Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.14, 2015

Effect of climate change on Rice Production in Punjab

Syed Hassan Raza
Lecturer, National University of Modern Languages Faisalabad Campus

Dr. Sofia Anwer
Professor, Head of Economics Department, G.C University Faisalabad.

Abstract
Basic purpose of this paper is to check the effect of climate on the rice production of Punjab Pakistan. Secondary data of rice crop production of seven districts of Punjab were used for analysis. These districts are Multan, Bahawalpur, Faisalabad, Lahore, Jhelum, Sialkot and Sargodha which are selected on the bases of high rice production. Data is taken from Pakistan Bureau of Statistic and Pakistan Meteorological development. Fixed Effect model was used to analysis the data. The finding shows that temperature has positive effect on rice but it became harmful after the optimum point .Rainfall does not affect the any stage of rice production of Punjab.
Keywords: Rice Production, Temperature, Rainfall, fixed effect model, climate, Pakistan

Section-I Introduction

Agriculture is one of the aged economic activities in all over the world. It is the backbone of food grain supply to the work force and supply raw material to the industries. Pakistan is an agricultural country. Forty seven percent Pakistani are related with agriculture sector. Its contribution to GDP is 22 percent. The rank of Pakistan is 28th among those countries which is highly damage to the climate change (economics survey 2011-12). Agriculture sector highly depends on climate conditions. Agriculture productivity is affected by many of climate variables which include change in temperature, change in the pattern of rainfall and changes in dates of sowing and harvesting.

About 60 percent of Pakistan's exports depend on agriculture sector. Population of Pakistan is increasing consistently so there is major problem to provide them adequate food without damaging fragile ecosystem. Climate changes affected the productivity of crops and also negatively affect the health of livestock which create the problem of food security in the country. Floods, cyclones and draughts etc. also reduced the productivity of crops and create shortage of agriculture related goods. (Task Force on climate change, 2010).

The phenomenon of climate change is more in Pakistan as compared to other countries because it is located in the area where the expected rate of increasing temperature is higher than the overall average. The land of Pakistan is mostly semi-arid and arid where 60 percent of that region receives fewer than 250 mille meter (mm) annually whereas 24 percent obtained 250 to 500 mm. Its rivers are mostly fed by the Karakoram, Himalayan and Hindu Kush glaciers which are accounted to be retreating rapidly due to the global warming. The economy of Pakistan is mostly depends on agricultural sector also very sensitive to climate. The variability in the rains of monsoon brings droughts and floods in the country but the food security, energy security and water security in Pakistan are very serious thrift (Task Force on Climate change, 2010).

Climate changes became the serious threat to the crop sector. The change in temperature and rainfall directly affect the crops. (Usman, et.al.,2011) found that temperature has negative and significant effect on the agricultural production. They found that 1% increase in temperature which cause by PRs. 4180 decreased by net revenue per annum. Increasing GHG's will change the agricultural farm in low developing countries as compare to developing countries (Kurukulasuriya et al.,2006; Mendelsohn and Seo,2008). Climate change could not have massive effect but regional effects are wider. Some region will advantage from climate change while some area will be severely affected. Climate change will only effect the production of agriculture commodities. (Kaiser and Drennen 1993). Some of the study shows that low temperature reduce the production of wheat crops (Kayam et al., 2000) whereas an increase in temperature and rainfall negatively correlated with the yield of rice crops (Saseendran et al,. 2000).1% raise the minimum temperature which decrease the rice production about 10% (Peng et al,. 2004).

The main purpose of this study to investigate the effect of climate change on rice production of Punjab (Pakistan).

Section-II methodology

In this study panel data is used of different station of Punjab i.e. Faisalabad Lahore Bahawalpur Sargodha Multan Sialkot and Jhelum. The analysis carried out on Rice production of Punjab. The information about scientific variables were taken from (PARC) Pakistan Agricultural Research Council. For Rice crops analysis, the station wise selection of the districts were made according to the productivity. Rice consists of three stages of production and three different temperature and rainfall.

Data of seven different districts of Punjab of crop production temperature and rainfall from period 1980 to 2012 are taken from

- Pakistan Bureau of statistics
- Pakistan Meteorological Department

Model of the study

$Crop_{iR} = \alpha_o + \alpha_1(FST) + \alpha_2(FSTS) + \alpha_3(SST) + \alpha_4(SSTS) + \alpha_5(TST) + \alpha_7(TSTS) + \alpha_8(FSR) + \alpha_9(FSRS) + \alpha_{10}(SSR) + \alpha_{11}(SSRS) + \alpha_{12}(TSR) + \alpha_{13}(TSRS) + €_{it}$

α_o = intercept of the model

α's = slope co-efficients of the model

Table: Labeling of Variables

Dependent variable.	Crops	Rice Production
Independent variables	*FST*	First Stage Temperature which consist on August month. Secondary data used which is taken from the Pakistan Meteorological Department (1980-2010)
2	*FSTS*	First Stage Temperature Square.
3	*SST*	Second Stage Temperature which consist on September and October. Secondary data used which is taken from the Pakistan Meteorological Department (1980-2010)
4	*SSTS*	Second Stage Temperature Square.
5	*TST*	Third Stage Temperature which consist on November. Secondary data used which is taken from the Pakistan Meteorological Department (1980-2010)
6	TSTS	Third Stage Temperature Square.
7	FSR	First Stage Rainfall
8	FSRS	First Stage Rainfall Square
9	SSR	Second Stage Rainfall. Secondary data used which is taken from the Pakistan Meteorological Department (1980-2010)
10	SSRS	First Stage Rainfall Square
11	TSR	Third Stage Rainfall. Secondary data used which is taken from the Pakistan Meteorological Department (1980-2010)
12	TSRS	Third Stage Rainfall square.

Analysis of the Data

Panel data is a data for different entities observed at different time periods it is also called longitudinal data. One of the advantages of panel data is that it allows controlling the influence of unobserved variable and the fixed effect regression method is used for this purpose. The Fixed effect regression model is applicable when data is observed at more than two time periods. In fixed effect regression model the unobserved variables are assumed to be time invariant and change across entity. Let suppose the following regression equation with single regressor as:

$$Y_{it}= \beta_o+\beta_1X_{it}+\beta_2Z_i+\mu_{it} \quad \ldots\ldots(1)$$

Where i=1,2,3,…,n and t=1,2,3,…,T and Z_i is omitted variable that is time invariant ($Z_{it}=Z_i$)

The above equation can be write as

$$Y_{it}= (\beta_o +\beta_2Z_i)+\beta_1X_{it} +\mu_{it}$$

Let $\alpha_i= \beta_o+\beta_2Z_i$

$$Y_{it}= \alpha_i +\beta_1X_{it} +\mu_{it} \quad \ldots\ldots\ldots\ldots(2)$$

The above equation is called fixed effect regression model in which $\alpha_{i=} \alpha_1 ,\ldots, \alpha_n$ are n different intercepts one for each entity and β_1 is slop of regression equation which remain constant for all entities. $\alpha_i$is also known as entity fixed effects because the variations in intercepts (α_i) comes from omitted variables that are constant over time and change across entity to entity.

There might be some omitted variables which may change over time but not change across entity. The regression equation with single regressor can be written as:

$$Y_{it}= \beta_o+\beta_1X_{it}+\beta_2\phi_t+\mu_{it} \quad \ldots\ldots(4)$$

Where i=1,2,3,…,n and t=1,2,3,…,T and ϕ_t is omitted variable that is entity invariant ($\phi_{it=}\phi_t$)

The above equation can be write as

$$Y_{it}= (\beta_o +\beta_2\phi_t)+\beta_1X_{it} +\mu_{it}$$

Let $\gamma_t= \beta_o+\beta_2\phi_t$

$$Y_{it}= \gamma_t +\beta_1X_{it} +\mu_{it} \quad \ldots\ldots\ldots\ldots(5)$$

The Eq. (5) is called time fixed effect regression model in which $\gamma_t = \gamma_1, ..., \gamma_T$ are different intercepts one for each year and β_1 is slop of regression equation which remain constant for all years. $\gamma_t$is also known as time fixed effects because the variations in comes from omitted variables that are constant across entity and change over time.

Time Fixed effect regression model can be represented in the form of dummy variables to symbolize the single time period. Equation (4) in the form of dummy variables can be write as:

$$Y_{it} = \beta_o + \beta_1 X_{it} + \delta_2 D_{2t} + \delta_3 D_{3t} + \delta_4 D_{4t} + \ldots + \delta_n D_{nt} + \mu_{it} \ldots\ldots \quad .(6)$$

It is assumed that $D_{2t} = 1$ for t=2 and $D_{2t} = 0$ for $t \neq 2$, $D_{3t} = 1$ for t=3 and $D_{3t} = 0$ for $t \neq 3$, so forth.

T-1 entity binary variables are included to avoid the dummy variable trap.

There is a possibility that some omitted variables are time invariant and some omitted variables are entity invariant. In such case to control the influence of omitted variables both entity fixed and time fixed effects are included. The regression model with both entity fixed effect and time fixed effect can be written as:

$$Y_{it} = \beta_1 X_{it} + \alpha_i + \gamma_t + \mu_{it}$$

Where α_i is entity fixed effect and γ_t is time fixed effect.

This model can be represented by n-1 entity binary variables, T-1 time binary variables and single intercept as:

$$Y_{it} = \beta_o + \beta_1 X_{it} + \pi_2 D_{2i} + \pi_3 D_{3i} + \pi_4 D_{4i} + \ldots + \pi_n D_{ni} + \delta_2 D_{2t} + \delta_3 D_{3t} + \delta_4 D_{4t} + \ldots + \delta_n D_{nt} + \mu_{it} \quad \ldots\ldots..(7)$$

Where $\beta_o, \beta_1, \pi_2, \pi 3, \pi 4, \ldots, \pi_n, \delta_2, \delta_3, \delta_4, \ldots, \delta_n$ are unknown estimators of regression equation (7)

III Results and Discussions

RICE

Rice is the major crop.The snowing date of rice is different for different qualities. For coarse rice nursery should be sown from 20th May upto 7th June and for fine rice nursery should be sown from 1st June to 20th June and the harvesting date is Sep to October. It also passes through some stages and that stages are

- Tillering
- Emergence of floret
- Anthesis
- Grain filling stage
- Physiological maturity

But the most critical stages are

- Tillering
- Grain filling stage

There is different temperature required at different stage of growth for rice that are as below

Temperature requirement for germination:

- Minimum 16 ºC
- Optimum 25-30 ºC
- Maximum 35 ºC

Temperature requirement for growth:

- Minimum 20 ºC
- Optimum 30-35 ºC
- Maximum 45 ºC

Table: Effect of temperature and rainfall on Rice Production in Punjab (1980-2012) through Fixed Effect Model

Dependent Variable: Production of Rice (Thousands of Tones)

Variable	Co-efficient	t- statistic
First stage temperature	-4.981129	-0.84
Second stages temperature	9.899661	2.44
Third stage temperature	10.9354	1.72
First stages rain	-0.0194619	-0.53
Second stage rain	0.0470745	0.31
Third stage rain	0.011017	0.04
Intercept	-260.0831	-1.16

Table: Robust Co-efficient Of Linear Rice Production Model in Punjab (1980-2012) Through Fixed Effect Model

Variable	Co-efficient	t-statistic
First stage temperature	-3.290258	-0.69
Second stages temperature	9.40179	1.71
Third stage temperature	11.15231	1.95
First stages rain	-	-
Second stage rain	-	-
Third stage rain	-	-
Intercept	-306.5024	-1.22

This section explores the effect of climate change on rice production of 4 districts of Punjab, Pakistan. Data of rice production of Lahore, Sargodha, Sialkot and Faisalabad is selected on the bases of their production. The rice crop consist on four month period August September October and November.it consist on three main stages of production that is Germination, Flowering and Ripening.in this study rice crop divided into three stages. First stage consists of only August month, second stage having two month, September and October and third stage consisting on November. The result of rice production is given in the above table.

Two models were estimated to estimate the effect of climate changes on rice production. The above table shows the stages of Temperature and rain fall used as independent variable. The results shows that second and third stage of temperature effects the crop production positively because seconding stage is flowering and third stage is ripening, at this stage croprequired high temperature. The co-efficient of second stage is 9.899 which show that 1^0C increase in temperature 9.899 thousand tones increase the rice production of four districts. Second stage temperature co-efficient also indicate that $1C^o$ increase in temperature in third stage which cause by 10.9354 thousand tones increase in production of rice. First stage temperature shows insignificant effect that shows temperature at this stage are in optimum point throughout the period. The effect of rainfall in all the stages have insignificant. Second table shows results of robust coefficient. Temperature and rainfall of significant variable used as independent variables that also indicate second and third stage temperature have positive and significant effect on the rice production. This shows the robustness in term of sign and significant.

Table: Effect of temperature and rainfall on Rice Production non-linear model in Punjab (1980-2012) through Fixed Effect
Dependent Variable: Production of Rice (Thousands of Tones)

Variable	Co-efficient	T statistic
First stage temperature	-14.36842	-0.26
First stage temperature square	.1936484	0.24
Second stages temperature	101.2737	1.92
Second stage temperature square	-1.452196	-1.72
Third stage temperature	67.03638	1.94
Third stage temperature square	-1.247912	-1.67
First stages rain	107.0744	1.51
First stage rain square	-.0000827	-0.70
Second stage rain	.297385	0.63
Second stage rain square	-.0024093	-0.70
Third stage rain	.0372766	1.01
Third stage rain square	.0000957	0.01
Intercept	2197.577	2.14

Table: Robust Co-efficient of Rice Production non-linear model

Variable	Co-efficient	t-statistic
First stage temperature	-15.8832	-0.36
First stage temperature square	.1812297	0.28
Second stages temperature	87.86657	1.91
Second stage temperature square	-1.248875	-1.67
Third stage temperature	74.12576	2.45
Third stage temperature square	-1.404528	-2.10
First stages rain	-	-
First stage rain square	-	-
Second stage rain	-	-
Second stage rain square	-	-
Third stage rain	-	-
Third stage rain square	-	-
Intercept	-1983.393	-2.64

The above table shows that rainfall and temperature used with their square term to find the non-linear relation impact on the variable. The result confirm that temperature nonlinear related to rice production in second and third stages the result shows that at second stage temperature is beneficer for rice production but the square term of second stage shows that at certain amount of temperature further increase in temperature harmful for production. The certain limit of second stage is 26.75^0C before this certain limit temperature has positive effect at the second stage and beyond this certain amount temperature effect negatively. Third stage temperature also shows that temperature has positive effect on production and it also show significant effect its co-efficient shows $1C^o$ increase in temperature cause by 67.03638 thousands of tones increase the rice production. Result of this stage also indicate that square term of third stage have negative and significant effect that shows after the optimum temperature at third stage temperature effect negatively and optimum temperature of this temperature is 24^0C (Chaudhary *et al*., 2002). It shows before this optimum temperature effect is positive after this limit temperature effect negatively. First stage result shows that at this stage temperature has insignificant effect and no evidence found the non-linear relationship. It means that temperature in all the stages remains in the optimum for the whole period of the stages. First stage optimum temperature is 27^0C. Tableshows the results of significant variables that also confirmed that second and third stages temperature has positive and significant effect on rice production and also showed existing of non-linear relationship.

An interesting result found in this study that rainfall shows insignificant effect in all three stages. The justification of this result is that the optimum 40mm rainfall required but the actual rainfall of this period is 20mm the deficiency is 20mm (siddiqi *et al*., 2011).this deficiency remove by artificial sources that is tube well and arrange irrigation through canal. The first two stages which almost include 75 days crops should have 6mm water. Third stage of rice is the maturity stages (month of November) at this stage less water required for rice crops the average rainfall in this stage is 6mm which is not harmful for the rice production.

Conclusion

The main purpose of this study was toanalyze the effect of climate variables on rice production of Punjab. Panel data used different station of Punjab. For data analysis Fixed Effect Model used. First model showed the linear effect of the variables and second indicated non-linear relation between the variables. The results of rice production show that temperature has positive effect on rice production but it is harmful after the optimum point. Rainfall result shows that it does not affect the rice production at any stage of production and no evidence found the existing the non-linear relation.

References

Chaudhary, R. C., Nanda, J. S. and Tran, D.V. (2002), "Guidelines for Identification of Field Constraints to Rice Production", International Rice Commission, Food and Agriculture Organization of the United Nations, Room.

Kayam, Y., U. Ozsoy, J. Lomas, O. Oden, M. Mandel and M. Gurbuz (2000). The impact of climatic change on wheat production of Aegean region in Turkey: The effect of a reduction of rainfall and the increase of temperature on wheat yields. Available online at http://www.fao.org/sd/climagrimed/pdf/ws01_26. pdf Parry, M. L., T. R. Carter and N. T. Konjin (1988b).

Kaiser,H.M and Drennen,T.(1993) Agricultural dimensions of global climate change. St. Lucie, FL:St. Lucie Press.

Kurukulasuriya,P. et al (2006) Will African Agriculture Survive Climate Change? The world Bank Econo.Rev. 20; 367-388.

Peng et al (2004). Rice yield decline with higher night temperature from global warming. In E.D. Redona, A.P. Castro & G.P. Llanto, eds. Rice Integrated Crop Management: Towards a Rice Check syatem in the Philippines, p. 46–56. Nueva Ecija, Philippines, PhilRice.

Saseendran, S. A., K. K. Singh, L. S. Rathore, S. V. Singh and S. K. Sinha (2000). Effects of climate change on rice production in the tropical humid climate of Kerala, India. Climate. Change. 44;495-514.

Siddiqui et at (2011) The Impact of Climate Change on Major Agricultural Crops: Evidence from Punjab, Pakistan. Pakistan institute of development economics.

Usman et al (2011). Impact of Climate Change on Agriculture: Empirical Evidence from Arid Region. Pak. J. Agri. Sci. 48(4), 327-333.

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

Academic conference: http://www.iiste.org/conference/upcoming-conferences-call-for-paper/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar