IMPACTS OF RAINFALL AND TEMPERATURE VARIABILITY ON WHEAT PRODUCTION IN DISTRICT BAHAWALNAGAR, PAKISTAN FROM 1983-2016

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ABSTRACT: In Pakistan, wheat is the principal food crop contributing 2.8 GDP in country's economy. For wheat production different factors are responsible, one of them is climate. This study has been carried out in Bahawalnagar, lying in arid zone of Punjab, to investigate the impact of year to year changes in meteorological parameters like rainfall and temperature on wheat production during the wheat cropping season i.e. November-April. This study focused to find out the impact of variation in temperature and rainfall on wheat production. Multiple linear regression model was applied to check out the relationship between the dependent (production) and independent (rainfall, temperature, area) variables. A significant regression equation was found with R^2 of .946, thus explaining 94% variance in the response variable. The model was also tested through ANOVA and the significance of p-value was .000. Results concluded a strong denial of relationship of temperature and rainfall variability with wheat production in Bahawalnagar, however a strong relationship between area under cultivation and wheat production ~~n~~was identified.

Keywords*:* Wheat production, rainfall, temperature, Bahawalnagar.

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INTRODUCTION

In the world, many people are dependent on agriculture for their food as well as for their source of earning. Food and Agricultural Organization (FAO), 2005, states that agriculture powers the economies of most developing countries. Poverty is also a common phenomenon in rural areas, therefore, agriculture can help to alleviate it (Ortiz, Sayre *et al*. 2008). Agriculture is the largest source of livelihood in Pakistan. It contributes 21% of the country's GDP. About 66%of the country's population is engaged in this profession. Cereals i.e. wheat, maize, barley, and millet are used for food. Wheat is the largest cereal among these all and is used as elementary food. Wheat is grown almost in every part of Pakistan because it is the basic food.

According to FAO, 2005, land cover of Bahawalnagar district has different categories, among which the largest area is covered by crop irrigated i.e. 66%. According to GIS lab, Punjab Forest Department (2013), district Bahawalnagar have 971209.4 acre agricultural land. Wheat is one of the important economic sector of Pakistan as in other developing countries. In Bahawalnagar, cultivated area is largely under wheat and cotton. According to the Punjab portal study conducted by the Government of Punjab in 2015 district Bahawalnagar experienced a very dry and hot climate during summer season.

There is an increase of 0.6°C in mean global temperature in the last 10 years as per IPCC. In the atmosphere, concentration of GHGs has increased temperature due to industrial activities. Average global temperature has increased over the last decade and is expected to increase in future. Besides this, extremely hot days will occur frequently (Asseng, Foster *et al*., 2011). The global average temperature in the 21st century is predicted between 1.4°C to 5.8°C (McCarthy 2001). As the overall increase in global temperature, IPCC (2001) also predicted a large increase or decrease in the global precipitation. This change in temperature and precipitation will be different for all regions of the world. There are many researches that prove change in our climate for different regions of the world. Some have correlated climate change with deforestation (Aslam, Amjad *et al*. 2019). Their direct and indirect impact on several socio-economic sectors, such as agriculture, health, water etc. will be significant all over the world. In Nepal, change in climate is highly dependant on variations in the temperature and climatic patterns. For agricultural development, precipitation is the key element in Nepal (Bhindari 2013).

According to FAO (2004), in many rain-fed environments, global wheat yields have been increased, predominantly in three last twenty or thirty years. According to Bhandari 2013, the temperature increase will be harmful to colder regions while it will be beneficial for wheat production in the hotter regions of the world. By altering the agronomic practices, the wheat yield can be amplified significantly in warm environments (Badaruddin, Reynolds *et al*., 1999). Wheat

is the potential cash crop vulnerable to the temperature variations. Under the selected scenarios of climate change in Pakistan, there could be a decline in the wheat production. In Pakistan, 1-4°C increase in temperature in semi-arid regions is projected to cause a decline in 9-30% irrigated wheat yield (Hussain and Mudasser, 2007).

MATERIALS AND METHODS

Bahawalnagar is a district of Punjab province in Pakistan. According to the pre-investment study conducted by the Government of Punjab in 2009, Bahawalnagar lies within 20°51' and 30°22' N latitudes, and its longitudinal location is 72°17' to 73°58' E. Figure 1 presents the base map of the district as prepared by TMA.

The production of wheat crop is highly dependent upon multiple factors. Some of important factors controlling wheat production are temperature, rainfall and area cultivated under wheat in Bahawalnagar. In order to find out the relationship of dependent variable, production with the independent variables' rainfall, temperature and precipitation, multiple linear regression model was applied in SPSS. MLR has also been used in national (Mazhar and Shirazi 2020) and international studies, focused on wheat yield and climatic variables. Bhandari (2013), Cheema, and Rasul (2013) applied MLR to prove linear relationship between production of crops, temperature and amount of rainfall. Similarly, Sitienei (2017) also used regression models to predict the tea crop yields relation to changing climate. In order to apply a model in this study, it was first ensured that all the assumptions of the MLR model were fulfilled.

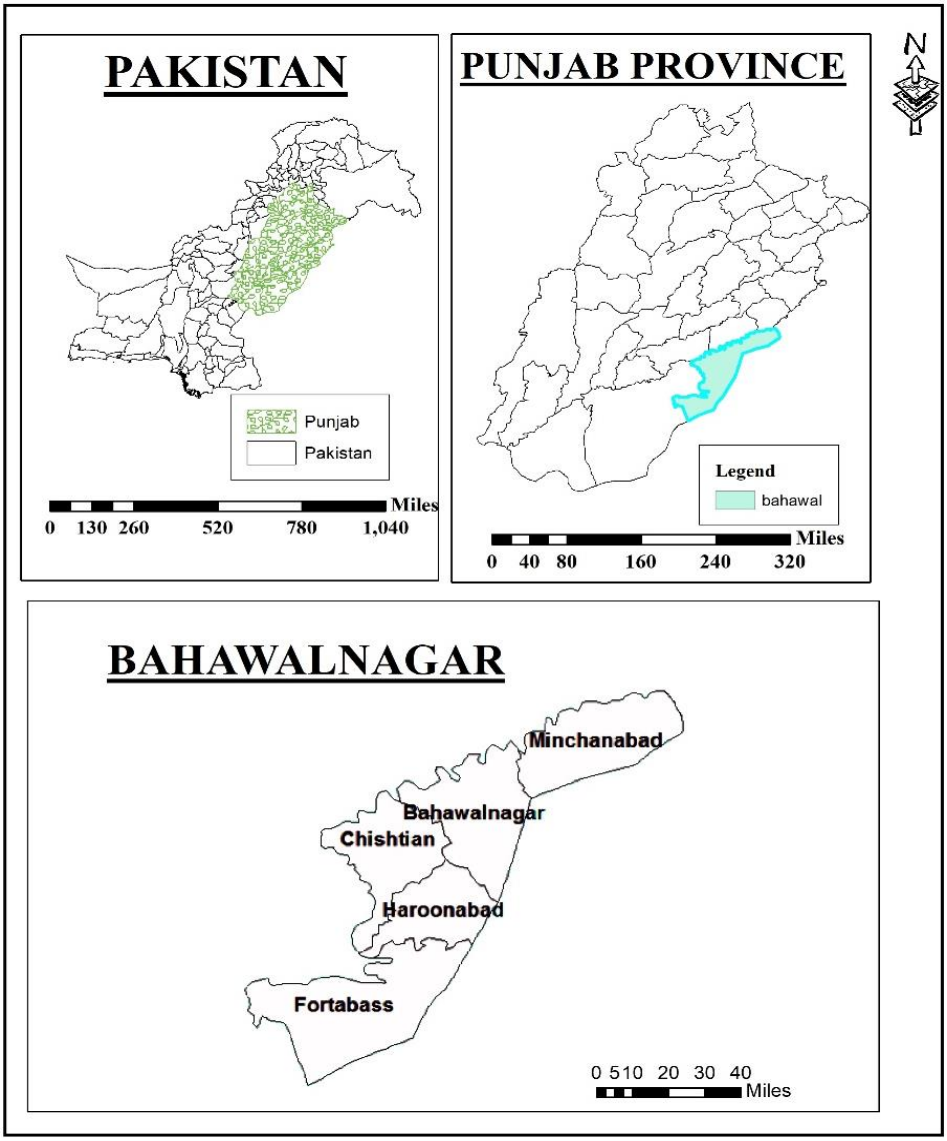

Figure 1: Study area map

Table 1: Model Summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.973[a]	.946	.940	58.33713	1.961

a Predictors: (Constant), Area, Precipitation, Temperature
b Dependent Variable: Production

RESULTS

For predicting wheat production, temperature, area under cultivation and precipitation were taken as predictors and multiple linear regression was applied. A significant regression equation was found with R^2 of .946, thus explaining 94% variance in the response variable (table 1). The ANOVA result of the MLR was F (3, 26) =151.526, with a p value of 0.000.

Wheat predicted production is equal to y= -980.064 + 5.614 – 3.161 + (-1.001), where with a unit increase in precipitation there was a -1.001 effect on wheat production (with a significance of .507), with a unit increase in temperature there was a positive 3.161 times increase in the wheat production (with a significance of .827) and with a unit increase of area under cultivation, there is an increase of 5.614 in the wheat production (with a significance value of .000). The results of MLR concluded most statistically significant impact of area under cultivation on wheat production, in Bahawalnagar, as compared to climatic variables of precipitation and temperature.

Correlation Between Production And Area: The Pearson correlation was performed using 30 years data set, i.e. from 1983-2013. This test showed whether production varies with the increase or decrease in cultivation area in Bahawalnagar. The three variables have also been analyzed individually in this research. Pearson's correlation was applied on this parametric data set. The Pearson Correlation value is .972 which presents a positive correlation between Production of wheat and area under cultivation. Since significance was .000, and thus $p < \alpha$, so it can be concluded that there was positive correlation between the area which was under cultivation and production of wheat, i.e. as the area under cultivation increases, the production of wheat crop also increases. Therefore, correlation analysis concluded that significance was at 0.01 level.

Table 2: Coefficients.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	-980.064	262.747		-3.730	.001
Precipitation	-1.001	1.487	-.032	-.673	.507
Temperature	3.161	14.338	.011	.220	.827
Area	5.614	.297	.959	18.874	.000
Dependent variable: Production					

Table 3: Correlation between wheat production and area under cultivation.

		Production	Area
Production	Pearson Correlation	1	.972
	Sig. (2-tailed)	30	.000
	N		30
Area	Pearson Correlation	.972	1
	Sig. (2-tailed)	.000	
	N	30	30

Correlation is significant at the 0.01 level (2-tailed)
Different simple and multiple bar graphs were used in the study to show association between variables.

a) Comparative Analysis of Area and Production: Figure 2 and 3 depicted the relationship between area under cultivation and production of wheat from 1984-2012 (fig. 2) and 2013-2016 (fig. 3). As area increased, wheat production also increased. Trend line of area and Production also gave the idea of positive direction. As area had increased with respect to time, production of wheat crop also increased with the passage of time. The highest wheat production was in year 2011 i.e. 1076.7 thousand tonnes. In the year 2015 and 2016, the

production increased but the area was larger with respect to production.

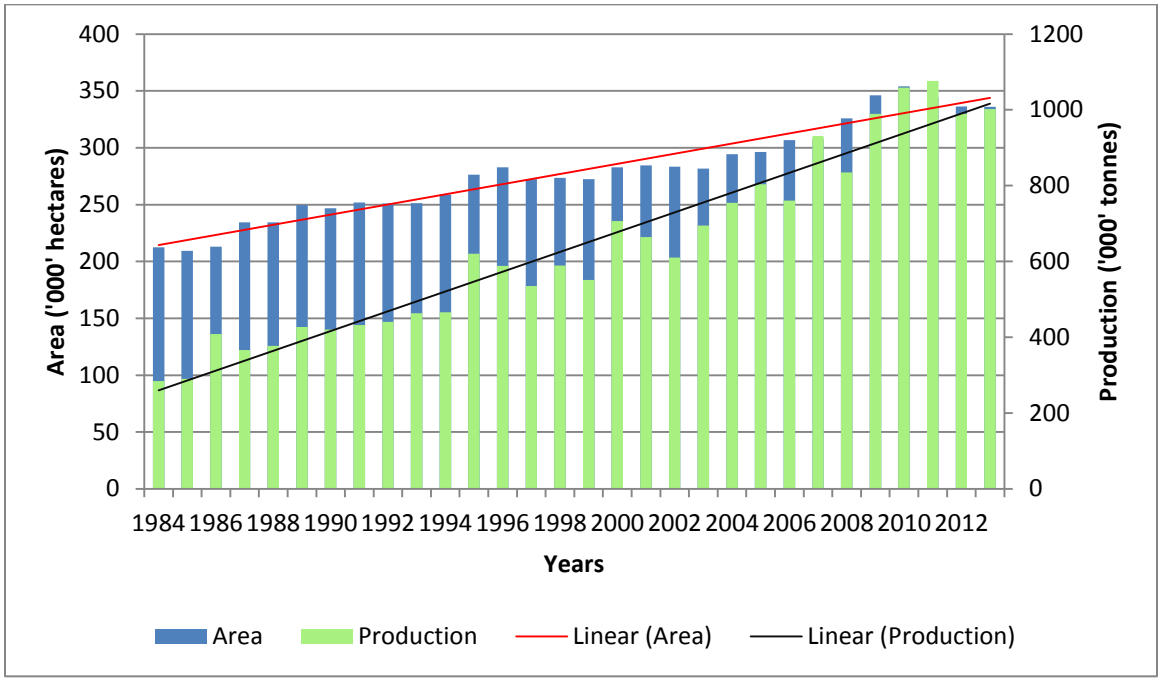

Figure 2: Comparative analysis of area and production 1984-2013.

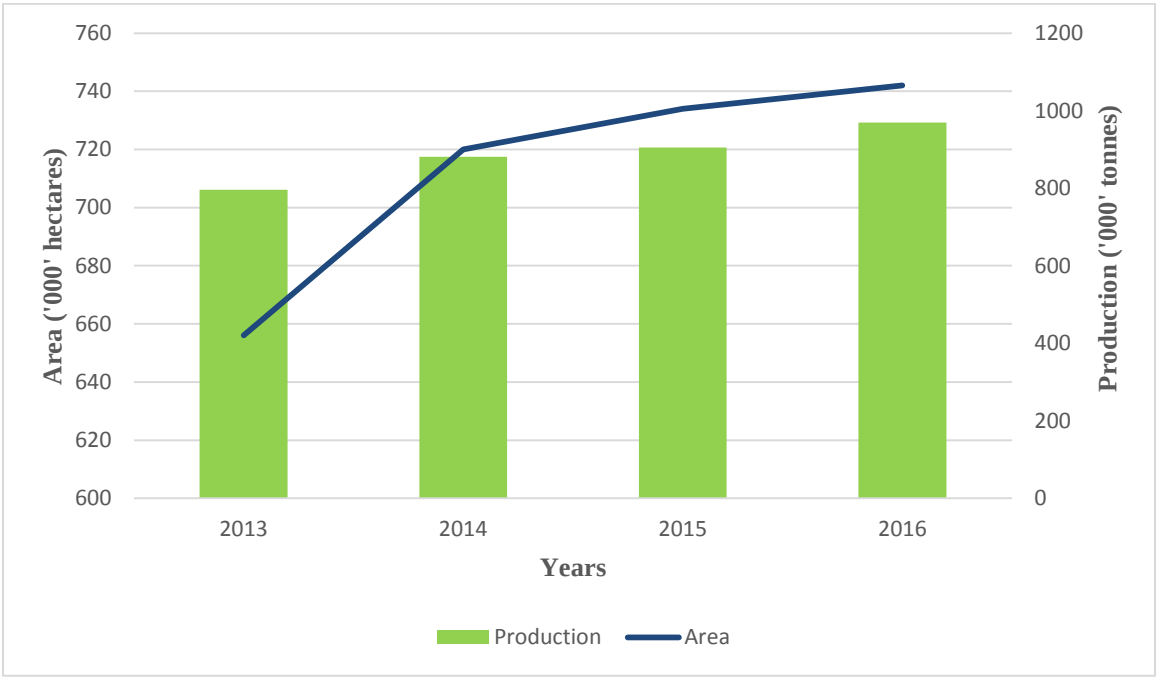

Figure 3: Comparative analysis of area and production 2013-2016

b) Comparative Analysis of Production and Temperature: The Figure 4 showed the relationship between wheat production and temperature. In which trend line presented the positive direction. The increase in the temperature did not affect the wheat production for the period under study. The highest wheat production was experienced in year 2011, i.e. 1076.7 thousand tonnes. As figure 5, it was clearly observed that there was weak relationship of temperature and production because from 2013-2016 temperature increased rapidly but production had a weak relationship with that.

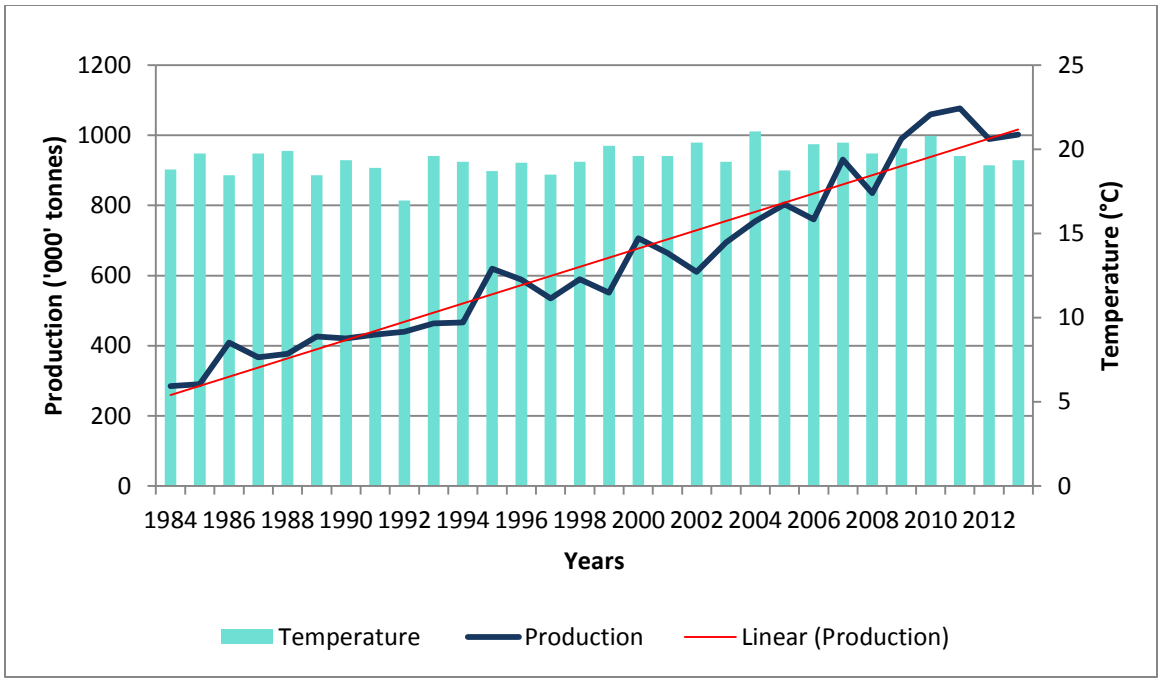

Figure 4: Trend line shows relationship between production and temperature 1984-2013.

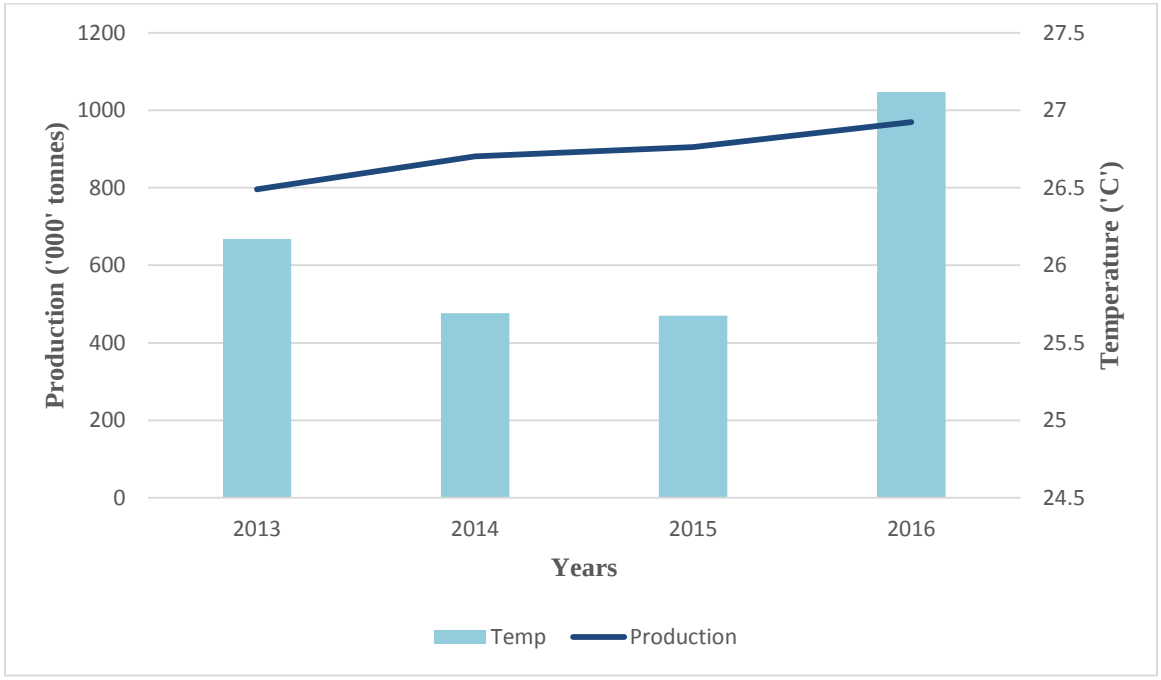

Figure 5: Trend line shows relationship between production and temperature 2013-2016

c) Comparative Analysis of Production and Rainfall: Figure 6 and 7 showed the relationship between wheat production and rainfall during the period of 1984-2013. The figures presented the rising trend of production while a decreasing trend of rainfall for the year 2011. On one hand the trend line of production showed the constant increase while on the other, rainfall trend showed a constant and gradual decrease. As per figure 7, in 2014, the rainfall was 21.66 mm. In 2016 the rainfall was 17.1 mm. The overall trend is depicting no true relationship between rainfall and wheat production as in some years the production is high but rainfall declines and vice versa.

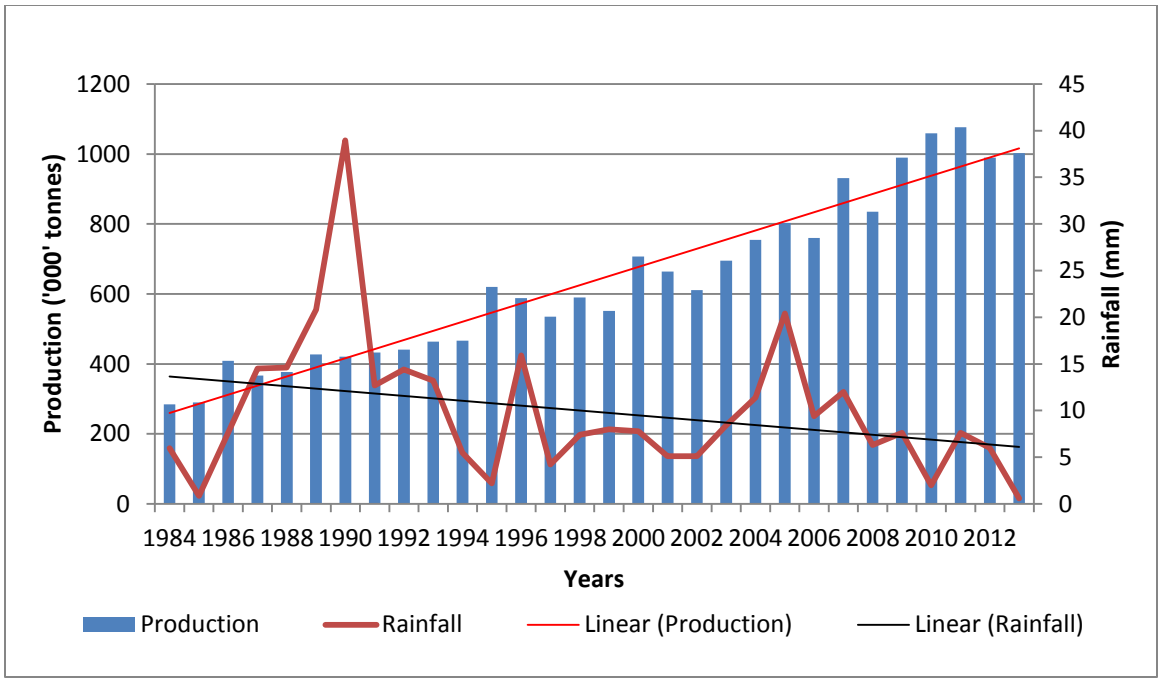

Figure 6: Comparative analysis of production and rainfall 1984-2013.

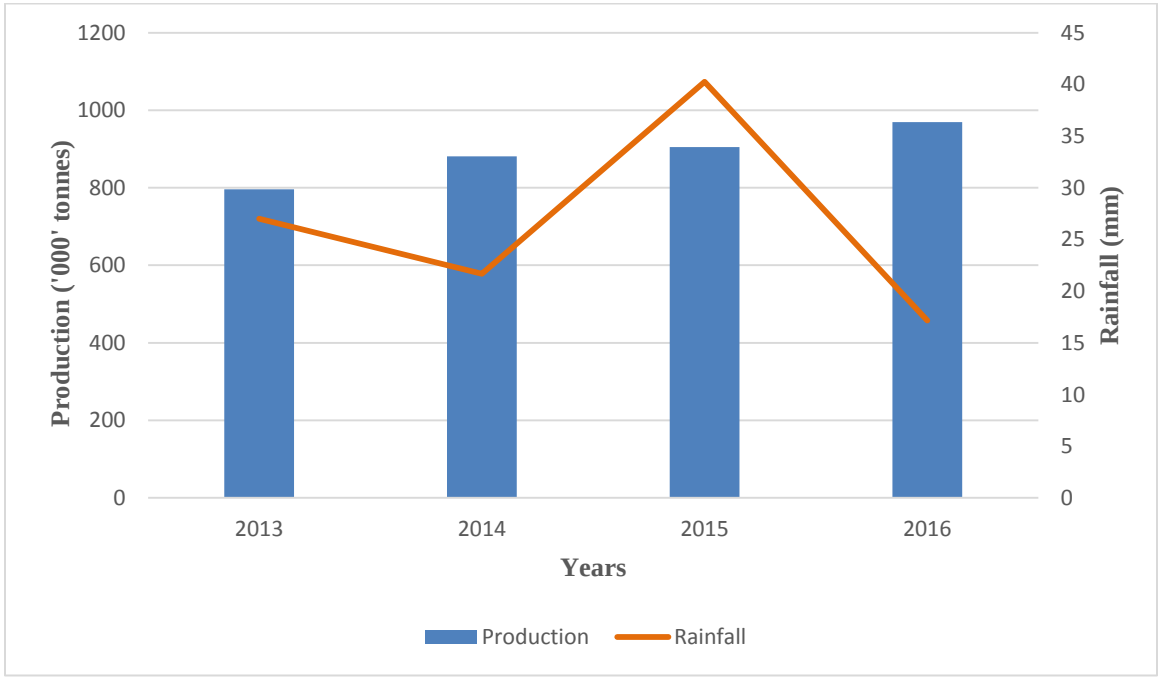

Figure 7: Comparative analysis of production and rainfall 2013-2016.

Thus, area shows positive correlation with production as compared to temperature which shows no significant relation. In addition, rainfall shows entirely negative correlation.

Production in decades: Figure 8 presented pie chart that shows decadal production of wheat. In which 30 years data was categorized into three decades. 1st decade i.e. 1983-1992 had the lowest production of wheat, while 2003-2013 had highest production. Production in decade 2003-2013 was high because of increase in area of cultivation. The highest wheat production i.e. 1076.7 thousand tonnes which was recorded in 2011.

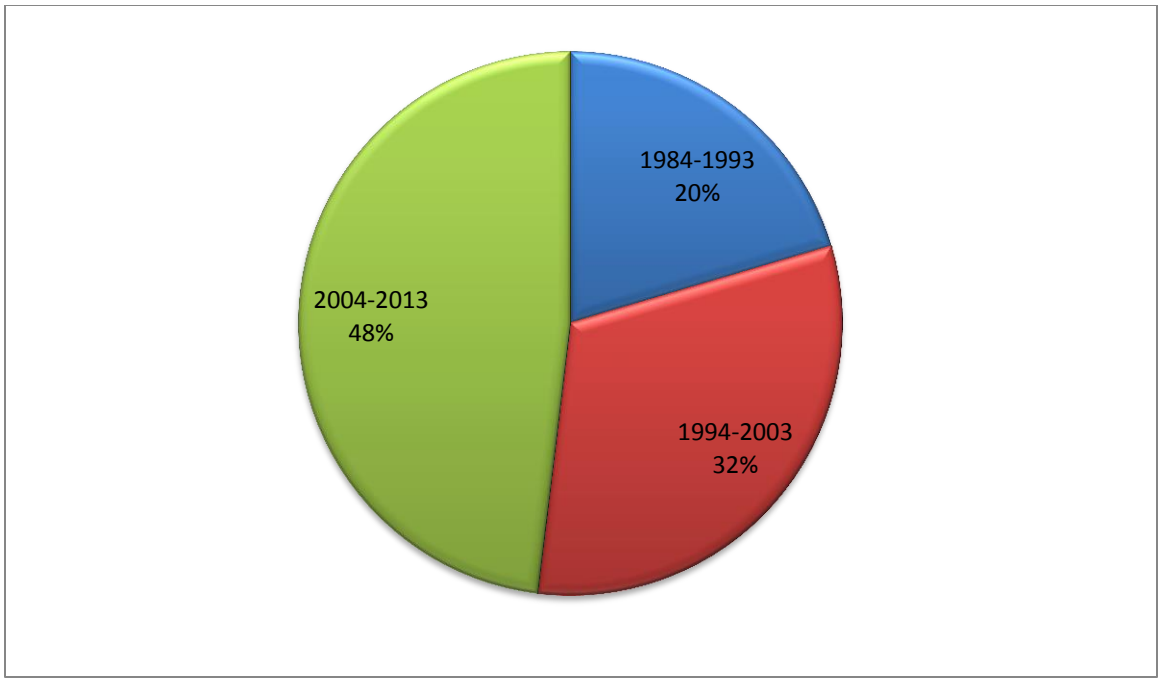

Figure 8: Decade wise percentage of production

Conclusion: This study concluded that change in the patterns of rainfall and temperature (i.e., decrease and increase) has nearly negligible effects on the wheat crop during the period 1984-2017. The area under cultivation was increased during the study period, therefore production also increased. In results, significant regression equation was found -980.064 + 5.614 – 3.161 + (-1.001) with an R^2 of .946. Percentage of wheat production varied in different decades. In decade 1984-1993 wheat production was 20%, 1994-2003 was 32% and in 2004-2013 48%. Therefore last and third decade experienced highest wheat production. After 2013 the area under cultivation was greater but area under production remained consistent. The overall area was greater in 2016 as compared to area under production. The reason behind this could be changing rainfall patterns and other techniques used for increasing production.

In future highly heat resistant varieties should be planted. It would increase the production of wheat under low water availability and high temperature. Since the temperature trend line in fig. 4 and 5 proves that the mean annual temperature will continue to rise in future thus highly heat resistant wheat diversities are suggested to be grown. For Pakistan wheat cropping regions with high temperature, some of the proposed varieties include MAYA/PAVON, CHENAB-2000 CBRD (CHUMA18/BAU), (SHALIMAR 88) PB81/HD2182//PB81. These are highly heat resistant varieties of wheat.

The soil quality decreases as the soil degrades so it is very important to conserve the quality of soil for better production. To preserve the organic quality of soil one method can be applied which is known as tillage method that can be used by the farmers to save fuel, time, machinery use.

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