LINKAGES AMONG CLIMATE CHANGE AND PRODUCTIVITY OF WHEAT IN SINDH PROVINCE OF PAKISTAN

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ABSTRACT

Climate Change is an assorted setback that shaped many more effects linked to environment and economic distress in Pakistan. The research is intended to find out those sound effects on wheat productivity and its importance in Sindh province of Pakistan. The present research is to estimation of dependent variable i.e. wheat yield/productivity on the basis of the known or fixed values of the explanatory variables (temperature and precipitation and others were agricultural credit, wheat procurement Price, fertilizer, land and water availability) with relation to the climate change impact. A time series data of last twenty (20) years (1994-95 to 2014-15) has been processed by using Vector Auto Regression (VAR) model. Pakistan is on 06th position of wheat production, 8th place of area except 59th in terms of productivity/yield and that is the big threat to agricultural productivity due to rapid climate change pattern. The average wheat yield of country is approximately 2504.58 kg ha-1. The results and predicted values after the analysis show that the rise in temperature will decrease the wheat productivity. The coefficient for the precipitation level and temperature were depressing as well as insignificant signifying negative link between planting phase and wheat productivity. The attended R square significance for the regression equation was 0.2731, engaging that factors and comprised in the equation have explained at the minimum 27 percent deviation in wheat productivity. The estimated values of regression parameters such as Y-intercept, temperature and precipitation level were calculated as -0.235 and -0.670532 respectively. It was observed comprehensively that the implication of climate change is the key threat to food security and its growth.

Keywords: Climate, Wheat, Productivity, Regression and Sindh

INTRODUCTION

Climate change is surfacing and loud as one of the major environmental challenge facing the whole earth. The prime part of global land use is for agriculture, rangeland and forestry around 70

percent, twelve 12 percent for divergent and permanent crops, thirty one 31 percent for forest and woodlands and twenty seven 27 percent for permanent pasture. Agriculture remains the major source of living wage of greater part of world's rural poor. Asian region's 60% of the population (2.2 billion) is relying on agriculture as a source of livelihood. Presently, agriculture is extremely at risk due to the climate change.

Pakistan's agriculture and other countries are affected mainly by climate change (Global Climate Risk Index Germany; 2012). Furthermore, country engaged in the variety of challenges and threats because of climate change repercussion such as shifting rainfall patterns, melting glaciers, heavy flooding, increasing sea level, desertification and inadequate water availability, going up temperatures, impulsive rains and floods, land erosion, deteriorating agriculture productivity, disturbed environment etc. For this purpose the climate change division and linked sectors require to take part in monitoring environmental changes, pollution and resulting development consistency in the country.

Linkages Between Pakistan Agriculture and Climate Change: During 2010, Pakistan was on top in calamities happened throughout the world due to the climate change disasters and very next year 2011 it was at position three. That dilemma effected very badly and damaged the Pakistan's economy up to $14 billion a year and it's alarming. Pakistan tolerated heavy loss around eighty (80) percent in the last four decades so that climate started which shows the scale of the challenge (IPCC 2012). Pakistan is primarily dependent on agricultural sector due to its reasonable share in gross domestic production which is around 21 percent and approximately more than 60 percent labor is directly or indirectly involved in agriculture. Agriculture is a single largest source of international trade and it enables the country to earn enough foreign exchange and it help to overcome the import bill of raw material for industries (Govt. of Pakistan, 2015).

Pakistan's agriculture sector also provides raw material to manufacturing industry. One of the major crops of Rabi season is wheat which is grown in various parts of the country. It contributes around 38 percent of the cultivated area and likewise 13 percent count in value added products. It shares about 2.8 percent in country's growth rate 2014-15. Pakistan ranks 6th in terms of wheat production,

8th in terms of area but 59th in terms of yield. The average wheat productivity is 2504.58 kg ha-1 (FAO, 2010).

Generally two crop seasons are in Pakistan i.e. Rabi and Kharif. Crops are grown in season Rabi usually in November to April and crops are cultivated from May to October that is Kharif season. Wheat is the winter (Rabi) crop of Pakistan and estimated area under wheat crop in Pakistan was around 9093 thousand hectares during 2013- 14 with per hectare wheat productivity or yield was 2797 kg/ hectare also per capita consumption of wheat in Pakistan has recorded nearby 129 kg that shows the vertex importance of this food crop (Economic Survey of Pakistan GOP; 2014). The water requirement for wheat production is roughly 30 Million Acre Feet (MAF) which is about 30% short than the routine. (Rosegrant *et.al.,* 2008:36). Less or more, all the models calculate that climate change will create the pressure on wheat productivity/yield specifically in South Asian region (IPCC, 2011).

The wheat productivity or yield of our country is much lower as compared to many other countries of the world. The reasons for low productivity include diseases caused by pests, environmental changes, low soil fertility, poor agronomic practices, the lack of awareness and the lack of modern technologies. In order to increase production, the breeding strategies are being taking place to improve the grain yield and its associated traits. Improvement of grain yield and yield components is underway throughout the world through conventional (hybridization, selection etc.) Wheat cultivation throughout the country and the wheat production share in four provinces such as: Punjab, Sindh, Khyber Pakhtun Khawah (KPK) and Baluchistan provinces? The average area under wheat cultivation is on 72, 17, 07 and 04 percent respectively.

Climate Change and Wheat Production in Sindh: The summer is hot and winter is cold in the north and extending up to central parts of Sindh. During May to August the average temperature frequently rise from *42°C to 51°C whereas* 16°*C to 22°C* observe between December to January. The rainfall is approximately (10) ten inches, go down in summer. Climatically three broad sections are marked, i.e., upper districts of Sindh, middle and lower districts. Jacobabad, Hyderabad and Karachi are the representatives of these divisions. The climate of Sindh is hot and dry yet great variability in temperature and rainfall experienced. Sindh is facing the issue of

wheat shortage which was 3.5 million tons during 2013-14, though Punjab is conserved wheat and store of six million tons. Therefore, Sindh has no choice rather importing wheat approximately figured out 1.5 million tons.

Global warming resultantly climate change would cause enhanced in rainfall in different areas of Sindh province of Pakistan. This situation of wheat crop requires special attention from decision and strategy maker also have challenge for researchers. So that, formulating more sagacious climate change versus agriculture performance policies. In the light of above facts and figures the present research has been conducted in Sindh province of Pakistan which is badly affected by climate change.

OBJECTIVES

* To find out the status and growth of agriculture sector development in Sindh and Pakistan;
* To identify the climate change impact factors affecting on yield of wheat production;
* To develop economic model and estimate the climate change impact factors of wheat production;
* To recommend policy measures and program initiatives for the consistent development for agriculture sector Sindh Pakistan;

LITERATURE REVIEW

Allison *et.al.,* 2009, observed that the many African countries such as; Uganda, Malawi, Senegal, and Guinea), Peru and Colombia in north-western South America, and four (04) tropical Asian countries namely Pakistan, Bangladesh, Yemen and Cambodia were identified as most vulnerable due to climate change.

Anwar *et.al.,* (2007) worked on the International Australian Organization (CSIRO) world metrological model for three grouping climate change small, medium and large for (2000-2007) in the selected portion of Australia. The outcomes revealed that for distributed groups the central part facing declining in wheat productivity at one fourth, CO2 were the cause of wheat shortage.

LEAD 2008, Pakistan's Climate Change Action Plan affirmed severe vulnerability due to the climate change. 12th globally, economic shortfalls around 4 to 5 billion $, Agricultural productivity and as a result crop and livestock yields are likely to suffer severely

Lobell *et.al.,* 2005, used wheat imitation model (CERES) for the tendency shift in climate and its effect on wheat crop in Mexico. Since last twenty years 1988-2002 the wheat productivity badly hit by climate change and its implications and in some parts its effect positively. So, the climate change had shifted the crop patterns in the study areas.

G. A. Gbetibouo & R. M. Hassan 2004, applied Ricardian model on wheat, maize and sorghum, in other hand imitation model in crops and edible oil crops such as soya bean and sunflower in South Africa. He observed that the increase in temperature which in favor of agriculture production. Further, opined that rise in temperature has occurred in that area. He suggested that may convert wheat by maize or heat absorbed crops.

Rasul G. Zaman *et.al.,* (2012), the findings of research were mainly based on climate change consequences and its future implications. Increase intensity in weather changes events, hefty monsoon rain, overflow, dearth and expanding areas of sea are justified the climate change vulnerability and which may damage the strategic agricultural production policies due to the challenges of climate change. Research indicated the expected impacts on agricultural production and main crop productivity decreased up to 30 percent, and fresh water accessibility ranging 12 to 20 percent by 2050 in South Asia particularly in River Indus.

RESEARCH METHODOLOGY

The study is based on exploratory research method by using econometric models and basic descriptive analysis to estimation the required values. An exploratory research accomplished for any setback that has not been evidently clear. Exploratory research helps find out the best research plan, data collection method and assortment of subjects. Exploratory research frequently relies on secondary facts as well as figures such as reviewing available literature and data. The goal is to learn 'what is going-on and to investigate social phenomena without explicit expectations (Russell, 2006).

DATA COLLECTION

The time series data based on climatic change variable such as temperature and precipitation trend level and wheat crop status viz. area, production and productivity or yield data of Sindh Province and

Pakistan. Data of climatic change variables obtained from Pakistan metrological department for the last 20 years (1994 to 2015) due to the rapid climatic changes occurred. The crop status data were collected from various books, Pakistan Bureau of Statistics (PBS), Ministry of Food, Agriculture and Livestock (MFAL) Government of Pakistan, FAO Publications, etc.

VECTOR AUTO REGRESSION (VAR) MODEL

This study is based upon the model of Vector Auto Regression (VAR) model. The economist 'Sim' discovered VAR model and to apply in applied economics mostly. Christopher Sim and Litterman recommended that it is good enough to use of VAR model for predicting model and VAR model apparently based on the coexisting equation modeling. VAR model is more appropriate for projected values. All the variables applied in this model are endogenous and supposed to act together. The estimation with VAR model is uncomplicated due to it used Ordinary Least Square (OLS) method for each equation.

GENERAL FORM OF VECTOR AUTO REGRESSION (VAR) MODEL

The model can be expressed as follows:

$$Y_t = \mu + Ly\,(t-1) + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + Lpy(t\text{-}p) + e_t$$

Or

$$(L)\ Y_t = \mu + e_t$$

where (L) is matrix of variable.

THE MODEL

The specific form of the model which is used for the study is as follow:

$$W_p = ß_1 - ß_{2Temp} + ß_{3Precip} + ß_{4Acrdt} + ß_{5wpp} + ß_{6Fert} + ß_{7Tech} + ß_{8Lw} + ß_{9Wa} + U_i$$

Where; Wheat Productivity = f (Agricultural Credit, Wheat Price, Fertilizers take off, Land under wheat cultivation, Water availability, Technology and Temperature, Precipitation) + Ui.

The order of data is in coding scheme and all the data tabulated systematically. The data examined with the help of Computer Software SPSS (Statistical Package for Social Science) and used regression methods for the estimation of required study objectives.

RESULTS AND DISCUSSION

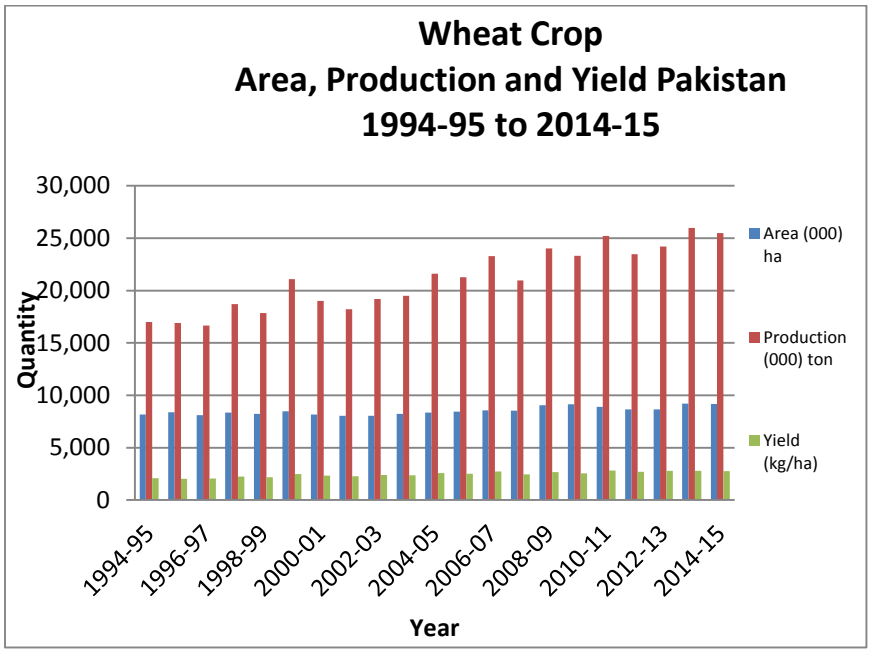
The country's wheat crop area were declined to 9180 (000 ha) 2014-15 since the 2013-14 area of 9199 (000 ha) at the rate of decrease of 0.2 percent. The wheat production has placed at 25.478 million tons in 2014-15, with the decreased rate of 1.9 percent as the last year's production of 25.979 million tons. The production shortfall due to shifting in weather trend apart from moderate and it was climate change. The wheat in Pakistan is given in table 1 and figure 1.

TABLE-1
AREA, PRODUCTION AND YIELD UNDER WHEAT CROP 1994-95 TO 2014-15 PAKISTAN

Year	Area (000 hec)	Production (000 tons)	Yield (kg/hec)
1994-95	8,170	17,002	2,081
1995-96	8,376	16,907	2,018
1996-97	8,109	16,651	2,053
1997-98	8,355	18,694	2,238
1998-99	8,230	17,858	2,170
1999-00	8,463	21,079	2,491
2000-01	8,181	19,024	2,325
2001-02	8,058	18,226	2,262
2002-03	8,034	19,183	2,388
2003-04	8,216	19,500	2,375
2004-05	8,358	21,612	2,568
2005-06	8,448	21,277	2,519
2006-07	8,578	23,295	2,716
2007-08	8,550	20,959	2,451
2008-09	9,046	24,033	2,657
2009-10	9,132	23,311	2,553
2010-11	8,901	25,214	2,833
2011-12	8,650	23,473	2,714
2012-13	8,660	24,211	2,796
2013-14	9,199	25,979	2,797
2014-15	9,180	25,478	2,775

Source: Pakistan Bureau of Statistics 2015

FIGURE-1



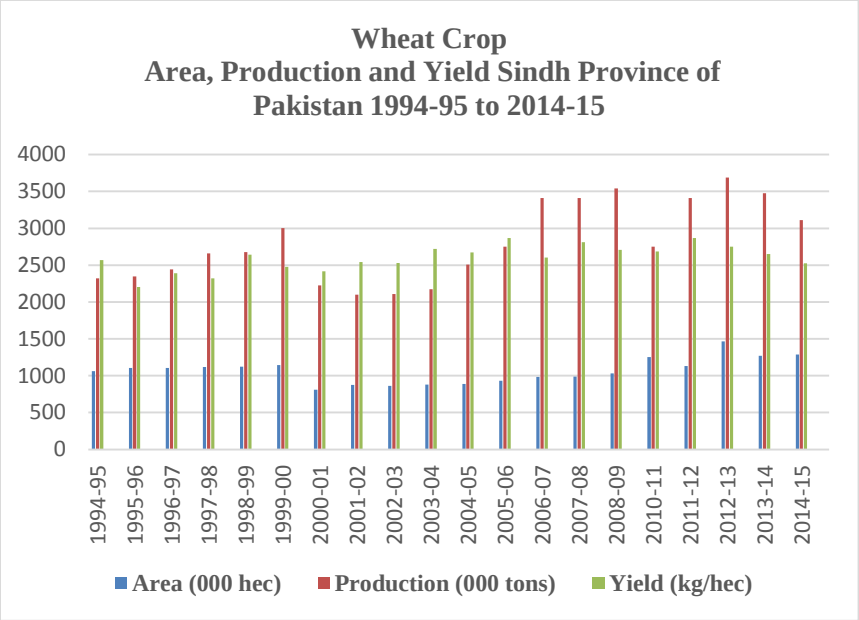
In Pakistan, Sindh province grow wheat crop which is only on 19 percent of the total wheat area as compared with other provinces. The area and production under wheat crop in Sindh province, during last 20 years is given in table 2 and figure 2.

TABLE-2
AREA, PRODUCTION AND YIELD UNDER WHEAT CROP
1994 T0 2014 SINDH PROVINCE OF PAKISTAN

Year	Area (000 hec)	Production (000	Yield (kg/hec)
1994-95	1063.0	2319.1	2568.8
1995-96	1106.4	2344.8	2205.2
1996-97	1106.8	2443.9	2390.4
1997-98	1120.2	2659.4	2322.9
1998-99	1123.7	2675.1	2643.2
1999-00	1144.2	3001.3	2477.1
2000-01	810.7	2226.5	2414.6
2001-02	875.2	2101.0	2540.5
2002-03	863.7	2109.2	2527.1
2003-04	878.2	2172.2	2720.7
2004-05	887.4	2508.6	2671.4
2005-06	933.2	2750.3	2868.6
2006-07	982.2	3409.2	2603.3
2007-08	989.9	3411.4	2809.3
2008-09	1031.4	3540.2	2705.1
2010-11	1252.4	2750.3	2685.2
2011-12	1131.4	3411.4	2866.4
2012-13	1466.5	3688.5	2748.8
2013-14	1272.2	3476.4	2649.1
2014-15	1287.1	3111.4	2527.0

Source: Pakistan Bureau of Statistics 2015

FIGURE-2



DESCRIPTIVE STATISTICS

Pakistan's wheat production covers less or more 8.6 million hectares followed per year production less or more 23.5 million tones. Sindh, wheat is on around 0.9 million hectares through an average year contribution of around 3 million tones. Table 03 presents the summary statistics of the climate and crop yield variables used in the study. The mean level of annual precipitation was 963 mm per annum with a standard deviation of 196.9 mm and the mean annual temperature over the past 20 years (1994-95 to 2014-15) was around 42.44°C with a standard deviation of 3.44°C.

TABLE-3
EXOGENOUS AND ENDOGENOUS VAR VARIABLES STATISTICS

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Wheat yield	kg/ha	2,172	812.29	1311	2,774
Precipitation/Rainfall	mm	963	196.9	653.7	1,716.5
Temperature	Celsius	35.44	3.44	21.68	49.19

PANEL UNIT ROOT TEST

It is essential to investigate the presence of panel unit roots for each variable before estimation of the data model. Table 04 presents the results of Sim, Pesaran & Shin (2003) unit root test with the assumption that error term in the autoregressive process of each variable is serially uncorrelated. The test figures out that the null hypothesis of the unit root is discarded for variable with trend (yield of wheat, precipitation trends / rainfall and temperature) at the one percent significance level. Since the panel unit root results reject the null hypothesis of non- stationary, each variable is stationary. Thus, there is no need to first-difference the data to eliminate unit roots (McCarl *et.al.*, 2008; Kim and Pang, 2009; Sarker *et.al.*, 2012) and we can estimate the panel data models. Furthermore, the following figure 03 to figure 06 showing the main affected associated factors of climate change viz. temperature and precipitation trend or level of differences. Resultantly, the both variables affect badly the productivity of wheat crop.

TABLE-4
PANEL UNIT ROOT TEST WHEAT VAR VARIABLES STATISTICS

Test	t-bar statistics
Wheat yield	-4.78***
Precipitation/Rainfall	-4.49***
Temperature	-3.63***

*** $p<0.01$

FIGURE-3
IMPACT OF RAINFALL ON WHEAT YIELD

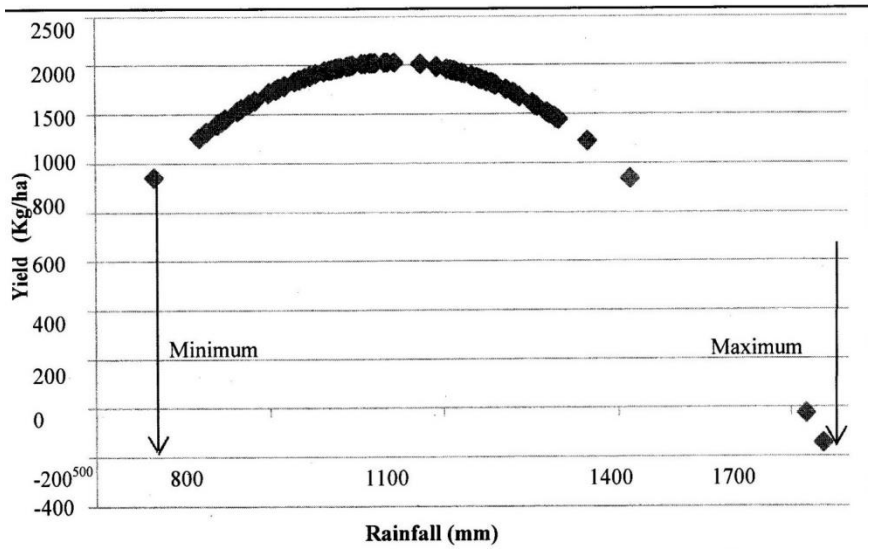


FIGURE-4
IMPACT OF TEMPERATURE ON WHEAT PRODUCTIVITY/YIELD

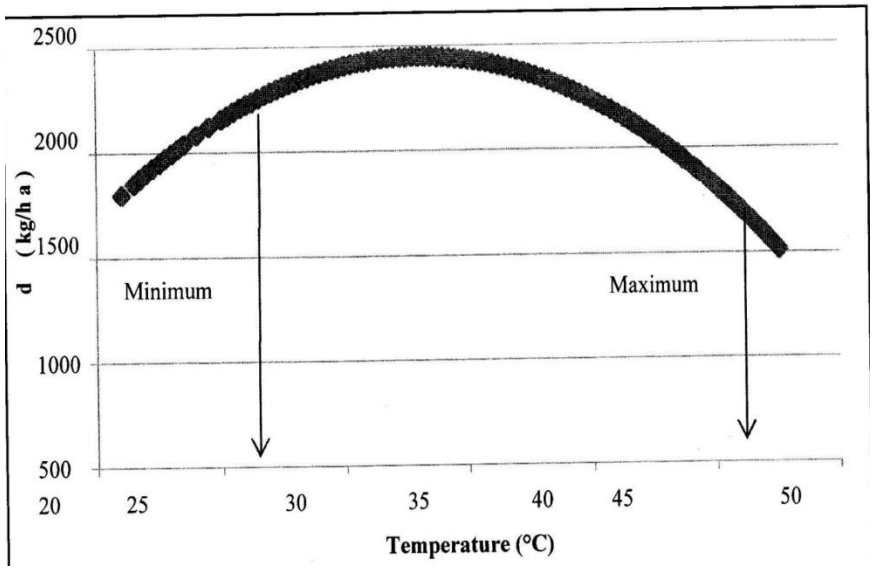


FIGURE-5
PROJECTIONS OF MEAN ANNUAL TEMPERATURE IN SINDH UNDER CLIMATE CHANGE
Scenario (degree Celsius)

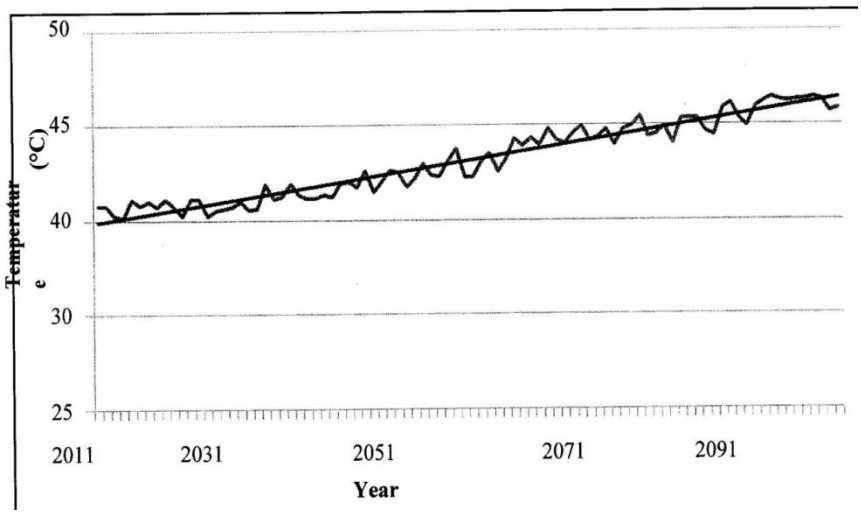
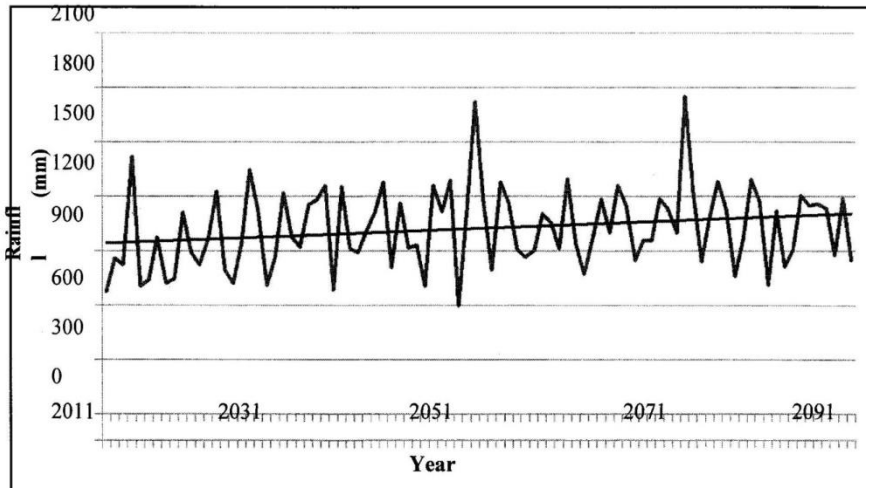


FIGURE-6
PROJECTIONS OF MEAN ANNUAL RAINFALL IN SINDH PROVINCE OF PAKISTAN UNDERCLIMATE CHANGE SCENARIO (MM PER ANNUM)



Regression Analysis of the Associated Factors Wheat Productivity/Yield: Wheat yield computed on the basis of secondary data. It was ranged from 20 (40kg/acre) to 30 (40kg/acre) with an average of 25 (40kg/acre). Regression analysis of the associated factors that impact on Wheat productivity is given in Table 05. It observed the temperature and precipitation trend were resulted non-significant, the planting method had significant effect on the yield. Similarly, the coefficient of planting phase was while helpful, but statistically non-significant. Coefficient of the precipitation level was negative and irrelevant indicating negative relationship between planting period and Wheat yields. The technique of adjusted R square value for the regression was 0.27, involving that associated factors in the equation have observed at the value of 29 percent variation in productivity and yield given in table 5.

TABLE-5
REGRESSION ANALYSIS OF THE FACTORS AFFECTING WHEAT YIELDS, 1995 TO 2014

Variable	Reg.	S. E.	t-value
Coefficient			
Planting method	0.282	0.090	3.73**
Planting period	0.139	0.132	1.08*ns*
Temperature	1.064	1.494	0.181*ns*
Precipitation	-0.689	1.269	-0.543*ns*
Constant	3.174	1.380	-
R-square	0.2731	-	-
F-ratio	5.088**	-	-

**⟹Highly significant
*⟹Significant
ns⟹Non-significant

The above results indicated that the high temperature range from $\mathbf{40^0C}$ to $\mathbf{51^0C}$ with the heavy precipitation trend found during the tie series data era for wheat productivity or yield has a negative effect on wheat crop.

VECTOR AUTO REGRESSION (VAR) ANALYSIS

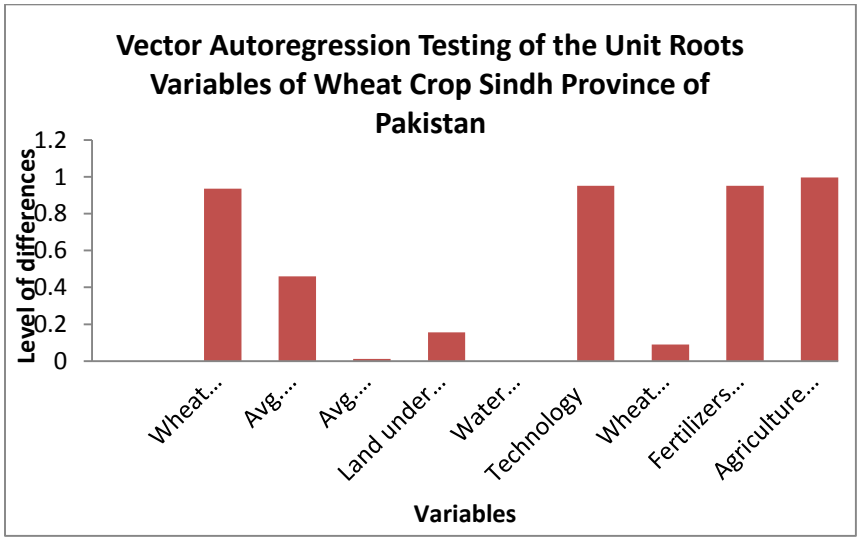
The Unit root testing is crucial for Vector Auto regression (VAR) variables. Then it is validates variables or inactive, therefore

the Augmented Dickey-Fuller (ADF) is included. The results of the unit root test are in table 06 and figure 7.

TABLE-6
VECTOR AUTO REGRESSION (VAR) TESTING OF THE UNIT ROOTS VARIABLES OF WHEAT CROP

S. No.	Variables	Level of differences
1	Wheat Production	0.9349
2	Avg. Temperature	0.4602
3	Avg. Precipitation	0.0116
4	Land under wheat	0.1565
5	Water Availability	0.0000
6	Technology	0.9512
7	Wheat procurement price	0.0900
8	Fertilizers off take	0.9512
9	Agriculture credit	0.9959

FIGURE-7



The outcome of the ADF test explains the non-stationary of the model variables at conservative levels of the significance. As a result, the values in the table confirm that all the variables are stationary at

level of first difference, which shows that all the variables are integrated of order 1, whereas water availability data is already in the stationary form.

Projected Wheat Availability for 2016 Using Vector Auto Regression (VAR) Model: The co-efficient of wheat crop variables from Vector Auto regression (VAR) applied and out-come expected values and it has verified after the VAR analysis that the projected figure for 2016 wheat availability/production will be 22,237.932 thousand ton. But the requirement of the country is estimated less or more between the 23 to 25 thousand tones. Nearly, the entire outcomes of the study are viewing that the slightly negative impact of climate change and damage will be on the wheat productivity for the year 2015-16. The results purely understood in parallel way that in theoretically and practically consideration of possible futuristic adverse climate change impacts. However, following factors might be less or more going, positively as well as negatively and this has the alarming icon for the requirement of better and sagacious policy to the sustainable agricultural development.

The following factors realized after the results that affecting the wheat productivity than volume of the production in Sindh province of Pakistan: (i) The country having world top most glaciers consequently melting of these glaciers due to the increased heat (temp.) makes extra volume water availability and more heavy floods happen in both negative (-) and positive (+) may impact on wheat productivity, (ii) Area of wheat crop is also rising or declining due to additional water supply within the risk of uncertainty of heavy floods. The other associated factors which could be making negative image on the production of wheat, (iii) The shifting trend of rainfall has globally. Heavy intensity of precipitation in the wheat areas than production may damage adversely including wheat productivity, (iv) Modification in the technology regarding new ways of cultivation with the help of adaptation and mitigation strategies, crossed new variety seeds, improved fertilizers, timely government facilities and subsidized reasonable procurement prices be also may create healthy better impact on the productivity.

CONCLUSION

This research concludes that the impact of climate change is the major element of uncertainty about wheat productivity and resultantly

adverse implications on food security and its growth. The results and predicted values after the analysis show that the raise in signify maximum temperature will decrease the wheat productivity. The coefficient for the precipitation level and temperature are negative as well as insignificant indicating negative relationship between planting period and wheat yields. Adjusted R square value for the regression equation is 0.2731, implying that factors included in the equation have explained at least 27 percent variation in wheat productivity. The estimated values of regression parameters such as Y-intercept, temperature and precipitation level are calculated as -0.235 and -0.670532 respectively. Furthermore, study results explored that not only affecting directly (health) but also severe and gradually affecting indirectly such as; agricultural productivity, livelihood practices and most importantly the damage in the process of economic growth and its development. The cost of cultivation in high yield areas will be increasing and land size decreasing that putting pressure for the agricultural production impediments.

RECOMMENDATIONS

The results suggested that the efficiency of land, water and fertilizer use practices should be modernized through the strategies of adaptation and mitigation in new emerging policies. It is deduced from the study outcome that government may take part in monitoring climate change and additionally very keen focused to agriculture productivity. A well-defined planning and sagacious policies will be play adaptation production practices of the wheat growers. New hybrid and climatic resistance controlled crop varieties may be introduced. Newly emerging crops may be introduced in those have ability with higher heat and malnourishment tolerance will help falling potential concerns. Lastly, the government could organize irrigation with other advance projects. The high temperatures region and inadequate irrigation system needs the accessibility of modern irrigation technologies may well increase agricultural productivity. Therefore, adaptation and mitigation strategies may overcome the situation and less or more face the climate change constraints.

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