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How do Climate Change, Environmental Degradation and Economic Growth affect Crops Production in Pakistan?

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ARTICLE DETAILS	ABSTRACT
History: Accepted 29 October 2021 Available Online December 2021	<p><i>Climate change has become one of the most imperative problems of this century. Climate change is a grave global threat, and Pakistan has been ranked eighth on the list of countries most vulnerable to climate change by the German watch Global Climate Risk Index. The increasing amount of carbon dioxide (CO₂), the foremost contributor to environmental degradation, seems to provoke this problem. Agriculture-based economies have always been dependent on the vagaries of nature and climate. Present study analyses the climate change, environmental degradation, input index and economic growth impact on crops production in Pakistan from 1977 to 2016. Our study employs Auto Regressive Distributed Lag Model (ARDL) to check the long run association among the variables. The results shows that positive association among climate change and crops production in the long run. On the behalf of results policymakers must drive attention to adopt advanced cultivation processes using farming practice through international research institutions' assistance to further improve crops production in Pakistan.</i></p>
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1. Introduction

From the last two decades global humanity facing a multi-complex problem that is known as climate change. Climate change events may vary from country to country, and no country is free from it (O'Neill, et al., 2020). The atmospheric situation that prevails for some days is known as weather

while if these circumstances conquer intended for a season, decade, or century known as climate (Bucchignani, *et al.*, 2021). Climate change influences agriculture production through temperature and precipitation (WB, 2008; Anderson, *et al.*, 2020). Climate change positively or negatively influences the agriculture sector varies from crop to crop and region to region (Aaheim *et al.*, 2012; IPPC, 2014; Dellink, *et al.*, 2019). Climate change is a mere threat as rich countries are thinking; rather, it has negative effect on economic growth (Johnsson *et al.*, 2019). The climate conditions are closely related to agriculture output and can dramatically reduce it (Raza *et al.*, 2019). Developing countries like Pakistan, India, and Bangladesh are more climate-sensitive than developed countries; they cannot cope with climate susceptibility because they do not have advanced technology and better adoption change (Shakoor *et al.*, 2011).

Pakistan entails arid and semi-arid areas: in the previous century, average temperature and precipitation increased 0.6 °C and 25% all over Pakistan. During 2000-2012 average temperature stood at 0.7 °C of which was higher than 1985 to 1999 (GOP, 2017). Figures 1 and 2 display the growth rate trend of average annual temperature and rainfall.

Fig. 1 Average Annual Temperature Growth Rate Graph

Source: Author's Contribution

Fig. 2 Average Annual Rainfall Pattern Growth Rate Graph

Source: Author's Contribution

Projections made by the Global Change Impact Studies Centre (GCISC) indicate that the average temperature over Pakistan would increase in the coming decades at a pace faster than the average global temperature and may even exceed it by 1°C at the end of the century. (GoP, 2013, p.244).

Agriculture is the cornerstone of Pakistan's economy and a major source of gross domestic product, unfortunately, this sector is going backward since its inception. The agriculture sector provides foods to living beings and the secondary sector attains fiber from cotton. However, it contributed 19.5% in gross domestic product and 43.5% labor force employed in it (GOP, 2017). As human beings, we cannot separate ourselves from nature, and while living in Pakistan, we cannot detach ourselves from it. This sector progression is linked with weather and climate circumstances like drought, flood, temperature, and rainfall pattern which negatively influences production and prices. Agriculture production plays a key role in poverty alleviation. A stable agriculture sector ensures food availability for the livelihood of a country. Figure 3 shows the Crops production growth trend.

Fig 3 Crops Production Growth Rate Graph

Source: Author's Contribution

Agriculture production is influenced by rainfall patterns, temperature variation, water accessibility, land suitability, evapotranspiration¹, vagaries sowing, and harvesting dates. (Harry *et al.*, 1993). The agricultural sector is based on non-supporting weather circumstances irrigation systems besides soil quality and other inputs (Gornall *et al.*, 2010). Deviation in climate variables (temperature and precipitation) has an enormous impact on crop production (Calzadilla *et al.*, 2014). Temperature and rainfall are known as the direct largest inputs influencing agriculture production (Akram and Hamid, 2015).

Environmental degradation is the most debating concern of this century. Carbon dioxide (CO₂) is a major contributor to it which is increasing over time (Kirikkaleli, *et al.*, 2021). Men play a pivotal role in increasing the carbon-dioxide concentration in the atmosphere; before industrialization, its amount was 280ppm² (Hashimoto K., 2019). It rises by 380ppm because of fossil fuels' enormous

¹The sum of evaporation and plant transpiration from the surface of the earth to the atmosphere.

²PPM means parts per million. It is used to measure the level of pollution in the air. It is a ratio between pollutant components and the solution.

practice besides deforestation. Carbon dioxide plays a pivotal role in the greenhouse gas effect (Ifeanyi-obi *et al.*, 2012). Carbon dioxide progressively influences plants through two channels. The first one is a rise in the plant's photosynthesis process, which is noticeable in C₃ crops. The second one is that the rising concentration of carbon-di-oxide in the atmosphere reduces the transpiration³ due to incompletely close by stomata and deterioration in water loss of plants. Both features improve the efficiency of plants refers to the escalation of growth. Intensification of the level of carbon-di-oxide illustrates the progressive influence on plant growth. (Maroco *et al.*, 1999; Admas *et al.*, 2000). The immense amount of carbon-di-oxide in the atmosphere alludes to an escalation of water consumption efficiency, crops growth and vastly upsets water availability (Gedney *et al.*, 2006; Long *et al.*, 2006 and Betts *et al.*, 2007). Economists are concerned about climate change and environmental quality in the economic framework because it has been observed that these are important concerns for the agriculture sector and policy-making of a country.

2. Review of Empirical Studies

Warrick (1988) examined the influence of carbon-di-oxide and climate trends on the agriculture sector. The researcher accessed a huge concentration of carbon-di-oxide in the atmosphere to increase water efficiency by transpiration in C₃ Crops in a particular wheat crop. The research validated that if the concentration of carbon-di-oxide doubles in the atmosphere, it will increase 10 to 50% of wheat production in the mid and high-latitude regions of Europe and America. Variation in temperature and precipitation refers to a 3-7 % decline in wheat production.

Hanif *et al.* (2010) quantified the negative economic impact of climatic change on major crops in Punjab. This study concerned agrarian economies directly interconnected with weather conditions and agriculture regions affected by rainfall variability and temperature variability. Janjua *et al.* (2010) researched the influence of climate change on wheat production in Pakistan. This research highlighted that industrialization is the key factor for global warming since pre-industrialization carbon dioxide emission is less than as compared to post-industrialization. The study concluded that climate change has not threatened wheat production in Pakistan.

Shakoor *et al.* (2011) traced the effect of climate change on the agriculture sector in the arid region. The study found that a 1% and 8% rise in temperature and rainfall would cause a loss of 4180 rupees per annum and an increase of 377 rupees, respectively. The adverse temperature impact is higher than positive rainfall effects. Siddiqi *et al.* (2012) rendered the climate change effect on four major crops in Punjab. The temperature rise is beneficial for wheat productivity in the long run but harmful in the short run while rising in precipitation is valuable in both periods. The increase in temperature is positive for rice crops just in the first stage, but afterward, it is damaged conversely, the rise in precipitation has no adverse effect on cultivation stages. This study further elaborated that increase in temperature and precipitation is not beneficial for Cotton production, and the temperature rise is also dangerous for sugarcane production.

Janjua *et al.* (2013) explored wheat production under climate change in Pakistan. The research examined that geographical location plays a pivotal role in determining the impact of climate change. Wheat crop faces the positive impact of climate trends in a long and short period. Akram and Hamid (2015) asserted the threat of climate change for economic growth in Pakistan. The research caught

³Loss of water by the plant during an exchange of gases.

on that temperature has a significant and adverse effect on gross domestic product and three economic sectors. Simultaneously, adverse influence on the agriculture sector is higher than the remaining two sectors of the economy. Rehman *et al.* (2019) find out the connection between CO₂ emission and agriculture productivity in the case of Pakistan. CO₂ emission has a positive association with agriculture inputs, energy consumption, and gross domestic product per capita while negative with food grains and seeds.

Climate change has made the agriculture sector prone economically. The major aim is to search out the climate change, environmental degradation, input index and economic growth effect on crops production and highlight some measures for enhancing crops production to cope with climate change. This research-based empirical review will provide robustness of the results, especially on the climate change and crops output in Pakistan's case.

3.Data Sources, Descriptive Statistics, and Correlation Analysis

In this research, secondary time series data employ for the period 1977-2016. Temperature, rainfall, Arable land, gross domestic product, and carbon-di-oxide emission data procured from World Development Indicators (WDI). Crops production, fertilizer's off-take, water availability, and improved seeds distribution acquired from Annual Economic Survey of Pakistan (different editions). Table 1 highlight the description of variables briefly while Table 2 and 3 carry out the descriptive statistics and correlation matrix results.

Table 1

Variables Notation	Data Description	Measurement Unit	Expected Sign
QG	Crops production	Percentage of growth rate	(Dependent Variable)
LG	Arable land	Percentage of growth rate	Positive
TG	Average temperature	Percentage of growth rate	Positive
RG	Average rainfall	Percentage of growth rate	Positive
GG	Gross domestic product	Percentage of growth rate	Positive
CG	Carbon dioxide emission	Percentage of growth rate	Positive
II	Input index	Percentage of growth rate	Negative

Source: Author's calculations

Table 2

Descriptive Statistics							
	QG	LG	TG	RG	CG	GG	II
Mean	2.62	0.02	0.13	3.23	5.06	14.60	5.16
Median	2.07	0.12	-0.34	-4.35	5.70	13.51	4.17
Std. Dev.	6.79	2.31	2.63	29.65	4.31	5.24	8.35
Skewness	0.44	-0.26	-0.04	0.90	-0.22	0.96	0.60
Kurtosis	2.79	4.54	2.51	3.41	2.59	3.78	3.48
Jarque-Bera	1.37	4.40	0.42	5.65	0.60	7.09	2.81
Probability	0.50	0.11	0.81	0.06	0.74	0.03	0.25

Source: Author Calculation

The mean and median of QG are 2.62 and 2.07, whereas its standard deviation is 6.79. Mean, median, and standard deviations of TG and RG are 0.13, -0.34, 2.63 and 3.23, -4.35, 29.65 respectively. The mean and median of LG and AII are 0.02, 0.12, and 5.16, 4.17, while their standard deviation s are 2.31 and 8.35 correspondingly. The mean and median of CG and GG are 5.06, 5.70 besides 14.60, 13.51 although standard deviations are 4.31 and 5.24. Furthermore, the Mean and median of gross domestic product growth are as well as the standard deviation is 5.24.

QG, RG, GG, and II are positively skewed, while the remaining variables are in the row of negative skewed. LG, RG, GG, and II are greater than three that refer to leptokurtosis and flat type, although the remaining variables that are less than three are known as platykurtosis. GG's probability value is near zero (at a 5% level of significance), so it is not normally distributed while other variables are normally distributed. Jarque-Bera engaged that the sample data is normally distributed.

Table 3

Correlation Matrix							
	QG	LG	TG	RG	CG	GG	II
QG	1.00						
LG	0.08	1.00					
TG	0.20	-0.06	1.00				
RG	0.13	-0.19	-0.33	1.00			
CG	-0.05	-0.06	0.22	-0.05	1.00		
GG	-0.03	0.14	-0.02	-0.09	0.09	1.00	
II	-0.37	-0.01	-0.08	-0.04	0.04	0.11	1.00

Source: Author's Calculation

The explained variable QG is constructively related, except CG, GG, and II. LG has a negative association with all variables except GG. TG has only a positive connection with CG. RG has a negative liaison with variables, while CG and GG have a progressive link with variables.

Table 4

ADF Test for Unit Root							
Model	Intercept	Lag	Intercept and Trend	Lag	None	Lag	Result
LG	-12.669	0	-12.535	0	-12.83	0	I(0)
RG	-12.266	0	-12.135	0	-11.905	0	I(0)
TG	-8.203	1	-8.087	1	-8.282	1	I(0)
GG	-4.668	0	-4.894	0	-2.457	0	I(0)
CG	-2.030	1	-8.404	0	-1.248	2	I(I)
II	-6.494	0	-6.214	1	-4.830	0	I(0)
QG	-7.897	1	-7.789	1	-5.815	1	I(I)

Source: Author's Calculation

Augmented Dickey-Fuller (ADF) test engaged here all the variables are stationary at I (0) excluding carbon-di-oxide and crops production which showed in table 4. So, concluded that the ARDL technique would employ on it.

4. Model Specification

In the desired model climate change and environmental degradation is measured with the help of proxy variables temperature, rainfall and carbon dioxide emission respectively. The Input index is the summation of (seeds, water, mechanics, and fertilizer). Crops production growth rate (QG) is the dependent variable while in contrast, land growth rate (LG), average rainfall growth rate (RG), average temperature growth rate (TG), gross domestic product growth rate (GG), carbon-di-oxide emission growth rate (CG), and agriculture input index (II) are independent variables. The long-run equation on the base of ARDL regressed;

$$\Delta(QG)_t = \lambda + \sum_{j=1}^{q_1} \delta_1(QG)_{t-j} + \sum_{j=0}^{q_2} \delta_2(LG)_{t-j} + \sum_{j=0}^{q_3} \delta_3(RG)_{t-j} + \sum_{j=0}^{q_4} \delta_4(TG)_{t-j} + \sum_{j=0}^{q_5} \delta_5(CG)_{t-j} + \sum_{j=0}^{q_6} \delta_6(GG)_{t-j} + \sum_{j=0}^{q_7} \delta_7(II)_{t-j} + \phi_t \quad (1)$$

δ is a long-term parameter, and λ is the intercept and ϕ_t is known as the stochastic term for time series.

The short-run error correction equation is;

$$\Delta(QG)_t = \lambda + \sum_{j=1}^{q_1} \chi_1 \Delta(QG)_{t-j} + \sum_{j=0}^{q_2} \chi_2 \Delta(LG)_{t-j} + \sum_{j=0}^{q_3} \chi_3 \Delta(RG)_{t-j} + \sum_{j=0}^{q_4} \chi_4 \Delta(TG)_{t-j} + \sum_{j=0}^{q_5} \chi_5 \Delta(CG)_{t-j} + \sum_{j=0}^{q_6} \chi_6 \Delta(GG)_{t-j} + \sum_{j=0}^{q_7} \chi_7 \Delta(II)_{t-j} + \omega ECM_{t-1} + \phi_t$$

(2)

χ is a short-term parameter, Δ represent as the first difference operator, and λ is the intercept and ϕ_t known as the stochastic term for time series.

5.Results and Discussion

Through the bound test, the F-statistics value catches out 5.72 more than upper besides lower bound values results recommended that H_1 accepted, referring to co-integration flanked by a long run mention in table 5.

Table 5

ARDL Bounds Test		
Test Statistic	Test Statistic	Test Statistic
F-statistic	F-statistic	F-statistic
Critical Value Bounds		
Significance	Significance	Significance
10 %	10 %	10 %
5 %	5 %	5 %
2.50 %	2.50 %	2.50 %
1 %	1 %	1 %

Source:Authors' Estimation

After finding out, the co-integration succeeding step is to estimate the long-run association among crops production and independent variables.

Table 6

Long Run Coefficients Results (1, 1, 1, 0, 1, 0, 0)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LG	2.252	0.919	2.450	0.020
RG	0.168	0.069	2.414	0.022
TG	0.961	0.431	2.226	0.033
CG	0.453	0.262	1.726	0.094
GG	0.074	0.103	0.718	0.478
II	0.325	0.119	2.725	0.010

Source: Authors' Estimation

Table 6 explored that the long-run coefficient of LG shows that a 1% increase in it caused a 2.25% increase in QG and a statistically significant result supported by Janjua et al. (2010) and Janjua et al.(2013). RG rise 1% leads to a 0.16% rise in QG,and it is also statistically significant. The result is compatible withJanjua *et al.*(2010)and Ahmad *et al.*(2014).TG shows 1% increase in it lead to 0.96% increasein QG,and it is statistically significant. Supported by Xiao*et al.*(2007); Ashfaq *et al.*(2011); Ahmad *et al.*(2014), and Hanif *et al.* (2015). CG increase 1% stands for a 0.45% rise in QG that is highly significant. The result is supported by Warrick (1988), Mendelsohn *et al.* (1994), Gedney (2006); Long (2006); Betts *et al.* (2007). GG rise 1% refer to the 0.07% increase in crops production that significantly insignificant. Finally, increase in input index 1% leads to a 0.3% increase in crops production, which is significant at 0.01.

Table 7

Short Run Error Correction Results				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LG)	1.264	0.551	2.293	0.029
D(RG)	0.090	0.042	2.139	0.040
D(TG)	1.013	0.417	2.425	0.021
D(GG)	0.078	0.109	0.717	0.478
D(CG)	-0.240	0.225	-1.064	0.295
D(II)	-0.342	0.116	-2.952	0.006
CointEq(-1)	-1.054	0.145	-7.267	0.000
Diagnostic Checks				
R^2	0.906	<i>LM Test</i>	2.108(0.168)	
<i>Adj R</i> ²	0.834	<i>J.B Test</i>	2.921 (0.232)	
<i>Hetero Test</i>	0.956 (0.519)	<i>Ramsey test</i>	0.299 (0.594)	

Source: Authors' Estimation

Table 7 highlights that CG and II have the harm Q; solitary in the CG probability value is insignificant. Any shock in a short interval of time is covered by II, LG, RG, and TG. The shows the crops do not observe CG because it is required in the growing phase of plants. ECM value is -1.054; it would be more than -1 in line with (Narayan, 2006), which postulates that monotonically congregating to straight-line equilibrium pathway, the error correction procedure varies nearby the long-run value in a diminishing way as soon as when this procedure is suffering on the way to end, quickly convergence toward the equilibrium path. The above table shows the diagnostic results of model results shown that model is free from problems like serial correlation, heteroskedasticity, normality and stability issues.

6. Cusum and Cusumsq Test

The stability of the regression coefficients test shows in figures 4 and 5 the sample period is stable. Because it falls within the transverse lines or critical boundaries at a 5% level of significance.

Fig. 4 Cumulative Sum Test Result

Source: Authors' Estimation

Fig. 5: Cumulative Sum of Square Test Result

Source: Authors' Estimation

7. Conclusion and Policy Recommendations

The present study gives attention to explore climate change, environmental degradation, input index and economic growth influence on crops production in Pakistan. Climate change has a positive and negative impact on the agriculture sector; it varies from one region to another. Pakistan is also bearing impact of variation in climate. Agriculture sector is a vital component of the agricultural country's economic system. Industrialization plays a pivotal role in increasing the carbon-dioxide concentration in the atmosphere which lead to environmental degradation. II, LG and RG are most effective while TG is more effective after this CG, and GG is less effective for crops production under climate change and environmental degradation. Nut Shell, the model, is healthy; three of the test results are valid besides assessing outcomes of the study disclosed that all the employed variables disclose the positive impact on crops production except input index. So, this study finds out some policy suggestions; Agriculture research institutes should develop new seeds and fertilizers varieties besides the supply of water with advanced technologies. The government must take firm steps for agriculture inputs accessibility on subsidizing price at crops cultivation time and should raise awareness about the usage of crops inputs through accessible media sources. The government needs to control water-logging and salinity problems through which uncultivated land is utilized for Crops production. The government levay heavy taxes on those industrial sectors which produce non environment friendly products.

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