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Climate Change and Its Impact on Cash and Food Crop Production in Pakistan: A Time Series Analysis

Chan Bibi[1], Muhammad Zahid Naeem[2]

Abstract
This paper has examined the impact of climate change on cash and food crop production in Pakistan from 1980 to 2014. The Augmented Dickey Fuller test and unit root test is used for examining the stationarity of the variables. Autoregressive Distributed Lag model (ARDL) is used to evaluate the impact of climate change on the production of cotton and wheat. The estimated results show that increase temperature has a negative and significant relationship between climate change and production of cotton and wheat in Pakistan. Water availability, fertilizer offtake and cropped area has positive and significant effect with climate change. Climate change has a negative impact on the production of cotton and wheat so Pakistan should take step to cope with the changing climate conditions to increase the productivity.
Keywords: Carbon dioxide, Wheat area, Cotton area, Cropped area
JEL Codes: Q35, Q10

1. Introduction

Climate change will encounter the agricultural productivity through a number of ways like change in rainfall pattern, sowing and harvesting dates, temperature, water availability and evapotranspiration. United Nation Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time period. According to (IPCC 2007),climate change can be defined as ''change in climate due to natural or anthropogenic activities and this change remain for a long period. Pakistan being a part of South Asia is very susceptible to clamities presumably caused by the climate change. Increased area creating significant positive impact on wheat and cotton production. Proper availability of water, fertilizers can increase the productive capacity of the fields. Wheat is main food crop of Pakistan. The newly emerging threat of climate change may influence wheat production in Pakistan. Being an agricultural country it should be capable to secure domestic consumption by increasing the level of wheat production and the surplus product can be exported abroad to earn foreign exchange. Increased temperature has increased the production of wheat. The direct impact of carbondioxide on the production of wheat is positive as it enhances the water use efficiency of plants. Cotton is cash crop of Pakistan. Pakistan is the fourth major producer of cotton in the world. Cotton is grown in summer which is characterized by very high temperature in most areas of Pakistan. Pakistan's agriculture is both rainfed and irrigated but cotton crop is normally sown in the irrigated and semi arid areas due to its water requirement for proper growth [Naheed and Rasul (2010)].Though cotton is not high water consuming crop but low public awareness and technical inability makes pakistan more prone to climate change [Sayed (2011)].Although pakistan is not a very active contributor in greenhouse gas emission but is highly vulnerable to climate change due to its geographical location (Sayed, 2011).

2. Literature Review

Mustapha et al., (1997) analyze the effect of climate change and CO2 fertilisation on agriculture in Quebec. Agriculture sector play an important role in the economy of Quebec. The risk of global increase of atmospheric CO2 concentration and associated climatic change and their influence on agriculture need to be assessed. Canadian Climate Centre (CCC) general circulation model coupled with the Food and Agricultural Organization (FAO) crop model is attempt to assesses the response of agricultural productivity to both direct (fertilization) or by indirect (climatic) effects of increased atmospheric CO2 concentration. Major crops that discusses in the study includes C3 and C4 cerals, egumes, vegetables and special crops grow in Quebec.The results show that Ca cereals (corn and sorghum) crops have beneficial effects of climate change but be least favoured by CO2 fertilisation effect.

Fischer et al., (2005) examine the socio-economic and climate change impact on agriculture. It is an integrated assessment from 1990-2080. An integrated ecological-economic modeling frame work is employed in compassing climate scenarios ,agro-ecological zoning information, socio economic drivers as well as world food trade dynamics. Specifically, global simulation is performed using the FAO/IIASA ago ecological zone model , in conjunction with IIASAs global food system model, using climate variables from five different general circulation model, under four different socio economic scenarios from the intergovernmental panel on climate change. The results suggest that critical impact asymmetries due to both climate and socio-economic structures may depend current production and consumption gaps between developed and developing world. Agricultural techniques should be adopt to reduce the damage due to climate change.

Munang et al., (2008) analyze the effect of climate change on crop production in cameroon. The methodology involves coupling the transient diagnostic of 2 atmosphere-ocean general circulation models ,namely NASA/Goddard institute GISS and the Hadley centre's HadCM3, to the crop syst crop model to simulate current and future (2080) crop yields. Major crops such as Bambara nut , ground nut , maize , sorghum and soybean is studied in 8 agricultural region of Cameroon. The finding reveals that the effect of temperature pattern on climate change is much more important than that of precipitation.Findings call for monitoring of climate change/variability and dissemination of information to farmers ,to encourage adaptation to climate.

Lema and Majule (2009) examine the impact of climate change variability,and adaptation strategies on agriculture in semi arid areas of Tanzania.Study is carry in two villages of kamenyanga and Kintinku of Manyoni District, central

[1] Lahore School of Accountancy and Finance, University of Lahore, Pakistan
[2] Department of Economics, University of The Punjab, Pakistan

Tanzania.The overall objective of the study is to understand local communities perception on climate and variability issues and establish its impacts and adaptation strategies within agriculture sector.Primary and secondary data is use.In each village, a sample size of 10% of all households was interview. Findings reveal that local people affect from changes in rainfall and temperature. The change have affect not only crops but also livestock sector as well in a number of ways resulting in reduce productivity. Empirical analysis of rainfall suggests that decreasing rainfall trend between 1992 and 2007.Whereas mean maximum and minimum temperature increased by 1.9 and 0.2`C. The study concludes that farmers should have plenty of knowledge to cope with the situation occurs because of climate change and adopt strategies.Furthermore,development initiatives at community level in semi aridareas should put more emphasis water harvesting to ensure water storage for crops and livestock.

Chaudary et al., (2009) examine Economic analysis of competing crops with special reference to cotton production in Pakistan. Study is carry in two districts Multan and Bahawalpur. The data use in the study is primary in nature using Policy Analysis Matrix (PAM) methodology to assess the comparative advantage of cotton crop over its competing crops i.e. rice and sugar cane in the study area.Thecomparative advantage of cotton over the other important crops was calculated by applying DRC technique.The respective DRC values for, cotton, sugarcane and rice indicate that Multan and Bahawalpur regions has comparative advantage in producing cotton in national as well as in international market. The result implies that government should give subsidy to the farmers, should adopt the policies to reduce the production cost, cotton yield would be increase by providing quality inputs and by adopting better management practices.

Sillah (2009) anlyze the impact of climate change on cash and food crop production in Gambia. The study discusse about the impact of climate change on cash and food crop production in the Gambia using pooled and de-pooled data econometrics method. The de-pooled method is EGSL panel data method with random time effect. The findings reveal that land size and rainfall determine changes in the crop production. Crop production does not respond to change in prices. But it respond to the yield changes. As the introduction of new variety groundnut and rice gives a positive response while cotton ,maize and sorghum production decreases in response to new variety innovation .The study conclude that new variety and technology innovation give positive response in the production of groundnut and rice while its results are negative in the production of cotton,maize and sorghum so it should be revisited. Increasing the size of land is not the solution of the problem.The agricultural scientist and the policy makers should encourage the innovations and the adoption of labor intensive crops such as vegetables and fruit plants .Land size and rainfall play an important role to determine the agricultural output.But the land size is fixed.Rainfall is decreasing and highly variable,and production of land intensive crops cannot be done by irrigation.The last thing reveals fromthe study is that farmers donot directly respond to changes in the crop own prices.

Wang (2009) analyze how expected changes in climate affect agriculture in China.The effects of temperature and precipitation on net crop revenues is analyze using cross sectional data consist of both rainfed and irrigated farms .Data is primary in nature. Survey data is based on 8405 households across 28 provinces. The result implies that global warming is harmful to rainfed farms but is beneficial to irrigated farms. The net impacts only mildly harmful at first,but the damages will grow over time. Ringler et al., (2010) examine the impact of climate change in Sub-Saharan Africa using a comprehensive climate change scenario (CCC) based on ensembles of 17 GCMs selected based on their relative performance regarding past predictions of temperature and precipitations at the level of 20x20 grid cells. The result shows that the CCC scenario predicts consistently higher temperatures and mixed precipitations changes for the 2050 period. It also tells that how climate has change from the lastfew decades has effect yield, area growth. It also rise the prices of food which reduces the affordability of food, reduce calorie availability, and growing childhood malnutrition in Sub-Saharan Africa.

Khadka (2011) examine the impact of climate change on production of cash crops in Annapurna Conservative area. The research is carried in LwangGhalel V.D.C., Kaski district of Nepal with an objective to see the reaction of local people towards climate change impacts, to analyze the production of cash crops annually and relation to climate change and to determine the measures taken by local people against the climate change on cash crop production.Major cash crops such as tea, amriso,cardamom is discusses in the study area. Primary data is collected from household survey with semi-structured questionnaires, interview with key informants, group discussion, formal and informal discussion with random sampling. Thirty years Meteorological data (rainfall and temperature) is collected to study the rainfall and temperature pattern. Different published and unpublished literatures is use for collecting secondary data. Data is analyze using MS-Excel and SPSS-11.5 and present using tables, graphs and diagrams. Rainfall pattern and temperature is increase. The study concludes that awareness on climate change causes, impacts and adaptation, draught resistant varieties of seedlings should be distribute and reforestation and afforestation programs should be distribute to adapt with climate change. The result conclude that climate change affect flowers and fruits, harvest time of cash crops and the reason which is major was snow fall. There is decrease in survival rate of cash crops and reason is defective seedlings, lack of knowledge of planting and draught .Production of tea increases due to climate change while problem of cash crops production increases. The sale of cash crops increases which increases the income of household.

Mkonda andyusuph (2011) analyze the impact of climate change and variability on crop production and its implication to food security in Mvomero District, Tanzania.A sample size of 7%of all household heads were sampled at random from two villages and interview through questionnaires Also;FG, interview with key informants and participants observation survey were use to collect data.Rainfall and temperature data were collect from Kongwa and Kinyasungwemetrological stations,and from farmers.Data is analyzeusing statistical package for social sciences (SPSS) version 12 and MS excel. The study conclude that there is no correlation between the amount of rainfall and the numbers of wet spells.Finding reveals that good number of wet spells is better for the crop production due to sustainability of moisture.Also an increase in

temperature leads to severe drought due to evopotranspiration.It leads to poor crop yield and subsequently food insecurity.Therefore, to ensure food security; adaptation and copping mechanism recommended.
Arndt et al., (2012) examine the impact of climate change on agriculture and food security in developing countries. Climate change is a serious problem for the developing countries. Due to their reliance on rain-fed agriculture, both as a source of income and consumption, many low-income countries are considered to be the most vulnerable to climate change. To estimate the impact of climate change on food security in Tanzania. Representative climate projections is used in calibrated crop models to predict crop yield changes for 110 districts in Tanzania. These results are in turn impose on a highly disaggregated, recursive dynamic economy-wide model of Tanzania. The result implies that, relative to a no-climate-change baseline and considering domestic agricultural production as the channel of impact, food security inTanzania appears likely to deteriorate as a consequence of climate change. The analysis points to a highdegree of diversity of outcomes across climate scenarios, sectors, and regions. Noteworthy differences in impacts across households are also present both by region and by income category.

Ning (2013) examine the economic impact of climate change on representative cash crop farms at selected sites in Quebec and Ontario over the period 2010 to2039 using a mixed integer dynamic linear programming model. Five climate scenarios (hot and dry , hot and humid , median, cold and dry, and cold and humid) and four weather condition is selected and combined to form 20 different scenarios. Historical data on crop yield is use to validate the decision support system for agro technology transfer support system for agro technology transfer (DSSAT) model which is used to project future yield. Economic variables such as, cost of production and crop prices is projected using Monte Carlo simulation with crystal ball predictor. The finding implies that the optimal resource allocation, output, net returns ,economic vulnerability and adaptation strategies is dependent on the climate scenarios ,wealth condition ,type of crops and variety as well as site.

Ali et al., (2015) analyze the production cost of major crops in District Bahawalpur (Pakistan). Aim of the study is to estimate the production cost per unit and net income per unit of major crops. The primary source of data collection was multistage purposive sampling technique in order from tehsil, village and respondents. The sample size consist of four tehsils such as Bahawalpur, Yazman, Ahmadpur East and Hasilpur, 12 villages and 120 correspondents. For analysis purpose two major crops take such as wheat and cotton. Results shows that high variation is caused in output/income due to fluctuations in cost of production of cotton and wheat. All results were found to be significant at p=0.000.Wherease, results of cotton is found to be insignificant and negative relationship was found between cost and output/income.

Amin et al.,(2015) examine the effect of climate change on the yield and cropping area of major food crop. The study is carry in Bangladesh .Four major food crops such as Aus rice, Aman rice ,Boro rice and wheat is studied. Heteroskedasticity and Autocorrelation consistent standard error (HAC) and feasible generalized least square (FGKS) method is used to determine the climate-crop interrelation using national level time series data for the period of 1972-2010. The result shows that the effects of all the climate variables have bad significant contributions to the yield and cropping area of major food crops with distinct variation among them. Maximum temperature adversely affect yield and cropping area . Rainfall severely affect Aman rice only. Finding implies that government should give considerable attention to the generation development and extension of drought and flood tolerant varieties.

Ning et al., (2016) examine the economic impact of alternative climate change scenarios on representative cash crops farms in Quebec and Ontario. Mixed integer dynamic linear programming models is used to determine the annual optimal land and labor allocation over a 30 year time horizon. In the modeling process five climate scenarios are modeled along with different combination of CO2 enhancement and water limitation. Parameters such as crop prices, cost of production and crop yield , area simulated and projected in to the future using various method such as Monte Carlo simulation, crystal ball predictor and DSSAT cropping system model rotation and diversification constraints as well as participate in public risk in management programs are also incorporated in to the optimization procedures .The result shows that the economic impact of climate change varies by scenario with the CO2 effect and water limitation having a more significant effect then the specific climate scenarios. Technology development, as well as the public insurance programs can contribute to the reduction of economic vulnerability.

Sajjad et al.,(2017) examinethe affect of climate change on the major crops of Pakistan.Major crops such as wheat, rice, maize, and sugar cane is studied. The method of feasible generalized least square (FGLS) and heterosecadasticity and autocorrelation (HAC) consistent standard error is employ. Using time series data from the period 1980 to 2015. The result of the study reveals that maximum temperature is positive and significant for all crops.Rainfall fall have negative effect on selected crops except wheat. Study reveals that resistant high-yielding varieties is needed, to ensure food security in the country.

3. Theoretical Model

We can construct economic model with the help of economic theory which will help us to understand the behavior of an individual as well as the society (Ali and Naeem, 2017; Ali, 2011; Ali, 2015; Ali, 2018; Ali and Bibi, 2017; Ali and Ahmad, 2014; Ali and Audi, 2016; Ali and Audi, 2018; Ali and Rehman, 2015; Ali and Senturk, 2019; Ali and Zulfiqar, 2018; Ali et al., 2016; Ali et al., 2021; Ali et al., 2021; Ali et al., 2015; Arshad and Ali, 2016; Ashraf and Ali, 2018; Audi and Ali, 2017; Audi and Ali, 2017; Audi et al., 2021; Ali and Ali, 2016; Audi et al., 2021; Imran et al., 2021; Audi et al., 2021; Audi et al., 2021; Haider and Ali, 2015; Kaseem et al., 2019; Roussel et al., 2021; Senturk and Ali, 2021). This study

is going to investigate the impact of carbon dioxide on cropped area, cotton area, fertilizer off take, wheat area, and overall water availability in the field of Pakistan.
where
Co2 = (CA,CAREA,FOT,WTA,OWA) (1)
Co2 = carbondioxide
CA = cropped area
CAREA = cotton area
FOT = fertilizer off take
WTA = wheat area
OWA = overall water availability
e= represent the base of log
t=1,2,……..,N.bo, b1,b2,b3 are the scalar parameters and b is the estimated vector of parameters.The model of climate change impact on agriculture productivity become as:
LCo2t=bo+b1LCDt+b2LCAt+b3LCTAt+b4LFOTt+b5LWTAt+b6LOWAt +et (2)

4. Econometric Methodology

Mostly time series data has non-stationarity problem and estimated regression results of this data become spurious for policy regression (Nelson and Polser, 1982). All co-integrational methods demand stationarity of the variables.In this study I use different econometric method or use different test to show that our results are stationary and significant. Time series data contain unit root problem and regression results of this data are spurious. To solve the problem of unit root, this study uses Augmented Dickey Fuller (ADF) unit root test is employed, calculated results of ADF test are presented in table-2.

5. Empirical Results and discussion

Table-1; Descriptive Statistics

	LCO2	LCA	LCTA	LFOT	LOWA	LWTA
Mean	11.39719	3.091092	7.921103	7.80428	4.824363	9.06772
Median	11.47939	3.112180	7.949885	7.86914	4.88113	9.01710
Maximum	12.03701	3.17178	8.068591	8.38034	4.93150	9.13345
Minimum	10.37561	2.961658	7.6537	6.984253	4.569025	8.851334
Std .Dev	0.518282	0.059470	0.112908	0.42046	0.112973	0.075190
Skewness	-0.428697	-0.79841	-0.89890	-0.467806	-0.992649	-0.16933
kurtosis	1.97018	2.576459	2.793049	2.101874	2.58683	2.311086
Jarque-Bar	2.69345	4.912380	4.912380	2.522997	6.16817	0.883948
Prob	0.26009	0.085761	.08576	0.283229	0.045778	0.642767

LCO2,LCAREA,LWTA,LFOT,LOWA show negative skewness.kurtosis show positive relationship with all variables.

Table-2; Results Of Unit Root Test

Variables	At level		At 1st difference	
	t-statistics	p-value	t-statistics	p-value
LCAERA	-2.30865	0.1755	-8.19058	0.0000
LCA	--2.02209	0.2764	-9.08541	0.0000
LFOT	-1.5658	0.4884	.6.56421	0.0000
LOWA	-3.14405	0.0332	-7.57615	0.0000
LWTA	-1.1359	0.6891	-7.46515	0.0000

Table-3; Bound Testing Analysis

F-Statistics (Wald-Test)=5.478		
Level of Significance	Lower Bound Value	Upper Bound Value
5%	2.62	3.79
10%	2.26	3.35

The estimated long run results are reported in table-4. This study uses carbondioxide as dependent variables where as cotton area, wheat area, fertilizer off take, overall water availability and cropped area are independent variables.

Table-4; Long Run Results

Dependent Variable=Co2			
Variable	Coefficient	t-statistics	p-value
LCAREA	-1.7915	-4.19975	0.0008
LCA	3.6927	3.34601	0.004
LFOT	1.0033	13.6929	0.0000
LOWA	1.5943	3.8889	0.0015
LWTA	-2.2550	-2..1577	0.0476

The coefficient of cotton area shows that carbondioxide has negative and significant relationship between cotton area and carbondioxide.The results show that 1% change (increase/decrease) in cotton area causes (-1.7915) percent change (increase/decrease) in carbondioxide. Coefficient of wheat area shows that carbondioxide has negative and significant relationship between wheat area and carbondioxide.Results show that 1% change (increase/decrease) in wheat area causes (-2.2550) percent change (increase/decrease) in carbondioxide.Coefficient of cropped area is positive and has a significant relationship (increase/decrease) in cropped area causes (3.6927) percent change (increase/decrease) in carbondioxide. Coefficient of fertilizer offtake shows positive and significant relationship (increase/decrease) in fertilizer offtake causes (1.0033) percent change (increase/decrease) in carbondioxide.Coefficient of overall water availability shows positive and significant relationship (increase/decrease) in overall water availability causes (1.5943) percent change (increase/decrease) in carbondioxide.The overall long run results of the model shows that cropped area, fertilizer offtake and overall water availability has a positive and significant relationship with carbondioxide. Wherease carbonioxide has a negative and significant impact on carbondioxide.

Table-5; Short Run Results

Dependent Variable=Co2			
Variable	Coefficients	t-statistics	p-value
LCAREA	-0.45544	-2.9247	0.0104
LCA	1.04687	2.6249	0.0191
LFOT	-0.30034	-2.624	0.0297
LOWA	-0.6453	--1.8880	0.0785

LWTA	-0.72044	-1.382721	0.187
Coint eq(-1)	-0.74828	.-3.52304	0.0031

The coint eq(-1) is negative and significant

6. Conclusion

The impact of climate change on the cash and food crop production in Pakistan from the period of 1980-2014. Augmented Dickey Fuller (ADF) unit root test is used for checking the stationarity of the variables. Autoregressive distributed lag (ARDL) model is used for co-integrating among the variables of the model. The estimated results of Augmented Dickey Fuller test showed that six variables are stationary at 1st difference and one is stationary at level. The long run results show that fertilizer offtake, overall water availability and cropped area are positive and significant with carbon dioxide in Pakistan, but cotton area and wheat area are negative but significant with carbon dioxide in Pakistan. Sort run estimated results have same direction of relationship as in they have in long run. The result shows that time series data contain unit root problem and regression results of this data are spurious. Unit root problem can be solved by using Augmented Dickey Fuller (ADF) unit root test. Results of Augmented Dickey Fuller (ADF) test shows in table 2, calculated results of ARDL Bound test are presented in table 3, calculated long run results show in table 4 while co-integrating results are presented in table 5. From the study we can conclude that climate change is the factor that effects crop production in case of Pakistan.

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