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Climate change impacts on agriculture productivity in district Zhob: A time series analysis

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Abstract

Agriculture is the most vulnerable sector to climate change by imposing serious threats to agriculture production in the regions, where food is already unsecured. A time series data of climatic variables and production of major crops from year 1981 to 2015 was taken into account to assess the impacts of climatic parameters on agriculture production and the farmer's perception on it. The data of both variables is presented in a combine graph and also by using multiple regression model to see the impacts of rainfall and temperature (Minimum and Maximum) on agriculture productivity such as crops, fruits and vegetables. This study revealed that after the period 1998 onwards, high variability in the temperature and rainfall has been observed and decreased in the production of most food verities has been observed in the entire time period in district Zhob. The statistical analysis and farmer's perception also indicate that climatic variables have significant impacts on almost all of the food verities production. The impact of climatic variables on agriculture production insure that there is need to make effective policies to assist adaptation to these changes.

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Introduction

Climate change impacts on crops production are already evident across several regions of the world. A number of studies to date suggested, over the past century due to climate change a reduction of 1-2 percent in crop productions per decade is observed. A rise of 0.85°C in the earth temperature from 1880 to 2012 has been observed, and the projected adverse impacts would be more increase in the future (Gourdji *et al*, 2013; IPCC, 2014). South-asian countries are highly effected by climate change because majority of the population are dependent on agriculture practices which mostly depends on climate related factors (Zhuang, 2009). Across the asian regions temperature increased with a rate of 0.14°C to 0.20°C per decade since 1960s, increasing numbers of hot days and warm nights (IPCC, 2014). Different crop and economic models have resulted reductions in the average production by 11 percent and will increased its prices to 20 percent of major crops by 2050 due to climate change (Nelson *et al*, 2014). A long term changes in shifting temperature zones and rainfall patterns would increase the intensity and frequency of droughts and floods which directly affect agriculture production (DFID, 2004). In future, agricultural production will fall further between 10% to 25% in developing countries (Cline, 2007). Globally including Pakistan a high variability in precipitation and temperature has been recorded (Gadiwalal & Burke, 2013). The increases in temperature rise up frequency, intensity and duration of heat waves that can severely affect crops and agriculture practices. Variation in climate system such as amount of precipitation, temperature, stream flows and as well as changes in the timing also affect agriculture production (Ashfaq Yusufzai, 2014). The deceleration in agricultural growth of 5.4% in the1980s to 4.4% in the 1990s to 3.2% in year 2000, 2.53% in year 2014-15 and extreme poverty -0.2% in 2015-2016 is a palpable manifestation of the sector poor performance (Khan D. J., 2015).Due to climate change, rising in temperatures, heavy rains, droughts and losses in agriculture production are expected in Pakistan (Shakoor *et al*, 2011). Due to global warming Balochistan is experiencing increase in surface temperature and low average rainfalls are likely to cause seasonal shifts and disturb weather parameters (Pachauri & Meyer, 2014; Saad Ullah Ayaz, 2012; Government of Balochistan, 2016). The unusual changes in the rainfall pattern, unexpected snowfall and hot spells has been observed by experts, which is disastrous for Balochistan, as it affect the forest and agriculture production (Dashti, 2017). The spatial and temporal trend changes in the climate can make Balochistan extremely prone to future drought (Ashraf & Routray, 2015).The aim of the current research work was to find out theclimate change impacts on agriculture productivity in district Zhob: A time series climate change impacts on agriculture productivity in district Zhob: A time series analysis.

Study area

Zhob district lies between 69°44'43" east longitudes and 31°57'32" at north latitudes, and covered an area of 12,400 square kilometers. An average minimum and maximum temperatures in the hottest month of June around 23°C and 37°C, while an average minimum and maximum temperatures in the coldest month of January around -1°C and 13°C, respectively (Khyber.org, 2005). The district also contain forest resources, famous plant species and rich by wild animals and birds. Majority of the farmers in district irrigate agriculture land by using springs and tube wells water sources (District development profile Zhob, 2011). The value of agricultural production per hectare is the third highest which could indicate a reasonably high productivity (Saffy, 2011). Zhob district covered total land area of 2,030 hectares, in which out of 87,612 hectares at 4.3% are considered non-cultivable land, while 6.2% of potential area is equal to 126,719 hectares are considered the area available for agriculture practices (Agricultural Statistics Balochistan, 2008-09).

Data and methodology

This study used both primary and secondary data to know the variability in agriculture production over a time. The statistical package for social sciences (SPSS) version 25 has been used as a tool for data analysis. A climate data of annual mean temperature (minimum and maximum), annual mean rainfall and annual agriculture production data were gathered to conduct a combined analysis with the help of graphs and statistical test. This study selected only the major cultivated crops of the district such as wheat, maize, apple, grape, apricot, peach, potato, tomato and onion. The data of climatic parameters and agriculture production was available from the period 1981 to 2015. The climatic data of district Zhob was obtained from the Pakistan meteorological department Quetta and agriculture production data of the district was access from the agriculture department Quetta. Moreover, this study encounter 35 years period of data to study the impacts of climate change on agriculture production. A multiple regression model was selected to see the impacts of rainfall and temperature (Minimum and Maximum) on agriculture productivity such as crops, fruits and vegetables. The anova of the model was good fitted. Every dependent variable is putted manually in the test, by predicting with the help of independent variables. A multi stage sampling method was used to survey 200 farm house hold, whereas each of the respondents were selected randomly to know their perception about changes in the agriculture production due to climate change in district Zhob.

Result and discussion

Climate change impacts on agriculture production

Figure 1 shows the inter-annual mean crops production (wheat, maize) and variation in the climatic variables (rainfall, minimum temperature, and maximum temperature) analysis over the period 1981-2015.

Table 1. Regression analysis of crops production (Wheat) and climatic parameters.

Variables	Coefficient bs	t	P-value	VIF
Constant	66824.553	8.144***	.000	
Minimum Temperature	8.396	.217***	.011	1.070
Maximum Temperature	-43.712	-.783**	.057	1.254
Rainfall	-15.141	-1.463**	.023	1.356
Year	-41.597	-8.009***	.000	1.317
R2 = .777, F = 14.615***, P-value = .001				

***,**,* Significant at 1, 5 and 10%, respectively.

Source: Secondary Data, 1981-2015.

Table 2. Regression analysis of crops production (Maize) and climatic parameters.

Variables	Coefficient bs	t	P-value	VIF
Constant	81353.473	7.442***	.000	
Minimum Temperature	7.614	.197**	.040	1.070
Maximum Temperature	-39.016	-.800***	.013	1.254
Rainfall	-14.773	-1.398**	.057	1.356
Year	-39.708	-7.202***	.000	1.317
R^2= .679, F = 15.863***, P-value = .000				

***,**,* Significant at 1, 5 and 10%, respectively.

Source: Secondary Data, 1981-2015.

The crops (wheat and maize) production are mostly dependent on initial rainfall in the winter season after sowing and played an important role in increasing the production level. The estimated mean rainfall and temperature variables indicate that the variation varied significantly from year to year. The crops also show high instability in the production over the period. The graph shows that the highest mean annual rainfall was recorded in the years 1990, 1991 and 1997 as compared with the earlier and later years, while the highest mean maximum temperature 28°C was recorded in the year 2000, indicating that the study area has experienced higher variability in the rainfall, minimum temperature and maximum temperature trends during the whole period.

Table 3. Regression analysis of fruit production (Apple) and climatic parameters.

Variables	Coefficient bs	t	P-value	VIF
Constant	-4226397.248	-8.934***	.000	
Minimum Temperature	-714.453	-.428**	.047	1.070
Maximum Temperature	953.275	.451**	.025	1.254
Rainfall	-515.456	-1.127***	.008	1.356
Year	2128.975	8.924***	.000	1.317
R^2= .802, F = 30.437***, P-value = .000				

***,**,* Significant at 1, 5 and 10%, respectively.

Source: Secondary Data, 1981-2015.

Table 4. Regression analysis of fruit production (Grape) and climatic parameters.

Variables	Coefficient bs	t	P-value	VIF
Constant	77717.184	4.921***	.000	
Minimum Temperature	-66.533	-1.194**	.022	1.070
Maximum Temperature	-127.652	-1.811*	.080	1.254
Rainfall	-4.766	-.312*	.075	1.356
Year	-35.462	-4.453***	.000	1.317
R^2= .568, F = 9.868***, P-value = .000				

***,**,* Significant at 1, 5 and 10%, respectively.

Source: Secondary Data, 1981-2015.

The climatic factors reliably predict (F = 14.615, P-value = .001) the variation in the wheat production. While in the case of maize, the independent variables reliably predict the variation in the dependent variables (F = 15.863, P = .000). Further, it has been observed that 77.7% and 67.9% of the variation in production of wheat and maize has been explained by the climatic factors such as rainfall, minimum temperature and maximum temperature (See Table 1 and 2), respectively. The VIF values also show there is no multi-collinearity between the dependent and independent variables.

Table 5. Regression analysis of fruit production (Apricot) and climatic parameters.

Variables	Coefficient bs	t	P-value	VIF
Constant	-831491.668	-7.056***	.000	
Minimum Temperature	-713.141	-1.716*	.097	1.070
Maximum Temperature	332.014	.631**	.033	1.254
Rainfall	-170.462	-1.497***	.014	1.356
Year	425.154	7.154***	.000	1.317
R^2= .742, F = 21.619***, P-value = .000				

***,**,* Significant at 1, 5 and 10%, respectively.

Source: Secondary Data, 1981-2015.

Figure 2 shows that only two fruit varieties (apple, apricot) showed high production during the study period. The increase in trends of apple and apricot production after the period 1999 onward, shows that there is positive relationship between apple and apricot production and rainfall. In addition, farmers shifted towards fruit production in the study area.

Table 6. Regression analysis of fruit production (Peach) and climatic parameters.

Variables	Coefficient bs	t	P-value	VIF
Constant	21338.966	2.018**	.053	
Minimum Temperature	-7.715	-.207***	.008	1.070
Maximum Temperature	-.998	-.021**	.030	1.254
Rainfall	22.360	2.188**	.057	1.356
Year	-10.226	-1.918*	.065	1.317
R^2 = .359, F = 4.206***, P-value = .008				

***,**,* Significant at 1, 5 and 10%, respectively.

Source: Secondary Data, 1981-2015.

Table 7. Regression analysis of vegetable production (Potato) and climatic parameters.

Variables	Coefficient bs	t	P-value	VIF
Constant	165418.039	4.722***	.000	
Minimum Temperature	53.592	.434*	.068	1.070
Maximum Temperature	63.802	.408***	.016	1.254
Rainfall	-51.738	-1.528**	.053	1.356
Year	-82.639	-4.677***	.000	1.317
R^2= .429, F = 5.624***, P-value = .002				

***,**,* Significant at 1, 5 and 10%, respectively.

Source: Secondary Data, 1981-2015.

The variability in climate variables had not much effected the production of apple and apricot, which indicate that these two varieties are more resilient to stress situation. Furthermore, the increase in apple and apricot production is also resulted due to the increase in cultivated area. On the other hand, grapes and peach production declined dramatically after the year 1998 and there production had significantly effected due to drought. It has been observed that there is positive and significant relationship between maximum temperature and fruits production. Moreover, peach production and rainfall are also positively associated.

Table 8. Regression analysis of vegetable production (Tomato) and climatic parameters.

Variables	Coefficient bs	t	P-value	VIF
Constant	32611.946	3.283***	.003	
Minimum Temperature	-46.679	1.332***	.019	1.070
Maximum Temperature	75.107	1.694***	.010	1.254
Rainfall	11.944	1.244**	.023	1.356
Year	-16.967	-3.386***	.002	1.317
R^2 = .417, F = 5.368***, P-value = .002				

***,**,* Significant at 1, 5 and 10%, respectively.

Source: Secondary Data, 1981-2015.

Climatic factors (rainfall, minimum temperature, maximum temperature) reliably predict the variation in the production of the all fruits. Further, it has been observed that 80.2% and 56.8% of variation in the production of apple and grapes (See Table 3, 4), while 74.2% and 35.9% of variation in the production of apricot and peach has been explained by the climatic factors such as rainfall, minimum temperature and maximum temperature (See Table 5, 6), respectively.

Table 9. Regression analysis of vegetable production (Onion) and climatic parameters.

Variables	Coefficient bs	t	P-value	VIF
Constant	89560.366	1.951*	.060	
Minimum Temperature	134.418	.830**	.041	1.070
Maximum Temperature	562.685	2.747***	.010	1.254
Rainfall	20.872	.471*	.064	1.356
Year	-52.552	-2.271**	.031	1.317
R^2= .288, F = 3.037**, P-value = .032				

***,**,* Significant at 1, 5 and 10%, respectively.

Source: Secondary Data, 1981-2015.

Table 10. Farmer's perception about change in agriculture production over the last 20 years.

Variables	Frequency	Percent
Increases	4	2.0
Decreases	178	89.0
Little Changes	17	8.5
No Changes	1	.5
Total	200	100

Source: Field Survey, 2017.

Figure 3 presents the relationship between vegetables production (onion, potato, tomato) and variation in the climatic variables (rainfall, minimum temperature, and maximum temperature) during the study period. It has been observed that vegetables (onion, potato, tomato) production declined due to the drought period after the year 1998 in the study area. The constant variation in rainfall in the entire period had severe impacts on the vegetables (onion, potato, tomato) production. After the year 1998 drought, a huge loss in the production has been observed over the period. Whereas the contribution of temperature had also played a dominant role in effecting the vegetables (onion, potato, tomato) production.

Climatic factors (rainfall, minimum temperature, maximum temperature) reliably predict the variation in production of the all vegetables varieties. Hence, the onion production had a strong relation with the independent variables. Further, it has been observed that 42.9% and 41.7% variation in the production of potato and tomato (See Table 7, 8), while 28.8% of variation in the production of onion has been explained by the climatic factors such as rainfall, minimum temperature and maximum temperature (See Table 9), respectively.

Farmers perception on agriculture production

Farmers have been observed changes in the crops production over the past 20 years due to the impacts of climate change (See Table 10). Farmers (2%) in the study area were respond that increase in the agriculture production has been observed, while majority (89%) of the farmers had experienced decreased in the agriculture production.

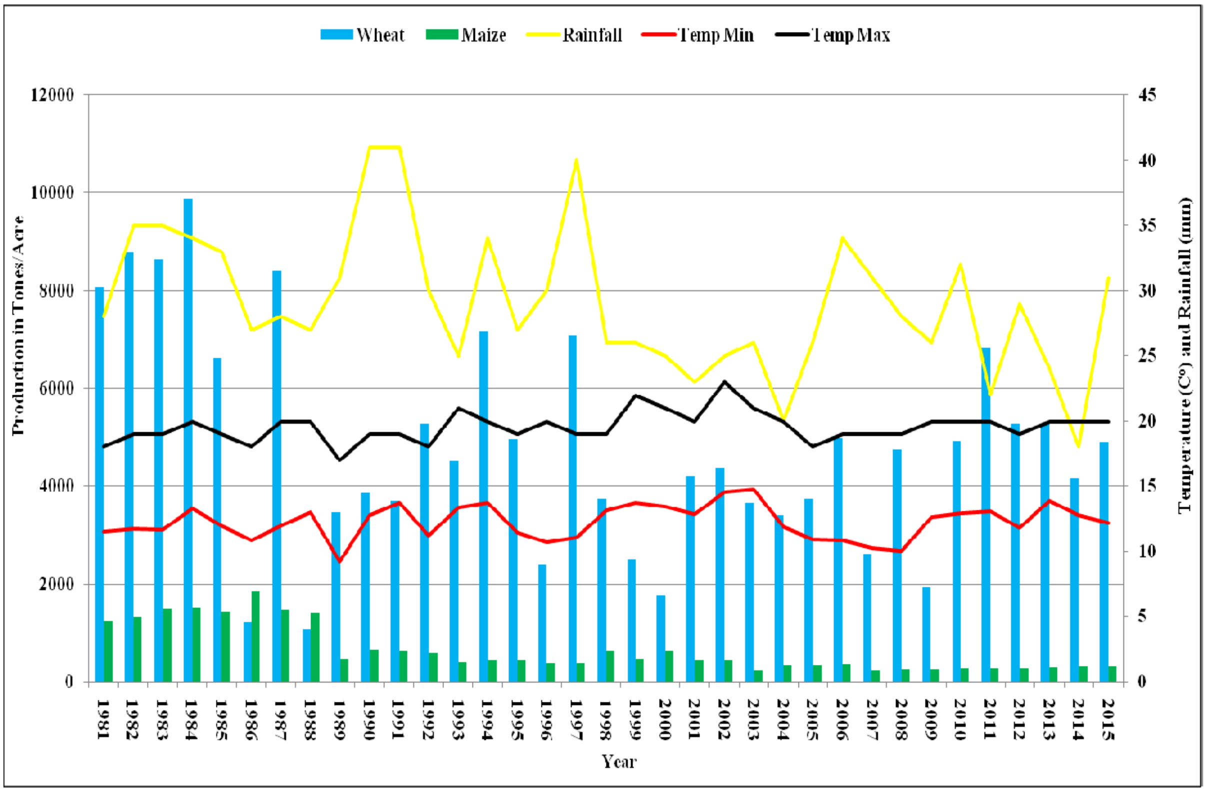

Fig. 1. Annual variability in crops production, mean rainfall, mean minimum and maximum temperature.

Farmers (8.5%) had observed little changes in the agriculture production, and very less of the farmers (.5%) had been observed no changes in the agriculture production over the past 20 years in district Zhob.

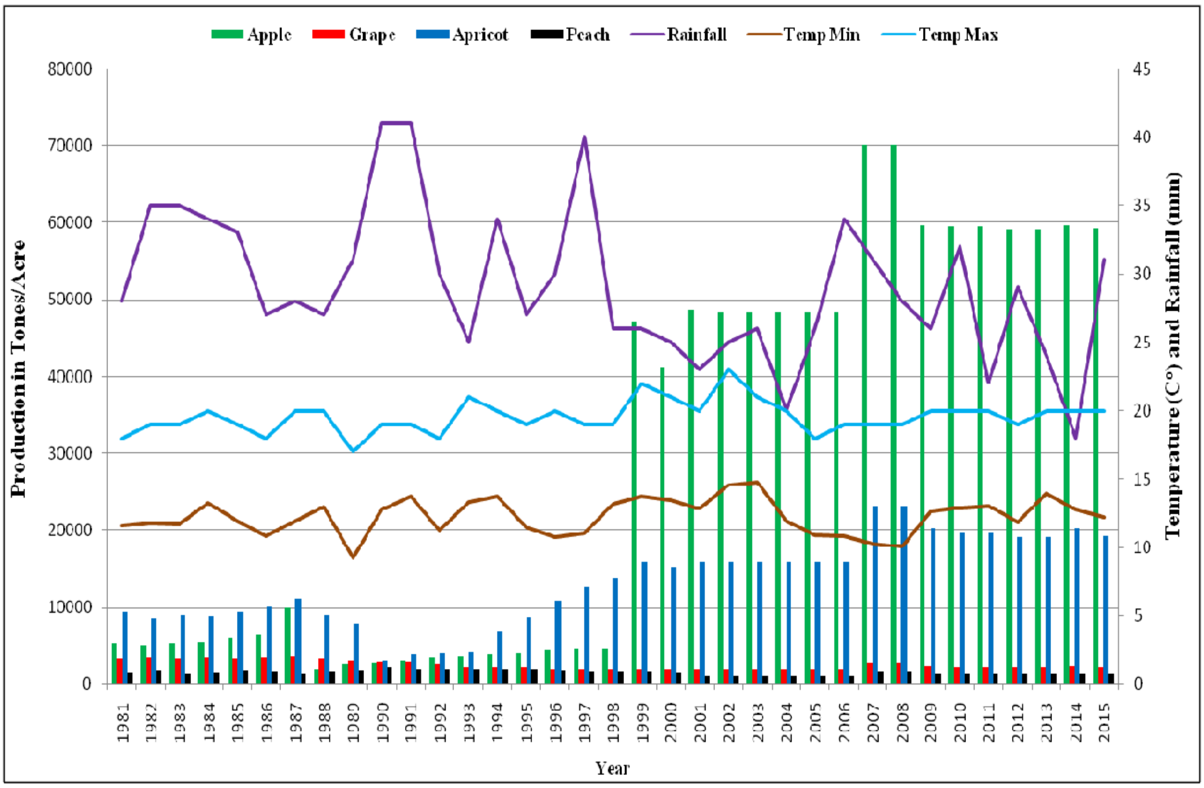

Fig. 2. Annual variability in fruits production, rainfall, minimum and maximum temperature.

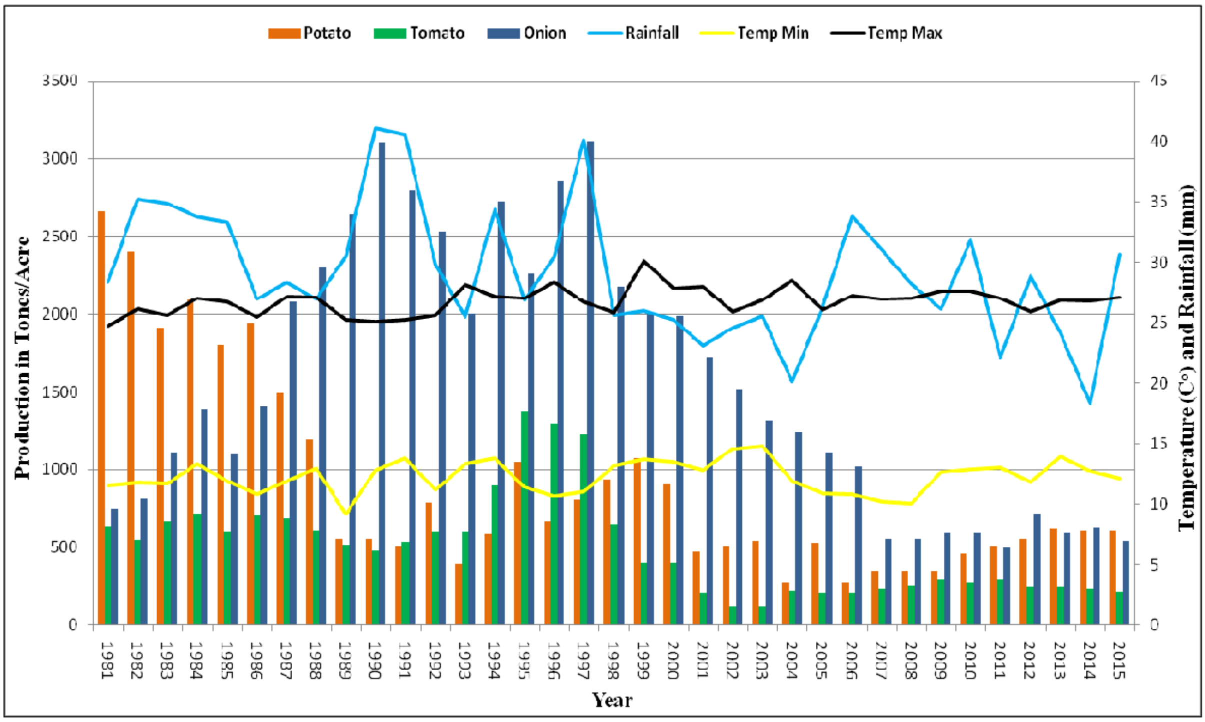

Fig. 3. Annual variability in rainfall, minimum and maximum temperature and vegetables production.

Conclusion and recommendation

Climate variability in district Zhob has been seen in the last few decades. A huge changes in the annual rainfall pattern and temperature trend (Minimum and Maximum) had been observed from year to year, which had adversely effected agriculture farms by decreasing in its food production. Apple and apricot production had not much effected by the climatic variables, which shows the resilience power as compare to other fruits verities. The statistical analysis indicate that all dependent variables are been significantly predicted by the independent variables. On the other side, majority of the farmers had also observed a great variation by decreasing in food production over the last 20 years. Finally, this study verified the impacts of climatic variables on agriculture production over the period. It is recommended that to make reform in the policies, trainings of adaptation techniques and providing resilient crops verities to farmers to make sustainable agriculture.

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