

Climate Changes and its Impact on the Agriculture Sector in Selected South Asian Countries

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Abstract: This study depicts an inclusive estimation of climate variation and its effects on agriculture sector in the selected South Asian countries (India, Bangladesh, Pakistan, Nepal, Bhutan and Sri-Lanka) over the period of 1990-2014. Agriculture sector plays vigorous role in the economy of selected South Asian states because more than 60% people work in this sector. The rapid growth of industrialization and weather variation causes the raise of the temperature level by which reduce production of agriculture crops and the people face heavy losses. Therefore, main objective of this study is to detect the influence of the global weather variation in agriculture sector of selected South Asian countries. Agriculture sector is used as dependent variable. CO₂ emission, gross capital formation, labor force and temperature are used as explanatory variables. Auto regressive distributed lag model is employed to examine the influence of climate variation on the agricultural sector. For analysis panel data were collected from selected South Asian countries. The existence of the short and long term relationship between dependent and independent variables is also assessed by this model. Thus, findings show the climate variation has significant effect on the agricultural sector. In a policy recommendation, government should use sector-wise policies and friendly environmental policies which minimize the negative effect of climate change.

Keywords: Climate change, agriculture sector, selected South Asian countries.

Introduction

There is a strong correlation between climate change and agricultural sector of economy. Every country uses energy and produces greenhouse gas (GHG). The estimation shows that all developed countries contribute to approximately 75% of total carbon dioxide emission. The service, agricultural and manufacturing sectors depend on the use of energy and environment. Nevertheless, growth of major sectors of economy may produce preliminary cycles of worsening but due to adoption of the modern technologies, the worsening of environment may disappear. Recently due to land use change, burning of fossils fuels, industrialization, development in agriculture sector and deforestation have released large amount of GHG in atmosphere in the form of nitrogen dioxide (N₂O), methane (CH₄) and carbon dioxide (CO₂). Excess emissions of these gases have caused increase in amount of heat from sun to earth atmosphere. These gases are main contributors to climate change in 20th Century and will further contribute in 21st Century and beyond (Sivakumar and Stefanski, 2010).

The rise in heat led to greenhouse effect resulting in climate change which is a long period challenge world facing in this era (Vaghefi et al., 2011). Climate change has begun as automotive and self-encouraging process due to greenhouse gases emission (Szijarto, 2012). According to current trends, in next 50 years average global temperature could rise by 2 to 3° as compared to pre-industrial period.

The selected South Asia countries like India, Bangladesh, Nepal, Pakistan, Bhutan, and Sri-Lanka are considered as one of the lowest areas in biosphere (Islam and Sultan, 2009). Most people of this region are engaged in agriculture sector (Sivkumar and Stefanski, 2010). Wave of globalization has opened many windows of opportunities but most of the region has not gained benefit from globalization. Although, GDP per capita of south Asian countries has increased during last decades but real poverty has not declined and income inequality is increasing. Besides all these issues, region is also vulnerable to disasters and climatic conditions. This vulnerability is due to socio-economic demographic backgrounds, geo-climatic conditions, growing population, natural resource degradation and huge dependence on agriculture sector for livelihood. Earthquakes, floods, storms, cyclones and landslides are some common disasters that South Asian countries face regularly. Economies of South Asian countries rely on agriculture, fisheries and natural resources. Increased risk of flood owing to climate change would decrease production in these sectors (Fischer et al., 2005). Many studies revealed that all these events are occurring due to climate change and environmental degradation. Majority of South Asian people live on climate sensitive sectors such as agriculture and variations in weather condition will affect crop productivity, arable land and influence the well-being of millions people of South Asia. Generally in past and present, climate shows increasing trend of changes in temperature and also increasing trend of strength and frequency of extreme actions during last century. In 21st Century temperature projections suggest significant acceleration of warming

as compared to 20th Century in South Asia countries.

Projected warming for South Asia is about 2-6 C° by the end of 21st Century (Ravindranath, 2007) and about 0.2 C° warming is projected per decade for future. Climate change has serious impact on economic performance, livelihoods and health of a large number of people in South Asia region (Islam and Sultan, 2009). Akram (2012) projects that change in temperature, precipitation, and population growth have negative impact on economic growth of selected South Asian countries which are more vulnerable to climate changes including their socio-economic, demographic backgrounds, geo- climatic conditions, rural sector for livelihood and dependence on agriculture (Yohe et al., 2008).

Roson et al. (2006), Kumar et al., (2004) and Gbetibouo and Hassan (2005) suggested that rainfall, sea level pressure and temperature significantly influence the crop production. Ciscaret et al., (2010), Schlenker and Roberts (2009) and Féreset et al. (2010) suggested that changes in climatic condition significantly affect the land use pattern such as conversion of forest land to pasture land and increased deforestation. Janjua et al. (2010) used vector auto regressive (VAR) model to assess the influence of climate change on wheat crop in Pakistan and suggested that there is no significant influence on production of wheat up to now but the projection period from 2010 to 2060 reveals that climate variations affect the yields of wheat in future. The studies of Vaghefi et al. (2011) and Ayinde et al. (2011) suggest that weather variation has negative effect on rice production and farm income. Mishra and Sahu (2014) revealed that climate variables and most of others control variables significantly influence the net revenue per hectare in region. The study of Gupta et al. (2014) emphasize that millets are less affected by climatic condition but Sorghum represents feeling to climate change. The research of Alboghdady and El-Hendawy (2016) advocate that precipitation increase in fall and winter season and it has negative effect on agriculture production. Akram and Hamid (2014) explored the influence of weather variation on two major component food security and health security in South Asia which are badly affected by climate change. Dumrul and Kilicaslan (2017) used ARDL approach and they determined positive relationship between precipitation and agricultural GDP.

The study of Bocci (2019) emphasizes the agricultural sector gains negative influence from climate variation and it is expected that due to rapid acceleration of pressure will get negative impacts. On other hand, the study of Sutton (2019) stated the impact of our food systems on weather variation and impact of weather variation on land and food production is just beginning to enter in vast area of research.

Materials and Methods

Data for climate variables temperature and precipitation will be obtained from World Bank climate change knowledge portal. Historical data for temperature and rainfall (main form of precipitation) is available from 1900 to 2015 on monthly basis. Because data of other variables is not available on monthly basis so annual averages for climate variables are calculated from monthly data and this type of data transformation has already been done in the study area by Akram and Hamid (2014, 2015). Data of other variables such as gross capital formation, CO₂ emission, total labor force, agricultures and temperature have been obtained from World Development Indicators.

Temperature is measured by using Celsius scale (denoted C°), and Fahrenheit (denoted °F). Carbon dioxide emission is greenhouse gas (GHG) which releases carbon into atmosphere. It is measured in metric tons per capita. Similarly, Gross capital formation is addition of fixed assets in economy. Labor force consists of all the persons who have age of working and are above 15 years.

ARDL model is used in this study for analysis, which was developed by Pearson et al. (1998) to determine the log-run relationship between variables. Decision to employ this approach is based on the results of unit's roots test. Either some variables are stationary at level I(0) and others are stationary at 1st difference I(1). Thus, ARDL technique is appropriate to find results, which has some advantages. First advantage of this technique is that problem of serial correlation and endogeneity are resolved by estimation of ARDL with appropriate lag. Second both short run and long run coefficients are estimated by ARDL.

$$\text{Empirical Model } LAGRI = \beta_0 + \beta_1 LTEM + \beta_2 LCO_2 + \beta_3 LGCF + \beta_4 LLFP + \mu$$

Where β_0 is intercept and μ represent error term while $\beta_1, \beta_2, \beta_3, \beta_4$ represent parameters of coefficients.

LAGRI= Log of agricultural growth

LTEM= Log of annual average temperature

LCO₂= Log of carbon dioxide emission

LGCF= Log of gross capital formation

LLFP=Log of labor force participation

Unites Roots Tests the classical methods follow assumption in econometric estimation that mean and variance of series are constant over a period of time. Whereas, during analysis of data in reality mean and variance of many macroeconomic series vary over time. These types of variables are known as non-stationary or unit root variables and these series have

unit root problems. When classical techniques such as Ordinary least squares OLS are applied on non-stationary variables its shows spurious estimation. Therefore, these findings are not valid. Nevertheless, stationarity of variables is tested by the Levin, Lin, Chu (LLC) test, Im, pesran and shin test. These tests are more valid than simple Dicky Fuller test.

Results and Discussion

Results of variables used in this study consist of mean, median, minimum, maximum and standard deviation (Table 1). These findings reveal validation of mean, variance and standard deviation for selected South Asian countries. For another variable LTEM value of mean is 1.288 while values of median and standard deviation are 1.354 and 0.142 respectively. Similarly values of mean, median and standard deviations of LLF are 7.234, 7.346 and 0.98 respectively. In contrast LCO₂ have mean and median values negative and standard deviation has positive value. The mean, median and standard deviation values of LCO₂ are -0.328, -0.214 and 0.346 respectively. Range of LAGRI is between 0.870-1.650 and its mean, median and standard deviation are 1.442, 1.4207 and 0.158 respectively. Values of mean, median and standard deviation for LLFP are 7.234, 7.346 and 0.983 respectively, while range lies between 5.287-8.695. LGCF range lies between 1.149-1.831 and mean, median and standard deviation values are 1.442, 1.4207 and 0.154 respectively. The LLF has highest value of standard deviation, which shows that it has high volatility than others variables.

Table 1 Descriptive statistics of data for selected South Asian countries during 1990-2014.

Variable	LTEM	LLFP	LCO2	LGCF	LAGRI
Mean	1.2882	7.234	-0.328	1.442	1.338
Median	1.3548	7.346	-0.214	1.4207	1.356
Maximum	1.4429	8.695	0.237	1.831	1.650
Minimum	1.053	5.287	-1.305	1.149	0.870
Standard deviation	0.1429	0.983	0.346	0.154	0.158

Table 2. Results of Panel unit root test (LLC test) for selected South Asian countries during 1990-2016.

Variable	Level			1 st Difference				
	Intercept	P-value	Trend and intercept	P-value	Intercept	P-value	Trend and intercept	P-value
LGCF	-2.831	0.00*	1.10	0.86	-7.20	0.00	-5.83	0.00
LLFP	-1.813	0.03*	-2.83	0.02*	-1.314	0.09	0.95	0.00
LTEM	-5.558	0.00*	-14.87	0.00*	-6.17	0.00*	-12.47	0.00*
LCO2	-1.332	0.091	1.605	0.945	-2.89	0.09*	-1.581	0.056
LAGRI	-1.314	0.09*	-11.70	0.00	-0.20	0.00	-10.07	0.00*

*Represent the significance level at 1% ** represent significance level at 5%

Before using cointegration technique, the Levin, Lin and Chu (LLC) unit root test was used on natural logarithms for selected variables in level and first difference for investigating stationarity of variables. Findings with intercept, intercept and trend at level and first difference reveal validation of unit root for selected South Asian countries for the period of 1990-2016 (Table 2). Some variables are stationary at level and others are at first difference and thus, order of integration is a mixture of I(0) and I(1).

Gross capital formation and carbon dioxide emission are not stationary al level with the specification of intercept and trend, and thus are not cointegrated at I(0), Whereas, agricultural sector, temperature and labor force participation are stationary at level, which they are integrated at I(0) with both specification trend, trend and intercept. This refers to a stable correlation among climate change and the agricultural sector.

The results of Auto regressive distributed lag model are shown in Table 3. The list of cointegrated variables are depicted in 1st column, while remaining 2nd, 3rd, and 4th columns represent coefficient, standard error, t-statistics respectively.

Table 3 Long run results of ARDL estimation for selected South Asian countries model (4, 1,1,1,1) during 1990–2014.

Var	Coeff	Std. Error	t-Stat	Prob.*
LCO2	-0.35	0.134	-2.611	0.012*
LLFP	1.61	0.63	2.53	0.012*
LTEM	-4.78	1.54	-3.09	0.001*
LGCF	0.396	0.286	1.383	0.169*

*Significance level of 1 % and ** significance level of 5%

Last column represents conclusion of variables which are significant or insignificant on the basis of probability values (p-values). The estimation of findings indicates that temperature has negative and significant impact on the agriculture sector in selected South Asian countries. The result explains that the agriculture is elastic with respect to temperature and 1% increase in temperature decreases agriculture production by 4.78%. These results are in accordance with the previous studies (Ayinde et al., 2011 and Kumar et al. 2004).

The coefficient of Gross Capital Formation (GCF) has been found to be positive and insignificant having p-values (0.169). While, positive coefficient of gross capital formation indicates that appropriate level of gross capital formation is required for agriculture sector growth. Results suggest that 1% increase in GCF increases agriculture production by 0.39%, but it is insignificant. In addition effect of labor force on agriculture is found to be positive (0.841) and significant at 1% level having p-value of (0.012). Positive value of coefficient indicates that 1% increase in labor force increases agriculture production by

1.61%. These results of LGCF and LLFP are in line with economic theory that both labor (L) and capital (K) are important factors of production. Thus, productivity of the agriculture sector is affected by the change in these factors.

Negative and significant association is found between CO₂ emanation and the agriculture sector. The coefficient of CO₂ emission is -0.35 and is significant at 1%, which means that 1% increase in CO₂ emission, decrease in agriculture sector is by 0.35% in the long-run. Moreover, 1% increase in LTEM can reduce the agricultural sector by 4.78% as estimated by ARDL. These findings are also supported by various studies on this subject, including, Akram and Hamid, (2015), Ayinde, (2011), Dumrul and Kilicaslan, (2017) and Bocci and Smanis, (2019).

Table 4 Results for panel data analysis estimation by ARDL for selected South Asian countries during 1990-2014.

Short Run Equation				
Var	Coefficient	St.error	t-stat	Prob
COINT-EQ01	-0.058	0.06	-2.22	0.028
D(LAGRRI(-1))	-0.143	0.11	-1.36	0.175
D(LAGRRI(-2))	-0.021	0.101	-0.26	0.781
D(AGRI(-3))	-0.072	0.10	-0.67	0.493
D(LCO2)	0.041	0.11	0.401	0.682
D(LLFP)	-0.375	0.21	-1.77	0.834
D(LTEM)	-0.582	0.54	-1.07	0.212
D(LGCF)	0.74	0.39	-1.87	0.321

Table 4 indicates findings of short run relationship among the variables and its first column consists of independent variables with and without lag. Remaining columns 2nd, 3rd and 4th represent coefficients of variables, t-statistics and standard errors respectively. The last column of table consists of P-values. Results show that coefficient of error correction model (ECM) is negative and significant at 1% level having p-value (0.028). Negative coefficient value 0.058 shows that model will converge from short run to long run annually at the speed of 5.8 % with change in independent variables employed in this study.

In short run, CO₂ without lag have positive and insignificant relationship with the agriculture sector, while labor force participation has negative and insignificant relationship in short run. Temperature without lag have negative coefficient which implies that increase in temperature decreases agriculture in short run. Similarly in long run temperature has negative impact on the agriculture sector. GCF have positive impact on the agriculture sector in short run, but it is insignificant and these results are in line with the fact that in short run it is not possible for labor to use advance technology efficiently rather it takes some time to get familiar with advancement in technology. Coefficient of last year CO₂ has positive but

insignificant relationship with the agriculture sector while coefficient value of CO₂emission of 2nd and 3rd year lag shows negative and insignificant association with agriculture. Gross capital formation shows positive but insignificant relationship with agriculture in last three years. Coefficient value of temperature is positively related with agriculture sector in last two years, while value of lag 3 is negatively related to agriculture in the short run. On the other hand, coefficient value of labor force is negative and insignificant in last year while positive but insignificant relationship is noted between labor force and agriculture in the second and third lag respectively.

Conclusion

Empirical results reveal that temperature has negative and significant effect on agricultural productivity and 1% increase in temperature reduces agriculture production by 5.5%. Similarly, 1% increase in carbon dioxide emission reduces agriculture production by 0.35%. Other variables such as labor force and gross capital formation show positive association with agriculture. The findings reveal that climate variation has a non- positive and significant impact on the agricultural sector. It is expected that in future the effects of climate variation on this sector will increase. Furthermore, government should use sector-wise and friendly environmental policies which minimize the adverse effect of climate change on agriculture.

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