International Journal of Agriculture and Plant Science
Online ISSN: 2664-7664; Print ISSN: 2664-7656
Received: 04-02-2020; Accepted: 06-03-2020; Published: 08-06-2020
www.agriculturejournal.in
Volume 2; Issue 2; 2020; Page No. 15-18

Impact of climate change on grape production; A case study of Lashkargah (Bost) district, Helmand province, Afghanistan

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Abstract
Global climate change is one of the major issues in the current century which has sizable impact on the livelihood. The effects of climate change on our ecosystems are already severe and widespread, and ensuring food security in the face of climate change is among the most daunting challenges facing humankind. While some of the problems associated with climate change are emerging gradually.

Afghanistan is ranked among the most vulnerable countries in the world to the adverse impacts of climate change. The horticulture subsector Contributes US$1.4 billion to the national GDP of the country. Tomato cultivation is a source of livelihood to most farmers in the country. Rising temperature and erratic rainfall pattern which are attributed to the varying climate have been the bane of the tomato farmers. The general consensus is that changes in temperature and precipitation will result in changes in land and water regimes that will subsequently affect agricultural productivity. The aim of this study was to improve understanding of the effects of climate change on grape crop production in the Lashkargah District of Helmand Province, Afghanistan under stipulated years of 2008-2017.

The result of the study suggests an increase in both maximum and minimum temperatures coupled with decrease in annual precipitation in an unreliable seasonal distribution over the last ten years. The study identified incidence of pests and diseases the major effect of climate variability on grape production as reported by the farmers in the District. The study highlights the role of climate variables (temperature and precipitation) on grape production area while controlling other confounding variables. The study found that an increase in temperature caused a significant decrease in grape production while some confounding variables such as market availability, irrigation water availability, pests and diseases, etc., held constant. The study further found a statistically positive relationship between precipitation and grape production. The implication is that as precipitation decreases, it potentially causes a reduction in area under grape productions.

Keywords: climate change and variations affect grape production

1. Introduction

Afghanistan is a landlocked, mountainous and very dry country in south and Central Asia with an area of 647500 square kilometers. It is bordered by Pakistan in the south and east, Iran in the west, Turkmenistan, Uzbekistan and Tajikistan in the north. Afghanistan lies between 29° and 38° N and 61° and 75° E (Thieme and Suttie, 2006). most of the country consists of mountainous terrain (Hindu Kush mountains), only 80,000 square kilometers are arable land and only half of that is cultivated (USAID, 2010).The altitude range is from about 470 m on the south west border with Iran to over 6 000 m in the eastern mountains. Afghanistan has an arid and semi-arid continental climate with cold winters and hot summers. The climate varies substantially from one region to another due to dramatic changes in topography.

Afghanistan has mountains, hills, plains and deserts. As such, its climate is extreme with dry bitter cold winters, very hot summers, snow falls on the higher altitude, and dust storms occur in dry areas. Substantial variation exists in day and night temperatures. Most of the rain falls between October and April. However, the agriculture sector remains very important in building Afghanistan's economy, in spite of the fact that only 12 percent of its land area is arable and only about half of that is cultivated. The Kunduz Province in the north and Helmand Province in the south constitute the primary agricultural areas. Most of the farms are very small, as about 69 percent of these farms are below five hectares. Only about 16 percent of the farms have over 10 hectares of arable land,

either irrigated or rain-fed and just 6.5 percent of these farms have over 20 hectares, cover about 33 percent of the irrigated and 50 percent of the rain-fed land (The World Bank; FAO, 2011).

1.1. Research Objectives

The primary objective of the study was to understand the impact of climate change on grape production in the Lashkargah (bost) District of Helmand.

Specifically, the study sought to

- Analyze the trend of climate change over the past 10 years (2008-2017) in Lashkargah (bost) District of Helmand.
- Assess how climatic variations affect grape production.

2. Material and Methods

The research was carried out in Helmand Province purposively in 2018. Mixed methods approach was employed in the investigation. During the research, both probability and non-probability sampling techniques were used for the study. The unit of analysis was individual grape 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 all 250 villages of Lashkargah district, 20 villages was randomly selected for study and from every village a total number of 10 grape growers were chosen randomly for interview in cooperation with the leader of the village. Both the quantitative and qualitative data were gathered from the study area. Data used for the study were collected from both primary and secondary sources. Primary data were collected from key informants such as grape growers, Agricultural Extension Officers of districts while the secondary data were obtained from the Meteorological Department of Civil Aviation Authority and the Ministry of Agriculture, Irrigation and livestock (MAIL) respectively and also by desk study within review of literatures.

3. Results and Discussion

3.1. Trend Analysis of Climate Variables

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 variations 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 the minimum and the maximum temperatures have increased over the past 10 years with rainfall showing a relatively decreasing

Trend. From Figure (3.1), it is obvious that the maximum temperature has varied over the past ten years (2008-2017). Maximum temperature in the district mostly oscillated and increased sharply, especially within the years (2010-2013) as compared to the other years. From the graph, maximum temperature decreased sharply from 2011 to 2012 but again there was a drastic

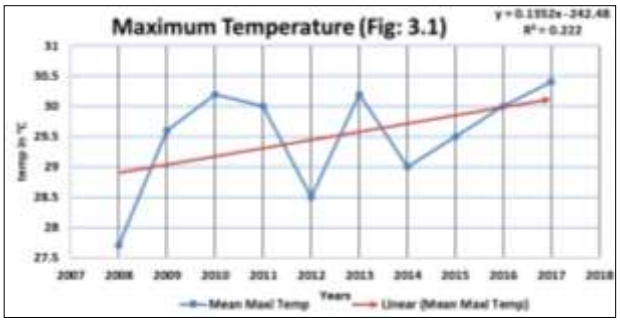

Fig 1: Maximum Temperature Trend in Lashkargah District, Helmand (Source: AMD, 2018).

decreased from 2013 to 2014. It is clear from the time series data that 2017 recorded the highest maximum temperature of 30.4 °C. The trend equation and the trend line of the mean maximum temperature generally shows an increasing trend (0.1352x) which means that the average maximum temperature over the years (2008-2017) has been increasing. The degree of variation (R^2=0.222) shows that the variability in maximum temperature in the area is approximately 1 percent.

Figure (3.2), portrays the minimum temperature trend in the district over the period, 2008 to 2017. From Figure, it is also apparent that the minimum temperature shows some variations over the past 10 years (2008-2017) in Lashkargah District of Helmand. The graph shows an increase in minimum temperature from 2010 to 2011. Then there was a drastic decline in 2012 and 2014 and again the graph shows a slight increase from 2015-2017.

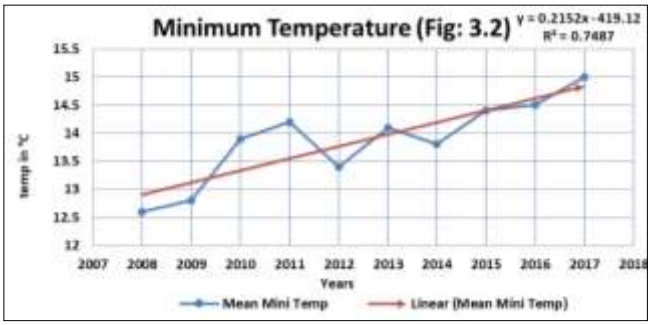

Fig 2: Minimum Temperature Trend in Lashkargah District, Helmand (Source: AMD, 2018).

The highest minimum temperature (12.6°C) is recorded in 2008. The trend equation and the trend line of the mean minimum temperature generally shows an increasing trend (0.2152x) which means that the average minimum temperature over the years (2007- 2016) has been rising. The degree of variation (R^2=1) shows that the variability in minimum temperature in the area is 1 percent. This indicates that there is an increasing trend in temperature in the district. The implication of an increase in the minimum temperature to crops in general is that, it will affect annual cycle of the plant grapevine growth directly as well as occurrence of pathogens and insect pests during growth season indirectly.

Figure (3.3), gives a detailed account of the rainfall variability trend in the study area. The

annual precipitation amount portrays a decreasing trend over the last ten years. From the graph,

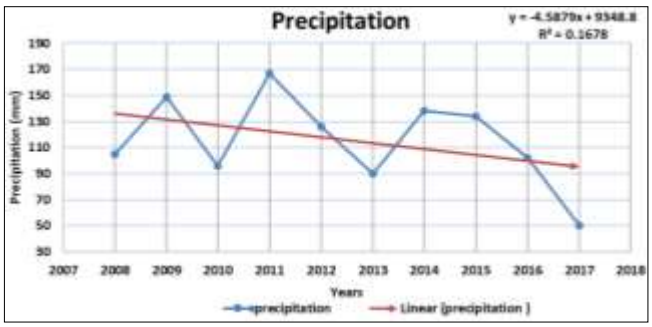

Fig 3: Annual precipitation Trend in Lashkargah District, Helmand (Source: AMD, 2018)

annual rainfall decreased drastically from 2009 to 2010 and then improved sharply from 2010 to 2011. Afterward there was a drastic decrease in annual rainfall from 2015 to 2017.
Decreased from 2015 to 2017. It is obvious from the graph that precipitation indeed experienced a number of variations over the period under consideration (2008-2017) with the highest rainfall (167 mm) occurring in 2011. The trend equation and the trend line of the annual rainfall shows a gradual decreasing (minus) trend (-4.5879x) which means that the annual rainfall pattern over the years (2008-2017) has been decreasing at a steady rate. This means that even though precipitation seems to be decreasing over the periods, the trend of decrease is generally gradual. The degree of variation ($R^2 = 0.1678$) shows that the variability in annual precipitation in the area is less than 1 percent. This clearly gives an indication of a decrease in precipitation in the district. In general, the total annual precipitation had been declined from last 10 years as there was a decreasing trend for both rainfall and snowfall in the district.

3.2. Effect of Climate variability on Grape Production

To see the data of the amount of production in the District in last ten years, it is clearly perceptible that the production in district is decreasing from 2008 to 2017. Many factors are responsible affect the production in the district. Climatic variability have been recorded to have its direct as well as indirect effect on production of grape in district.

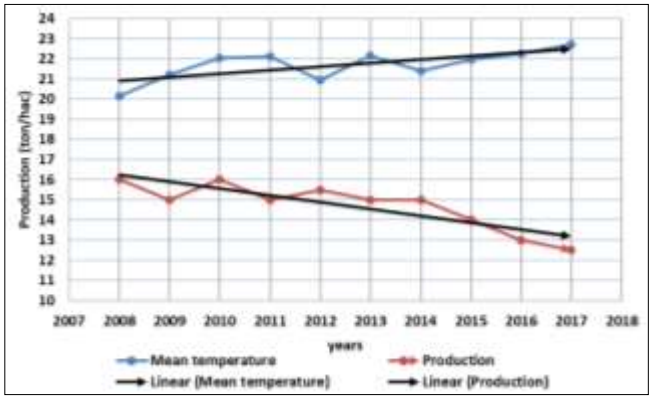

Fig 4: Production in contrast with temperature

Figure (3.4), details the relation of temperature with production from 2008 to 2017.
The amount of annual precipitation also had its effect on grape production in the district in last ten years (2008-2017). With dissembling the effect of other variables, we can see that by declining the
Precipitation the production also decreases. From figure (4-4), it is clear that the production in the district has changed in relation with amount of precipitation. By decreasing the level of precipitation, the production also decreases.

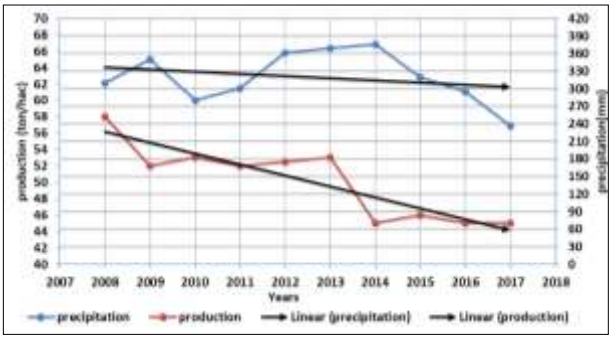

Fig 5: Production in contrast with precipitation

To analyze the data in accurate manner and have a good result from it, correlation in SPSS 16.0 was used in order to explore the relationship between climatic variables and grape production. The data of rainfall and temperature was use to show the correlation of these two variables with the area of grape production in the district. From the Pearsons Product – moment correlation results, it is clear that there is relationship between both the mean temperature and production area as well as the precipitation and the production area in the district.

Table 1: Relationships between Precipitation, temperature and production in Lashkargah District

Correlations				
		Production	**Temperature**	**precipitation**
Production	Pearson Correlation	1	-.521	.410
	Sig. (2-tailed)		.122	.239
	N	10	10	10
Temperature	Pearson Correlation	-.521	1	-.268
	Sig. (2-tailed)	.122		.454
	N	10	10	10
precipitation	Pearson Correlation	.410	-.268	1
	Sig. (2-tailed)	.239	.454	
	N	10	10	10

The result of correlation shows that there is a relatively large negative relationship between the temperature and the production of (r = -.521) in the district. It means that by increasing the annual temperature in last ten years of 2008 – 2017 the production of grape in Lashkargah district has been decreased.
From the Pearsons product moment correlation table, it is clear that the relationship between precipitation and production in the district is positive and it is quite large relationship of 0.410. It means that there is large effect of precipitation on the area of grape production in the district.

Table 2: Descriptive statistics of the Data for Production, Precipitation, and temperature.

	Mean	Std. Deviation	N
Production	14.7000	1.18322	10
Temperature	29.5100	.86852	10
Precipitation	115.70E2	33.90526	10

The descriptive statistics of precipitation indicates that there is slightly difference in amount of precipitation with the standard deviation of 33.9 in last 10 years. The result shows that by decreasing the amount of precipitation in the district the grape production has also decreased in the last 10 years of 2008 to 2017.

4. Conclusion

The main objective of this study is to improve understanding of climatic change and the impact of climate change on grape production in Lashkargah district of Helmand, Afghanistan. The study made fairly significant contribution to previous methodologies regarding climate variability and crop production. In the first place, the study has provided a framework for further research regarding climate change impacts and adaptation strategies relationships. The study found that both minimum and 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 minimum and maximum temperature are increasing in Lashkargah district. The number of very cold days are getting lower during winter oppositely the number of hot days in summer is increasing. This shows that the climate tend 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 precipitating has diminished. The precipitation takes place mostly in rain type rather than snow fall and also it takes place in very sever rainfall manner during spring and summer seasons which is an indicator of disparity in distribution and type of annual precipitation.

The correlations between temperature, precipitation and production in ten years of 2008 – 2017 was drawn and showed that there is relationship between both temperature and production of grape and the precipitation with production in the district. The study found that by increasing of mean temperature in ten years of 2008 – 2017 the production is decreased and the correlation result shows that there is a relatively large negative relationship between the temperature and the production of (r = -.521) in the district. This means that an increase in temperature caused a significant decrease in grape production area with some confounding variables such as market availability, irrigation water availability, pests and diseases, etc., held constant. The study further found a statistically positive relationship between precipitation and grape production area. The implication is that as precipitation decreases, it potentially causes a reduction in area under grape productions.

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