



Influence of Greenhouse Gas Emissions and Green Revolution on Agriculture Production in Case study of Pakistan: Policy Adoption

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ABSTRACT

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Anthropogenic actions amplify the greenhouse gas concentration in the atmosphere since the 19th century which leads to noticeable variation in climate that has a significant influence on different regions across the globe. World-wildly, Pakistan is participating insignificantly in greenhouse gas emissions but facing significant effects on several segments of the economy. The green revolution boosts agriculture production and a significant increase in productivity against before it. The agriculture sector is considered to be lifeline of Pakistan's economy it contributes significantly to the gross domestic product, gives employment opportunities to huge number of the working population and provides raw materials to other sectors. A drastic increase in population had led to rising demand for agricultural products in Pakistan and it highlights the importance of agriculture sector in Pakistan. Several current studies had concentrated on greenhouse gas emissions in the agriculture sector in Pakistan but ignored the green revolution aspect. It is a pioneer study which has a central aim to explore the influence of greenhouse gases emission and the green revolution on agriculture production with the help of Cobb Douglas Production Function (CDPF). The current study uses the four decades' time series data using Auto Regressive Distributed Lag (ARDL) approach with the help of Bound Test run to observe the long and short-run impact of greenhouse gas emissions and green revolution on agriculture sector in Pakistan. Findings revealed that greenhouse gas emissions have a negative while the green revolution has a positive influence on agriculture production in the long and short run. These results have some policy implication, government should spend more budget on research and development related to the agriculture sector and levy high taxes on those sectors which are emitting greenhouse gases and these policies can dramatically boost agriculture production which will boost Pakistan's economy.

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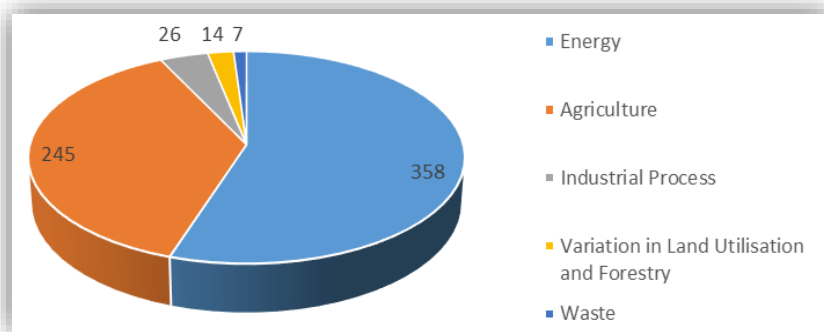
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1. Introduction

Greenhouse gases are an amalgamation of carbon dioxide, methane, nitrous oxide, water vapour, ozone and other fluorinated gases which engrosses heat and discharge it to turn back towards the earth's surface. Human-related activities such as burning fossil fuels, industrialization, deforestation, population explosion play a core role in the dramatic rise in greenhouse gas concentration in the atmosphere. During 1994-2020 their concentration raised by from 182 to 650 MtCO₂ (million tons of carbon dioxide equivalent). Just only carbon dioxide

emission increased from 280 ppm to 421ppm during 2022 which is near about 50% above pre-industrial time. Pakistan's participating rate is less than 1% and 1.9 tones per capita across the world but unfortunately facing catastrophic effects, especially increasing the future temperature by 4⁰c by the end of 2100. Greenhouse gases are impacting on primary, secondary and tertiary sectors of the economy but they vary among different sectors. It also had a great impact on the agriculture sector in the form of variation in productivity or production. Figure 1 displays the pie chart of greenhouse gas emissions which is measured into MtCO₂ (million tons of carbon dioxide equivalent) from different sectors during 2020.

Figure 1: Greenhouse Gas Emissions



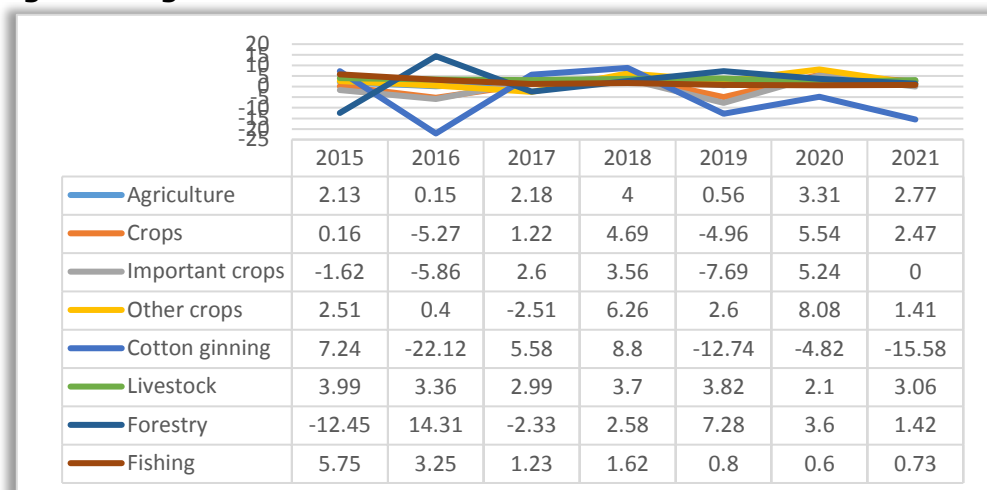
Source: (GoP, 2015)

The agriculture sector is a summation of the farming sector and non-farming sector (Majumdar, 2020). After the 1950s enormous innovation occurred in the agriculture sector which played a key role in poverty alleviation and food security in the presence of a rising population (Godfray, et al., 2010, Nouman, et al., 2021). The national income of less developed countries is determined by this sector. A stable agriculture sector ensures food security and livelihood to the nation (Pachapur, et al., 2020). It has strong backward and forward linkages with secondary and tertiary sectors so it plays a crucial role to spur economic growth, poverty alleviation, food security, fibres to the secondary sector and employment generation. In the early years 1947-55, it participated more than 53% in the gross domestic product (GDP) but over time, it decline abruptly now it reached 19.2 % which is less than half, 65-70% of the population relies on it instead of its livelihood 38.5% of the total working force also engaged in it (GOP, 2021). Moreover, over time agricultural growth rate is deteriorating due to several challenges for instance shrinking arable land, water shortages, climate change, rural-urban migration of the working force, dramatically increase in population and input prices.

Pakistan's agriculture sector is distributed into four sub-sectors which are crops, livestock and poultry, fisheries and forestry. Its crop seasons are Kharif and Rabi: it's sowing and harvesting seasons start from April to June and end in October to December while its crops are cotton, rice, maize, sugarcane, sesame, bajra, mash and mong. In the contrast, Rabi's sowing season starts from October to December and ends in April to May while its crops are wheat, barley, gram, tobacco, lentil, mustered and rapeseed (GOP, 2021). Furthermore, crops have two major categories such as food crops wheat, rice, gram, bajra, maize, jawar and barley while cash crops are cotton, sugarcane, mustard, tobacco, sesame and rapeseed.

Figure 2 highlighted that in the fiscal year 2021, agriculture sectors keep count 2.77% growth while the targeted was 2.8% and less than the previous year which was 3.31% (GOP, 2021). Growth rates of crops, important crops, other crops, cotton ginning and forestry declined while livestock and fisheries accelerated from last year. The important and other crops have a share of value addition of 22.49% and 11.69% correspondingly while participating in GDP at 4.32% and 2.24% respectively(GOP, 2021). The prevailing agriculture production level of Pakistan is not enough to full fill the population requirement. In the last few decades, agriculture production displayed a declining trend as compared to the fast-growing population trend and the major reason is less practice of advanced agriculture techniques (FAO, 2019)and (WB, 2019)So, the government introduced "Agriculture Transformation Plan" to boost output and farmer's livelihood during 2021.

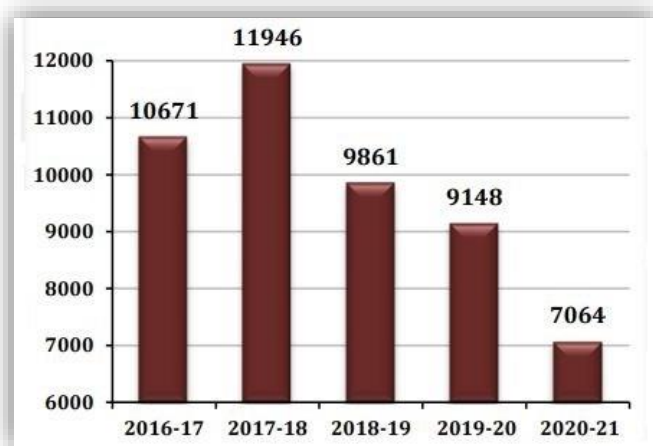
Figure 2: Agriculture Sector Growth Rates from 2015-21



Source:(Pakistan Bureau of Statistics, 2021)

According to International Cotton Advisory Committee (ICAC), Pakistan stood in 5th position as a major producer of cotton. It is the main cash crop and first largest agro-industry sector which provide raw material to different industries. It contributes 0.6% to GDP and 3.1% to agriculture value addition. Current year production decreased by 22.8% to 7.064 million bales less than last year which was 9.148 million bales due to numerous challenges and competition as compared to other crops such as sugarcane, maize and paddy. International prices of cotton play a major role due to export-oriented countries of raw materials in the textile industry. Crop cultivated on an area of 2,079 thousand hectares is 17.4% lower than the last year's area which was 2517 thousand hectares. Cotton ginning witnessed a fast decline of -15.58% in comparison to -4.82% of the previous period's growth (GOP, 2021). Furthermore, Biotic and biotic stresses, excessive usage of pesticides and old agriculture practices are major factors in the declining factors of the cotton crop.

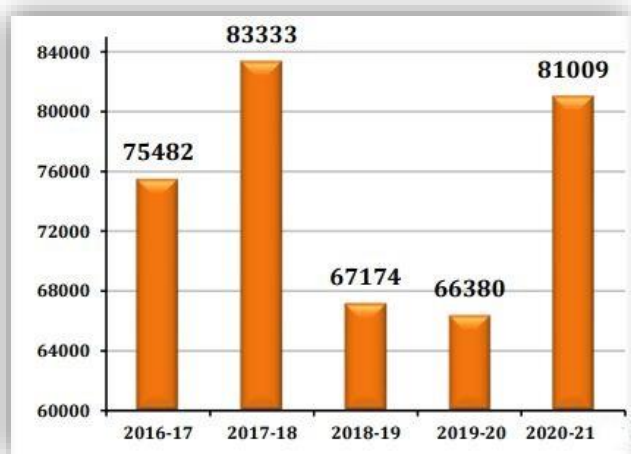
Figure 3: Cotton Production



Source: (Pakistan Bureau of Statistics, 2021)

Sugarcane is a lucrative crop and second largest agro-industry sector it keeps a significant position as raw material, for sugar and other related industries. Its residue also provides raw materials to the paper industry for their production. It can account for 0.7% of GDP and 3.4% value-addition in agriculture. Total production endured at 81.009 million tons during 2020-21 against the 66.380 million tons in the last year which showed a 12.0% increase in production. During 2020-21 sown over 1165 thousand hectares, greater than last year's area of 1040 thousand hectares show an increase of 12.0%(GOP, 2021). The foremost causes of the increase in production are intensification in the cultivated area, yield, weather conditions, greater economic return, and accessibility of high-quality inputs on time as well as better management.

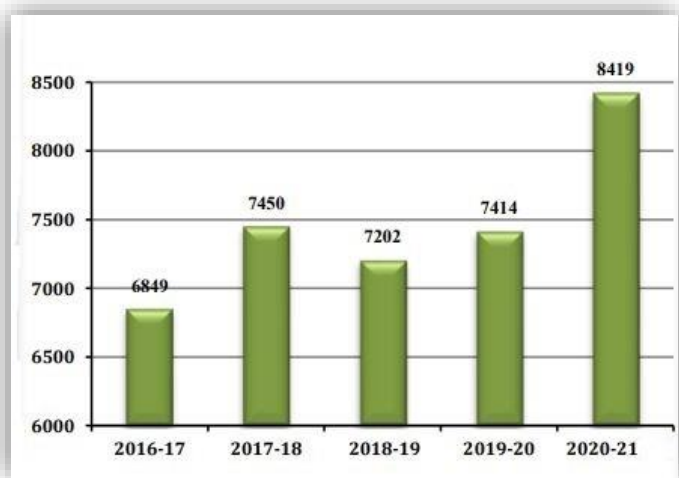
Figure 4: Sugarcane Production



Source: (Pakistan Bureau of Statistics, 2021)

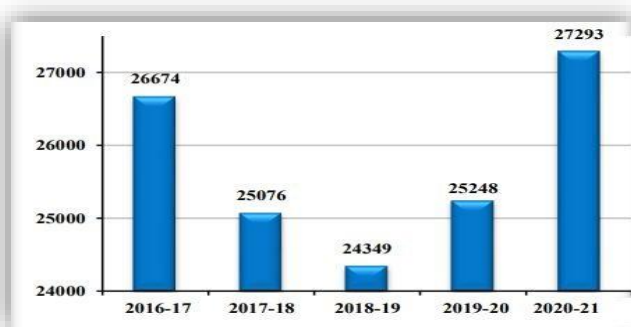
Rice is the second largest staple food crop after wheat and an exportable commodity after cotton. It is also a cash crop which contributes 0.7% to GDP and 3.5% value addition in its agriculture. Its production comprises of two types basmati and coarse during last few years the second type of production is showing an increasing trend. In 2020-21 its total output witnessed a record production of 8.419 million tons in comparison to last year which was 7.414 thousand tones that show growth of 13.6%. The area used for rice cultivation in 2020-21 was 3,335 thousand hectares against 3034 thousand hectares which increase of 9.9% from last year(GOP, 2021). This is owing to an increase in demand and price on an international level.

Figure 5: Rice Production



Source: (Pakistan Bureau of Statistics, 2021)

Figure 6: Wheat Production



Source: (Pakistan Bureau of Statistics, 2021)

Wheat holds a crucial position in Pakistan's economy, being a staple crop it fulfills the prime requirements of food nutrition for the resident of the country. It accounts for 1.8% of GDP besides the amount of 9.2% value-addition in agriculture. During 2020-21 broke a historic record of 27.293 million tones which is 8.1% higher than the previous year's production of 25.248 million tones. The total sown area increased by 4.2% to 9178 thousand hectares from 8805 thousand hectares (GOP, 2021). Firstly, every government's core objective is self-sufficiency secondly, increase in sown area and wheat-supporting policies.

Maize is considered as third most important food crop after wheat and rice. It cultivates varieties of products and by-products are manufactured by grinding the wet maize gains such as food, feed and fodder. Its consumption trends in human beings are decreasing while in the feed and wet milling industry is increasing fastly. During 2020-21 it participates 3.4% in value addition in the sector of agriculture and 0.6% in GDP. Its production rose by 7.4% amounting to 8.465 million tons in comparison to 7.883 thousand tones from last time furthermore, it cultivated 1418 thousand hectares which is 1.0% greater than the previous year which was 1404 thousand hectares (GOP, 2021). It is grown in warm places with moderate rainfall other factors for instance increase in sown area, availability of high-quality seed and economic returns play a pivotal role to boost its production.

Figure 7: Maize Production



Source: (Pakistan Bureau of Statistics, 2021)

During 2020-21, gram production dramatically declines by -47.6% to 261 thousand tons against 498 thousand tones in the previous year. In 2020-21 Bajra and Jowar crops also showed negative trends such as -30.7% and -20.0% of growth rates while production stood at 266 and 96 thousand tons against 384 and 120 thousand tones respectively. Major reasons for downward production trends are unfavorable weather conditions and a decrease in cultivation area and yield. Barley, tobacco, rapeseed and mustard production stood constant over the last year such as 47,133 and 488 thousand tons respectively (GOP, 2021). In 2020-21 production of Moong, Mash and Potato showed positive growth such as 62.4%, 7.7%, and 2.8% respectively as compared to last year while masoor stood constant as compared to last year. On the other hand, chillies and onion production exposed negative growth of 26.7% and 1.1% correspondingly (GOP, 2021).

Oilseed takes into account sunflower, canola, cottonseed, and rapeseed /mustered crops. Domestically edible oil produces 374 thousand tons against 545 while the remaining requirement is met through imports for instance 574.199 million tones value of Rs 574.199 billion imported during 2021-22. Cultivated area and production also declined such as 5,973 thousand acres and 2, 256 thousand tones as compared to 7,602 and 3,127 respectively (GOP, 2021). National Oilseed Enhancement Programme was launched to provide subsidies to cultivators on inputs and machinery.

2. Role of Green Revolution in Agriculture Production

During the 1950, research actions have taken related to the transfer of technology and advancement toward the agriculture sector known as the "Third Agriculture Revolution" or "Green Revolution" after the 1960s agricultural production dramatically increased across the

world. Dr. Norman Borlaug came in front of the world as a "Father of Green Revolution" and received Nobel Peace Prize in the year 1970 and saved a billion of lives from starvation around the globe. The fundamental approach consisted of the adoption of advanced technologies and innovation in the cultivation process including mechanization, provision of high-yield grains, chemical fertilizers and pesticides, expansion of irrigation system and controlled supply of water. First time in history in 1963 Dr. Borlaug visited Pakistan and after it many times in the coming five decades. During 1961-1969 he work with Pakistani scientists to develop wheat varieties those increased wheat yields by 25%.

A lot of studies disclosed that Green Revolution appeared as a game changer, for instance, averted millions of masses from malnutrition, and poverty alleviation, reduce income inequality, arable land decline due to conversion from horizontal to vertical farming, decrease greenhouse gas emissions and a sharp decline in infant mortality rate (Pingali, 2012); (Stevenson, Villoria, Byerlee, Kelley, & Maredia, 2013; von der Goltz, et al., 2020; Bharadwaj, Fenske, Kala, & Mirza, 2020; Gollin, Hansen, & Wingender, 2021). Green revolution through high-yield varieties played a significant role to enhance wheat, rice and maize production (Eliazar Nelson, Ravichandran, & Antony, 2019; Nouman, et al., 2021). Improved seeds quality, mechanization, fertilizers, water availability and credit availability dramatically improved agriculture production (Rehman, Chandio, Hussain, & Jingdong, 2019), these factors played a crucial role in the production of rice and wheat in Latin America and Asia at the start of the 1960s and it was the beginning of the green revolution (Matson, Parton, Power, & Swift, 1997; Nouman, et al., 2021). It also plays quite an impressive role to boost Pakistani's economy in such a way per capita income increased by 27 % in 1963-72.

No one else can deny the importance of capital in the economic system because it is considered as blood of economic activities, the majority of Pakistani farmers are standing in a pitiable situation and they fall in low-income brackets. Pakistan is also facing water shortage so, efficient utilization is also necessary to provide safe drinking water, agriculture and industrial growth. Furthermore, the Government of Pakistan took several initiatives to push the green revolution in Pakistan.

Fertilizers are known as vital inputs intended for the agrarian sector. It improves the yield of land and the productivity of crops. Soil productiveness is incessantly running down because of drawing out the important plant nutrients from the soils under rigorous cultivation and high-yielding crossbreed crop. During 2020-21 domestic fertilizers produce 84% while the remaining 16% of fertilizer was imported. Domestic production increased by 5.9% against last year owing to the supply of gas to Pak Arab Fertilizer and imported supply decreased by 20.1%. In the period of 2020-21 total availability of fertilizers slightly increased by 0.3% because the government took another initiative in 2020 declaring subsidies in form of providing natural and LNG gases at a low rate and cash subsidy. In Kharif 2021, urea overall availability stood at 3536 thousand tones entailing an opening stock of 304 thousand tones of which nothing was imported and 3232 thousand tones were locally produced. Its remained at 3033 thousand tones, the closing stock was 503 thousand tones. In the case of DAP overall availability remained at 566 thousand tonnes, opening stock was 101 thousand tones. Imported supplies remained at 45 thousand tones while local production was 420 thousand tones.

Seed is a fundamental input for the agriculture sector and the quality of seeds plays an essential role to enhance agriculture productivity. For the period of 2020-21 overall seed requirements remained at 1,736,161 thousand tones while the accessibility of advance seeds remained at 847,411 thousand tones which were publically and privately provided by 10968 and 134923 thousand tones and imported 53835 thousand tones. There is a demand for time to improve the availability of quality seeds through revitalizing research, development and practices which meet up international standards. MNFS&R revised Seed (Business Regulation) Rules, 2016 and Seed (Regulation) Rules, 1987 have been amended by the suggestions of the Agriculture Transformation Plan.

Mechanisation is the practice of different technologies in farm operations like leveling, sowing, irrigating, spraying, harvesting, threshing and hoeing to expanding per hectare yield which is known as crucial elements to accelerate the growth of the agriculture sector. The

working capacity of mechanization is better than outdated and old equipment and reduces the losses of the farming community. The barren lands can be brought under cultivation by mechanization and it also facilitates managing the crops in a short period. The federal government continued its policy to encourage mechanized farming such as reducing the tariff on the import of farm machinery and equipment. The tractor industry contributed significantly to full fill local tractor demand, overall tractors production accounted for 36,653 against 23,266 last year that illustrates a rise of 57.5 % (GOP, 2021) furthermore, farmer's liquidity position plays a significant role to increase production.

During 2020 in the months of July-September, the rainfall pattern fell 198.9 mm, which was more than 41.2% from the usual average monsoon rainfall of 140.9 mm although in the post-monsoon season (October-December) rainfall received 22.2 mm was less than the average rainfall 26.4 mm fall of 15.9.0%. During 2021 in the months of January-March rainfall was recorded at 40.3 mm against to normal average rainfall of 74.3 mm which showed a decline of 3.0% (GOP, 2021). Canal head withdrawals remained in Kharif season 2020,65.11 MAF against 65.23 MAF last year reduced by 0.2 % furthermore, in Rabi season 2020-21 showed 31.21 MAF against 29.20 MAF previous year increased by 6.9 %. National water policy 2018 was adopted to store access water ability of 10 MAF now its capacity improved to 13.68 MAF for a month. Diامر Basha, Mohamand Dam, 518 medium and small dam construction started with a capacity of 8.33 MAF across the country.

Agriculture credit considers an imperative tool for higher production. There are two sources of agricultural credit: informal sources; formal sources. The informal sources of credit allude to the financial services made available by landlords, money-lenders, traders, and commission agents in contrast to formal sources of credit imply the financial institutions. In the year 2021, the State Bank of Pakistan (SBP) assigned Rs 600 billion for 2021 agriculture credit disbursement against Rs 1215 billion from last year which is 23.5% higher than the previous year. SBP gave bull's eye to 50 institutions in detail five major commercial banks (Zarai Taraqati Bank Limited, Punjab Provincial Co-operative Ba), 14 domestic private banks, 5 Islamic banks, 11 microfinance banks and 13 microfinance institutions (MFIs/RSPs) worth Rs 953.7 billion (GOP, 2021).

After industrialization greenhouse, gas emissions are growing at a fast pace while Pakistan's ratio is minor in it but facing a significant impact on various sectors. The instrument of the green revolution plays the title role in most successful stories of developing countries. The current local production and demand for agriculture have reemphasized the costliness of Pakistan's failure to accomplish agriculture security and poverty alleviation. It also considers a major source of food and employment for the residents of Pakistan. No, any single study implicates greenhouse gases emission and the green revolution on agriculture production with the help of Production Function in the case of Pakistan. Current study results will be supportive of the government of Pakistan, non-government organizations in addition to policymakers to design a policy to boost agriculture production in the presence of greenhouse gases emission and the green revolution. The rest of the research consists of a literature review, methodology and conclusion with policy implications.

3. Literature Review

Sial, Awan, and Waqas (2011), searched out the impact of institutional credit on agriculture production with the help of time series analysis. They employed CDPF on time series data during 1972-2008. They found a positive relationship between agriculture credit, water availability, labor force and cropping intensity and the agriculture sector. Ayaz, Anwar, Sial, and Hussain(2011),examined the influence of agriculture credit on farming sector production efficiency in the case of Pakistan. The researcher surveyed farm level and employed data envelopment analysis techniques in Faisalabad. Experience in the farming sector, farming credit, education level, mass size and cultivation practices have a positive and significant impact on the technical efficiency of farmers.

Saleem and Jan(2011),accessed the influence of credit on agriculture productivity in Dera Ismail Khan district of (Khyber PakhtunKha) KPK. This study used CDPF on the data of 1990-2008. Agriculture credit utilized for purchasing purposes of seeds, pesticides, fertilizers, tractors and irrigation has a positive association with agriculture's gross domestic product. Hussain (2012), Impact of credit disbursement, area under cultivation, fertilizer consumption

and water availability on rice production in Pakistan (1988-2012) explored the influence of credit disbursement, cultivated area, fertilizer off-take, and water accessibility on rice production empirical evidence from Pakistan. The researcher examined log-linear CDPF on time series data during 1988-2010. Cultivation area and water availability have positively significant while credit and fertilizer have a positively insignificant relationship with rice production.

Hussain and Taqi (2014), discussed the influence of credit on agriculture productivity in a case study of Pakistan. This research focused on just one Bahawalpur district of Punjab and adopted logit regression analysis. Household income, size, farmer's education, and credit are positively linked with agriculture productivity in this district. Ahmad, Jan, Ullah, and Pervez, 2015 researched the effect of credit on wheat productivity in the Jhang district. In 2013 primary data was collected from 160 farmers and CDPF was used on it. Agriculture credit has a positive impact on wheat productivity. Saqib, Ahmad, Panezai, Hidayatullah, and Khattak(2016), explored the credit access and its adequacy to farmers in the Mardan district of KPK. Primary data was collected through 87 farming households and selected probit model. Small farmers faced the most credit adequacy as compared to medium and large. The informal sector played an important role in the full credit gap. Education, land size and income are positive while age and groups have negative effects on access to credit.

Chandio, Yuansheng, Joyo, and Rehman(2016), examined the influence of cultivated area, water, credit and fertilizers on wheat production in the case of Pakistan. The researchers employed log-liner CDPF on time series data from 1982 to 2011. The analysis results showed that water, cultivated area, and credit have a positive and negative association with wheat production. Chandio, Yuansheng, Sahito, and Larik(2016), investigated the effect of formal credit on agriculture output in the case of Pakistan. The ordinary Least Square method was employed on data from 1996-2015. Results highlighted that formal credit positively influenced agriculture output. Asghar & Salman (2018), inspected the influence of agriculture credit on food production and security in the case of Pakistan. This primary study focused on the Bahawalnagar district of Punjab. They find out that if financial restrictions are detached then production will progress and help food security for future generations.

Rehman, Chandio, Hussain, and Jingdong (2019), revealed the impact of fertilizer, water and credit on agricultural productivity in Pakistan. CDPF was explored on data from 1978-2015. They researched the positive impact of fertilizer consumption, improve seeds distribution and credit distribution have positive and significant while water accessibility has negative and significant linkages with agriculture productivity. Ullah, Mahmood, Zeb, and Kächele(2020), scrutinize the determinant factors and sources of farmer's credit in the rain-fed region of Pakistan. Logistic models indicated moderate positive linkages among agriculture credit availability for farmers' implementation of advanced technology. Binary logit models accessed that those farmers who have large-scale farm size, ownership and high income showed a progressive connection with credit while farming experience negatively influences on farmer's credit accessibility. Nouman, et al. (2021), explored the green revolution implication for food security in Pakistan with the help of multivariate co integration decomposition analysis. The researchers employed Johansen co-integration and ARDL test on time series data from 1975-2017. Agriculture land, machinery, credit, fertilizers, seeds, and fuel consumption consider crucial factors of the green revolution which progressively improves food security in the case of Pakistan.

4. Model and Methodology

This current research scrutinized the influence of greenhouse gases emission and the green revolution on agriculture production from 1981-2021 and data picked up from the World Bank and Economic Surveys of Pakistan. Augmented Dickey-Fuller test results produce Autoregressive Distributed Lag Approach with Bound test. The green revolution will be measured with the help of improved seed quality, water ability, mechanization (number of tractors produced) and credit accessibility. Dependent in addition to independents variables with the help of acronyms and measuring units are; agriculture production (AP) whereas independents are agriculture area (AA) (million hectares), water accessibility (W) (million-acre feet), tractors production (T) (000 tonnes), fertilizer off-take (F) (000 nutrient tonnes), greenhouse gases emission (G) (kit of CO₂ equivalent) seed availability(S) (000 tonnes) and

credit distribution (C) (million Rs.). Moreover, the Cobb-Douglas Production Function is employed here.

$$X = DK_1^{i_1} K_2^{i_2} K_3^{i_3} K_4^{i_4} K_5^{i_5} K_6^{i_6} K_7^{i_7} \quad (1)$$

Taking a log of all independent variables so, Eq.1 makeover in this forms where;

$$\ln X = D_0 + i_1 \ln K_1 + i_2 \ln K_2 + i_3 \ln K_3 + i_4 \ln K_4 + i_5 \ln K_5 + i_6 \ln K_6 + i_7 \ln K_7 \quad (2)$$

D_0 = intercept, $\ln X$ = agriculture production, $\ln K_1$ = agriculture area, $\ln K_2$ = greenhouse gases emission, $\ln K_3$ = credit distribution, $\ln K_4$ = water accessibility, $\ln K_5$ = seeds availability, $\ln K_6$ = fertiliser off-take, $\ln K_7$ = tractors production. The long and short-run equations (3) and (4) are expressed in further down lines;

$$\Delta(AP)_t = \mathfrak{S} + \sum_{f=1}^{k_1} \wp_1(AA)_{t-f} + \sum_{f=2}^{k_2} \wp_2(G)_{t-f} + \sum_{f=3}^{k_3} \wp_3(C)_{t-f} + \sum_{f=4}^{k_4} \wp_4(W)_{t-f} + \sum_{f=5}^{k_5} \wp_5(S)_{t-f} + \sum_{f=6}^{k_6} \wp_6(T)_{t-f} + \sum_{f=7}^{f_7} \wp_7(F)_{t-f} + \hat{\partial}_t \quad (3)$$

$$\Delta(AP)_t = \mathfrak{S} + \sum_{f=1}^{k_1} \wp_1 \Delta(AA)_{t-f} + \sum_{f=2}^{k_2} \wp_2 \Delta(G)_{t-f} + \sum_{f=3}^{k_3} \wp_3 \Delta(C)_{t-f} + \sum_{f=4}^{k_4} \wp_4 \Delta(W)_{t-f} + \sum_{f=5}^{k_5} \wp_5 \Delta(S)_{t-f} + \sum_{f=6}^{k_6} \wp_6 \Delta(T)_{t-f} + \sum_{f=7}^{f_7} \wp_7 \Delta(F)_{t-f} + \omega ECM_{t-1} + \hat{\partial}_t \quad (4)$$

\mathfrak{S} , $\hat{\partial}_t$ and Δ are denoted intercept, stochastic term and first difference respectively.

5. Results with Discussion

Bound test results highlighted in table 1 explained that F -test values are 2.649 which is above the $I(0)$ and $I(1)$ values so, cointegration exists.

Table 1: Bound Test

Optimum lags	(1,1,1,0,0,1,1,1)
F-statistics	2.649
Critical Values	10%
I(0)	2.05
I(1)	3.22

The long-run estimation presented in table 2 with 5% significance level; C has a positive relationship with AP and a 1 % increase in C can raise the 0.051 % AP supported by (Ahmad N. , 2011; Sial, Awan, & Waqas, 2011; Hussain & Taqi, 2014; Ahmad, Jan, Ullah, & Pervez, 2015; Chandio, Yuansheng, Sahito, & Larik, 2016; Chandio, Yuansheng, Joyo, & Rehman, 2016 & Ullah, Mahmood, Zeb, & Kächele, 2020). S and W have a positive association with AP which leads to a 1 % rise in them will 0.131 and 0.576 % enhancement in AP respectively results are similar to Saleem & Jan, 2011 and Hussain, they evaluated the Impact of credit disbursement, area under cultivation, fertilizer consumption and water availability on rice production in Pakistan (Chandio, Yuansheng, Joyo, & Rehman, 2016; Rehman, Chandio, Hussain, & Jingdong, 2019; Ullah, Mahmood, Zeb, & Kächele, 2020). Moreover, 1 % increase in AA will boost 1.166 % AP, results are similar to those studies by (Ahmad N. , 2011; Hussain; Chandio, Yuansheng, Joyo, & Rehman, 2016). Moreover, results are also in line with Pakistani studies that 1% rise in F lead to 0.272 % AP (Saleem & Jan, 2011). Furthermore, the impact of credit disbursement, area under cultivation, fertilizer consumption and water availability on rice production in 1 % increase in T will enhance 0.021 % AP (Hussain; Rehman, Chandio, Hussain, & Jingdong, 2019; Chandio, Jiang, Rehman, & Dunya, 2018; Ullah, Mahmood, Zeb, & Kächele, 2020). G is indicating a negative response such 1 % increase in it referring to 0.073 decreases in AP similar in line with Saleem & Jan, (2011).

Table 2: Long-run Estimation

Variables	Coefficient	standard-error	t-ratio	Probability
Ln C	0.051	0.014	3.642	0.015
Ln S	0.131	0.151	0.867	0.481
Ln W	0.576	0.251	2.294	0.061
Ln AA	1.166	0.405	2.879	0.012
Ln F	0.272	0.130	2.092	0.011
Ln T	0.021	0.103	0.203	0.771
Ln G	-0.073	0.422	-0.1729	0.764
C	-7.648	11.105	-0.688	0.541

Table 3: Short-Run Estimation

Variables	Coefficient	Standard-error	t-ratio	Probability
Δ Ln C	0.010	0.001	1.022	0.205
Δ Ln S	0.052	0.050	1.046	0.201
Δ Ln W	0.070	0.051	1.372	0.106
Δ Ln AA	0.255	0.105	2.428	0.004
Δ Ln F	0.110	0.037	2.972	0.024
Δ Ln T	0.196	0.113	1.734	0.011
Δ Ln G	-5.360	1.207	-4.440	0.000
ECM(-1)	-0.175	0.040	-4.375	0.000

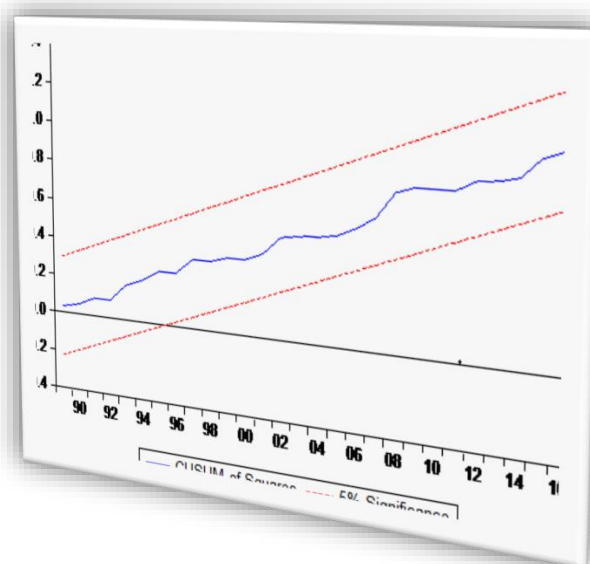
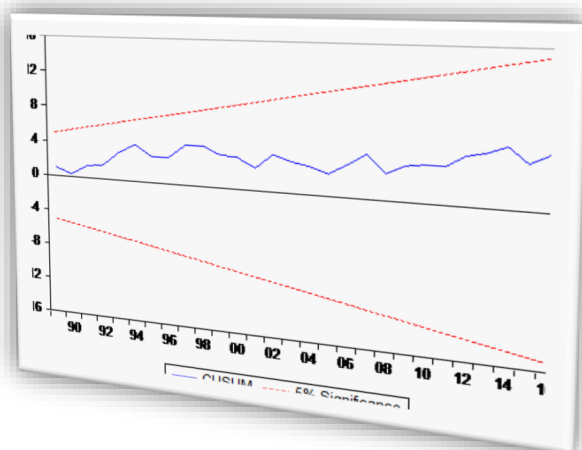
The results of the short-run estimation are illustrated in table 3. The coefficient of c is 0.010 which means that a 1 % increase in it will increase 0.010 % AP. 1 % increase in S and W will enhance 0.052 % and 0.070 % AP respectively and both are insignificant. AA, F and T are significant and a 1 % increase in all of them will boost 0.255, 0.110 and 0.196 AP correspondingly. 1 % increase in greenhouse gases emission will decrease 5.36 % AP. Furthermore, the ECM value is -0.175 and significant which shows quick adjustment occurs due to shocks from the short to long run.

Diagnostic Tests

The findings confirmed that residuals are normally distributed and the estimated model is free from autocorrelation, Heteroscedasticity and coefficients are stables.

Table 4: Diagnostic Results

Tests	Results
Arch	0.350 (0.600)
White	1.058 (0.424)
Reset	1.456 (0.148)

Figure 8: Cusum & Cusum SQ

5. Conclusion and Policy Implications

Anthropogenic activities play a core role to increase greenhouse gas concentration in the atmosphere and Pakistan is participating insignificantly but facing significant effects on different sectors of the economy. The green revolution boosts agriculture production and significantly increases productivity against before it was. The Government of India introduces the green revolution to reduce rural poverty and World Bank applauds it. The agriculture sector has a huge contribution to GDP and plays a crucial role in the economic development of the developing country. This sector provides food to the mass of the population, fibres to the industry and hoist employment opportunities in the economy. Different political regimes adopted diverse economic policies that show affirmative and undesirable impacts on agriculture production. Cobb-Douglas Production Function espoused on time series data from 1977-2016 with the help of the ARDL approach to explore the long and short-run impact of greenhouse gas emissions and the green revolution on agriculture production in the case of Pakistan.

This research concluded that the green revolution (improved seeds accessibility, water availability, fertilizers and mechanisation) have a positive while greenhouse gas emissions have a negative impact on agriculture production during the long and short run. The findings confirmed that the estimated model is free from autocorrelation, and Heteroscedasticity, residuals are normally distributed and coefficients are stables. Keeping in mind the results of this research some policies are suggested to further improve agriculture production, particularly in the case of Pakistan. Government must levy a tax to cut greenhouse gas emissions. Government spends more budget on research and development programmes to further enhance the green revolution for agriculture production which will increase GDP and balance of trade.

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