Journal of Agroecology and Natural Resource Management
p-ISSN: 2394-0786, e-ISSN: 2394-0794, Volume 6, Issue 2; January-March, 2019, pp. 25-31

http://www.krishisanskriti.org/Publication.html

# Impact of Climate Change on Barley Production; a Case Study of Injil District, Herat Province, Afghanistan

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**Abstract—***The study was focused on barley production understanding the impact of climate change in the Injil District of Herat Province, Afghanistan under stipulated years of 2008-2017. The result of the study suggests and relatively increase in both mean maximum and mean minimum temperature coupled with relatively decrease in annual precipitation in over the last ten years. The study identified incidence of the pest and disease are very few and not damaged to the area of barley production as reported by the farmers in the District. The study highlights the role of climate changes (temperature and precipitation) on barley production area relatively good. The study further found a statistically negative relationship between temperature and barley production and found that a relatively increase in temperature caused a significant increase in barley production with use of best variety resistant against pest and disease and suitable weather. The study further found astatistically negative relationship between precipitation and barley production. The implication is that as precipitation relatively decreases, the area of barley production is increased, because another factor affecting to increase of barley production like use of stream water, wells and kariz for eliminate shortage of water for irrigation and use of best varieties and resistant against diseases and pests.*

## INTRODUCTION

Climate change influences agriculture and water sectors and eventually food security and livelihoods of a large section of the rural population in developing countries. The most optimistic scenario (RCP4.5) shows Afghanistan warming approximately 1.5°C until 2050, followed by a period of stabilization and then additional warming of approximately 2.5°C until 2100.In contrast, the pessimistic (RCP8.5) scenario shows extreme warming across the whole country of approximately 3 °C until 2050, with further warming by up to 7 °C by 2100.(NEPA and UNEP, 2015).

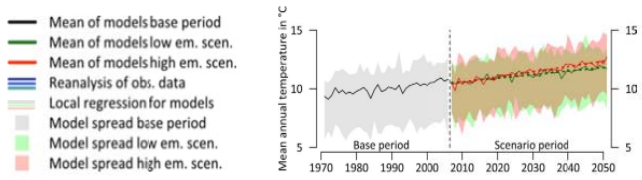


**Figure 1: Mean annual temperature for Afghanistan of seven different regional climate models and the RCPs 4.5 (green) and 8.5 (red). Source: (NEPA and UNEP, 2015).**

Mean rainfall over the same period has decreased slightly at an average rate of 2 per cent per decade, mainly due to decreases in spring precipitation. This combination of factors has led to a prolonged drought in recent years.(Savage *et al*., 2009).

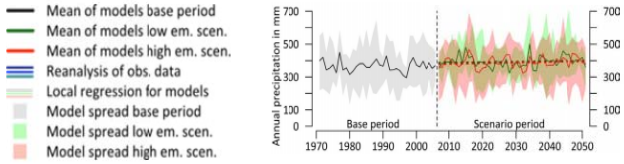


**Figure 2: Annual Afghanistan precipitation trend of seven different regional climate models under RCP 4.5 (green) and 8.5 (red). Source: (NEPA and UNEP, 2015).**

## RESEARCH OBJECTIVES

The primary objective of the study was to assess the impact of climate change on barley production in the Injil district of Herat.

Specifically, the study sought to:

1. Analyze the trend of climate change over the past ten years (2008-2017) in the Injil District of Herat.
2. Examine how to climate change effect on barley production.
3. Investigate how the farmers perceive the effects of climate change on barley production.

## RESEARCH QUESTIONS

The study sought to find answers to the following questions:

1. What is the trend of climate change over the past 10 years (2008-2017) in injil district of Herat?
2. How does climate change affect barley production in the district?
3. How do the farmers perceive the effects of climate change on barley production?

**Study Area**

This study was conducted to analyze the Impact of Climate Change on Barley Production in Injil District of Herat Province, Afghanistan.

Injil is a district of Herat Province in northwestern Afghanistan. Itsurrounds Herat City and borders Kushk District to the north, Karukh District to the east, Guzara District to the south, and Zinda Jan District to the west. Injil district of Herat Province has around 1333 sq.km of land, which includes 17000 hectares of agriculture lands. The District includes 486 minor and major villages'. Injil district is famous for producing cereals crop like Wheat, Rice, Barley, Bean, pea, cotton, vetch, and producing fresh and dried fruits like raisins, grape, peaches, apricot, mulberries, appleand pomegranate. It also produces vegetable like onions, tomato, cucumbers, carrot, turnip and garlic. The water source for irrigation is river water from Hariroad River, wells, springs and kariz.

Injil has moderate climate and rainfall in the early winter and early spring. Spring is hot and dry and winter is cold. This makes condition suitable for growing of different type of cereal crops with good quality specially barley. The main water source for irrigation in Injil is Harriroad River.

**Research Approach**

For this study the mixed methods approach was employed. A mixed method is a procedure for collecting, analyzing, and "mixing" both quantitative and qualitative research and methods in a single study to understand a research problem. According to Creswell (2010), believes that both quantitative and qualitative data together provides a better understanding of a research problem than either type by itself.

**Sampling Technique**

To have adequate data for enabling of researcher in generalization of major results, both probability and non-probability sampling techniques were used for the study. The unit of analysis was individual barley growers from different villages in the district. However, the views of key informants such as the Agricultural Extension Officers and the Plant Pathology Officer of Agriculture directorate of the District were solicited. Out of 486 villages of Injil district 26 was randomly selected for study and from every village a total number of 5 barley growers were chosen randomly for interview in cooperation with the leader of the village.

**Source and Method of Data Collection**

Both the quantitative and qualitative data were gathered from the respondents of the communities. The Data used for this study was collected from both primary and secondary sources. Primary data were collected from key informants such as barley farmers, Agricultural Extension Officers of districts while the secondary data will be obtained from the Meteorological Department of Urdokhan Agricultural Research Station of Herat Directorate of Agriculture, irrigation and livestock (DAIL) respectively.

**Data Processing and Analysis**

The data for this study were processed and analyzed quantitatively and qualitatively. The quantitative data were analyzed using descriptive statistics with the help of Statistical Package for Social Science Software and the Microsoft Excel Software. Analytical tools such as cross- tabulation and graphs.

Secondary data (climate and barley production data) covering a period of over 10 years (2008-2017) were employed for the study. The climate data was used for the trend analysis while a combination of the climate data and the barley production data were concurrently used to analyze the effects of climate change. The Changes used for the trend analysis were temperature and rainfall.

For study of the impact of climate change on barley production area and also to analyze the data in accurate manner and have a good result from it, correlation in SPSS Statistical Software version 24 was used in order to explore the relationship between climate variables and barley production.

**RESULT**

**Trend Analysis of Climate Change**

For better studying of climatic condition in last ten years the trend lines were drown to show the how the climatic parameters (temperature, precipitation) has undergone up and down variation within stipulated years as linear trend line usually shows better how a parameter is increasing or decreasing at a steady rate.

It is quite evident from the trend analyses that,both mean minimum and mean maximum temperatures have increased over the past 10 years with precipitation showing a relatively decreasing trend.

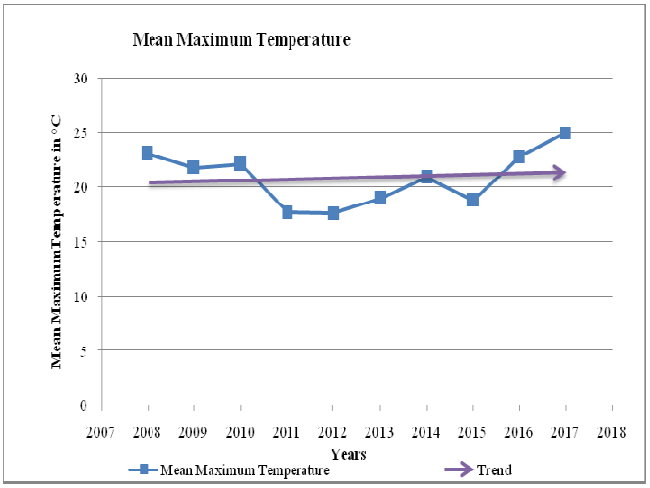


**Figure 3: Mean Maximum Temperature Trend in Injil District, Herat Province (Source: UARS, 2018).**

From figure (3), it is obvious that the mean maximum temperature has varied over the past ten years (2008-2017).Mean maximum temperature in the district mostly oscillated and decreased especially within the years 2008-2009as compared to the other years. From the figure, mean maximum temperature increased from 2009 to 2010and then very sharply decreased from2010 to 2011 and thereafter increased from 2011 to 2014 and then decreased from 2014 to 2015 and after that very sharply increased from 2015 to 2017.It is clear from the time series data that 2017 recorded the highest mean maximum temperature of 24.9$^{o}$C.

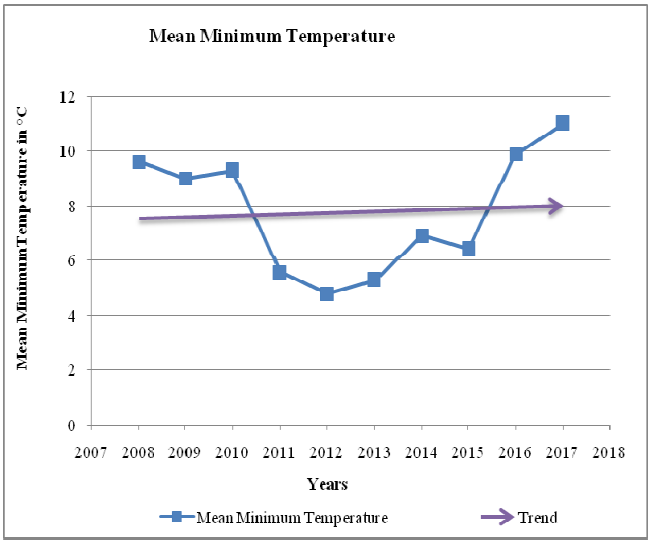


**Figure 4: Mean Minimum Temperature Trend in Injil District, Herat Province (Source: UARS, 2018).**

Figure (4), portrays the mean minimum temperature trend in the district over the period, 2008 to 2017. It is also apparent that the mean minimum temperature shows some variations over the past 10 years (2008-2017) in Injil District of Herat.

The graphs show a decrease in mean minimum temperature from 2008 to 2009 and then increased from 2009 to 2010. Afterward there was a drastic decline from 2010 to 2012 and then increased from 2012 to 2014 and after that decreased from 2014 to 2015 and then very sharp increase from 2015 to 2017.

It is clear from the time series data that 2017 recorded the highest mean minimum temperature of 10.9$^{o}$C.

This indicates that there is an increasing trend in temperature in the district. The implication of an increase in the minimum temperature of crops in general is that, it will affect annual cycle of plant, barley growth and disease not found and not damaged to area of barley production.

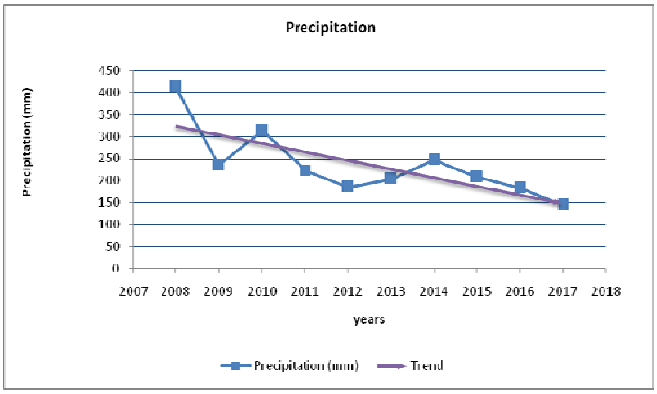


**Figure 5: Annual Precipitation Trend in Injil District, Herat Province (Source: UARS 2018).**

Figure (5), gives a detailed account of the precipitation of the variability trend in the study area. The annual precipitation amount portrays a relatively decreasing trend over the last ten years. From the graph, annual precipitation decreased drastically from 2008 to 2009 and then increased moderately from 2009 to 2010. Afterward there was decreased from 2010 to 2012 and after that increase from 2012 to 2014 and then very sharply decreased in annual precipitation from 2014 to 2017.

It is clear from the figure that precipitation indeed experienced a number of variations over the period under consideration (2008-2017) with the highest precipitation (415mm) occurring in 2008. In general the total annual precipitation had been decline fromlast 10 years as there was adecreasing trend for rainfall in the district.

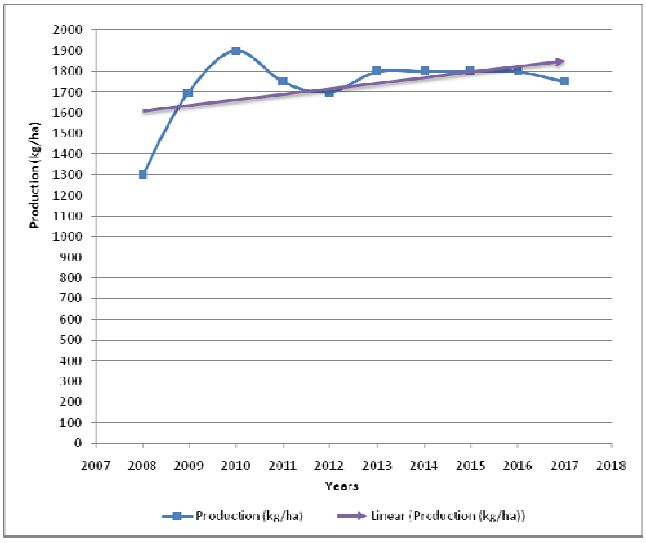


**Figure 6: Production of Barley Trend in Injil District, Herat Province (Source: UARS, 2018).**

Figure (6), Production in the district mostly oscillated and increased from 2008 to 2010 and then very sharply decreased from 2010 to 2012 and thereafter increased from 2012 to 2013 and then decreased from 2013 to 2017. It is clear from the time series data that 2010 recorded the highest production of 1900kg/ha.

**Effect of Climate Change on Barley Production**

To see the data of barley production as well as the amount of production in the Injil District in last ten years, it is clearly perceptible that barley production in district is increasing from 2008 to 2017. Many factors are responsible affect the area under cultivation likewise the production in the district. Climate Change has been recorded to have its direct as well as indirect effect on production of barley in district.

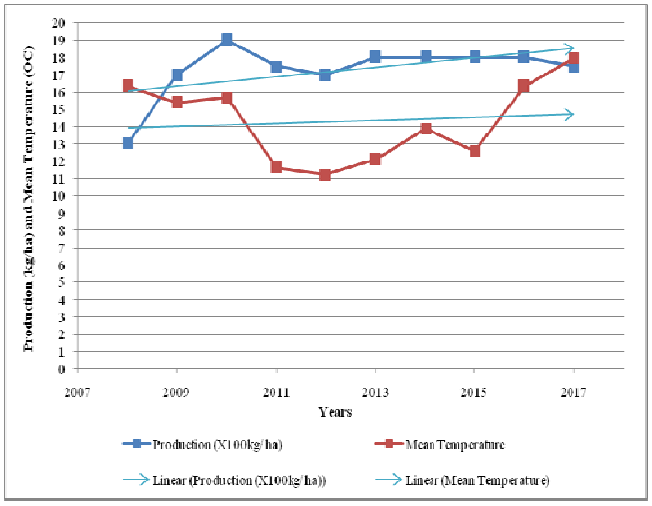


**Figure 7: Production in Contrast With Mean Temperature in Injil District, Herat Province.**

Figure (7), details the relation of temperature with the production from 2008 to 2017.

Production in the district mostly oscillated and increased from 2008 to 2010 and then very sharply decreased from 2010 to 2012 and thereafter increased from 2012 to 2013 and then decreased from 2013 to 2017 that can be as result of other factors affect in coordination with the temperature in the district. By contemplate the effect of somefactors (i.e. soil type, regular weeding, good irrigation, good sun solar for irrigation, use of resistant variety against diseases and pests and use of Hariroad river water for irrigation); we get best area of barley production. We can see from the trend line that the barley production has increasedover the last ten years.

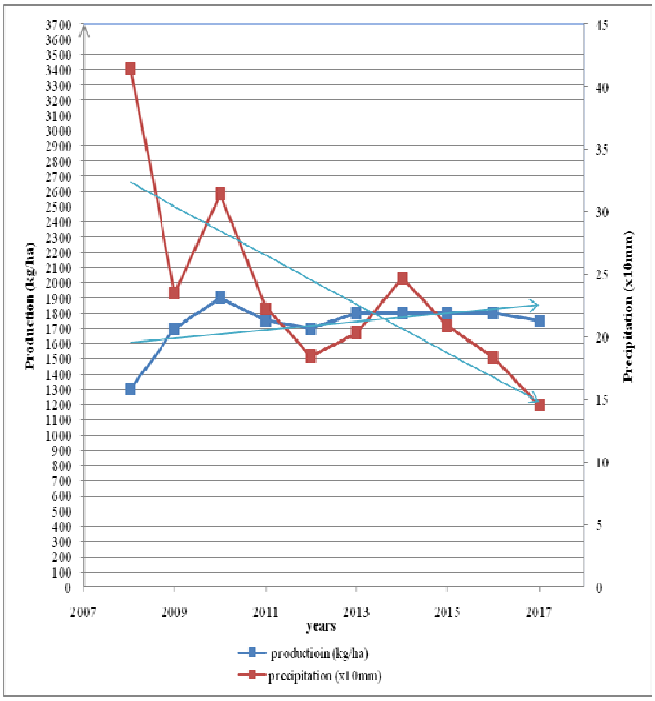


**Figure 8: Production in Contrast With Precipitation in Injil District, Herat Province**

Figure (8), the amount of annual precipitation also had its effect on barley production in the district in last ten years. We can see that by decline the precipitation the production also increasing. It is clear that the production in the district has changed in relation with amount of precipitation and another factors are affected on barley production in the district like decrease in relative humidity when the precipitation is decrease the relative humidity is decreasing and most of the diseases is not found and not damaged to barley production, use of deep wells, water solar, use of Hariroad river water for irrigation, use of springs and kariz, use of the Salma Dam which collection the waters of the Hariroad river and eliminate the shortage of water for irrigation of barley and use of bestresistantvariety against diseases and pests.

To analyze the data in accurate manner and have a good result from it, correlation in SPSS 24 was used in order to explore the relationship between climate change and barley production. The data of temperature and rainfall was use to show the correlation of these two variables with the area of barley production in the district. From the Pearson product – moment correlation results, it is clear that there is relationship between the mean temperature and production, as well as the mean precipitation and the production in the district.

**Table1: Relationship between Precipitation, Mean Temperature and Production in Injil District.**

| Correlations | | | |
|---|---|---|---|
| | Production | Mean Temperature | Precipitation |
| Production Pearson Correlation | 1 | -0.209 | -0.632 |
| Sig. (2-tailed) | | 0.562 | 0.050 |
| N | 10 | 10 | 10 |
| Mean Temperature Pearson Correlation | -0.209 | 1 | 0.206 |
| Sig. (2-tailed) | 0.562 | | 0.568 |
| N | 10 | 10 | 10 |
| Precipitation Pearson Correlation | -0.632 | 0.206 | 1 |
| Sig. (2-tailed) | 0.050 | 0.568 | |
| N | 10 | 10 | 10 |

The result of correlation shows that there is a relatively negative relationship between the mean temperature and the production of (r = -0.209) in the district. It means that there is effect of mean temperature on the barley production from 2008 - 2017 in the district.

From the Pearson product moment correlation table, it is clear that the relationship between precipitation and production in the district is negative and it is quite relationship of -0.632. It means the effect of precipitation is was low and farmers eliminate shortage of water for irrigation barley with use of stream water, wells and kariz, and its effect for the barley production in the district.

**Table 2: Descriptive Statistic of the Data for Production, Mean Temperature, and Precipitation.**

| Descriptive Statistics | | | |
|---|---|---|---|
| | **Mean** | **Standard Deviation** | **N** |
| Production (kg/ha) | 1730.00 | 161.933 | 10 |
| Mean Temperature ($^{o}$C) | 14.32 | 2.346 | 10 |
| Precipitation (mm) | 235.88 | 77.404 | 10 |

The descriptive statistics of precipitation indicates that the amount of precipitation with standard deviation of 77 in last 10 years. The result shows that by relatively decreasing the amount of precipitation in the district the barley production has increased in the last 10 years of 2008 to 2017, because another factor affecting to increase of barley production like use of stream water, wells and kariz for eliminate shortage of water for irrigation and use of best varieties and resistant against disease and pest.

**Result of Questionnaires Interview with Farmers Perception in Injil District**

In this district, different varieties of barley, are cultivated, see in Figure 9, which are resistant against diseases and pests and it has a good adaptation to the environment and there is more demand for the market.

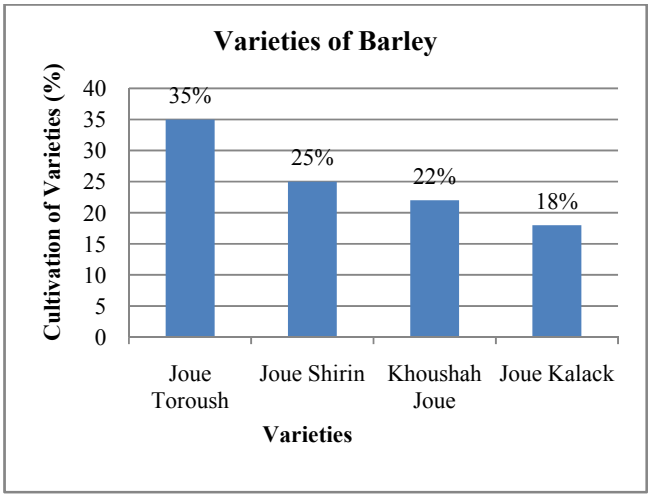


**Figure 9: Different Varieties of barley in Injil District, Herat Province. (Source: Survey interview).**

In this district, all farmers use all water resources to irrigate their land, about 75% of the stream water, about 20% of the wells use about 5% of the kariz, see in Figure 10. The amount of precipitation plays an important role in the growth and development of barley and increases the production. The precipitation during these years has been relatively low and has effect to area of barley production. With the use of the Heriroad River Water and Salma Dam Water, shortage of water for irrigation is eliminated and the growth of the crop is increased. (Survey interview).

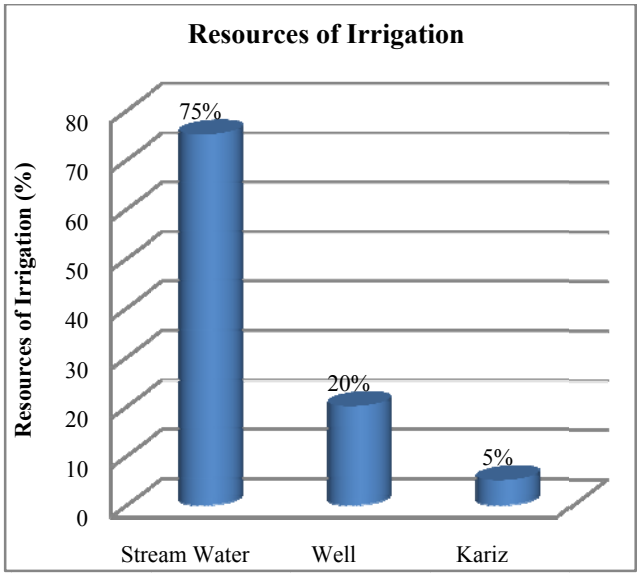


**Figure 10: Resources of Irrigation in Injil District, Herat Province. (Source: Survey interview).**

## DISCUSSION

In assessing the effect of climate change on barley production the study sought to analyze the trend of climate change and the level of inter-annual variation over the past ten years (2008-2017) in the District, and to analyze how climatic variations affect barley production and also investigated how the farmers perceive the effects of climate change on barley production.

The climatic variable both temperature and precipitation shows variation within the last ten years. The study found that bothmean minimum and mean maximum temperature characteristics of the area experienced some level of variation within the stipulated years under consideration (Figures (3) and (4)).

The effect of climate change on barley production was analyzed and studied. The correlations between temperature, precipitation and production in ten years of 2008 – 2017 drawn and showed that there is relationship between both temperature and barley production and precipitation with production in the district. From figure (7), it is clear that by relatively increasing of mean temperature in ten years of 2008 – 2017 the area for production increased and the correlation result shows that there is a relatively negative relationship between the mean temperature and the production of (r = -0.209) in the district.

The effect of climate change on barley production was analyzed and studied. The correlations between temperature, precipitation and production in ten years of 2008 – 2017 drawn and showed that there is relationship between both temperature and barley production and precipitation with production in the district. from figure (8), it is clear that by decreasing of mean precipitation in ten years of 2008 – 2017 the area for production is increased, because another factor affecting to increase of barley production like use of stream water, wells and kariz for eliminate shortage of water for irrigation and use of best varieties and resistant against disease and pest and the correlation result shows that there is a relatively negative relationship between the precipitation and the production of (r = -0.632) in the district.

## CONCLUSION

The main objective of this study is to improve understanding of climate change and the impact of climate change on barley production in Injil district of Herat, Afghanistan. The study found the both mean minimum and mean maximum temperature characteristics of the area experienced some level of variations within the stipulated years under consideration in the district. Study of the trend lines shows that overall mean minimum and mean maximum temperature relatively increasing in Injil district. The numbers of very cold days are getting lower during winter oppositely the number of hot day in summer is increasing. This shows that the climate tends to more hot days and the mild winters in the area.

Besides the precipitation had inverse variability with temperature and the trend line shows that in last ten years of 2008 – 2017 the amount of precipitation has relatively low. The study of barley production and the area under the barley production shows that from 2008 to 2017 the barley production had increasing trend in district.

The main reason for the increase in barley production in this area is good climatic conditions, and use of best varieties like JoueToroush, Joue Shirin, Joue Kalack andKhoushah Joue, and resistant against diseases and pests and it has a good adaptation to the environment and there is more demand for the market. The system of irrigation for barley production is surface irrigation. The amount of precipitation plays an important role in the growth and development of barley and increases the production. The precipitation during these years has been relatively low and has effect to barley production. With the use of the Heriroad River water and Salma Dam water, shortage of water for irrigation is eliminated and area of barley production is increased.

This means that an relatively increase in mean temperature caused a significant increase in barley production with contemplate some effect of such as soil type, regular weeding, good irrigation, good sun solar for irrigation, use of resistant variety against disease and pest. The study further found a statistically negative relationship between mean temperature and barley production. The precipitation in this district is relatively decreased and all farmers eliminate the shortage of water for irrigation with use of 75% of Stream River, 20% of well and 5% of kariz, and its effect for barley production.

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