educational and economic means, the residents have not been able to develop robust adaptation strategies to increase their resilience in dealing with these events. An intervention that addresses these key issues is thus a key policy matter. For the intervention to be systematic and effective, understanding the current state of play through the eyes of the farmers is an important first step.

In this paper, we have provided evidence on the farmers' perception of the risks of extreme weather events. In this regard, our subjects perceived the risks of drought, flooding, and cold/heatwaves as high. In particular, the perceived risk of drought is very high. This observation indicates that these events are constant threats to farming in the study area, and second, that the farmers appear unable to deal with their consequences.

Like the impacts of climate change, the risks of extreme weather events vary across space. For instance, the risk of drought is highest in Ghazni province and smallest in Bamiyan province. The reason for this is the Baba Mountain Range which extends from the northeast (Shibar district) to the southwest (Yakawlang district) of Bamiyan. The Baba Mountain Range sustains snowfall throughout the year which supports the water resources in the attached districts and provinces. The existence of the Baba Mountain Range coupled with further warming has resulted in positive impacts in some parts of Bamiyan province. With additional warming, the length of cultivation and harvesting seasons have increased. As a result of this, the farmers in these areas not only have more time to cultivate and harvest (and hence get more out of their farms) but can also grow a greater varieties of products. For instance, most of the farmers in Bamiyan mentioned that in the past they were only able to cultivate a limited number of products with very small economic value. For instance, such products included wild types of wheat, barely, and alfalfa. With further warming, farmers can now cultivate products such as potatoes, which Bamiyan is now famous for.

The study area is historically one of the most marginalized areas in Afghanistan. Its mountainous structure limits the size of arable land available and with climate change farmers' vulnerability keeps increasing. Hence, in order to help the inhabitants of this region continue and develop their farming under the changing environment, adaptation is a key policy concern. Adaptation for all farmers is a crucial issue. Farmers who are negatively affected by climate change need to be supported. Such interventions include water resources management, introduction of new types of seeds (which are drought and disease tolerant with higher yield), educating them on how to deal with consequences of climate change, and the introduction of affordable insurance tariffs (which will increase their risk tolerance). Altogether, the interventions should increase the resilience of farmers.

Since the impacts of climate change and extreme weather events are very much location specific, it is important that the design of any intervention to be community (village) specific. This objective is achievable if the interventions are based on rigorous studies at the local level. In this regard, the role of universities, such as Bamiyan University, is decisive. Students' projects, supervised by professors of different relevant fields, can generate reliable, detailed, and local-level evidence at a very low cost.

In summary, a multidimensional approach is needed for addressing adaptation: the intellectual intervention should aim to inform the farmers of the reality of the changing climate, future possible scenarios, and how they should prepare themselves to face the related effects. Physical interventions should start with generating evidence at the community level, which should be done by local universities. The evidence collected should then be used by the relevant government authorities for designing proper intervention actions. With proper interventions, climate change could be turned into an opportunity, helping the farmers stay their homes, continue farming and increase their production.

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Appendix A: Additional Tables

Table A. 1: Instruments Definition and Descriptive Statistics

Variable	Description	Sample Mean(SD)
Climate factors[7]		
Winter precipitation	The total precipitation in the traditional winter season: January, February, and March (in mm): continues	70 (25)
Spring precipitation	The total precipitation in the traditional spring season: April, May, and Jun (in mm): continues	33 (17)
Summer precipitation	The total precipitation in the traditional summer season: July, August, and September (in mm): continues	2.4 (2.5)
Fall precipitation	The total precipitation in the traditional fall season: October, November, and December (in mm): continues	24 (10)
Winter temperature	The average temperature in the traditional winter season (°C): January, February, and March: continues	-7 (3)
Spring temperature	The average temperature in the traditional spring season: April, May, and Jun (°C): continues	10.4 (2.3)
Summer temperature	The average temperature in the traditional summer season: July, August, and September (°C): continues	14.4 (1.7)
Fall temperature	The average temperature in the traditional fall season (°C): October, November, and December: continues	0.19 (2.8)
Irrigation water River Stream Karez++	Irrigation type: categorical	 .18 (18%) .41 (41%) .41 (41%)
Environmental/farm characteristics		
Risk of drought	Perceived risk of drought: Categorical (1 no risk to 4 very high risk)	3.1 (1.2)
Risk of flooding	Perceived risk of flash-flooding: Categorical (1 no risk to 4 very high risk)	3.0 (1.1)
Risk of cold/ heatwaves	Perceived risk of cold/heatwaves: Categorical (1 no risk to 4 very high risk)	.91 (.29)
Distance to the market	Distance to the nearest market by car/motorbike in minutes: continues	41 (43)
Farm size in acres	Farm size (in acre): continues	7.0 (.95)
Household head characteristics		
Primary employment	Farming is the primary occupation of the household head: dummy [1=yes]	.80 (.40)
Literate	Household head is literate: dummy [1=yes]	.59 (.49)
Farming experience	Farming experience of the household head in years: continues	22(14)
Household size	Household size: continues	9 (3.5)
Age	Age of the household head (in years): continues	46.8 (15)

[7] The climate data are obtained from the following database: https://globalweather.tamu.edu/