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The Climate Change Dynamics and its Impact on the Wheat Productivity in Pakistan: A VAR Approach

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Abstract

The protracted change in climatic conditions because of the natural or anthropogenic activities is termed as climate change. It is mainly caused by human induced emission of greenhouse gases like Carbon dioxide CO_2, Methane CH_4, Nitrous oxide NO_2. These gases trap the sunlight, rising the earth's temperature and altering the pattern of precipitation, humidity across countries and causing some sever damages to the economies. Yearly data (from 1971 to 2009) published by the Metrological Department of Pakistan and Agriculture Statistics of Pakistan is being used. Vector Autoregressive Modeling is applied to study the impact of the climate change on wheat productivity. The result of the model shows that the rising temperature leads to reduction in output as the variation in the wheat productivity has been brought mainly by the variation in the temperature that is 25 percent in the tenth period as shown by the variance decomposition.

Keywords: Anthropogenic activities; Variance decomposition; Impulse response function; Climatic and non-climatic variables

Introduction

Global warming will trigger severe changes in the global climate in near future and will have significant impacts on economies round the globe. This potential threat to our existence has been steadily growing as a major concern of scientists and economists. It is therefore imperative to understand the impacts on the world economies that changes in climate might cause. This threat is a result of anthropogenic emissions of certain gases, most notably CO_2, CH_4, CFC, NO_2 and water vapors into the atmosphere, contributing to a general process known as the greenhouse effect. The term greenhouse gas has been applied to atmospheric gases that are relatively transparent to incoming short wave solar radiation but which absorb the long wave radiation from the surface of the earth and remit it downward, warming the surface of the earth and the lower atmosphere.

Climate change refers to 'changes in climate due to natural or anthropogenic activities and this change remains for a long period of time', (IPCC, 2007). To understand the whole picture of impacts of climate change, all sectors of the economy need to be examined. Although agriculture may be less sensitive to these changes but it is necessary to capture the impact that has significant impact on agriculture sector in the long run.

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Climate change is a dynamic process and has multifaceted impacts on regular natural resources. Even though Pakistan has a very limited role in causing global warming and climate change but its geographical location makes it vulnerable to these changes and there worsening impacts. The climate change is mainly caused by the emission of greenhouse gases like carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2) through anthropogenic activities. These gases trap the sunlight and do not let it return, rising the earth's temperature and altering the pattern of precipitation, humidity across countries and causing some sever damages to the economies. The primary concern to date is with CO_2 which is released from the burning of coal and other carbon-based fuels and the burning of decayed forests. While methane is mainly produced during the mining of coal, gas and oil, industrial chimneys and waste are the main source of Nitrous Oxide (NO_2).

Human beings themselves are solely responsible for this newly CO_2 enriched atmosphere as CO_2 has significantly increased from 280 parts per million square to 380 parts per million square due to heavy deforestation and greater usage of the fossil fuel in post industrial era (Stern, 2006). The contribution of different sectors of the economy in atmospheric concentration of greenhouse gases are 63 percent from energy sector, 13percent from agriculture, 3percent from industrial sector, 18percent from land use and forestation and 3percent from waste (Rosegrant *et al.*, 2008). The high concentration of these gases is likely to affect the climate, causing a change in climate. However analysts have already determined that changes will affect different areas to different extent. Decker and Achutuni (1990), suggest that climate change could alter the way the agriculture sectors are managed but it does not necessarily mean that these changes in climate would have a negative impact on agriculture causing a reduction in the productivity level and productivity. But there is no surety that these changes would not lead to a significant reduction in agriculture output in yield in the long run.

In the long run changes in the climate may distress land productivity by affecting water levels, the pattern of rain falls and leads to changes in cropping pattern which may further exacerbates the output. The impact on agriculture is many folds, including the decreased level of output in shortening the growth periods. Countries laying in the tropical and sub tropical regions would face severe results and consequences and those in temperate zone may be on the beneficial side.

One of the driving factors of climate change is CO_2, but CO_2 itself has a positive effect on plants. The CO_2 affect can be elaborated as; First, CO_2 increases the photosynthesis process in plants which is known as CO_2 fertilization effect. This is more prominent in C3 plants. C3 plants are characterized as those plants which exhibit positive response to enhance CO_2 such as wheat, rice, soybean, cotton, oats and barley. The high level of CO_2 increases the rate of fixed carbon and also photorespiration (i.e. the displacement of fixed carbon). CO_2 also decreases the loss of water by closing the stomata partially. It enhances the water use efficiency of plants causing increased growth.

In Pakistan wheat is sown in winter season. Wheat is cultivated in 9045 thousand hectares approximately and per hectare wheat productivity is 2657 kg. Per head consumption of wheat in Pakistan is about 120 kg which shows how much the crop is important for the country. The water available for wheat cultivation is 26 million acre feet which is still 28.6 percent lower than the normal requirement for wheat productivity (Rosegrant *et al.*, 2008).

The economic assessment of climate change and its impact on the wheat productivity in Pakistan, as expected, shows that the rising temperatures and the unusual pattern of rainfall will severely affect the productivity. It is clearly indicated by the reduction in yield in the past several years. Punjab and Sindh are the major wheat producing states and have a greater share in the total productivity of the crop, have encountered temperature hypes which in turn are expected to reduce the wheat production in the region causing the farmers to bare the losses. Retrospectively Pakistan has faced many droughts periods like in 1951, 1974, 1991, and 2002. The recent drought periods have especially clearly reduced the crop yield in the most vulnerable regions, such as Baluchistan and Sindh as reported by Mirza and Schmitz (2011). The rising temperatures in turn leads to melting of the glaciers accompanied by unusual pattern of the rainfall which has devastating effect on the agriculture sector. The recent flood has ruined almost all the crops and has caused negative growth in the agriculture sector i.e. -3.4 percent as stated by the Economic Survey of Pakistan (2005).

Pakistan is ranked 12 among those countries that are most vulnerable to the climate change devastating effects by the vulnerability index. According to the *LEAD Climate Change Action Program*, *LEAD Pakistan*, Pakistan is facing 4.5 billion dollars losses annually where as increase of 10 °C in temperature would result in net reduction of the wheat yield from 6 to 9 percent, gross land productivity up to 40 percent, and the per capita surface water availability would reduce from $5000m^3$ to $1100m^3$.

The simple production function approach is as follows:

$$WP = A\ (t)\ f\ (K, L)$$

where WP is wheat productivity which is some function of K capital, L labor, and A captures the impact of the climate change on wheat productivity.

VAR econometric technique is applied as it is simple and involves the OLS dynamics to each equation where the variables are treated as endogenous and are believed to interact with each other. The temperature as expected is the continuous trend of the temperature hype that results in reduction of the wheat yield that has significant negative impact on that of wheat productivity.

CO_2 as mentioned above has positive impact for a midterm long period due to its inner CO_2 fertilization impact and is expected to have positive impact on the growth of plant. The changing pattern of the rainfall may have both positive and negative impacts on wheat productivity, like for example, the rainfall just before the pre-harvesting period would lead to bonus crop and has a positive impact on that of productivity. It may have negative impact just as recent impacts of the devastating floods in the country have resulted in the negative growth of the agriculture sector.

Literature review

World Bank (2007) study of the climate change and its impact on agriculture in developing countries specially India, concludes that these changes in climate and temperature hypes have significant and adverse affects on agriculture. India has suffered losses of 30 percent to 40 percent agriculture production depending upon the high level of CO_2 which gives a significant fertilization effect. The study further extends its scope to all the neighboring countries of India that is near to the equator where temperatures are higher. Further hype in temperature will surpass the crops tolerance level. The study of the World Bank concludes that there has been slow down in the green revolution and globally, the pace of technological change in yield productivity per hectare has been slower in the past two decades to that of 60's and 70's. World Bank study recommends that the special emphasis on developing new varieties that are resistant to drought and are resistant to heat is highly desirable.

Adams *et al.* (1990), study while discussing the economic consequences of climatic change, concludes that climatic change reduces productivity in the United States where consumers face severe consequences as they are suppose to pay higher prices and receive relatively low quantities. The study further elaborates that as the demand for most of the crops are inelastic, further reduction in the quantity will result in even greater percentage hype in prices. They conclude that producers are going to gain more as the average revenue for them goes on increasing.

Rao and Sinha (1994), study the impact of climate change on wheat productivity and show that wheat productivity could decrease between 28 percent to 68 percent excluding the CO_2 fertilization effect and would range between +4.0 percent to -34 percent if the CO_2 fertilization effect is included. Mathauda *et al.* (2000), analyze the impact of projected climate change on rice production in Indian Punjab. The CERES Rice model is used where six input files were created to run the model. Their results show that in case of moderate warming, the average temperature rise of 1°C is expected around the year. In 2010, this will reduce the crop duration by three days and might have a negative impact on yield. Under extreme warming condition, maximum reduction of 12.4 percent will be observed in the coming years as predicted.

Indian metrological department presented a study on climate change and food security in India in an international symposium on climate change and food security in South Asia (2008), held in Dhaka. The results depict the fact that as temperature goes on increasing in different parts of India; the yields of different crops will go on decreasing i.e. a 2°C increase in mean air temperature, rice yields could decrease by about 0.75 tons / hectare in high yield areas and by 0.6 tons / hectare in low yield coastal regions. The study concludes that the temperature hype from 2 to 3.5°C would result in the loss of farm level net revenue between 9 percent to 25 percent.

Hussain and Mudasser (2007), investigate the impact of the climate change on wheat productivity in the upper region of Chitral and Swat. They specifically studied the Swat and Chitral regions by applying OLS method. Their result indicates that an increase in temperature create positive impacts on Chitral district as its location is on high altitude and negative impact on Swat because of its low altitude position. Increase in temperature up to 1.5°C would create positive impacts on Chitral thus enhancing the yield by 14 percent and has a negative impact on the yield of Swat by decreasing its yield by 7 percent. A further hype in temperature up to 3°C would decrease the wheat yield on Swat by 24 percent and increase in Chitral district by 23 percent.

Anwar *et al.* (2007), investigate global atmospheric models fewer than three climatic change scenarios i.e. low, mid and high for the south eastern Australian location. Their study concludes that for all the three scenarios, medium wheat yield declines by about 29 percent. However presence of elevated CO_2 affect reduced the decline in production from 25 percent to 29 percent. CO_2 fertilization affect offset a very small level of low rain fall and higher temperature. Their study suggest that higher wheat productivity could be obtained through agronomic strategies and breads of wheat.

Hanif (2009) studies the economic impacts of climate change on agriculture sector in Punjab Pakistan. Their study shows that the climate change will affect the land prices in Punjab which is the long run variable for net revenue. FGLS panel regression estimation method is being applied in order to check for the influence of the average precipitation and maximum & minimum temperature, on the land prices in the eleven representative districts of Punjab. Their results show that in Kharif season the mean minimum temperature and mean precipitation has a significant positive impact on the land prices. An increase in one mm in precipitation leads to the increase in land price, on an average by 166.57 Rs/acre, in Kharif season. While in Rabi season the precipitation and mean minimum temperature has significant negative relationship with the land prices that is a decrease in Rabi precipitation along with an increase in maximum Rabi temperature would raise the land prices. The study concludes that climate changes has a significant impact on land prices in the Punjab region which is a long run variable for the net revenue.

Janjua *et al.* (2010) investigate the impact of climate change on wheat production. They use simulations models for the expected impact of the climate change on wheat productivity accompanied by the VAR technique. Climate variables are represented by the average annual temperatures and precipitation. The result of the VAR model indicates that up till now there is no significant negative impact of climate change on wheat production in Pakistan but through simulation techniques they showed an increase in the temperature by 2 to 3°C in 2050 and 2060 will definitely lower the productivity across the country. They conclude that the policy makers should take care of the issue of rising temperature which is being a long run consequence for wheat productivity in Pakistan.

Mirza and Schmitz (2011) study the economic assessment of the impact of climate change on the agriculture of Pakistan. They developed a panel model for modeling climate change and its impact on agriculture in Pakistan. Their study shows, how changes in climate affects the agriculture productivity in Pakistan measured as weighted food crop wheat, maize and rice. They conclude that areas with greater climatic pressures will be affected and hence lower level of productivity in the arid zone. The proposed hypothesis is that changing climatic variables have reduced and are reducing the agricultural productivity and posing a threat to long term food security.

Data sources and variables

Annual data from 1971 to 2009 for the variables in the model have been obtained from the Agriculture Statistics of Pakistan, the Metrological Department of Pakistan and the data for CO_2 emissions is from the United Nations data base.

The variables are divided further into two categories.

1) Climatic Variables
2) Non-Climatic Variables

where the definitions for different variables included in the model are as under.
To capture the impact of climatic change, the Annual Mean Temperature (LNTEMP), Precipitation (LNPERC), Humidity (LNHUM) and CO_2 emissions (LNPERC) have been taken as explanatory variables in the model. The annual mean temperature, precipitation and humidity of those districts which have greater share in the wheat production are taken as proxy variable to estimate the climate change impact on wheat productivity in the country.

The data for non-climatic variables comes directly from the Agriculture Statistics of Pakistan which are the Fertilizer off-take (LNFERTK), Water availability (LNWATAV), Land under wheat cultivation (LNLANDWHT), Agriculture credit disbursed by different agencies and the support price (LNSUPPR) for wheat. They are included in the model to check the impact of these variables on wheat production in Pakistan. Theoretically, the climatic variables other than CO_2 are expected to impact negatively on wheat productivity in the long run where as the CO_2 as explained above has the fertilizing affects which results in positive significant impact on wheat production.

Methodology

The vector auto regressive technique is applied to capture the impact of all these variables in the model. As the VAR method provides detailed results and also decomposes the individual effect which in turn gives us the individual impact of these climate change variable on the wheat production in the country. The impulse response function is to check for the shocks in the variables and their impact on the explanatory variable.

The General VAR model with only one lag in each variable if the constants are held suppressed are given as:

$$Y_{1t} = \alpha_{11}Y_{1,\,t-1} + \alpha_{22}Y_{2,\,t-1} + \varepsilon_{1t}$$
$$Y_{2t} = \alpha_{21}Y_{1,\,t-1} + \alpha_{22}Y_{2,t-1} + \varepsilon_{2t}$$

As the AIC and SIC suggest to include two lags in the model, general VAR model can be written as under;

$$Y_{1t} = \alpha_1 Y_{1,\,t-1} + \sum_{j=1}^{2} \alpha_j Y_{1,\,t-j} + \sum_{j=1}^{2} \beta_j Y_{2,\,t-j} + \varepsilon_{1t}$$

Results for the VAR model

Lag selection criteria for VAR model:

Most of the criteria suggest 2 lag model as shown in the following table. We therefore use 2 lag VAR model to estimate the long run dynamics of wheat productivity.

Table 1: 2 Lag model for long run dynamics of wheat productivity:

Lag	LogL	LR	FPE	AIC	SC	HQ
0	380.8824	NA	1.51e-20	-20.10175	-19.70991	-19.96361
1	618.1109	346.2253	3.66e-24	-28.54653	-24.62808*	-27.1651
2	745.7849	**124.2234***	**6.86e-25***	**-31.06946***	-23.6244	**-28.44473***

Table 2: Results for VAR equation

	LNWHTPRO	LNWATAV	LNTEMP	LNSUPPR	LNPERC	LNLANDWHT	LNHUM
LNWHTPRO(-1)	-0.4768	0.2078	0.2343	0.3681	0.7097	0.1354	0.0714
LNWHTPRO(-2)	-0.3824	0.1657	0.6221	1.2191	0.3970	-0.0969	0.0865
LNWATAV(-1)	-0.2875	0.1338	0.5830	-0.5578	0.9557	0.4926	0.2870
LNWATAV(-2)	0.0949	0.4277	1.0390	0.7697	0.8450	0.1000	0.4877
LNTEMP(-1)	0.0249	0.1079	0.2475	0.2071	-1.8709	-0.0764	-0.4622
LNTEMP(-2)	0.0989	-0.0894	-0.2568	-2.0916	-1.0941	-0.2736	0.8313
LNSUPPR(-1)	0.2330	-0.0223	-0.0650	0.4457	-0.4285	0.0038	0.0269
LNSUPPR(-2)	0.0146	-0.0921	-0.1649	-0.0783	-0.1806	-0.0236	-0.2875
LNPERC(-1)	-0.0980	0.0262	0.0551	0.0647	0.1478	0.0092	0.0524
LNPERC(-2)	0.0316	0.0357	0.0435	0.3417	0.3498	0.0472	0.0210
LNLANDWHT(-1)	0.5580	-0.0515	-1.2700	0.0516	-5.6519	0.0536	-1.0637
LNLANDWHT(-2)	-0.2007	-0.0725	-0.7137	-3.1737	1.1502	-0.1712	-0.4213
LNHUM(-1)	0.4906	0.0716	-0.3393	-0.2025	-0.5339	-0.0401	-0.3110
LNHUM(-2)	0.3588	-0.1643	-0.6070	-1.5125	-0.9259	-0.1838	0.0476
LNFERTK(-1)	0.0093	-0.0432	0.1474	-0.4031	1.4065	0.0800	0.2620
LNFERTK(-2)	0.3720	0.0342	-0.0500	0.1652	-1.1902	0.0871	-0.0795
LNCO2KT(-1)	0.1103	0.0649	-0.3403	0.9539	0.6143	-0.0709	0.1605
LNCO2KT(-2)	0.0837	0.0383	-0.0282	-0.1999	-0.3243	-0.0767	-0.0586
C	6.3079	-0.9684	12.2523	17.9618	36.5799	8.8493	9.8641

Dynamics: Impulse response functions of the wheat productivity

From the impulse response function of the temperature and wheat productivity it is clear that a unit shock in the temperature will die out in the fourth period i.e. any increase or decrease in the temperature will affect the wheat productivity and this effect will die out in the fourth period. The impulse response functions of the precipitation and wheat productivity it is clearly evident from the following table that it will die out in the second period. From the impulse response function of the humidity and the wheat productivity it is clearly evident that it will die out in the third period. A one unit shock in the CO_2 will die out in the ninth period. The non-climatic variables that are support prices for wheat, land available for wheat cultivation will die out in the eighth and fourth period respectively. A one unit shock in the water availability and fertilizer off-take is persistent and will never die out as clear from the table. The CO_2 has a persistent effect and will remain for long that is as expected per theory that CO_2 fertilization effect will lead to growth in the plant that is good for the cereal crops.

The above results of the impulse response function are presented in figure 1 (see Appendix A) depicting the corresponding figures graphically.

Variance Decomposition

The variance decomposition results explain 23 percent variation in the tenth period in wheat productivity which is due to itself. As clearly evident from the table below (Table 4), most of the variation in the wheat productivity is due to the temperature which is the core climatic variable. This indicates that in the long run the rising temperature will have a significant reduction in the wheat productivity. The variation in the wheat productivity due to variation in temperature is 25 percent in the ninth period. Other climatic variables like humidity, precipitation and CO_2, will have a variation of 4 percent, 4 percent and 1.5 percent in wheat productivity, respectively. The non-climatic variables that are the core variables of the traditional wheat production function also show considerable variation in the wheat productivity. That is variation in water availability will bring about 18 percent variation, support prices will create 6 percent variation, land available for wheat cultivation may cause 5 percent and fertilizer off-take tend get 14 percent variation in the wheat production.

Table 3: Results of impulse response function

Period	LNWHTPRO	LNWATAV	LNTEMP	LNSUPPR	LNPERC	LNLANDWHT	LNHUM	LNFERTK
1	0.0637	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	-0.0097	0.0075	0.0085	0.0183	-0.0072	0.0056	0.0082	0.0020
3	0.0033	0.0113	0.0092	0.0105	0.0149	0.0073	-0.0057	0.0207
4	0.0104	0.0118	-0.0008	0.0151	-0.0030	-0.0143	-0.0187	0.0284
5	-0.0113	0.0013	0.0022	0.0102	-0.0017	-0.0037	-0.0001	0.0190
6	0.0112	0.0162	0.0278	0.0170	-0.0022	0.0137	0.0092	0.0219
7	0.0186	0.0251	0.0366	0.0170	-0.0066	-0.0057	-0.0104	0.0237
8	0.0007	0.0295	0.0311	-0.0016	-0.009	-0.0219	-0.0138	0.0182
9	0.0004	0.0307	0.0276	-0.0061	-0.0117	-0.0066	-0.0000	0.0157
10	0.0211	0.0370	0.0434	-0.0056	-0.0168	0.0056	0.0032	0.0139

Table 4: Variance decomposition of wheat productivity

Period	S.E.	LNWHTPRO	LNWATAV	LNTEMP	LNSUPPR	LNPERC	LNLANDWHT	LNHUM	LNFERTK	LNCO$_2$KT
1	0.0637	100.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0692	86.8179	1.1774	1.5260	7.0415	1.1056	0.6739	1.4309	0.0875	0.1389
3	0.0768	70.6272	3.1365	2.6719	7.5879	4.6606	1.4735	1.7259	7.3421	0.7740
4	0.0884	54.7289	4.1585	2.0269	8.6494	3.6410	3.7528	5.8221	15.9180	1.3019
5	0.0924	51.5223	3.8219	1.9105	9.1345	3.3660	3.5947	5.3234	18.8110	2.5152
6	0.1042	41.6677	5.4269	8.6484	9.8658	2.6924	4.5649	4.9702	19.2282	2.9350
7	0.1194	34.1788	8.5604	15.9837	9.5477	2.3600	3.7096	4.5504	18.6033	2.5056
8	0.1311	28.3535	12.1900	18.8841	7.9356	2.4278	5.8731	4.8920	17.3627	2.0808

Economic assessment of the impact of the climate change on wheat productivity

For economic assessment of the impact of the climate change on wheat production, yield kg/hectare of wheat is regressed on the climatic variable and some of the non-climatic variables. Yield kg/hectare is a proxy for the net revenue. This is an appropriate variable to examine the economic assessment in the light of the climatic change in the country. The Lin-Log model is applied so that we can have the elasticites of the variables directly.

The model is stated as follows:

Yield kg/hectare = β. +β_1 lntemperature hike + β_2 lnhumidity+ β_2 lnCO_2+ β_3 lnprecipitation+ β_4 lnfertilizer off-take+ β_5 lnwheat land+ ε_t

Table 5: Impact of climate change on wheat productivity

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNTEMPHIKE	-0.063989	0.304458	-0.210174	0.0349
LNPERC	-0.024257	0.057183	-0.4242	0.0743
LNHUM	-0.156827	0.232374	-0.674893	0.5046
LNCO2KT	0.232141	0.071762	3.234882	0.0028
LNFERTK	0.152947	0.100818	1.517066	0.1391
LNLANDWHT	-0.227528	0.389707	-0.583843	0.5634
C	6.801065	3.661037	1.857688	0.0724
R-squared	0.948551	Mean dependent var		7.53017
Adjusted R-squared	0.938904	S.D. dependent var		0.24080
S.E. of regression	0.059522	Akaike info criterion		-2.6437
Sum squared resid	0.113372	Schwarz criterion		-2.3452
Log likelihood	58.55392	F-statistic		98.3285
Durbin-Watson stat	1.896962	Prob (F-statistic)		0

Yield kg/hectare = 6.801065 -0.063989 temperature hike -0.156827 humidity+ 0.232141 CO_2 -0.024257 precipitation+ 0.152947 fertilizer off-take -0.227528 wheat land+ ε_t

An increase in the temperature of 1 degree Celsius results in a 0.6 kg/hectare reduction in the wheat production. A one unit increase in the humidity and precipitation would result in the 0.16 and 0.02 kg/hectare reduction in the yield respectively. Whereas CO_2 was expected to show positive impact on the production of wheat i.e. an increase in the CO_2 emission of 1 KT that would lead to increase in the yield by 0.23 kg/hectare. Though some of the variables are insignificant but as the F-Statistics is highly significant, it indicates that the regression is a valid one. The R^2 and the adjusted R^2 values are high, indicating the model is good fitted.

The economic consequences due to the climatic change are most likely to be influenced by the adaptation made by the agents associated with the agriculture sector in the country i.e. farmers and government agencies. The farmers can adapt by altering the plantation dates, high temperature resistant hybrid seeds and changing the irrigation practices etc. while the consumers can adapt by substituting the low priced products for that of high priced products due to changes in the climate.

Conclusion and Recommendations

The impact of climate change on wheat productivity is being quantified here by taking two different sets of variables that is the climatic variables and the non-climatic variables. CO_2 emission, annual mean temperature, humidity and annual mean precipitation has been taken as climatic variables to capture the impact of these variables on wheat productivity. Non-climatic variables are the core variables included in the production function of wheat that are fertilizer off-take, land available for wheat cultivation, available water and support prices for wheat.

VAR technique has been applied where the Impulse Response Function and Variance Decomposition gives us the detailed results of the examination. The variation in the wheat productivity has been largely brought by the variation in temperature which is almost 25 percent in the tenth period which indicates that the change in climate is most likely to have a significant impact on wheat productivity. CO_2 emission which as expected has significant positive impact on wheat production where variation in CO_2 can bring about 1.5 percent variations in the wheat productivity.

The economic assessment is measured by regressing the yield (kg/hectare) on climatic and non-climatic variables which is taken as a proxy variable for the net revenue. The yield kg/hectare will reduce quite significantly as the temperature goes on increasing.

As the farmers across the country are mostly illiterate, they need to know that changes in climate will lead to reduction in the output so need to have in time knowledge as in the long run these changes will affect the farmers throughout the country. The temperature may shorten the growth periods; hence the cultivation should be adjusted accordingly. The government has to take initiative to introduce the high temperature resistant seeds as the increase in temperature in future will affect the productivity. Climate change also alters the rain fall pattern across the country; therefore it is necessary for researchers to introduce the drought resistant seeds. The recent floods in the country have destroyed almost all major crops, the government need to store the excess water by constructing more dams as the floods leave the soil more fertile after it ruin all the land once.

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Appendix A:

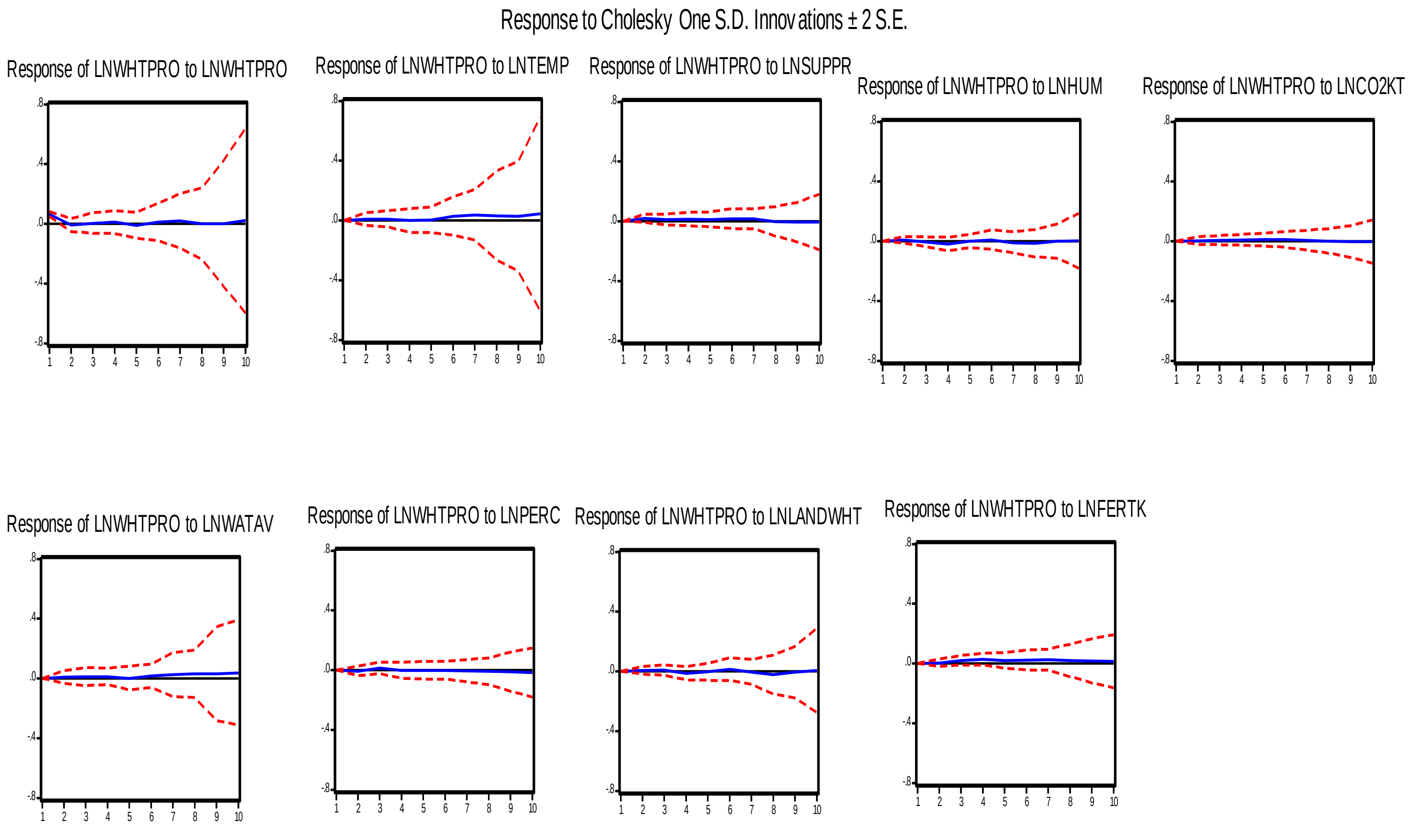

Figure 1: Graphs of impulse response function

Appendix B:

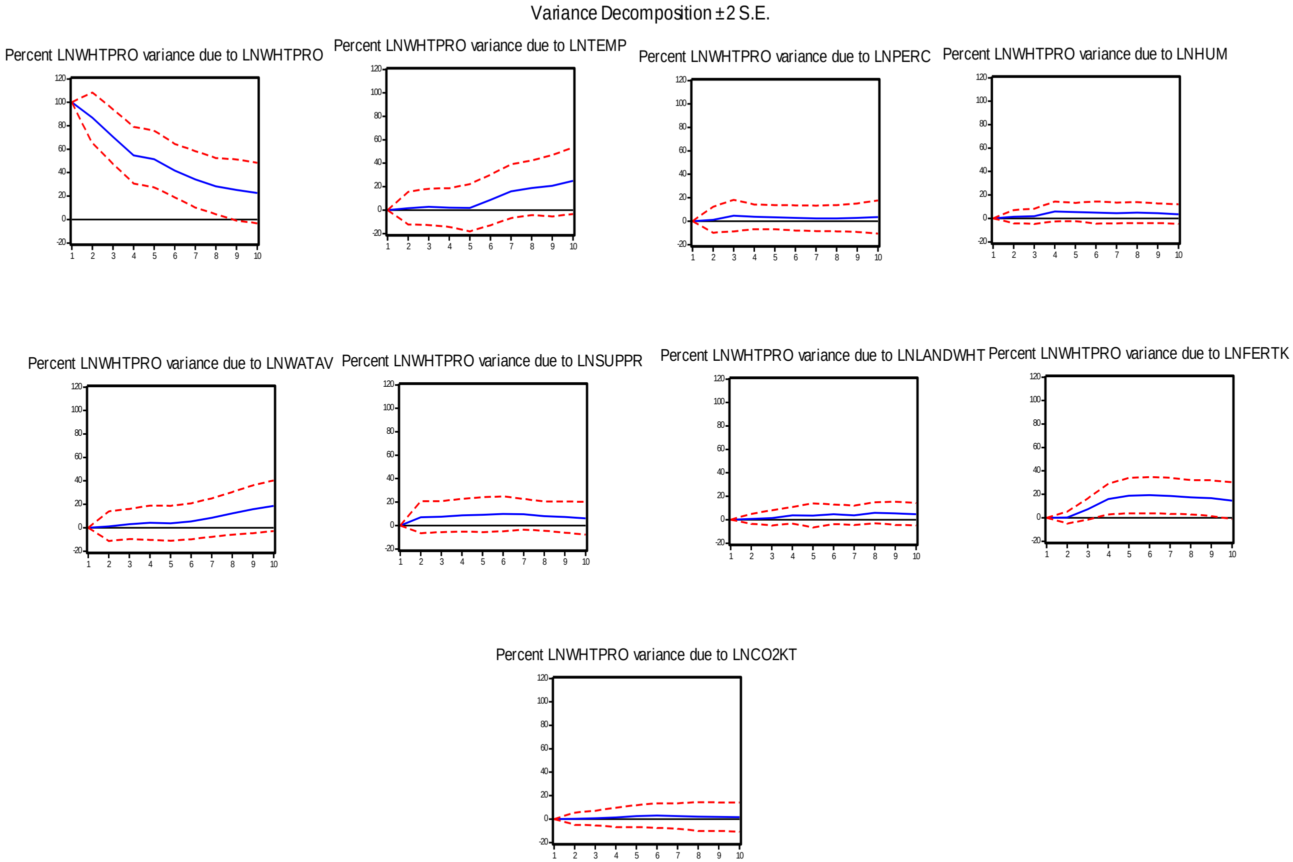

Figure 2: Graphs of variance decomposition