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IMPACTS OF CLIMATE CHANGE ON AGRICULTURAL LAND PRODUCTIVITY: AN EVIDENCE FROM PUNJAB PROVINCE OF PAKISTAN

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ABSTRACT

The recent change in climate has affected the global agricultural land productivity. In the current agrarian economy of Pakistan, climate change is becoming the burning issue. The change in temperature and rainfall patterns has become very threatening factor in the crop sector of the arid zone. The study undertaken carries an empirical investigation to estimate the impacts of climate change on the agricultural land productivity of Province Punjab, Pakistan. Auto Regressive Distributed Model has employed for this purpose. Time series data from 1985 to 2015 has been used in the research undertaken. The estimation of the study confirmed that a rise in average temperature and increase in average rainfall along with two non-climatic variables, i.e. fertilizer and credit disperse are affecting the agricultural land productivity significantly. Hence, it is critical to formulate the policy measures to mitigate the adverse impact of climate change on agricultural land productivity. Plant breeders should focus on the heat resistant seed varieties to mitigate the effect of increasing average temperatures and drought resistant to bear the water shortage because of disturbances in rain patterns in Province Punjab, Pakistan.

Keywords: Agriculture, average temperature, average rainfall, change in climate and land productivity, Punjab.

INTRODUCTION

Climate change effects in three ways to the crop sector. Firstly, soil moisture is changed due to changes in temperature and rainfall. Secondly, the temperature has a straight effect on yield. Different crops need different optimal growing conditions, so a minor increase in temperature damages the production levels of those crops which are exposed under some given conditions. Thirdly, increasing level of CO_2, concentration improves growth of certain crops (Houghton *et al.*, 2001). Climatic aberrations are happening in Pakistan across the whole country. Investigation of historical meteorological factors depicted the altering nature of climate. The nature of change in climate along its rate impacts will swing over time throughout Pakistan. Earlier record and forecasts by GCMs (Global Climate Model) and RCMs (Regional Climate Model) described that acute events would turn out to be more recurrent and of greater scale in diverse parts. Expected climate deviation in the area includes intensification in earth temperature, sea level rise and rise in the extent and rate of extreme rainfall happenings. Agricultural efficiency is expected to hamper intensively due to high temperature, severe drought and flood conditions. Improved forecasting systems for precise projection of regional climate change and its variableness must be developed (Farooqi and O'Rahilly, 2005).

Rainfall effects on South African agriculture were optimistic. Early summer and winter precipitation was useful in South Africa (Benhin, 2008). Bhutan's agriculture's reliance on monsoon and temperature change pattern is essential to evaluate because the evidences of climatic change in Bhutan are mostly extreme. Marginal changes in weather extremes are expected to bring food production losses to the sector in coming years. The treacherous effects of these adverse factors are concentrated in production agriculture and on food security (UNEP, 2009). It is important to understand that specific intensity of GHGs (Green House Gases) are obligatory to sustain the temperature of planet earth in order to sustain human and animal life. With and without these GHGs, the average earth temperature would set at a difference of stand at 15°C and -18°C, becoming mismatched for efficient sustainable life (Cattivelli and Sayed, 2010).

In the Asian Countries, the significant rise in the temperature has been estimated. The scenarios relating to the climate has forecasted the rise in temperature in the whole Asian region. The cooler parts of the globe are becoming warmer. The less certain alterations in the precipitation pattern are making the region wetter. During the wet seasons, heavy rain falls has been forecasted that will ultimately increase the chances of the flood. Moreover, on the other part, the dry regions are becoming drier. The current climate change is alarming for the agricultural land by minimizing the productivity and diminishing the economic growth (ADB, 2009)

In a recent study, Ricardian approach was used for wheat crop of Barani areas of Punjab in Pakistan. The

cross sectional data of farm inputs and outputs exposed that the increasing temperature has negative while increasing rainfall has a positive impact on net farm revenues as well as on crop production. But the overall beneficial impact of increasing level of rainfall cannot hack it with increasing levels of temperature. With all these climatic concerns, which may also increase in the recent future, improvement techniques are suggested including, changing cropping pattern, new and innovative irrigating methods with least loss of water during irrigation operation and new methods of crop farming (Shakoor *et al.*, 2011).

Agriculture sector of India has also veteran effects of climatic changes. Many studies have revealed that an increase in temperature could increase the rice yield, but would reduce wheat yields (Guiteras, 2009) United Nation Framework Convention on Climate Change (UNFCCC) acknowledged the environmental changes; a change which is the direct or indirect product of mankind's activities and which has brought changes in composition of the worldwide environment and which is pragmatic over comparable time periods. Climatic changes are the changes in the weather on the lengthened basis (Zeb *et al.,* 2013). The research undertaken also estimated the impact of many other variables on agricultural land productivity. Research also proposed significant policy measures to mitigate the adverse effect of climate change on land productivity in Province Punjab, Pakistan.

MATERIALS AND METHODS

Auto Regressive Distributed Lag (ARDL) approach: In macro-economics, initially the model was employed to estimate the impacts of all climatic variables along with the non climatic variables was Auto Regressive Distributed Lag Model (Janjua *et al*., 2010). Bond testing techniques have been employed to estimate the empirically long-run relations along the dynamics connections between the variables and the model used is named as ARDL model using bond testing method.

ARDL is an econometric technique that has been used mainly to capture the relationship between some important variables. Recently, in time series data, ARDL bond testing, method is considered a very useful tool to estimate the long-term relationship. In the "autoregressive" model, the lag of the independent variable is taken of itself. Likewise, it is also: distributed lag" because independent variable are stationary on level zero or level one respectively (Gujrati, 2009).

The significance of ARDL model is that it provides the comprehensive estimates of the variables. Moreover, it also decomposes the effect of every climatic and non- climatic variable individually on the agricultural land productivity in arid zone of Punjab, Pakistan. It is very easy to interpret the results of ARDL model because it is same as OLS regression model (Janjua *et al*., 2010).

Specification of the model: To estimate the climatic variables along with non climatic variables that have been taken under study, the general form of equation is as under:

Land Productivity= f (Average temperature, average rainfall, fertilizer used and credit disperse).

Econometric form of the model: The econometric form of model consist of lag of each independent variables which are as following

$$\Delta LP_t = \gamma_1 + \sum_{i-1}^{n} \alpha i \Delta AT_{t-1+} \sum_{i-1}^{n} \beta i \Delta AR_{t-1+} \sum_{i-1}^{n} \gamma i \Delta CR_{t-1+} \sum_{i-1}^{n} \delta i \Delta FR_{t-1+} \varepsilon_t$$

Here,

PD=Agricultural land productivity

AT=Average temperature

FR=Fertilizer used

CD=Credit disperse

AR=Average Rainfall

Variables and data requirements: Agricultural Statistics of Pakistan and Economic Survey of Pakistan are the secondary sources of the data used in the current study for the agricultural land production. The unit use for the agricultural land production is thousand tons. Pakistan Meteorological Department has provided the secondary data of climatic variables, i.e. average temperature and average rainfall. The average temperature is expressed in degree Celsius and average rainfall is expressed in milli meters. Data of credit disperse and fertilizer used are collected from the Agricultural Statistics of Pakistan.

RESULTS AND DISCUSSION

Testing of Stationary is the basic requirement for the employment of any time series model. The study undertaken has been used Augmented Dickey Fuller (ADF) test statistics to check the stationarity condition of the data (Dickey and Fuller, 1981).

The data set used for the assessment of extent of current problem has number of observation more than 20 years therefore unit root test is necessary to check the stationarity condition of the data (Chen *et al*., 2004). For the measurement of stationarity Augmented Dickey Fuller test statistics is employed here and the estiamtes are presented in table 1. All these calculated results show that maximum number of variable are integrated at order 1 or stationary at 1st difference except average temperature that is integrated at level. Estiamted results significantly represents that variable integrated at order 1 generlly become stationry only after taking their first difference after estimation (Gujarati *et al*., 2009).

ARDL results for Punjab Province: For the measurement of appropriate outcomes from ARDL method current study used following (4, 3, 0, 3, 0). The lags of such model is selected by using AIC and SBC lag selection criteria (Farooq and Kannan, 2015). The estimated value of F-statistics for long run relationship or cointegration is 7.09 which is greater than upper and lower bound value 2.86 and 4.01 at 5% level of significance. Thus, the null hypothesis of no co-integration has been rejected, suggesting long run relationship among variables or simply means that all above discussed variables have significant effect on the productivity. Estimated table of the results is given below:

Table 1. Estimated Results of ADF.

Variables	Stationary at Level (0)		Stationary at 1st difference		LEVEL
	Intercept	Trend & Intercept	Intercept	Trend & Intercept	
Land Productivity	-2.23	-3.19	-4.99	-6.09	*I(1)*
Average Temperature	-3.30	-4.46	-8.52	-8.56	*I(0)*
Credits Disperse	-0.88	-1.56	-4.21	-4.13	*I(1)*
Average Rainfall	-3.06	-1.60	-7.68	-8.83	*I(1)*
Fertilizer Use	-2.04	-0.18	-4.09	-4.77	*I(1)*

Table 2. Estimated results of ARDL.

Variables	Coefficients	Std. Error	T-statistics	Probability
PRR(-1)	0.5795	0.1736	3.33	0.005
PRR(-2)	-0.5042	0.2221	-2.27	0.042
PRR(-3)	0.9460	0.2773	3.41	0.005
PRR(-4)	-0.7289	0.2380	-3.06	0.009
AT	-3045.24	1384.45	-2.19	0.048
AT(-1)	-360.47	1576.95	-0.22	0.823
AT(-2)	-3601.82	1369.66	-2.62	0.022
AT(-3)	-2067.42	1493.42	-1.38	0.191
CD	591.42	205.43	2.87	0.013
AR	304.04	1264.33	0.24	0.814
AR(-1)	609.59	1311.46	0.46	0.650
AR(-2)	-1007.08	1188.35	-0.84	0.413
AR(-3)	-2305.78	1315.44	-1.75	0.105
FR	1014.47	732.34	1.38	0.191
C	27038.59	7992.74	3.38	0.005
R-Square	**0.98**	**F-Statistics**	**80.69(0.000)**	**DW. Stat=1.82**

The calculated coefficient of long run relationship shows that averge temperature along with lag value have highly significant negative effect on productivity. On the contrary estimated measure of credit disburse has significant positive effect of productivity while average rainfall and use of fertilizer have individually no significant effect but in overall situation both of the varibales has great imporatance and positive sign suggest that rise in both at certain level are benifical for productivity. However, goodness of fit of the model is arbitrated through R-square value which is 98 percent presenting that variation in productivity due to average rain fall, credit disperse, average temperature and fertilizer use is 98 percent while ramining 2 percent is due to other factors that are included in error term. In a given model value of R-square is quite high that cause the estimated reuts doubtful but such higher value is due to inclusion of large number of lags and having maximum significant value of lags. In time series modeling overall significane of the model is checked by F-statistics that is 80.69 with probability 0.000 showing that overall all model is significance by rejecting null hypothesis of at least coefficient estimates of one variable is non-zero. Similar to above discussion value of diagonestic test also prove that there is no auto correlation in the given data because Durbin Watson Statistics is closer to 2 which is the area of no auto correlation (Asteriou and Hall, 2015).

The Equilibrium Correction Coefficient has employed to verify the long term relationship. The values should be negative, significant and less than one. However, estimated measure of ECM is -0.7076 percent which is highly significant and have correct sign, imply that high speed of adjustment toward equilibrium after shock. In a simple word such meausres explains that around 70 percent disequlibrium from the preceding year's shock converge back to the long run equilibrium in

the current year.

Table 3. ECM estimates of Province Punjab.

Variables	Coefficients	Std. Error	T-statistics	Probability
D(PRR(-1))	0.287	0.1518	1.89	0.080
D(PRR(-2))	-0.217	0.1866	-1.16	0.267
D(PRR(-3))	0.728	0.2380	3.06	0.009
D(AT)	-3045.24	1384.45	-2.19	0.048
D(AT(-1))	3601.81	1369.66	2.62	0.022
D(AT(-2))	2067.46	1493.42	1.38	0.191
D(CD)	591.42	205.43	2.87	0.013
D(AR)	304.04	1264.33	0.24	0.814
D(AR(-1))	1007.08	1188.35	0.84	0.413
D(AR(-2))	2305.78	1315.44	1.75	0.105
D(FR)	1014.47	732.34	1.38	0.191
ECM(-1)	-0.7076	0.1328	-5.32	0.002

Conclusion and Recommendations: From the estimates, it is articulate that the evolving risk of the change in climate is affecting the agricultural land productivity adversely in Province Punjab. The increase in average rainfall and average temperature could be valuable for increasing the land productivity. The study undertaken carries an empirical investigation to estimate the impacts of climate change on the agricultural land productivity of Province Punjab, Pakistan. Auto Regressive Distributed Model has employed for this purpose. Time series data from 1985 to 2015 has been used in the research undertaken. The estimation of the study confirmed that rise in average temperature and increase in average rainfall along with two non-climatic variables i.e. fertilizer and credit disperse are affecting the agricultural land productivity significantly. Hence, it is critical to formulate the policy measures to mitigate the adverse impact of climate change on agricultural land productivity. It is drawn from the findings that government can play its role by monitoring climate change and its likely impact of agriculture and then disseminate the results of this monitoring in addition to level play field for adaptation practices of the farmers. New crop varieties along with conservation agriculture practices should be followed which are more suited to a warmer climate of the Punjab region. New crops with increased heat and drought tolerance will help reducing potential damages. Policies that increase farmer flexibility would also help allow farmers to adjust to new conditions. Finally, the government could help organize irrigation and other development projects. Irrigation water and the availability of modern irrigation technologies could become increasingly valuable. Different research groups have to evaluate new methods of crop farming and also revaluate cropping patterns according to new world of climate change. Accessibility of the farmers to seeds, fertilizers and pesticide before the new season will certainly improve the net revenues of the farm. The role of Extension services is very important for dissemination of scientific based information to the farmer on their farms.

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