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Assessing Climatic Variation, Farmer's Perception and their Adaptive Strategies in District Zhob, Balochistan

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Abstract

This paper analyzes variation in climatic factors, farmer's perception and their adaptive strategies towards climate change in Zhob district, Balochistan. The minimum and maximum mean temperature and rainfall data over a period of 35 years (1981-2015) has been used to analyze variation in climate in the study area. Linear regression model has been used to assess the variation in climatic factors by using SPSS. In addition, perception and adaptive strategies of the 200 farm households towards climate change have been assessed following an in-depth survey. The results indicate that high temperature has been observed in the months of May to September, while extreme variation in rainfall was observed during the last two decades. The most significant decline in rainfall (33mm) was recorded in the year 2014 over the last 35 years. The results further reveal that farmer's perceptions regarding climatic variability are in line with the results obtained using the secondary climatic data and information. Farmers' adapted number of strategies such as crop management, adjustment in input use, water management etc., to mitigate the impacts of climate change on their agro-based practices.

Keywords: Climate Change, Perception, Adaptive Strategies, Zhob

Introduction:

Climate change variation contributes to global climate over a time (UNFCCC, 2001). The globally combined ocean and surface temperature data show a

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warming trend of 0.85°C, over a period 1880–2012 (IPCC, 2014). South-Asian countries are highly affected by climate change, because majority of population are engaged in agriculture which mostly depends on climate related factors. These conditions present serious challenges to their environment such as social, economic and ecological systems (Zhuang, 2009). Declining precipitation and rising temperature are making farming increasingly more difficult and aggravating food insecurity in area (Dube & Phiri, 2013). Across the Asian regions temperature increased at a rate of 0.14ºC to 0.20ºC per decade since 1960s, increasing numbers of hot days and warm nights. A strong variability is observed in increasing and decreasing precipitation trends and extremes in different parts and seasons of Asia (IPCC, 2014). Globally, including Pakistan a high variability in precipitation and temperature has been recorded (Gadiwala & Burke, 2013).

The average precipitation 25.03mm recorded from 1901-2015 reached at high 170.66mm in august 1916 and lowest 0.15mm in December 2014, with average temperature of 20.61ºC recorded from 1816-2015, a high temperature recorded of 31.23ºC in June 2011 and low 5.95ºC in January 1934 (Trading Economics, 2018). The drought in late decades of 1990s and early 2000s in southern parts of Pakistan is an example of severe challenges posted by climate change (Mustafa, Akhter, & Nasrallah, 2013). It has been observed the drastic change in weather conditions is a reason of failure to centuries old farming system in Balochistan which is main stay of the provincial economy (Bari, 2013). Climate change and its affects make the Balochistan more vulnerable in terms of increasing temperature, rising sea level, droughts and heavy floods (Lehri, 2016). Balochistan is experiencing increase in surface temperature and low average rainfall due to global warming, likely to cause seasonal shift and disturb the weather parameters (Rajendra K. Pachauri, Leo Meyer, 2014; Ayaz, 2012; Explore Balochiatan, 2016). A warming trend has been observed in Balochistan mean temperature 1.15°C and 2.2mm increase in rainfall from 1960-2007, with wide variation observed in annual rainfall 158.4mm in Balochistan respectively (Chaduary et al, 2009; Bhutto & Ming, 2013). The observed changes in secondary combine with local perception of environmental change is important to access the factors and driving forces of change (Ole Mertz C. M., 2009; Ole Mertz C. M., 2010). The perception can't represent the actual changes as the findings assessed by observed data that can actually determine the exact human actions by their perceptions (C.T.West, 2008). It is important to examine and understand changing climatic conditions of 35 years (1981-2015) in the area and in addition to know farmers' perception on climate to conceive this change and how they cope and adapt during these changes in district Zhob.

Study Area:

District Zhob has been selected as a study area in this research paper. The district is administratively divided into two tehsils (Zhob, Kakarkhurasan) and twenty-four union councils (According to 1998 Census Report). The district is vulnerable to many man-made and natural disasters, whereas drought, floods and earthquakes are most common natural hazards in the area (Anonymous, 2016). Climate of district is hot and dry in summer and cold in winter. The wind from north occasionally blows during September to April that brings drought and damage the standing crops (Khyber Organization, 2015). Heavy rainfall causes severe flash floods and has played havoc situation in Zhob district such as damaged roads, bridges, standing crops, water supply etc. (Rafiullah, 2015).

Data and Methodology:

To assess the variation in climatic factors of rainfall and temperature (Minimum and Maximum), a long time series data of 35 years (1981-2015) was selected. The magnitude of the trends increasing or decreasing temperatures were derived from the slope of the regression line using the least squares method. The temperature range was obtained by taking the difference between them, maximum and minimum monthly mean temperature values. The highest and least annual total and maximum rainfall received on different occasions over the period. A percentage of seasonal maximum rainfall in the different months of the year received by a district. Simple descriptive methods were used to calculate standard deviations and variation in the annual mean rainfall. A rainfall index was used to calculate the dry periods during months of the year.

The rainfall index equation proposed by (UNESCO, 1977) and used by (Elagiba & Abdu, 1997):

$$A = P/T \quad (1)$$

Where P is monthly mean precipitation in millimeters and T is the monthly mean temperature in °C.

The aridity index, characterized by dearth of water (Parry, 1986) is defined as a permanent climatic condition and can be estimated as follows by Lang's Index (Kamil, 1983).

$$AL = PA/TA \quad (2)$$

Where AL is Lang's Index, PA is the mean total annual precipitation and TA is the annual mean temperature.

The coefficient of variation (COV) was calculated as follows.

$$COV = SD/M * 100 \quad (3)$$

Where SD is standard deviation and M is the mean value of a meteorological parameter.

The climate data was collected from Pakistan Meteorological Department Quetta. The primary sampling unit was the individual farm household. A multi-stage sampling technique was used to survey 200 farm household in the study area by following the Arkin and Colton (1966). In the first stage, based on agricultural activities, 12 union councils out of 24 were selected purposively. In the second stage, villages were randomly selected within each union council and finally, due to lack of information and availability of sampling frame of farm households at village level, the farmers were selected purposively. Descriptive as well as inferential statistics has been used to achieve the desire objective of the study.

Result and Discussion:

Mean Temperature Variability:

The annual mean temperature is calculated by using the average values of monthly mean temperature during the study period. Figure 1 shows the minimum monthly mean and maximum monthly mean temperature of the entire period data. From rest of the months, a higher mean temperature has been observed from May to September. The minimum and maximum monthly mean temperature is -0.54ºC and 36.44ºC for the months of January and July respectively during the study period.

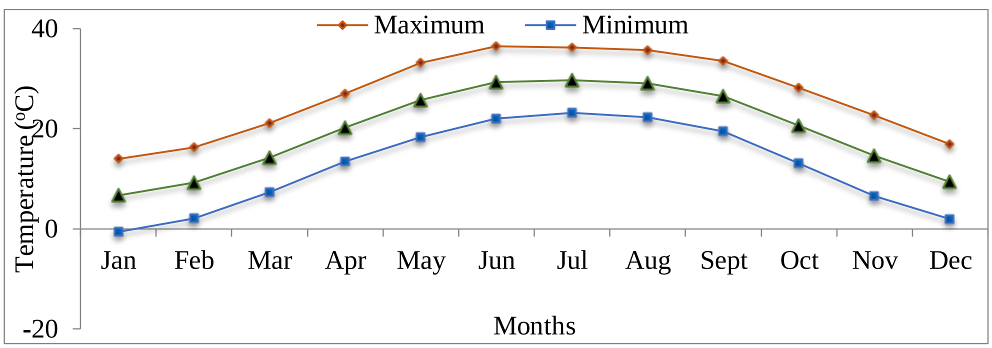

Figure1. Seasonal monthly mean variation, minimum and maximum mean temperature during the year 1981-2015.

There is great variation between the minimum monthly mean and maximum monthly mean temperature has been observed in Zhob district. In the entire record, the highest range value of 16.08ºC was obtained in November and lowest value of 12.99ºC in July. In brief, higher variation has been observed in summer months and lower variation in winter months as shown in Figure 2.

The annual mean temperature is analyzed through the liner regression in Figure 3. The trend line shows that there has been an average increase of 0.03^{o}C in temperature per year in the area from 1981-2015. Lower average annual temperature has been detected in the years 1989 with a mean of 17.2^{o}C, whereas the warmest temperature was in the year 2003 with an average of 23.1^{o}C. The overall increases in the temperature throughout the entire period was about 1.50^{o}C in the study area.

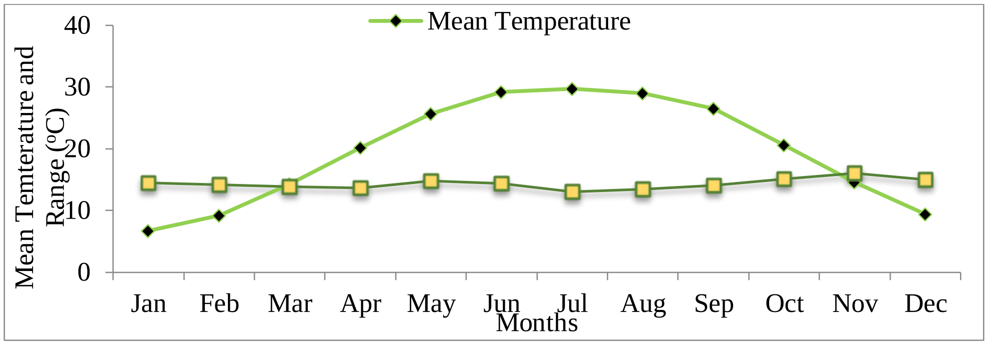

Figure 2. Monthly mean temperature and range during year 1981-2015.

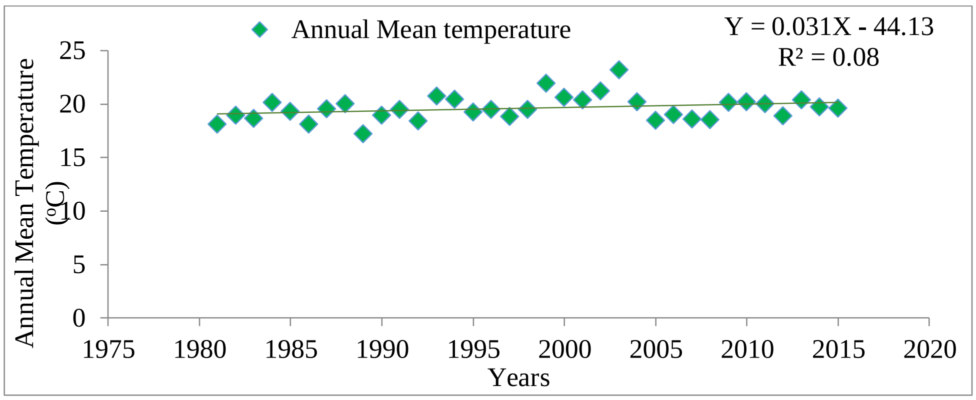

Figure 3. Annual mean temperature and liner regression model during year 1981-2015.

Annual Mean Variability of Minimum and Maximum Temperature:

The annual minimum and maximum mean temperature is presented in Figure 4 and Figure 5 respectively. The regression line indicates an increment of 0.016^{o}C and 0.038^{o}C per year in annual minimum and maximum mean temperatures respectively throughout the study period. Chaduary et al, (2009) point out that increase in annual maximum temperature is higher in Balochistan 1.10^{o}C as compare to other provinces in Pakistan.

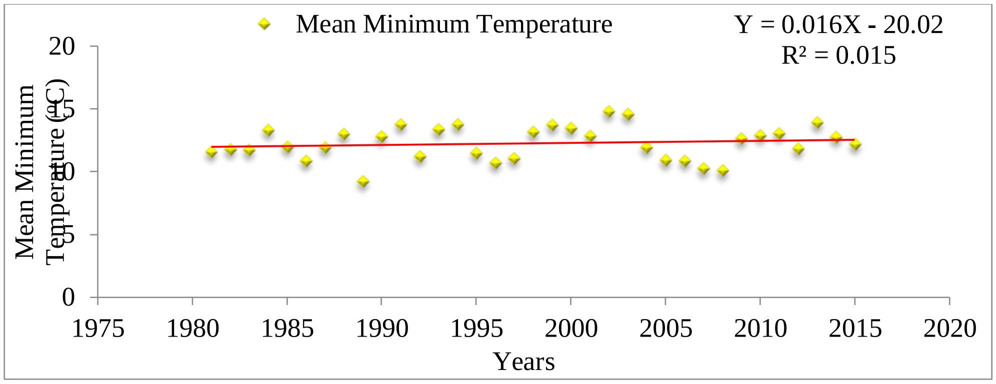

Figure 4. Annual mean variation of minimum temperature during year 1981-2015.

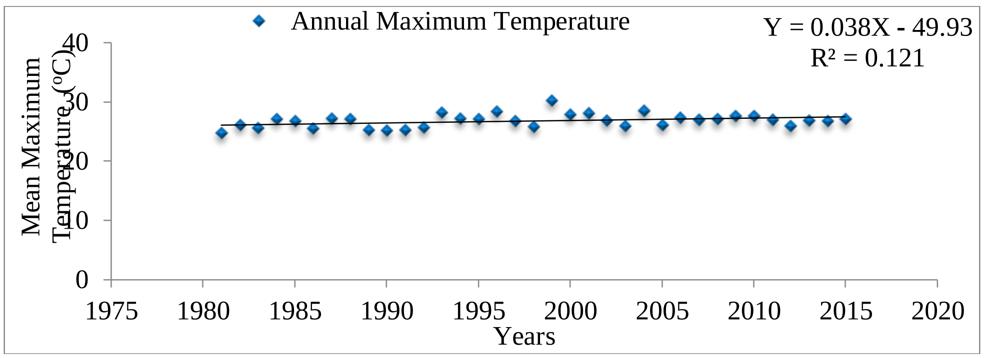

Figure 5. Annual mean variation of maximum temperature during year 1981-2015.

Analysis of Rainfall Variability:

The annual amount of rainfall and annual maximum rainfall is show in Figure 6. A high variability in rainfall has been seen after every 2 years. The district received 495mm annual total rainfall in year 1997 and minimum 153mm in 2001. At three occasions, the district has received total annual rainfall above 400mm during the years 1990, 1991 and 1997. The least annual maximum rainfall of 33mm was observed in the year 2014 and the highest maximum rainfall 165.1mm was observed in the month of August 1990.

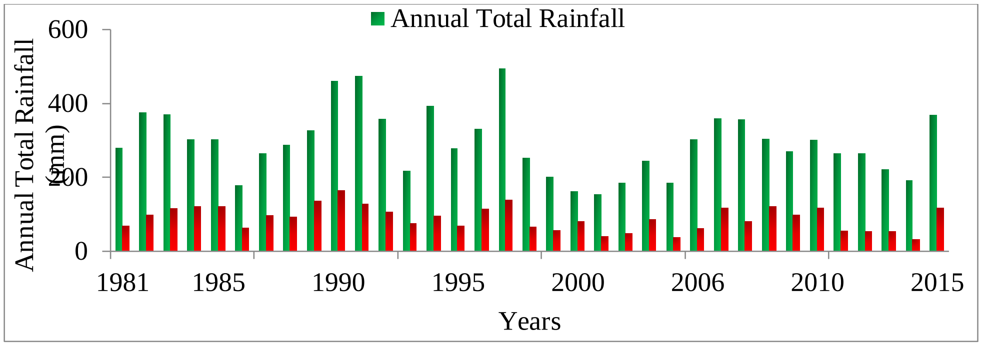

Figure 6. Annual total and maximum rainfall during year 1981-2015.

The seasonal rainfall pattern is presented in Figure 7, which shows that the district has received below 2% rainfall in the months of October and November during the years 1981 to 2015. Whereas, maximum rainfall has been recorded in the months of July and August comprising of 21.55% and 16.69% respectively. The district received enough rainfall in the monsoon season (July and August) as compare to winter season in the entire period.

Standard deviation on mean annual basis is presented in Figure 8. Figure shows the relationship between annual mean rainfall and variation in rainfall on annual basis. Regression line indicates that there is high variability (R^2 = 0.69) in rainfall is observed in the district, clearly show a instability in the annual mean rainfall throughout the study period.

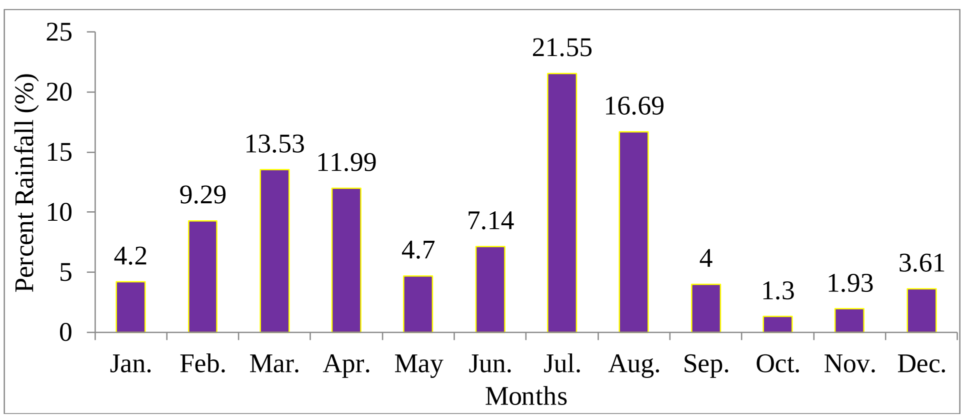

Figure 7. Percent of total rainfall in different months during year 1981-2015.

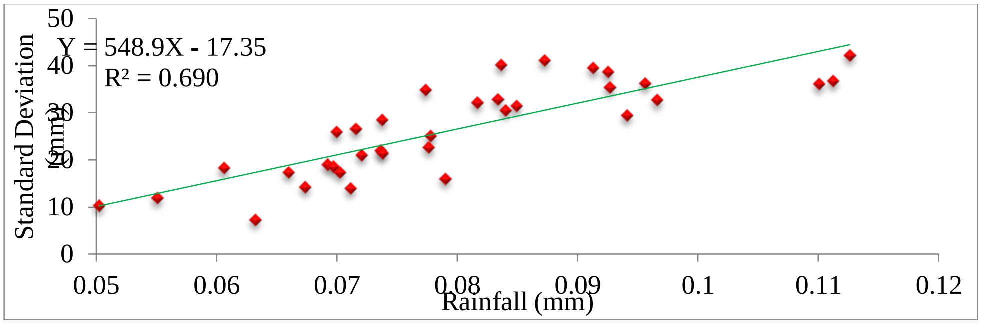

Figure 8. Standard deviation versus annual mean rainfall during year 1981-2015.

In order to identify the dry period during the year, rainfall index is calculated using equation 1. The rainfall index line shows that district Zhob faces dry period in (May, June, September, October and November). According to the (Anonymous, 2015) Zhob district received most of the rainfall during winter seasons. The maximum rainfall index of 2.97mm was observed in the month of February (See Figure 9) during the study period.

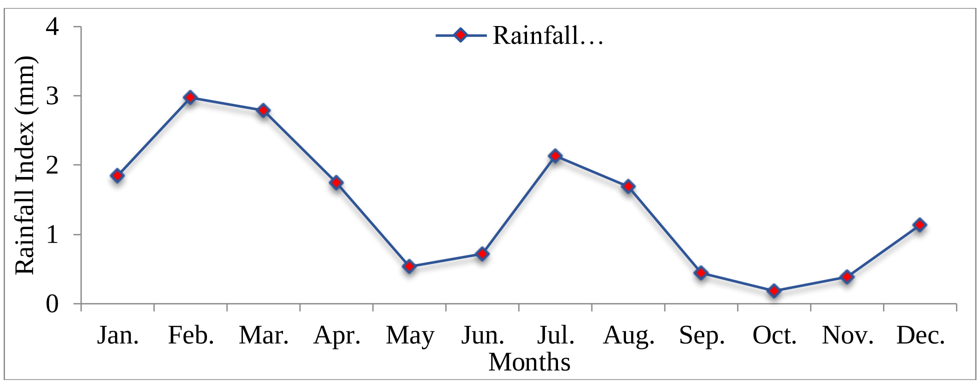

Figure 9. Rainfall index variation with monthly mean rainfall during year 1981-2015.

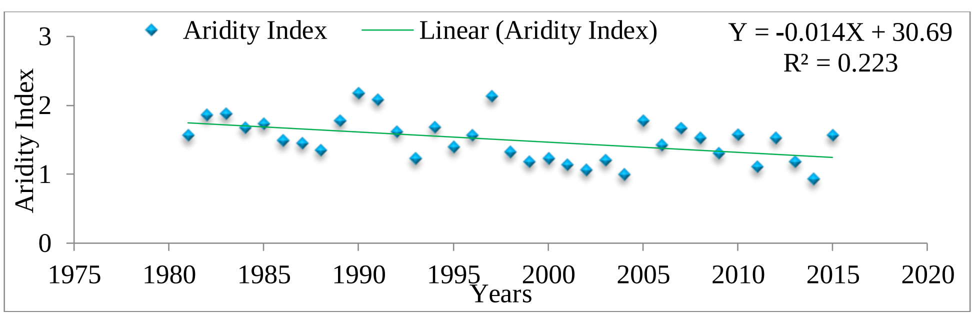

Figure 10. Aridity variation with annual mean rainfall during 1981-2015.

Moreover, aridity of the study area is calculated by using equation 2, based on annual rainfall data for the period 1981-2015 and presented in Figure 10. It has been observed that 2014 was the driest year, while 1990 was the wettest year with the aridity index values 0.92mm and 2.17mm respectively during 1981-2015 in district Zhob. A high variability ($R^2 = 0.2$) has been observed throughout the year, with aridity of Y = -0.014 per year show aridity in annual mean rainfall is not significant. The aridity index which is characterized by scarcity of water can more or less define permanent climate (Parry, 1986; Elagib & Addin Abdu, 1997).

Farmers Perception on Climate Change:

Moreover, farmers confirmed that daily changes in the weather condition and seasonal rainfall make them unpredictable to forecast the future climatic conditions. About 93% of the farmers in the study area have observed variability in rainfall over the last 20 years (See Table 1). Whereas 60% of farmers experienced rainfall decreased in study area. 34% of farmers were unable to predict the rainfall variability and very less number of farmers responded that rainfall has increased. In addition, 81% of the respondent realized change in rainy seasons and further 78% said that rainy season arrived late with decrease in rainfall and 95.5% of farmers experienced the rainfall that it arrives early. Famers' perception regarding variation in rainfall is also in line with the secondary data. Lemma & Sugulle, (2011) point out that the changes in rainfall patterns are characterized by decrease in precipitation quantity and frequency.

Table 1. Rainfall Variability and Seasonal Changes

Variables	Response	Frequency	Percentage
Rainfall Variability Observed Over the Last 20 Years	Yes	186	93
	No	14	7
Rainfall Variability			
Rainfall Increases		12	6
Rainfall Decreases		120	60
Unpredictable		68	34
What do you Think Rainy Season Change?			
Rainy Season Changed	Yes	132	81
	No	68	19
How Rainy Season Changed?			
Rainfall Later Arrival	Yes	44	22
	No	156	78
Rainfall Early Arrival	Yes	9	4.5
	No	191	95.5
Rainfall for Shorter Time Period	Yes	137	68.5
	No	63	31.5
More Severe Rain	Yes	151	75.5
	No	49	24.5
Dry Season	Yes	79	39.5
	No	121	60.5

Source: Field Survey, 2017

The 68.5% of farmers observed that the rainfall precipitation in seasons occurred for short period of time and 75.5% of the farmers responded the more severe rash in rainfall has been observed. A very less 39.5% were agreed that some time dry seasons occur in the area. Belachew & Zuberi, (2015) reported that according to farmers' perception rains comes later and finishes earlier, dried rivulets and springs and patchy distribution of rainfall with longer dry seasons.

Table 2. Temperature Variability

Variables	Response	Frequency	Percentage
Temperature Changed Over the Last 20 Years?	Yes	194	97
	No	6	3
How Temperature Changed?			
Increases		97	48.5
Decreases		24	12
Heat Waves		14	7
Unpredictable		65	32.5

Source: Field Survey, 2017

Table 2 shows, almost all (97%) of the farmers agreed that temperature is also increasing over the last 20 years or so in the study area. In addition, farmers indicate that major changes occur after every 35 years, as the earth completes its cycle and turned to its old position. Majority of the farmers 48.5% responded that increase in temperature has been observed. Only 7% of farmers agreed that heat waves happen in atmosphere due to increase surface temperature. Furthermore, 32.5% of farmers answered that temperature is erratic and out of their prediction, while 12% of the respondents answered temperature has been decreased. During the main season delay in rainfall, less amount of rainfall is considered insufficient rainfall for cropping (ACCCA, 2010).

Farmers Adaptation Strategies:

To overcome the challenges of climate change, famers have used different agriculture adaptive activities. For instance, most of them (86%) were practicing mixed cropping system. To protect plants from the high temperature, 14% farmers used trees bushes and grass to cover their agriculture plants. The farmers (42.5%) were practicing more water in their field because plants needed more water due to increase in temperature and decrease in rainfall. They have changed watering frequency from weekly to every 2 days. Adaptation to climate specially where is less precipitation a new cropping patterns, water management, resistant heat and drought crop varieties are needed for agriculture development (Ahmed & Schmitz, 2011). Due to climate change, almost three-fourth of the farmer has applied many time fallow on land. More than two-third of the farmers have diversified to other crop products because of cash shortage, less agriculture production, plants irresistibility to environment and less profitable prices in market.

Table 3: On-farm and Off-farm Adaptation Strategies

Adaption Measures		Response	Frequency	Percent
On-Farm	Cropping Pattern	Mixed Cropping Practices	185	86
		Cover Cropping	15	14
		Crop Rotation	0	0
	Practice More Water	Yes	115	42.5
		No	85	57.5
	Applied Fallow on Land	Yes	147	73.5
		No	53	26.5
	Crops Diversification	Yes	141	70.5
		No	59	29.5
	Use of Fertilizer	Yes	82	41
		No	118	59
Off-Farm	Diversify Income	Yes	69	34.5
		No	131	65.5
	Sold Non-Movable Assets	Yes	1	.5
		No	199	99.5
	Sold Moveable Assets	Yes	133	66.5
		No	67	33.5
	Started Business	Yes	72	36.0
		No	128	64.0
	Migrated to Other Area	Yes	1	.5
		No	199	99.5
	Access to Credit	Yes	200	100.0
		No	0	0.0

Source: Field Survey, 2017

Majority of the farmers (59%) were not using fertilizer products in agriculture field. While only 41% of farmers were using fertilizers to protect their crops from insects during plant flowering, ripe food and also used for toxic and unusual plants, which causes interruption to stop plant growth in early state and also effect at production stage.

The income generation from agriculture land is less profitable for 34.5% of the farmers due to which they have diversified their source of income. Due to climate change, farmers (66.5%) had sold their movable assets such as goat, sheep, cow, hen, donkey, wood, car, bike, tractor, truck. While only .5% of the farmers have sold their non-moveable assets such as house, shop and building in order to cope with the impacts of changing climatic conditions in the study area. About 36% of the famers invested their income in other business activities in order to maintain their livelihood. Knowler & Bradshaw, (2007) reported that income from farm and non-farm sources represent wealth. Apart from losing their agriculture land, livestock, forest etc., farmers' (99.5%) didn't migrated to other places and still living in their villages or area and coping with the consequences of climate change. Farmers (100%) in study area were access to credit, got from their fellow farmers, relatives, brokers, NGOs and government department.

Conclusion and Recommendation:

Climate variability in district has been noticed in the last few decades, a recorded climatic data was analyzed to discover climate change and know farmers' perception on changing climate and their encounter strategies. This study indicates that the annual rise in temperature is 0.02ºC in district Zhob. A moderate variability is observed in the mean temperature with unstable change in the annual rainfall pattern. The trend line shows slope to down ward in the annual rainfall, clearly define a decline in rainfall over the period. Farmers had observed a significant change in rainfall pattern and temperature. A farmers' perception on both rainfall and temperature are highly fluctuating from decades and are now became unpredictable. Farmers experienced changes in rainfall intern of occurring for short period, dry spells in rainy seasons, early arrival and decrease in average rainfall. The increased in surface temperature and numbers of heat waves spells in study area has also been observed by the farmers. This indicates that farmers' perceptions are almost in line with the secondary information. In order to cope with the impacts of climatic variations, farmers adopted number of adaptive strategies that ranges from crop diversification, input adjustment, income diversification and asset depletion etc. In addition, training and awareness campaign regarding crop management, providing subsidies can make farmers more empower to better adapt with climatic consequences.

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