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Climate Change, Cereal Production and Economic Growth: An Application of Generalized Method of Movement (GMM)

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Abstract: Developing countries like Pakistan, India and Bangladesh shares various common challenges in addressing existing and future climate hazards. This study examines the impact of climate change and cereal production on economic growth in Pakistan, India and Bangladesh for the period 1971–2013. The variables employed in the study are carbon dioxide emissions, methane emissions, nitrous oxide emissions, total greenhouse gases emissions, cereal production and GDP growth rate. Generalized method of moments (GMM) analysis is used to evaluate different equations in relation to climatic factors and cereal production with economic growth in Pakistan, India and Bangladesh. The results show that effects of climate change variables have negative relationship with economic growth both in case of Pakistan and India. While the situation is different in case of Bangladesh. Carbon dioxide emissions and methane emissions are positively while nitrous oxide emissions and total greenhouse gases emissions are negatively related with economic growth. There is need to overcome the problem of climate change by expanding climatic and agricultural research to improve the economic situation of a country.

Keywords: climate change, cereal production, economic growth, generalized method of moment,
JEL Classification: Q54, F43, E23

1. Introduction

Climate change is one of the very challenging and difficult problems now a days faced by the global world. The phenomena climate change affects agriculture in a number of ways, especially crop productivity which receive the direct impact from climate change (Ziervogel, Bharwani & Downing, 2006). According to 4th Assessment Report of Integrated Panel of Climate Change (IPCC), climate change mainly increased threat of floods and droughts which probably have severe influence on the economies of South Asian countries. South Asian economies mainly rely

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on agriculture, natural resources, forestry and fisheries. Though South Asia has very low greenhouse gas (GHG) emissions and climate change has severely affected the economic development & growth. Almost 70% of South Asians live in rural area and account for about 75% of the poor, who are the most impacted by climate change (IFAD and UNEP, 2015).
The rise in temperature could be coupled with changes in rainfall pattern, rise in sea level, frequency and severity of extreme events namely, cyclones and droughts etc. The sum of all these changes is referred to as climate change. During last century average annual temperature in Pakistan increased by 0.6^0 C and at global level it is increased by 0.9^0 C. It is estimated that average temperature in Pakistan will increase upto 1.3 ^{0}C -1.5 ^{0}C and at global level it will increase upto 2.8 ^{0}C -3.4 ^{0}C by 2020 (Five Year Plan of Pakistan, 2013-2018). Modern world is facing one of the prominent problems in the form of climate change. GHG emission, generate many gases like carbon dioxide (CO_2), methane (CH) and nitrous oxide (N_4O) which are responsible for causing climate change. Concentration of CO_2, out of overall GHG is greater as compared to other gases. For example, in Pakistan from overall GHG, CO_2 is 54%, methane is 36% and nitrous oxide is 10%. While the concentration of CO_2 is 0.48% in Pakistan, 6.8% in India, 15% in USA and 30% in China. Climate change has highlighted severe concerns for developing countries like Pakistan, India and Bangladesh which are facing remarkable social, economic and environmental impacts.

Agricultural production is primarily determined by climate change and slightly adverse variations will have damaging affects in agriculture sector. Change in climatic situations initiating crop failures and also affects the livings of the population which involves in the agricultural practices and applications for their support (Calzadilla, 2008). Agriculture is the central element of an economy like Pakistan because it is a major source of raw material and food security. Agriculture, food security and economic growth mutually interact and reinforce each other in the process of growth (Government of Pakistan, 2016).

Cereal crops which includes wheat, maize & paddy, and these cereal crops are the primary & staple crops which full fill the hunger of many people

globally (Godfray, et. al. 2010). There is need to boost up the production of cereal crops to meet the increasing demand and fill the increasing gap between supply and demand of food. Boosting the production rates is generally accepted as the solution to meet the increasing demand, it is observed that the current rate of production is closer to the past one and to maintain this level of production we have to overcome the phenomena of climate change. (Ray, el at. 2013). Climate change could leads to decrease in fertile and arable land via flood and drought which also need concentration of policy makers (Hawkesford, et. al.2013).

The main purpose of this study is to empirically explore the relationship between CO_2 emissions, methane emissions, nitrous oxide emission, cereal production and economic growth of Pakistan, India and Bangladesh. Different from earlier studies in the literature, we used generalized method of moments (GMM) technique. To the best of our knowledge, there has been no study that tried to estimate these variables for Pakistan, India and Bangladesh through generalized method of moment .The rest of the paper is organized as follows. Section 2 describes the literature review, section 3 contain methodology, while section 4 provides the results, section 5 concludes and section 6 continue with references.

1.1. Problem Statement

Empirical studies revealed that climate change affects agriculture sector that is at risk to climate change economically and physically both (Gbetibouo & Hassan, 2004). Climate changes can reduce the cereal production considerably. We can say that cereal production is mainly determined by climate and its variations. Changing situation of climate, reduce the chances of crop's cultivation, which disturbs the livings of the population especially those who opt agriculture as a source of income in the form of agricultural practices and applications (Calzadilla, 2008). Climate change then further affect food production (Funk & Brown, 2009), agriculture and food systems are the important elements of nutrition and public health (Kanter, et al. 2015) and health is an important element of economic growth (Barro, 2013).

1.2. Novelty of the Study

International Organizations publish reports to highlight the status of the countries all around the world considering the significance of climate change and its impacts globally. There is a significant body of research on climate change, cereal production and economic growth. But the objectives of this study are unique and have not been addressed before in the case of South Asia (Pakistan, India and Bangladesh). Therefore a great research gap is observed to see the impact of climate change on economic growth through agricultural production.

1.3. Research Question

- How does climate change affect the economic growth through cereal production?

1.4. Hypothesis

Following are the null and alternative research hypothesis:

1. H_0 = Climate change has no impact on cereal production.
   H_1 = Climate change has impact on cereal production.
2. H_0 = Climate change has no impact on economic growth.
   H_1 = Climate change has impact on economic growth.
3. H_0 = Cereal Production has no impact on economic growth.
   H_1 = Cereal Production has impact on economic growth.

1.5. Objective of the Study

- To empirically investigate the effect of Climate Change and Cereal Production on Economic Growth in Pakistan, India and Bangladesh.
- To provide policy implications.

2. Literature Review

Following are some research works which have done to see the issue of climate change and its affected dimensions.

Afzal, et al. (2016) empirically investigated the impact of climate change on three major crops, produced in Punjab, Pakistan, they used Cobb-Douglas production function by using panel data. They used district level data from 1981-2012. They also find that temperature has negative relationship with the wheat production in flowering stage. Rainfall is negatively related with wheat production in every stages. They concluded that minimum temperature, rainfall pattern and humidity have positive relationship with rice production.

Qureshi, et al. (2016) they examined relationship between agricultural production, energy demand, fuel energy, air pollution and GHG emissions in Pakistan by using data from 1980 to 2013. Agricultural production variable further divided into wheat, sugarcane, rice, cotton production and agriculture value added. They used Generalized Method of Moments (GMM) estimator to estimate the environmental factors and agricultural production in a country through different simultaneous equations. They find out that CO_2 emissions is positively and energy sources is negatively related wit agricultural value added. Sugarcane production and cotton is directly related with fossil source of energy, while sugarcane production and wheat are directly related with CO_2 emission. Greenhouse gas emission severely affect agricultural production which includes cotton, rice and wheat production.

Tebaldi & Beaudin (2015) explored the impact of climate change on economic growth in Brazil. They used precipitation data monthly from 1970 to 2011 from different 265 weather stations and Real GDP data annually from 1985 to 2011. They applied dynamic panel model for analysis. They concluded that Real GDP growth rate decreased by 0.92% in the direct result of spring droughts in Northeast region while there will be no significance effect on other region. In case of summer flood, real GDP growth rate decreased by 0.39% in Northeast region and Southeast region has no effect.

Wei, et al. (2014) estimated the climate change impact on crop yield. They used provisional panel data of China to estimate constant & inconstant elasticities. Elasticities was used according to temperature and precipitation. They concluded that change in temperature has positive relationship with wheat and rice. They also concluded that impact of climate change on crop yield would not be an issue in China if positive impacts of other socio-economic factors continue in the future.

Yang & Zhu (2013) they analyzed the two-sector model, both for traditional agriculture and modern agriculture. Comparative price of industrial product will reduce by industrial development in case of traditional technology development. This reduction in prices has very low effect on income per capita. When traditional agricultural techniques turn into modern agricultural techniques than income per capita will be increased and economy will lead towards sustainable growth.

Shakoor, et al. (2011) examined the impact of climate change on agriculture in arid region of Pakistan. They used a cross-sectional data from Rawalpindi Metrological Stations. They used Ricardian Approach to investigate the relationship among climate change and Net Farm Revenue (NFR) and climate of the arid region. Results show that increase in temperature has negative impact on agriculture production. Additionally, with the increase in rainfall, revenue will also increase. It is estimated that 1% increase in temperature will lead to decrease the net revenue by Rs. 4180. It is recommended that for rapid and efficient agricultural production in arid region of Pakistan, there is need to adopt the new methods of irrigation, crop farming and crop pattern.

Janjua, et al. (2010) analyzed the impact of climate change on wheat production in case of Pakistan. They used Vector Autoregression (VAR) to see the impact of climate change in Pakistan particularly wheat production. The data was based on last half century. Results show that there is that negative effect of climate change on wheat production is not exist presently. Though in future the effect of climate change in the form of water availability and temperature will affect the wheat production in Pakistan.

Dell, et al. (2008) analyzed the effect of climate change on economic growth. They used annual data of temperature and precipitation of 50 years all over the world. They used Panel data analysis for this purpose. The results reveal that with the increase in temperature economic growth tends to reduce in case of poor countries, in other poor countries growth rate tends to reduce with the increase in temperature while in the third type of poor countries agricultural and industrial output will increase along with investment and political instability.

3. Methodology

Methodology has a very important role in accomplishing the desired objectives of the study through using various tools & techniques. As the situation of climate change is worsen day by day all around the world especially in South Asian countries, so the selected research areas in this study are Pakistan, India and Bangladesh.

3.1. Data and Variables

Required secondary data is collected from World Development Indicators (WDI) from 1971 to 2013. A various number of variables will be utilized to fulfill the desired objectives of the study which are cereal production and GDP growth rate and various climate change variables along with instrumental variables. E-views 10 was used for generalized method of moment analysis. List of cereal crops are given below[1];

- Rice (mainly Oryza sativa)
- Job's Tears, salay, adlay, tigbe, pawas (Coix lachryma-jobi)
- Oat (Avena sativa)
- Fonio (Digitaria exilis)
- Wheat, bread wheat (Triticum aestivum)
- Barley (Hordeum vulgare)
- Rye (Secale cereale)
- Wild rice, Canada rice, Indian rice, water oats (Zizania spp.)
- Durum wheat, macaroni wheat (Triticum durum)

[1] https://www.cropsreview.com/cereal-crops.html

- Millet (Panicum miliaceum, Eleusine coracana, Setaria italica, Pennisetum glaucum)
- Triticale (Triticosecale)
- Spelt (Triticum spelta)
- Corn or maize (Zea mays)
- Sorghum (Sorghum bicolor)
- Teff, taf (Eragrostis tef)
- Canary grass (Phalaris sp.)

3.2. Description of Variables:

Here is the description of the variables used in the study.

3.2.1. Cereal Production

Data related to cereal crops harvested are taken from the dry grains only and crops used only for grazing are not included in this data (WDI-2018).

3.2.2. GDP Growth Annual

GDP growth rate is the annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2010 U.S. dollars (WDI-2018).

3.2.3. Carbon Dioxide Emissions

Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring (WDI-2018).

3.2.4. Methane Emissions

The emissions are taken from the whole energy process, either its production, handling, transmission or combustion of fossil fuels and biofuels (WDI-2018).

3.2.5. Nitrous Oxide Emissions

Nitrous oxide emissions are emissions from agricultural biomass burning, industrial activities, and livestock management (WDI-2018).

3.2.6. Total Greenhouse Gases

Total greenhouse gas emissions in kt of CO_2 equivalent are composed of CO_2 totals excluding short-cycle biomass burning but including other biomass burning, all anthropogenic CH_4 sources, N_2O sources and F-gases (WDI-2018).

3.3. Econometric Modeling

The relationship between climate change variables, cereal production and economic growth can be expressed in a linear relationship as shown:

$$EG = f(CC, CP)$$

EG is economic growth, CC is climate change and CP is cereal production. To determine the relationships between endogenous and exogenous variables under study Generalized Method of Movement (GMM) method is employed by using Eviews-10. Nevertheless, following econometric models are selected to explain the results of the study for Pakistan, India and Bangladesh.

Model-I: Impact of Carbon Dioxide Emissions and Cereal Production on Economic Growth.

$$ln(GDP)_t = \alpha_0 + \beta_1 ln(GDP)_{t-1} + \beta_2 ln(CO_2)_t + \beta_3 ln(CP)_t + \lambda_t + \varepsilon_t$$

Model-II: Impact of Methane Emissions and Cereal Production on Economic Growth.

$$ln(GDP)_t = \alpha_0 + \beta_1 ln(GDP)_{t-1} + \beta_2 ln(CH)_t + \beta_3 ln(CP)_t + \lambda_t + \varepsilon_t$$

Model-III: Impact of Nitrous Oxide Emissions and Cereal Production on Economic Growth.

$$ln(GDP)_t = \alpha_0 + \beta_1 ln(GDP)_{t-1} + \beta_2 ln(N_4O)_t + \beta_3 ln(CP)_t + \lambda_t + \varepsilon_t$$

Model-IV: Impact of Total Greenhouse Gases and Cereal Production on Economic Growth.

$$ln(GDP)_t = \alpha_0 + \beta_1 ln(GDP)_{t-1} + \beta_2 ln(GHG)_t + \beta_3 ln(CP)_t + \lambda_t + \varepsilon_t$$

GDP= GDP Growth Rate, CO_2= Carbon Dioxide Emissions, CH= Methane Emissions, N_4O= Nitrous Oxide Emissions, GHG= Total Greenhouse Gases, CP = Cereal Production, 't' represent time period, ln represents natural logarithm, λ shows lagged of the explanatory variables, and ε_t represents error term.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

Table 4.1: Descriptive Statistics of variables in case of Pakistan

	Cereal Production	**GDP Growth Annual (%)**	**CO2 Emissions (kt)**	**Methane Emissions (kt) of CO_2 Equivalent**	**Nitrous Oxide Emissions Thousand Metric Tons of CO_2 Equivalent**	**Total Greenhouse Gases Emissions (kt) of CO_2 Equivalent**
PAKISTAN						
Mean	23541427	4.710102	81103.21	97495.25	21417.56	195766.2
Median	22123350	4.832817	72789.95	92710.90	20912.17	175960.6
Maximum	38157384	10.21570	163060.5	158336.6	30651.23	369734.6
Minimum	11336393	0.468373	18929.05	1590.000	0.000000	0.000000

Std. Dev.	7919981.	2.267079	49295.11	35088.04	6094.909	91788.51
Probability	0.257837	0.721961	0.163999	0.963310	0.006176	0.404471
Sum	1.01E+09	202.5344	3487438.	4192296.	920955.3	8417947.
Sum Sq. Dev.	2.63E+15	215.8652	1.02E+11	5.17E+10	1.56E+09	3.54E+11
Observations	43	43	43	43	43	43
INDIA						
Mean	1.98E+08	5.519930	835920.8	516963.3	167674.3	1550341
Median	2.04E+08	5.829938	711392.5	526819.0	178341.1	1464843
Maximum	2.94E+08	10.25996	203752.	636395.8	239755.1	3002895
Minimum	1.07E+08	-5.238183	205869.0	401434.0	86999.95	754018.5
Std. Dev.	55714892	3.022796	558487.2	70450.92	48694.37	633484.8
Probability	0.338844	0.000192	0.089338	0.292234	0.157192	0.222600
Sum	8.70E+09	242.8769	36780514	21712460	7042323.	65114332
Sum Sq. Dev.	1.33E+17	392.9036	1.34E+13	2.03E+11	9.72E+10	1.65E+13
Observations	43	43	43	43	43	43
BANGLADESH						
Mean	313898	4.051	24567.	90831.6	17684.	135477.

	97	639	90	9	51	8
Median	28031812	4.802472	17577.76	88402.00	19172.57	128764.0
Maximum	55069990	9.591956	68950.60	105141.6	26682.82	183300.6
Minimum	15088878	-13.97373	3509.319	83607.60	9460.425	107540.6
Std. Dev.	11916122	3.794028	20015.23	6027.641	5481.405	22547.33
Probability	0.134845	0.000000	0.039091	0.002468	0.210093	0.057523
Sum	1.38E+09	178.2721	1080988.	3996594.	778118.5	5961024.
Sum Sq. Dev.	6.11E+15	618.9700	1.72E+10	1.56E+09	1.29E+09	2.19E+10
Observations	43	43	43	43	43	43

Table-4.1 shows the descriptive statistics of the variables for ready reference. The minimum value of CO_2 is 18929.05 (kt), and the maximum value is 163060.5. The mean value of CO_2 is 8 1103.21 with the standard deviation of 49295.11. In case of Methane emissions (kt) of CO_2 equivalent, mean value is 97495.25, median is 92710.90, minimum value of methane emission is 1590.000 while the maximum value is 158336.6 and Standard deviation of methane is 35088.04. It is shown in the table that mean value nitrous oxide emissions thousand metric tons of CO_2 equivalent is 21417.56, median is 20912.17, maximum value is 30651.23, minimum value is 0.000 and standard deviation is 6094.909. Mean value of total greenhouse gases emissions (kt) of CO_2 equivalent is 195766.2 while median, maximum, minimum and standard deviation are 175960.6, 369734.6, 0.000 and 91788.51 respectively. Descriptive statistics of the variables for India, the minimum value of CO_2 is 18929.05 (kt), and the

maximum value is 205869.0. The mean value of CO_2 is 835920.8 with the standard deviation of 558487.2. In case of Methane emissions (kt) of CO_2 equivalent, mean value is 516963.3, median is 526819.0, minimum value of methane emission is 401434.0 while the maximum value is 636395.8 and Standard deviation of methane is 70450.92. It is shown in the table that mean value nitrous oxide emissions thousand metric tons of CO_2 equivalent is 167674.3, median is 178341.1, maximum value is 239755.1, minimum value is 68999.95 and standard deviation is 48694.37. Mean value of total greenhouse gases emissions (kt) of CO_2 equivalent is 1550341 while median, maximum, minimum and standard deviation are 1464843, 3002895, 754018.5 and 633484.8 respectively.

Descriptive statistics of the variables for Bangladesh, the minimum value of CO_2 is 3509.3 (kt), and the maximum value is 68950.6. The mean value of CO_2 is 24567.90 with the standard deviation of 20015.23. In case of Methane emissions (kt) of CO_2 equivalent, mean value is 90813.69, median is 88402.0, minimum value of methane emission is 83607.60 while the maximum value is 105141.6 and Standard deviation of methane is 6027.64. It is shown in the table that mean value nitrous oxide emissions thousand metric tons of CO2 equivalent is 17684.51, median is 19172.57, maximum value is 26682.82, minimum value is 9460.4 and standard deviation is 5481.40. Mean value of total greenhouse gases emissions (kt) of CO2 equivalent is 135477.8 while median, maximum, minimum and standard deviation are 128764.0, 183300.6, 107540.6 and 22547.33 respectively.

4.1.1. Generalized Method of Moments (GMM) Analysis:

Generalized Method of Movements is a technique used to analyze the relationship between cereal production, climatic factors and economic growth in order to address the country's fixed effects and to solve the endogeneity problem of the studied models. The robust factor's evaluations will be obtained by taking first lagged of the dependent variable and by using number of instrumental variables. The GMM estimator is typically used to correct for bias caused by endogenous explanatory variables.

In the context of Pakistan, India and Bangladesh, the study will use GMM estimator for estimating the simultaneous equations modeling by monitoring possible heteroscedasticity and endogeneity problems from the evaluated model. Traditional OLS model holds the endogeneity problem, that's why we have applied the GMM model, proposed by Arellano and Bond (1991), with lagged dependent variables. The GMM, which is a form of instrumental variable estimation, relaxes the assumptions of both serial correlation and heteroscedasticity, also solve the problem of endogeneity among variables.

Table 4.1.1: Impact of Climate Change Variables and Cereal Production on Economic Growth in case of Pakistan

	Model-1		**Model-2**		**Model-3**		**Model-4**	
Dependent Variable = lnGDP								
Independent Variables	**Co-efficient**	**p-value**	**Co-efficient**	**p-value**	**Co-efficient**	**p-value**	**Co-efficient**	**p-value**
Constant	-19.92440	0.2124	-9.283409	0.3382	6.038094	0.2648	-42.75990	0.0089
$GDP_{(-1)}$	0.094352	0.2961	0.026725	0.8084	0.043149	0.6564	0.171418	0.0834
$lnCO_2$	-1.108045	0.0933						
lnCP	1.988254	0.1461	3.186942	0.0768	0.019751	0.9872	6.069542	0.0033
lnCH			-3.765755	0.0454				
lnN_4O					-0.494663	0.7786		
lnGHG							-	0.00

							4.823761	20
R-square	0.268		0.216		0.185		0.305	
Prob (J-statistic)	0.0051		0.0254		0.00098		0.0438	

Table 4.1.1 shows the GMM estimation on carbon dioxide emissions, cereal production and economic growth. The results show that carbon dioxide emissions have negative relationship with economic growth, with the decrease in carbon dioxide emissions, economic growth tends to reduce. Cereal production has positive relationship with economic growth, with the increase in cereal production economic growth will increase. Because when there is more cereals or food are available, hunger will reduce and people gain the desirable health by completing their daily calorie intake requirement. As health is an important element of human capital development, so with increase in health status of a country, human capital development environmental leads in a country. With the efficient scale of human capital development, a country will definitely improve. The coefficient values indicate that when there will be 1% increase in carbon dioxide emissions and cereal production and, economic growth will tend to decrease by 1.10% and increase by 1.98% respectively.

Table 4.1.2: Impact of Climate Change Variables and Cereal Production on Economic Growth in case of India

	Model-5		**Model-6**		**Model-7**		**Model-8**	
Dependent Variable = lnGDP								
Independent Variables	**Co-efficient**	**p-value**	**Co-efficient**	**p-value**	**Co-efficient**	**p-value**	**Co-efficient**	**p-value**
Constant	-28.41734	0.0751	-0.918360	0.9439	-32.83377	0.0015	-30.39201	0.0028
$GDP_{(-1)}$	0.075452	0.1145	0.065136	0.0310	0.065807	0.0257	0.069051	0.0184
$lnCO_2$	-0.358	0.4552						

	898							
lnCP	1.828292	0.1171	2.986144	0.0395	2.903450	0.0132	2.497791	0.0173
lnCH			-4.132405	0.1667				
lnN_4O					-1.738671	0.0968		
lnGHG							-1.027484	0.1456
R-square	0.613		0.580		0.601		0.597	
Prob (J-statistic)	0.0692		0.0908		0.0562		0.0597	

Table 4.1.2 shows the GMM estimation on carbon dioxide emissions, cereal production and economic growth in case of India. The results show that carbon dioxide emission, methane emission, nitrous oxide emission and total greenhouse gases have negative relationship with economic growth in case of India, with the decrease in carbon dioxide emissions, economic growth tends to reduce. Cereal production has positive relationship with economic growth, with the increase in cereal production economic growth will increase. The coefficient values indicate that when there will be 1% increase in carbon dioxide emissions and cereal production, economic growth will tend to decrease by 0.35% and increase by 1.82% respectively. With the 1% increase in methane emission, nitrous oxide emission and total greenhouse gases, the economic growth will tend to reduce by 4.13%, 1.73% and 1.02% respectively. In the presence of these climatic variables, cereal production will affect the economic growth by 2.98%, 2.90% and 2.49% respectively in a positive manner.

Table 4.1.3: Impact of Climate Change Variables and Cereal Production on Economic Growth in case of Bangladesh

	Model-9	**Model-10**	**Model-11**	**Model-12**

Dependent Variable = Log of GDP Growth Annual (%)								
Independent Variables	**Co-efficient**	**p-value**	**Co-efficient**	**p-value**	**Co-efficient**	**p-value**	**Co-efficient**	**p-value**
Constant	15.53512	0.2704	3.401918	0.8538	-6.903056	0.0744	-17.00435	0.0309
$GDP_{(-1)}$	0.091326	0.0014	0.086958	0.0101	0.0.89411	0.0013	0.051681	0.0286
$lnCO_2$	0.885903	0.0646						
lnCP	-1.323925	0.2224	0.964837	0.0285	-0.158473	0.7588	-0.137167	0.8589
lnCH			-1.627313	0.4554				
lnN_4O					1.134887	0.0809		
lnGHG							1.764348	0.3010
R-square	0.317		0.296		0.333		0.398	
Prob (J-statistic)	0.0693		0.0201		0.0994		0.0234	

Table 4.1.3 shows the GMM estimation on carbon dioxide emissions, cereal production and economic growth in case of Bangladesh. The results show that carbon dioxide emission, nitrous oxide emission and total greenhouse gases have positive relationship with economic growth in case of Bangladesh, while only methane emission has negative relationship with economic growth. The scenario is different from Pakistan and India. The situation of relationship among cereal production and economic growth in the presence of climate change variable is also opposite in Bangladesh as compared to Pakistan and India. With the increase in carbon dioxide emissions, nitrous oxide emission and total greenhouse gases, economic growth tends to increase by 0.88%, 1.13% and 1.76%

respectively. While with the 1% increase in methane emission, economic growth will reduce by 1.62%. Cereal production has positive relationship with economic growth, with the increase in cereal production economic growth will increase. The coefficient values indicate that when there will be 1% increase in carbon dioxide emissions and cereal production and, economic growth will tend to decrease by 0.88% and increase by 1.82% respectively. With the 1% increase in methane emission, nitrous oxide emission and total greenhouse gases, the economic growth will tend to reduce by 4.13%, 1.73% and 1.02% respectively. In the presence of these climatic variables, cereal production will affect the economic growth by 2.98%, 2.90% and 2.49% respectively in a positive manner.

5. Conclusion and Policy Recommendations

The study focuses on the impact of climate change on production of two major crops of South Asian countries mainly Pakistan, India and Bangladesh. Time-series analysis is done for each country; data was collected from different secondary sources from 1971 to 2013. Generalized Method of Movement is used for analysis. Agricultural production depends on climatic situation of a country which plays a vital role in the economies, particularly agricultural economies like Pakistan, India and Bangladesh. Results show that effects of climate change variables which are carbon dioxide emission; methane emission, nitrous oxide emission and total greenhouse gases emission have negative relationship with economic growth both in case of Pakistan and India, while the situation is different in case of Bangladesh. According to results, out of four climatic variables two variables effect the economic growth positively (carbon dioxide emission and methane emission) and the other two effect the economic growth of Bangladesh negatively (nitrous oxide emission and total greenhouse gases emission). The reason might be that carbon dioxide emission is the result of industrialization which positively contributing in the economy by increasing GDP, but due to increase in CO_2, atmospheric temperature will also increase which is harmful for crop production (agriculture sector). Concentration of carbon dioxide emissions Effect of cereal production on economic growth is same in

Pakistan and India while Bangladesh shows contradictory results as compared to Pakistan and India.

There is need to overcome the problem of climate change both in Pakistan and India particularly in the situation of total greenhouse gases which includes carbon dioxide emission, methane emission; nitrous oxide emission and total greenhouse gases. When the atmospheric concentration of these gases increases, it leads to increase in the atmospheric temperature which further effects the agricultural production and ultimately leads to decrease in the economic growth of an economy. There is a dire need to expand climatic and agricultural research for the improvement of the farmers. Agricultural sustainability is one of the required ways to alleviate the climatic fear & air pollution that would more support the agricultural set-up for healthy life. There should be an improvement in education, awareness raising and institutional capacity building on early warning signs, climate change reduction, and adaptations.

Finally, the Government of Pakistan and India should assimilate climate change actions into the national policies, strategies and planning to support the economy's effort for attaining a sustainable environment. Implementing air pollutant emission control modules, other cleaner and more proficient technologies will certainly decrease air pollution. These technologies will mitigate final energy use and developing countries like Pakistan, India and Bangladesh will be able to reduce total greenhouse gas emission particularly the CO_2 emissions because it has more concentration as compared to other greenhouse gases. We can summarize the results by stating that South Asian agriculture is sensitive to climate variations. Policy implications and adaptations have been recommended to mitigate the impacts of climate change on agricultural productivity and economic growth.

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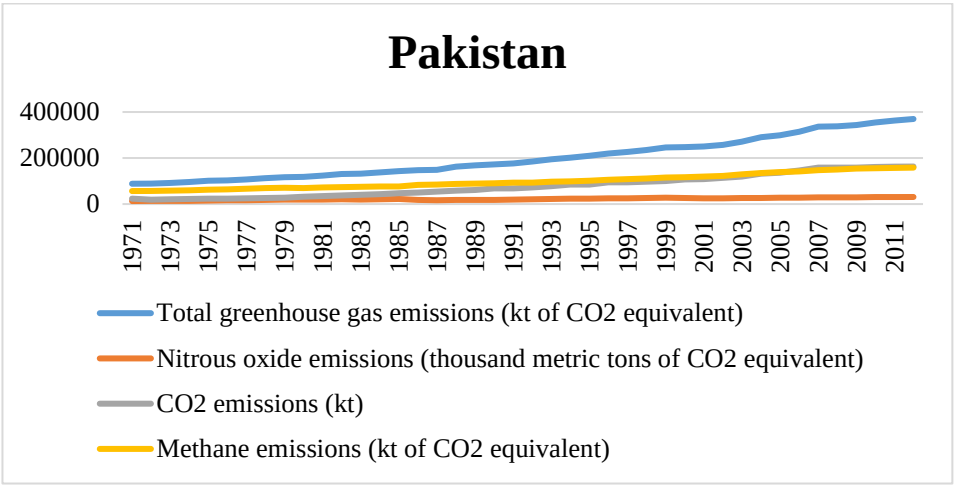
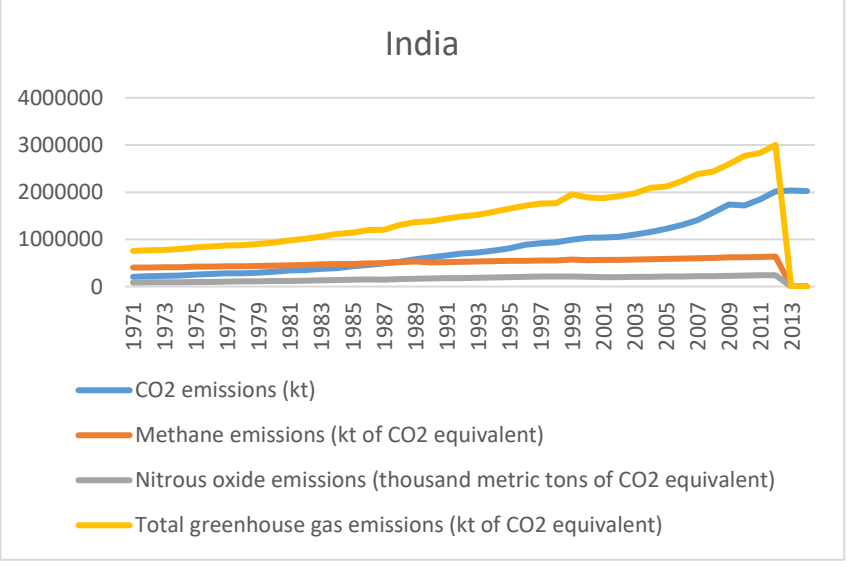
Appendix

Appendix-1: Situation of Climate Change in case of Pakistan.



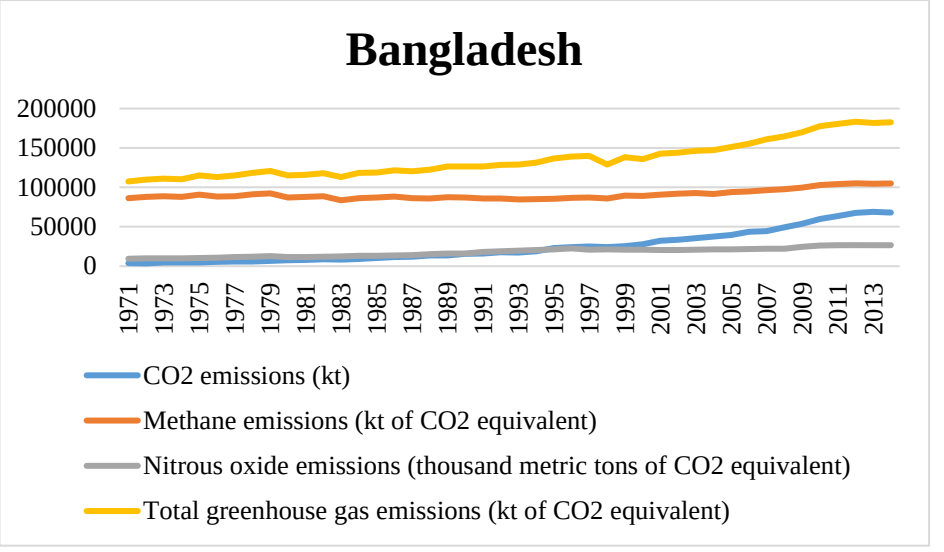
Source: WDI, (2015).

Appendix-2: Situation of Climate Change in case of India.



Source: WDI (2015)

Appendix-3: Situation of Climate Change in case of Bangladesh.



Source: WDI, (2015)

GCU Economic Journal, Volume LII (1&2), 2019, pp. 1-23

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