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Farmers' perceptions of and adaptations to drought in Herat Province, Afghanistan

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Abstract: Drought is a significant natural hazard in Herat Province, Afghanistan. The objective of this study was to explore farmers' perceptions of the drought's prevalence and characteristics, its socio-economic and environmental impacts, their strategies for coping with and mitigating it, and types of conflicts and resolution mechanisms. A questionnaire was completed by 147 farming households. The results indicate that farmers' perceptions regarding drought are in line with the results obtained using the precipitation data. Even though the respondents have religious belief in interpreting the weather related issues, they also perceived drought as the climatic and environmental factors such as increased temperature, decreased precipitation, and other factors like war, financial weakness, deforestation, over-exploitation of groundwater, lack of electricity supply etc. The results show that drought has had serious economic impacts, including loss of employment and reduction in crop yield and livestock production, which have reduced farmers' livelihood options and weakened their financial situation. Social impacts have included migration, a sense of hopelessness and loss, conflicts over water, health problems, impacts on the schooling of children, malnutrition, and limits to food options. Significant environmental impacts such as an increase in temperature, pasture and forest degradation, deterioration of water quality, damage to fish and wildlife habitats, and groundwater depletion were also reported. Farmers used local techniques to adapt to drought and lessen its effects. Farmers perceived irrigation water to be a major source of conflict. Local elders, water-user associations, and formal courts were reported to be the most successful conflict resolution methods. It is expected that the results of this study will support policy makers within government and development agencies in Afghanistan to develop future drought adaptation policies.

Keywords: Adaptation strategies; Perception; Agriculture; Drought impacts; Water conflict

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Introduction

Increasing risk of climate extremes is directly linked to increase in climate variability caused by warmer climate (Wetherald & Manabe 2002).

Consequently, changes in the magnitude, frequency, duration, and extent of natural hazards such as flood and drought are brought about. Hazard events are ranked based on their characteristics and impacts. A number of such assessments have indicated that drought stands first among all hazard events (Hewitt 1997; Obasi 1994; Wilhite 2000). A review of the studies by (Wilhite and Pulwarty 2005; Keshavarz and Ezatollah 2014) revealed that although drought has not been well documented, the high dependency of agriculture on natural resources results in adverse impacts of drought on this sector. Therefore, droughts are recurrent phenomena in arid and semiarid regions and continue to cause loss of crop production, food shortages and starvation, if not managed effectively (Paul 1998). Drought relief should not be thought of as a merely short-term concept; rather, major drought-related problems and constraints should be referenced and explained (Garg et al. 2012; Pandey & Bandhari 2009; Surinaidu et al. 2013).

There are various underlying problems in understanding and developing a suitable definition of drought, like differences in hydro-meteorological variables, socio-economic issues, and the stochastic nature of water demand in different regions of the world (Wilhite 2000). Although the definition of drought varies significantly from region to region and sector to sector, it is water scarcity caused when precipitation is less than average over an extended period of time. Drought can be meteorological (caused by deficiency of precipitation), hydrological (caused by insufficient surface or sub-surface flows of water), agricultural (occurring when a specific crop encounters a soil moisture deficit in a certain interval of time due to lack of surface water resources), and socio-economic (occurring when water resources cannot meet demand, which will impact human activities directly or indirectly) (AMS Council 2004; Wilhite 2000; Wilhite & Glantz 1985).

Zarafshani et al. (2007) argued that drought management practices, along with the perception and understanding of the severity of drought, should be considered as important factors in coping with the impacts of drought. However, some aspects of decision-making in response to drought have been poorly understood as a result of incorrect assumptions about farmers' homogeneity (Keshavarz et al. 2010). According to Keshavarz et al. (2010), of three levels of preparedness for adaptation to drought impacts, the micro (farm) level has greater importance than the meso (local) and macro (national) levels.

River discharges in Afghanistan are unreliable and vulnerable. Therefore, focusing on river discharges as the only strategy to reduce drought impacts is problematic. However, integration of river flows and water harvesting techniques could be an appropriate and safe drought mitigation strategy. Water harvesting techniques have a high potential to supply water to villages in all five river basins of Afghanistan (Beekma & Fiddes 2011). The drought return period differs in different parts of the country. Local droughts have return periods of three to five years. Larger-scale droughts recur every 9 to 11 years, and nationwide droughts have a return period of 20 to 30 years (Muhammad et al. 2017; Bhattacharyya et al. 2004). However, recent droughts are said to be unusual because of their wide geographical extent and duration (Bhattacharyya et al. 2004).

Scientific studies have found a drastic shrinking of water resources in Afghanistan due to climate change. The adverse consequence has been prolonged drought, which has forced people to leave many regions of the country. The continued drought has caused the loss of many plants and made traditional farming of staple crops more difficult. The rise of drought-resistant opium poppies in the country can be recognized as a result of drought (Shroder and Ahmadzai 2016). Western Afghanistan is located in an arid environment, in which people have survived for years but have considerable concerns over the scarcity of water (Bhattacharyya et al. 2004).

Based on the socio-economic impacts of drought in Afghanistan and the dependence of its people on agriculture, the country is categorized as one of most drought-sensitive countries in the world (Eriyagama et al. 2009). Still, few studies have focused on the local and regional complexity of drought impacts (Bhattacharyya et al. 2004; Hirway 2000; Pandey & Bandhari 2009). As drought impacts spread, policy makers need accurate information about drought-related issues — such as its causes and socio-economic and environmental impacts, as well as effective coping and mitigation strategies — in order to reduce human stresses (Reynolds 2008; Roy & Hirway

2007).

This information should include farmers' perceptions of drought and of their ability to cope with it. No studies thus far have assessed these aspects in the context of Herat Province, Afghanistan. This study aimed to help fill that gap by exploring farmers' perceptions of the prevalence and characteristics of drought (such as frequency, environmental hazards, and socio-economic impacts) as well as their coping and mitigation strategies, by conducting a structured questionnaire survey in this drought-prone region. The methodology and results of this study can provide practical support for the development of drought policy in Afghanistan.

1 Research Design

The study incorporated a review of earlier drought-related socio-economic studies and a structured questionnaire survey of farmers.

1.1 Study area

Herat Province in Afghanistan has been taken for macro level analysis while district Ghoryan (Figure 1) has been taken as the study area for micro level analysis. The study area, situated in the west of Herat, is part of drought prone region of Herat Province and was severely affected during the recent drought (Arun Amatya 2012). Herat Province in the lower Hari Rud basin in western Afghanistan (Figure 1), is divided into 17 districts and contains over 1000 villages that are severely drought prone (Bhattacharyya et al. 2004).

According to the 2014 census, the population of the study area was 85,900. Total area of the district is 738,500 ha. The population density is 12 persons per square kilometre with an average household size of 8 persons. The main livelihood source is agriculture. Seasonal migration for work to Herat city or to Iran is also common; other income sources are the sale of livestock and other household assets and the mortgaging of land.

There is usually no rain during the hot months of June through September and relatively high rainfall between December and March (Arun Amatya 2012; Figure 2). The study area has an average elevation of 790 m. The climate is very pleasant in the summer, and it is not very unpleasant for the rest of the year. Water surface and pan evaporation rates are highest (10 mm) from May to August, due to the combination of

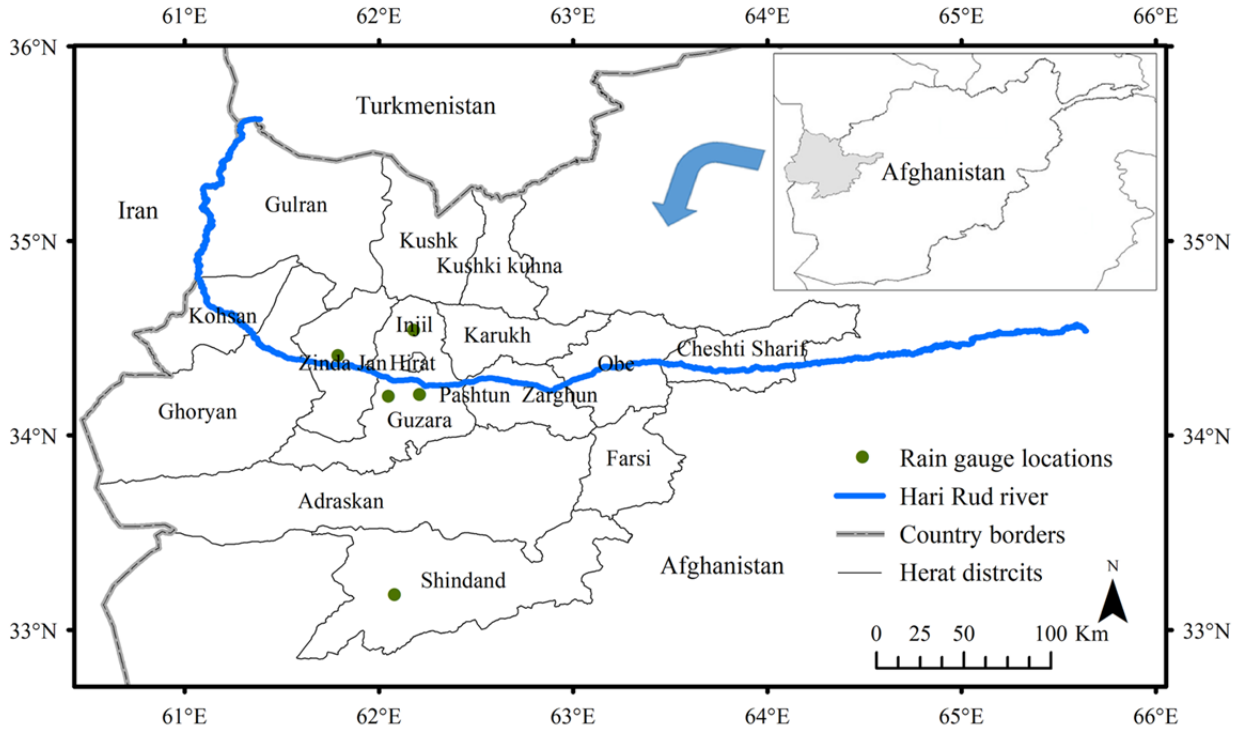

Figure 1 Study area showing the districts together with Hari Rud river basin and location of rain gauges.

high temperatures and wind speeds and low relative humidity (Arun Amatya 2012). The winter is not very extreme, and snows melt quickly; even in the mountains, snow does not last long. Mean monthly temperatures range from almost 30°C in June–August to 5°C in December–February (Virgo et al. 2006).

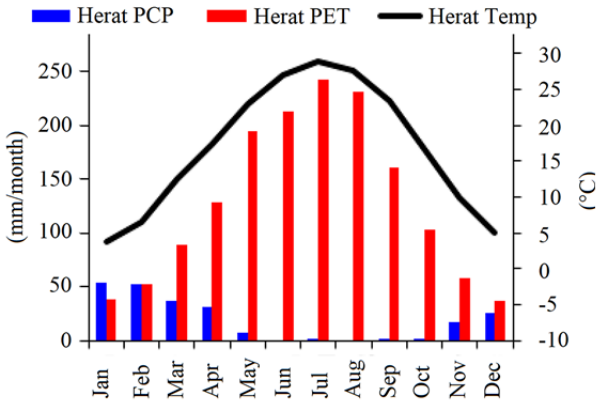

Figure 2 Monthly precipitation (PCP) and potential evapotranspiration (PET) in study area. (Source: Ministry of Agriculture, Irrigation & Livestock 2012).

The socio-economic situation in the study area is mainly defined by the agricultural sector. The effect of drought on agricultural production is the most critical drought-related effect. The main crop is wheat, with the secondary production of barley, peas, corn, and cumin. Vineyards and orchards with peach, apricot, plum, and walnut trees are irrigated with river water. Fruits and vegetables — melons, eggplants, tomatoes, and okra — are also grown in the area (Bhattacharyya et al. 2004). In some parts, farming relies on *karez* irrigation. A *karez* (a traditional structure used to harvest groundwater) is typically dug by local people, creating shafts at close intervals, small but ranging in length from under 5 km to 16 km (UNFAO 2013).

Droughts have had significant economic and social impacts on farming communities in the study area. The most immediate economic impacts have been reductions in crop diversity and yield, livestock production, and employment opportunities. Previously, farmers cultivated seven crops: wheat, barley, peas, mung bean, clover, cotton, and melon. The number of crops has been reduced to two, wheat and peas, and yields have fallen by 17% to 88%, due to a serious drought; work opportunities and livestock numbers have also decreased significantly. Child labour, early marriage of girls, conflicts over water, and impacts on children's education are common social impacts of drought. The economic difficulties, in particular lack of jobs for young people, have caused many families, especially young farmers, to migrate to cities within Afghanistan, and further to Iran and Pakistan (Bhattacharyya et al. 2004).

Drought has had high environmental impacts in this area, including temperature increase, falling groundwater levels, and pasture and forest degradation (Bhattacharyya et al. 2004). Forests and pastures have been extremely reduced. The majority of the grazing lands have been eliminated, and the productivity of the remaining communal grazing lands has significantly decreased. The population suffers from a shortage of potable water; several shallow wells have dried up throughout the study area.

1.2 Questionnaire design

A structured questionnaire was designed for this study, based on earlier drought-related socio-economic studies (e.g., Ashraf & Routray 2013; Habiba et al. 2012; Keshavarz et al. 2013; Manandhar et al. 2011; Udmale et al. 2014), to elicit information on farmers' perceptions of the characteristics and impact of drought and their coping and mitigation strategies. The questionnaire contained both closed-ended and open-ended questions. It was pretested by selected farmers from the target group, to identify questions that did not make sense to participants or that might lead to biased answers. Various steps suggested by (Choi and Pak 2005; Colosi 2006; Quelhas et al. 2011; De Leeuw 1992; Bowling 2005) were considered during design and administering the questionnaire for avoiding biases. Based on the pretest results, the questionnaire was modified, and people who participated in the pretest were excluded from the survey.

1.3 Determination of sample size and sampled respondents

The survey was conducted in August 2015. The individual farming household was designated as the

primary sampling unit. Survey participants were selected from the target population using a multi-stage stratified systematic sampling technique (villages as a penultimate unit (cluster) and household as a final unit) (Ashraf & Routray 2013; Udmale et al. 2014). The total irrigated area was divided into three categories — low (0%-15%), medium (15%-30%) and high (more than 30%) irrigation — based on the assumption that the amount of irrigated area affects farmers' perceptions of drought and their adaptation and mitigation strategies. The required data such as population and a list of villages were collected from the Agriculture, Irrigation, and Livestock Department of Herat Province.

Villages were selected for the study using the probability proportional to size sampling technique, and individual households were selected using the random walk sampling technique. A sample size determination formula proposed by Arkin and Colton (1950) and a household survey sample design procedure recommended by the UN Statistics Division (2008) were used to calculate minimum sample size. A total of 147 households were included in the survey, representing the three irrigation categories (low, medium, and high). Taking into account the population portion, 49, 50, and 48 households were selected from low, medium, and high-irrigated areas respectively from 14 villages. Face-to-face interviews were conducted in the local language, mostly with heads of households but sometimes with other family members. Interest in drought-related issues was high in the area, and the response rate was almost 100%.

1.4 Methodology

The primary data were processed and statistically analyzed using SPSS. Responses to open-ended questions were coded 1 for an affirmative response and 0 for no response. The affirmative responses were expressed in percent. Farmers' responses to close-ended questions were coded on a five-point Likert scale (1 for very less to 5 for very high). The internal reliability analysis which is represented by Cronbach's alpha show 0.79 and 0.76 for items related to drought impact and adaptation respectively. It indicates that all of the Likert-type items have a good internal consistency (the acceptable limit is > 0.70). Descriptive and inferential statistics were used to assess farmers' perceptions of drought and the coping and adaptive strategies being practiced to mitigate its effects.

In order to analyse differences in respondents' perceptions, study households were grouped based on sub-district-level irrigation strata and on landholding size (marginal, <0.2 ha; small, 0.2-1.2 ha; medium, 1.2-6 ha; large, >6 ha), annual income (low, <USD 730; middle, USD 730-1790; high, >1790), education (none, primary school, secondary school, higher education), and drought intensity (severe or moderate). Non-parametric significance testing was carried out, using the Kruskal-Wallis H-test for comparison of three or more groups with multiple variables and the Mann-Whitney U-test for comparison of two groups with multiple variables, to analyze the data at the 5% significance level (Alipour et al. 2013; Field 2009; Fielke & Bardsley 2014; Gbetibouo 2009; Pallant 2007; Taylor et al. 1988). Non-parametric testing was applied because this method is generally valid whatever the population distribution; also, the data in this study were measured using an ordinal five-point Likert scale, which usually need non-parametric statistical approaches.

In this study, independent variables are irrigation strata, education, landholding size, income, and drought intensity; while the dependent variables are farming community's perception of drought impacts on their socio-economic activities and environment (19 items), and their strategies for coping with and mitigating it (16 items).

2 Results and Discussions

2.1 Profile of the farm households

Table 1 summarizes the characteristics of participating farm households. Participants ranged in age from 26 to 73, with an average age of 42.2 years. Most respondents were illiterate or had only a primary education. Crop farming was the largest source of income, followed by livestock farming and agricultural labour.

2.2 Perception and awareness of drought impacts

Table 1 Characteristics of respondents' households (n = 147)

Characteristics		Low irrigation		Medium irrigation		High irrigation		Average	
		No.	%	No.	%	No.	%	No	%
Household (HH) characteristics	Households per irrigation category	49	33.4	50	34.1	48	32.6		
	Household head interviewed	114	77.5	127	86.4	115	78.3	119	80.9
	Other household member interviewed	33	22.6	20	13.6	32	21.7	28	19.1
	Average age of respondents (years)		38.4		41.2		47		42.2
	Average household/family size (persons)		6.8		6.6		6.1		6.5
Education	None	117	79.6	110	74.8	100	68.2	109	74.2
	Primary school	14	9.5	12	8.2	17	11.5	14	9.6
	Secondary school	6	4.1	9	6.2	11	7.5	9	5.9
	Higher secondary school	10	6.8	16	11.0	20	13.0	15	10.3
Source of household income	Agriculture	145	98.7	141	96.0	140	95.2	142	96.7
	Animal husbandry	124	84.3	121	82.3	102	69.3	116	78.6
	Wage/farm labour	69	46.9	57	39	34	23.1	53	36.2
	Gross annual household income (USD)		1607		1584		1440		1544

It is very important to understand the impacts of drought while formulating drought policies. By assessing severe droughts and understanding their multiple adverse impacts, policy makers can avert or reduce drought's destructive impacts (Dziegielewski et al. 1997). Drought has adverse impacts on society, the economy, and the environment (Ashraf & Routray 2013; Garg et al. 2012; Paul 1998; Wilhite et al. 2000).

The meaning of drought differs based on people's knowledge of the physical environment, type and degree of involvement with agriculture, and degree to which their financial well-being is dependent (Ashraf & Routray 2013; Dagel 1997). However, almost all respondents said they had experienced acute economic loss due to multi-year drought. The questionnaire included an open-ended question about what drought means to the farmers. The majority of the farmers said that drought is linked to their religious beliefs. According to Schipper (2010), religious belief is an important factor in understanding and responding to natural hazards, and traditionally, natural hazards have been seen as an act of God or forces against which humanity had no defense. Farmers believed that drought is a result of human actions such as committing sin wilfully, cheating and deceiving others, and failing to pay *zakat* (money collected from the rich and distributed to the needy, a commandment of Allah). Alshehri et al. (2013) argue that in strictly religious communities, faith and culture can influence perception more often than experience. Apart from religious explanations, respondents attributed the shortage of water mostly to lack of rainfall.

In terms of the impacts of drought, respondents pointed primarily to damage to crops and livestock, food scarcity, poor cereal and grain production, and a decrease in the availability of agricultural employment. A minority of respondents also perceived drought impacts as including change in soil type, change in vegetation, increased temperature, war, financial weakness, deforestation, increasing population, over-exploitation of groundwater, increased commodity prices, and lack of electricity supply. Most respondents (85.7%) perceived drought as a natural event; the rest (14.3%) saw it as a result of poor government management of water resources.

Figure 3 summarizes farmers' perceptions of the immediate impacts of drought. Most said that drying of water resources was the most immediate impact of drought in the area. Other factors of high concern were increase in food prices, crop failure, the decline in livestock prices, and loss of livestock.

2.3 Temporal variation of drought

To understand the history of drought in the study area, this study calculated the standardized precipitation index (SPI) for monthly precipitation data for the period 1979-2016. A comprehensive explanation and procedure of calculation of standardized precipitation index (SPI) is found in (Lloyd–Hughes and Saunders 2002; Hayes et al. 1999). The SPI was calculated for multiple time scales: a 3-month period (January–March), which covers the winter or rainy season in the study area; a 6-month period (November–April), the time from cultivation (fall)

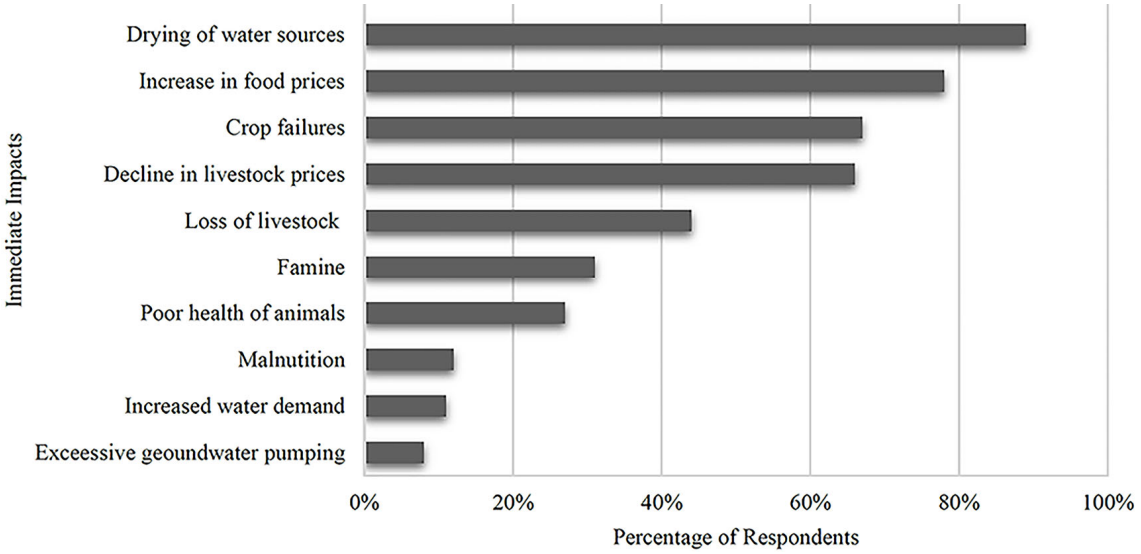

Figure 3 General perceptions of drought impacts.

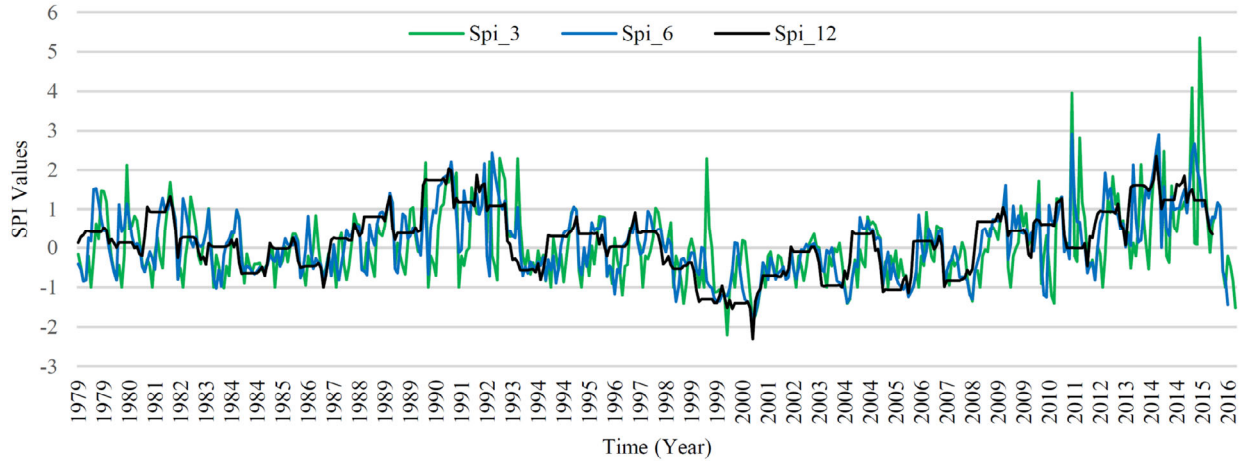

Figure 4 Temporal variation of drought at multiple time steps in Pul-i-Hashime Station. Spi= Standardized Precipitation Index.

to harvesting (spring) for most crops; and a 12-month period (March–February), which covers both dry and wet periods. For SPI-3, one extreme (SPI≤−2) and two severe (−2≤SPI≤−1.5) droughts were observed, and for SPI-12, one extreme and four severe droughts (Figure 4). The reason for the higher number of severe droughts during SPI-12 may be related to inter-seasonal fluctuations of precipitation.

A key feature of SPI is that it can represent a drought condition. Precipitation deficit is accumulated over a specific time scale, which indicates various drought situations and shows how drought impacts the availability of water in the region. The results obtained from the computation of SPI show the occurrence of extreme and severe drought events for all time scales. As the research results indicate, drought has caused serious socio-economic and environmental impacts in the study area. The study found that farmers' perceptions and understanding of drought were in line with the SPI results obtained using precipitation data.

2.4 Perceptions of the socio-economic impacts of drought

Assessment of socio-economic impacts of drought is crucial for providing information toward rational decisions of effective drought mitigation policies (Golmohammadi 2016). Qureshi & Akhtar (2004) indicate that understanding of various socio-economic impact of drought in Afghanistan is an essential step for a long-term drought

management. Crop failure, yield reduction, dying of fruit trees and vineyards, and decrease in livestock production are the main diverse impacts of drought in Afghanistan which lead to considerable reduction in farm income and force male family members to migrate in search of a job (Qureshi and Akhtar 2004; Bhattacharya et al. 2004). Figure 5 shows responses of the farmers' perception based on Likert type scale to various socio-economic questions regarding drought impacts. The vast majority of respondents reported loss of employment as a major impact of drought. Consequently, farmers are persuaded to leave agriculture for off-farm sources of income. Respondents said that if vulnerable farmers are not given support, the most striking negative effect is loss of young frames, which eventually lead to more vulnerability in the agriculture sector and more drought impacts. According to (Bhattacharya et al. 2004) drought and the resultant huge economic losses caused reduction in employment opportunity and increased in poverty (Bhattacharya et al. 2004). It was found that farm households depend heavily on farming for their economic well-being. However, almost three-quarters of the respondents had experienced a major reduction in income during drought; well over half saw food scarcity and insecurity as a drought impact. Other impacts included loss of access to preferred foods and reduction in spending on festivals.

The intense economic impacts of drought have in turn had social impacts, including water conflicts, reduced school attendance, migration, malnutrition, poor health, and a sense of hopelessness or loss. Farmers said that their religious beliefs were the main reason they were able to withstand long periods of drought and refrain from suicide. The socio-economic impacts mentioned in this study have also been reported in previous studies in some countries neighboring Afghanistan (Karpisheh et al. 2010; Keshavarz et al. 2013; Udmale et al. 2014).

Table 2 summarizes nonparametric statistical tests (asymptotic significance, Kruskal-Wallis H test, and Mann-Whitney U test) values for perceived severity of socio-economic impacts of drought by various groups of respondents. A significant difference in food preferences based on household income was observed (Kruskal-Wallis H = 7.72; $p < 0.05$), as farmers from low-income families, who suffer more during drought, reported that drought had a strong influence on their food choices for their families, and they were unable to meet the goal of consuming healthy and nutritious foods. Farmers believed that food scarcity, which is due to low crop yields and low income, is one of the biggest problems in severely drought-affected areas (Mann-Whitney U = 2148.5; $p < 0.05$). During drought periods, farmers in those areas consume

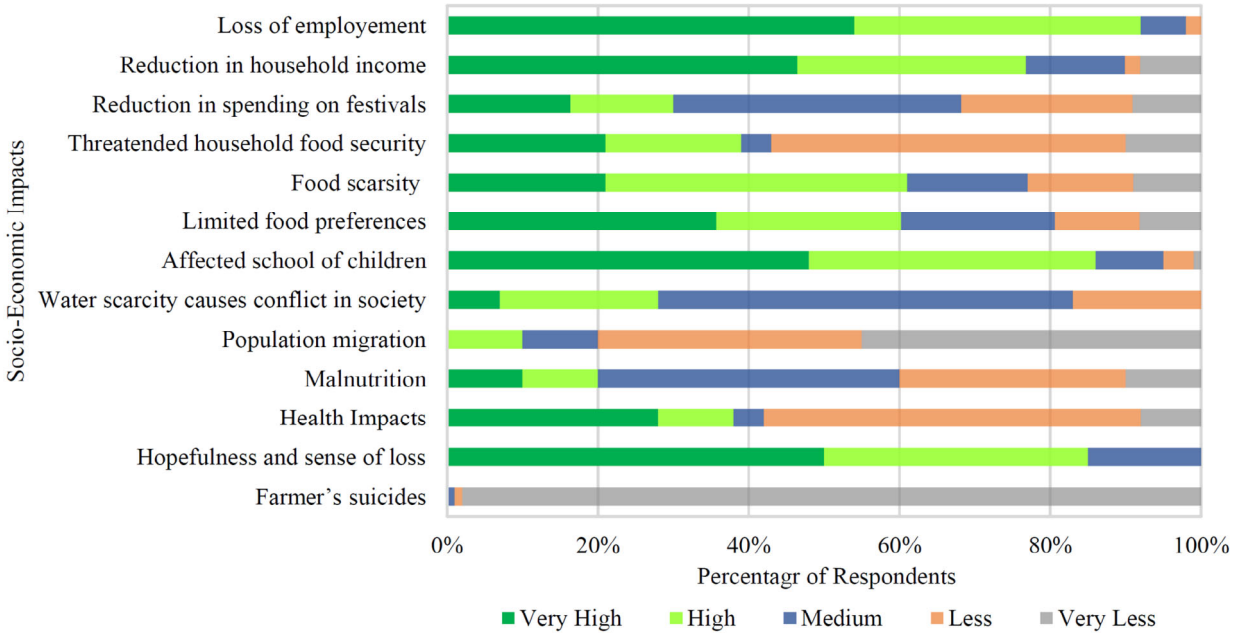

Figure 5 Perceptions of the socio-economic impacts of drought.

Table 2 Perceptions of the socio-economic impacts of drought (asymptotic significance values)

Socio-economic impacts	Irrigation strata		Land holding size		HH income		Education		Drought intensity	
	H	*p*	*H*	*p*	*H*	*p*	*H*	*p*	*U*	*p*
1. Caused unemployment	0.42	0.81	3.83	0.28	0.3	0.86	0.5	0.92	2528	0.91
2. Caused reduction in household income	0.65	0.72	0.96	0.81	2.28	0.32	0.96	0.81	2417	0.78
3. Reduction in spending on festivals	0.21	0.9	1.05	0.79	5.05	0.08	3.83	0.28	2148.5	0.13
4. Caused food scarcity	1.51	0.47	1.17	0.76	1.12	0.57	1.96	0.58	2023	0.04**
5. Threatened household food security	0.98	0.61	2.31	0.51	0.66	0.72	0.11	0.99	1982	0.38
6. limited food preferences	1.27	0.53	1.01	0.8	7.72	0.02*	3.59	0.31	2314	0.31
7. Caused conflicts for water in society	3.43	0.18	0.88	0.83	0.4	0.82	9.84	0.02*	2409.5	0.76
8. Affected schooling of children	5.32	0.07	1.6	0.66	1.2	0.55	6.49	0.09	2332.5	0.53
9. Caused population migration	0.123	0.94	1.96	0.58	0.23	0.89	0.58	0.89	2080	0.08
10. Caused malnutrition	4.81	0.09	2.47	0.48	3.12	0.21	1.82	0.61	2273	0.38
11. Affected on health	0.77	0.68	3.83	0.28	2.7	0.26	4.31	0.23	2393	0.81
12. Caused hopelessness and sense of loss	0.655	0.72	3.07	0.38	2.54	0.28	5.03	0.17	2313	0.48
13. Caused farmers suicide	0.35	0.84	0.58	0.89	0.69	0.71	3.01	0.4	2139.5	0.12

Note: * Kruskal-Wallis H - test significant at 5% significance level; **Mann-Whitney U - test significant at 5% significance level; *p* is Asymptotic Significance value. HH = Household; H= Kruskal-Wallis H;U= Mann-Whitney U.

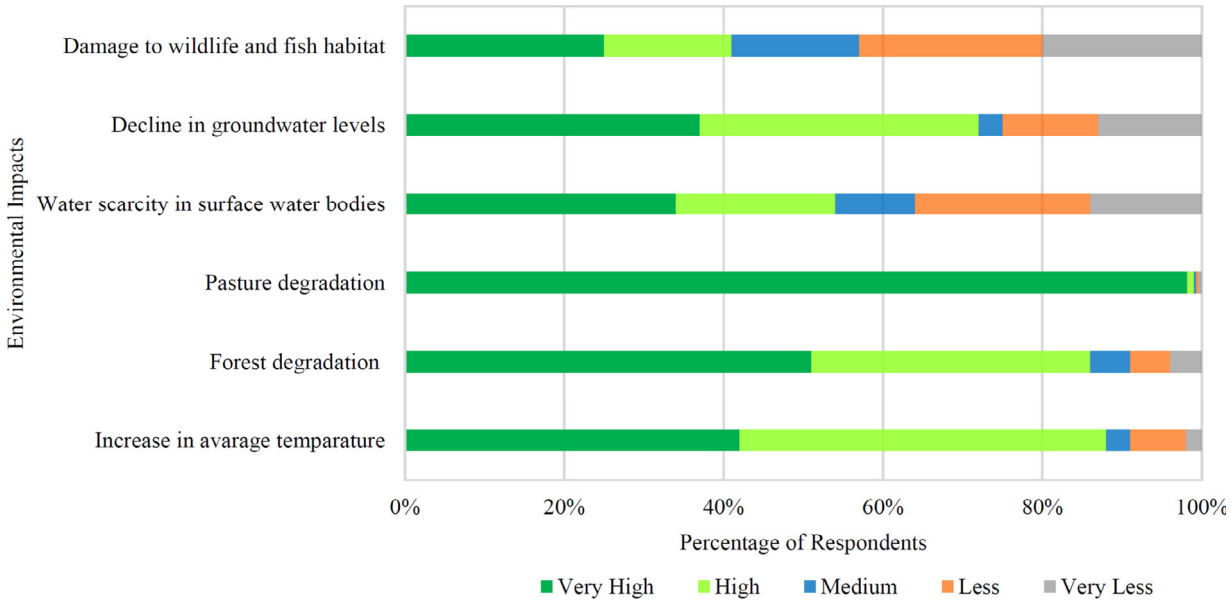

Figure 6 Perceptions of the environmental impacts of drought.

their entire harvest, including the portion set aside for planting, which reduces their food security. Education level was an important factor in farmers' perceptions of conflicts over water, as less educated farmers had greater concerns about conflicts caused by drought (Kruskal-Wallis H = 9.84; p < 0.05).

2.5 Perceptions of the environmental impacts of drought

Drought affects the environment in a number of ways including decreasing river flows, water levels in lakes, and the groundwater table. Lessened flow and increased water temperature may cause critical deterioration of water quality (Massarutto et al. 2013; Udmale et al. 2014). Depletion of soil water content affects soil fertility and biodiversity and increases vulnerability to wildfire (Knutson et al. 1998; Olsson et al. 2009; Udmale et al. 2014). Respondents reported that drought has had high environmental impacts (Figure 6), including temperature increase, decline in groundwater, and pasture and forest degradation. As a result of the prevailing drought in the area, forests and pastures have drastically decreased. Majority of the grazing lands have been eliminated, and the productivity of the remaining

Table 3 Perceptions of the environmental impacts of drought (asymptotic significance values)

Environmental impacts	Irrigation strata		Land holding size		HH income		Education		Drought intensity	
	H	*p*	*H*	*p*	*H*	*p*	*H*	*p*	*U*	*p*
1. Increase in average temperature	0.35	0.84	1.09	0.78	1.74	0.42	0.54	0.91	2264	0.09
2. Forest degradation	1.69	0.43	1.34	0.72	2.34	0.31	1.69	0.64	2273	0.38
3. Pasture degradation	0.57	0.75	2.7	0.44	1.27	0.53	11.34	0.01*	2391	0.7
4. Water scarcity in surface water bodies	0.43	0.81	3.07	0.38	0.74	0.69	1.3	0.73	2332.5	0.53
5. Decline in groundwater levels	1.12	0.57	3.43	0.33	1.09	0.58	3.36	0.34	2432	0.94
6. Water quality deterioration	0.04	0.98	1.17	0.76	3.44	0.18	0.41	0.94	2418.5	0.89
7. Damages to wildlife and fish habitat	2.28	0.32	0.8	0.85	7.72	0.02	1.55	0.67	2528	0.91

Note: *Kruskal-Wallis H - test significant at 5% significance level; **Mann-Whitney U - test significant at 5% significance level; *p* is Asymptotic Significance value. HH = Household; H= Kruskal-Wallis H;U= Mann-Whitney U.

communal grazing lands has significantly decreased (Bhattacharya et al. 2004).

Only one significant difference was observed in perceptions of the environmental impacts of drought between the different groups of respondents (Table 3): less educated farmers believed that drought was one of the major causes of pasture degradation (Kruskal-Wallis $H = 11.34$; $p < 0.05$). As the entire study area is extremely vulnerable to drought intensity (Bhattacharya et al. 2004), no significant difference was observed in perceptions of other environmental impacts of drought.

2.6 Adaptation and mitigation measures

Drought has forced farmers to sell their land and use the money to meet short-term food needs. Survey results suggest that drought often brings about chaotic behavior among the households who experience its effects. The process of adaptation to drought has two steps: first, assessing perceptions and understanding of the occurrence of drought, and then choosing different adaptation and mitigation options in response to drought impacts (Habiba et al. 2012). The evidence presented in the previous section indicates that farmers were well aware of the different impacts of drought and its severity. Based on this perception and awareness, various preparedness and adaptation measures were developed by the farmers to mitigate drought impacts.

The most common drought preparation measures adopted by farmers (Figure 7) were storing the harvest rather than selling it, storing crop residues as feed for animals, particularly when drought is anticipated, and reducing their spending on some items to save money. Casual labour provides swift, efficient access to food during drought for those who have little or no land and animals. However, where animal husbandry is the main livelihood source, villagers prefer the sale of livestock and livestock products over casual labour and other drought preparedness activities.

In the most severe droughts, a minority of the young farmers, especially from rain-fed farming areas, also migrate to Iran to work and send back a major part of their earnings to their families. However, migration was almost always seen as a last resort. Few farmers said they chose early sowing. Farmers who practiced this preparedness measure indicated that due to drought, they could not sow crops on time. About 5% of respondents said they relied on their strong belief in God's mercy and did not prepare for drought in any other ways.

Similar coping strategies were reported in Helmand, neighbouring province of the study area, by Qureshi and Akhtar (2004).

The outcome of the Kruskal-Wallis test (Table 4) confirms that farmers from less irrigated areas were more likely to store harvested crops (Kruskal-Wallis $H = 7.01$; $p < 0.05$), save money (Kruskal-Wallis $H = 5.98$; $p < 0.05$), and select less water-consuming crops (Kruskal-Wallis $H = 7.01$; $p < 0.05$) to mitigate the impacts of drought. Selling livestock is a well-accepted drought coping strategy used by farmers with small landholdings (Kruskal-Wallis $H = 8.94$; $p < 0.05$). Farmers from low income groups reported that selling some livestock was their main ways of coping with drought (Kruskal-Wallis $H = 6.64$; $p < 0.05$). A significant difference was observed, based on farmer's education level, in storing crops residues for

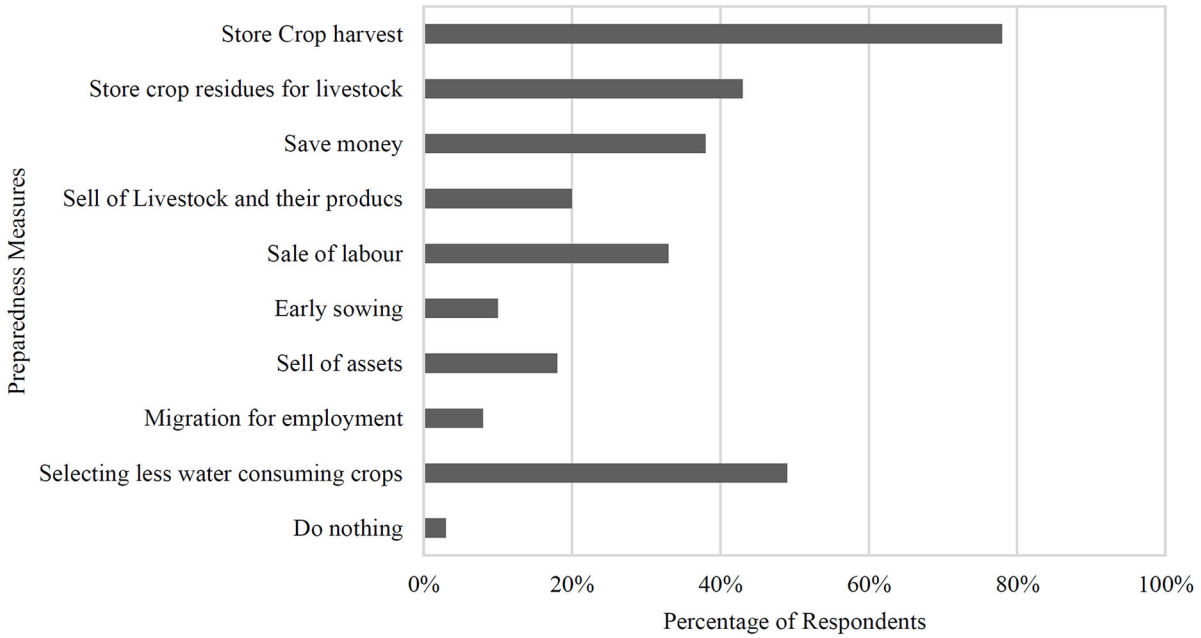

Figure 7 Drought preparedness measures adopted by farmers.

Table 4 Drought preparedness measures adopted by farmers (asymptotic significance values)

Preparedness Activities	Irrigation strata		Land holding size		HH income		Education		Drought intensity	
	H	*p*	*H*	*p*	*H*	*p*	*H*	*p*	*U*	*p*
1. Do nothing	0.42	0.81	3.28	0.35	0.63	0.73	0.88	0.83	2506	0.45
2. Store crop harvesting	7.01	0.03*	3.36	0.34	1.27	0.53	3.68	0.3	2285	0.41
3. Store crop residues for livestock	0.14	0.93	0.84	0.84	1.59	0.45	9.84	0.02*	2449	0.88
4. Save money	5.98	0.05*	0.84	0.84	0.3	0.86	11.34	0.01*	2382	0.67
5. Migration for employment	0.49	0.78	4.9	0.18	0.89	0.64	2.16	0.54	2290.5	0.42
6. Sell some livestock	2.28	0.32	8.94	0.03*	6.64	0.04*	4.21	0.24	2396	0.72
7. Seek alternative source of income	0.77	0.68	11.34	0.01*	0.65	0.72	2.59	0.46	2023	0.04**
8. Selecting less water consuming crops	7.01	0.03*	3.83	0.28	0.23	0.89	8.94	0.03*	2427.5	0.93

Note: *Kruskal-Wallis H - test significant at 5% significance level; **Mann-Whitney U - test significant at 5% significance level; *p* is Asymptotic Significance value. HH = Household; *H*= Kruskal-Wallis H;*U*= Mann-Whitney U.

livestock (Kruskal-Wallis $H = 9.84$; $p < 0.05$), saving money (Kruskal-Wallis $H = 11.34$; $p < 0.05$), and selecting less water-consuming crops (Kruskal-Wallis $H = 8.94$; $p < 0.05$). Farmers from frequent and severe drought affected area were more likely to seek alternative source of income to cope with drought (Mann-Whitney $U = 2148.5$; $p < 0.05$).

In addition to drought preparedness activities, farmers reported various autonomous adaptation strategies to mitigate drought impacts, as shown in Figure 8. The main agricultural adaptation strategies were reducing water waste during drought, using low-water-consuming crops, reducing the cultivated area, and changing the crop calendar. When soil moisture is insufficient for plant growth, farmers do not sow crops, in order to successfully maintain the crop. The reasons for wide use of these adaptation practices were easier implementation and lower cost. Recent studies (Dhaka et al. 2010; Gandure et al. 2013; Habiba et al. 2012; Roy & Hirway 2007; Sahu & Mishra 2013; Udmale et al. 2014) have found similar agricultural adaptation strategies. However, farmers reported non-use of modern micro-irrigation options such as sprinkler and drip irrigation because of their high initial cost. Farmers also reported a low preference for rainwater harvesting using a physical structure, also because of its high cost.

The outcome of the Kruskal-Wallis test (Table 5) confirms that changing the crop calendar

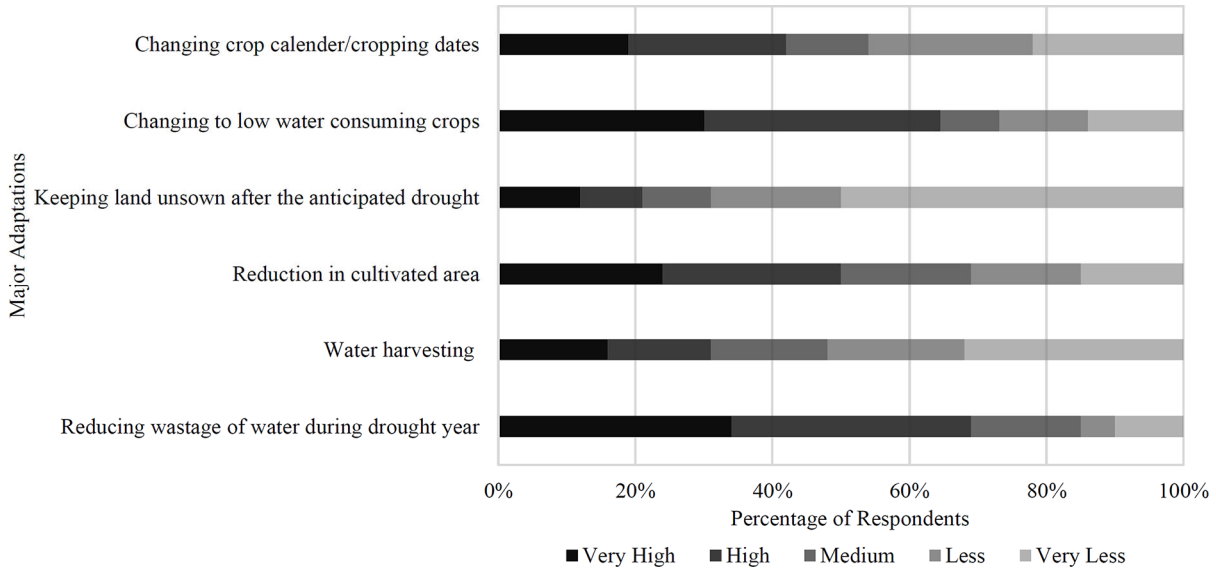

Figure 8 Major agricultural adaptation measures adopted by farmers.

Table 5 Major agricultural adaptation measures adopted by farmers (asymptotic significance values)

Major Agricultural Adaptations	Irrigation strata		Land holding size		HH income		Education		Drought intensity	
	H	*p*	*H*	*p*	*H*	*p*	*H*	*p*	*U*	*p*
1. Change their crop calendar	0.32	0. 85	8.94	0.03*	7.01	0.03*	1.08	0.78	2360.5	0.61
2. Changing to low water consuming crops	1.69	0.43	6.04	0.11	1.09	0.58	3.43	0.33	1978	0.05**
3. Keeping land unsown after the possibility of drought	2.34	0.31	11.34	0.01*	0.28	0.87	1.96	0.58	2423	0.8
4. Reduction in cultivated area	2.94	0.23	4.11	0.25	1.69	0.43	1.38	0.71	1930	0.02**
5. Water harvesting	0.57	0.75	0.04	0.98	2.55	0.28	2.16	0.54	2292.5	0.43
6. Reducing wastage of water during drought year	0.19	0.91	8.31	0.04*	7.72	0.02*	2.28	0.32	2393	0.81

Note: *Kruskal-Wallis H - test significant at 5% significance level; **Mann-Whitney U - test significant at 5% significance level; *p* is Asymptotic Significance value. HH = Household; H= Kruskal-Wallis H;U= Mann-Whitney U.

(Kruskal-Wallis $H = 8.94$; $p < 0.05$), leaving land unsown (Kruskal-Wallis $H = 11.34$; $p < 0.05$), and reducing wastage of water (Kruskal-Wallis $H = 8.31$; $p < 0.05$) were well accepted drought adaptation strategies used by farmers with small landholdings. Farmers from low-income families preferred changing their crop calendar (Kruskal-Wallis $H = 7.72$; $p < 0.05$) and reducing wastage of water (Kruskal-Wallis $H = 7.01$; $p < 0.05$). Farmers believed that adaptation strategies such as changing to low-water-consuming crops (Mann-Whitney $U = 1978$; $p < 0.05$) and reducing cultivated area (Mann-Whitney $U = 1930$; $p < 0.05$) were more efficient practices in the frequently and severely drought-affected areas.

2.7 Water conflicts and conflict-resolution mechanisms

Water is a pivotal resource for agriculture-dependent Afghanistan. There are two main irrigation management systems in the country: a traditional system known as *mirab,* and the formal or government irrigation system. *Mirab* has been in use for many centuries and has been proven to be very useful in managing irrigation water. However, in recent years, this system has been damaged tremendously due to increased dominance by local power groups, lack of government support, and changes in traditional rules of irrigation water management (Asim 2016).

Study respondents reported that irrigation water is a major source of conflict. The vast majority of the respondents said that the conflicts arise when some users fail to comply with the rotating water allocation and try to divert water illegally. They believed that serious conflicts would not arise if all farmers adhered to their fixed-

interval rations and respected the rights of others. About 26% of the respondents indicated that conflicts arise because of water scarcity, which intensifies during drought years. A few farmers (12%) reported insufficient irrigation structures (too old and inefficient) as a factor contributing to conflicts. The old water allocation system, along with water stealing, and the wasting of water have also been reported as causes of severe conflict (Asim 2015). Additional causes include an increase in overall irrigation demand (12%), theft of irrigation equipment (10%), and insufficient flood control structures (6%).

Conflict-resolution mechanisms seem to vary from province to province in Afghanistan depending on factors such as canal layouts, water-sharing rules, types of conflict, and *mirab* organizational structure (Thomas et al. 2013). Local elders, *mirabs,* water-user associations (WUAs), and formal courts were the most successful conflict resolution examples reported by farmers.

Local elders are traditionally the first and most popular mechanism to be used; their success is largely due to the *shura* system. *Shuras* are community councils made up of local elders and other respected individuals (Thomas et al. 2013). They are comprised of age-grade classes who take over political, economic, religious, military, ritual, and social responsibilities. In rare cases a teenager may also be elected as member of a *shura*, usually inheriting the position from a deceased father. Men who have entered the *shura* are considered elders. Study respondents reported that many severe conflicts have ended because *shuras* made decisions that were acceptable to all parties.

Respondents said that *mirabs* and (WUAs) are also important in the consensual, informal resolution of water conflicts. In some cases, provincial *mirabs* and WUAs have resolved conflicts better than any other party. Formal WUAs have recently been established in Afghanistan and have played a substantial role in decreasing conflicts (Asim 2016). If these mechanisms are not successful, the parties refer the conflict to a formal court for resolution. Formal courts are usually involved when water-related conflicts escalate to the point that criminal acts occur. However, they are less trusted by farmers.

Provincial governments are in charge of facilitating conflict resolution and legitimizing the outcomes rather than playing the main role in deciding on the case. For example, water management departments provide only technical and logistical support. To be successful in resolving future conflicts, a new organizational system must be created. The system must address and standardize the crucial elements of effective distribution, management, and enforcement of water rights, and the cleaning and maintenance of canals (Asim 2016).

3 Conclusions

Drought is a significant natural disaster in Herat Province. The results indicate that farmers are well aware of different climate factors and drought-related issues. Their perception and understanding of climatic variability and drought are in line with the results obtained using climatic data. In terms of the severity of drought in the study area, farmers pointed out religious beliefs such as committing sin wilfully, cheating others, and falling to pay *zakat*; climate factors such as lack of rainfall, increased atmospheric temperature, and variability of monsoon rainfall; and non-climatic factors such as lack of electricity supply, deforestation, overexploitation of groundwater, increasing population, war, financial weakness, and increased commodity prices. Survey responses suggested that age, knowledge, and background have the most influence on farmers' perceptions of drought. As the research results indicate, drought causes serious socio-economic and environmental impacts in this province, while the economy of rural Herat is heavily dependent on agriculture and livestock raising. Thus, failure of agriculture severely reduces employment opportunities among unskilled labourers, which results in worsening livelihood conditions, and subsequently a weakened financial situation.

Skilled farmers also had to relinquish agricultural activities and look for off-farm sources of income, which eventually led to more vulnerability in the agriculture sector and, in turn, more drought impacts in the area. Because of drought and the failure of agriculture, poor farmers can no longer afford to hold their traditional festivals, and conflicts among the farmers over irrigation water are noticeable in some villages.

Farmers have used local techniques to lessen the effects of drought and thus have adopted various preparedness and adaptation measures. Adaptation measures include storing the harvest (rather than selling it), storing crop residues for use as fodder, saving money, migrating for employment, doing casual labour, selling livestock and livestock products, and selling assets. Local elders usually play the central role in resolving conflicts over water use. *Mirabs* and WUAs are also important in the consensual and informal resolution of water conflicts. However, when the conflicts escalate to the point of criminal cases, they are referred to a formal court.

Analysis of farmers' preparedness and adaptation measures in Herat Province suggests that low education, low income, and a tendency to rely on off-farm sources of income led to the implementation of more reactive and autonomous adaptation measures, and that the current adaptation strategies are insufficient to respond to a serious drought. Although research has indicated the effects of harsh drought conditions in Herat, and diminishing the effects of severe drought needs accurate and long-term strategies, effective steps have not been taken yet. Respondents' level of satisfaction with the government was very low, as the government has not undertaken any notable relief measure yet.

Based on the analysis and findings of this study, the following recommendations are offered by which government can strengthen farmers' adaptation strategies, and farmers can implement proactive and well-planned adaptation measures.

(1) Establish and implement an effective national drought strategy and policy.

(2) Effective water harvesting can contribute substantially to meeting irrigation requirements. Therefore, government officials and relevant organizations should prioritize providing financial and technical support to farmers for construction and maintenance of water-harvesting structures.

(3) The study area possesses a favourable climate for growing multiple crops in different seasons. Introduction of low-water-consuming crops can reduce drought impacts on agriculture.

(4) Traditional irrigation systems have apparently failed to function in drought-prone areas of Herat. Rehabilitation of these traditional systems will foster agricultural production and will increase farmers' ability to withstand drought.

(5) The government should give priority to financially supporting farmers affected by drought so that they can buy modern agricultural machinery and cope with drought-induced damages.

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