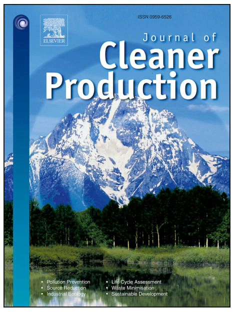
Journal Pre-proof



Addressing the effect of climate change in the framework of financial and technological development on cereal production in Pakistan

Abbas Ali Chandio, Yuansheng Jiang, Waqar Akram, Sultan Adeel, Muhammad Irfan, Inayatullah Jan

PII: S0959-6526(20)35683-3

DOI: https://doi.org/10.1016/j.jclepro.2020.125637

Reference: JCLP 125637

To appear in: *Journal of Cleaner Production*

Received Date: 28 April 2020

Revised Date: 16 December 2020

Accepted Date: 21 December 2020

Please cite this article as: Chandio AA, Jiang Y, Akram W, Adeel S, Irfan M, Jan I, Addressing the effect of climate change in the framework of financial and technological development on cereal production in Pakistan, *Journal of Cleaner Production*, https://doi.org/10.1016/j.jclepro.2020.125637.

Credit Author Statement

Abbas Ali Chandio: Conceptualization, Writing-Original Draft, Formal Analysis

Yuansheng Jiang: Supervision

Waqar Akram: Writing-Review & Editing

Sultan Adeel: Methodology, Data Collection

Muhammad Irfan: Software, Validation

Inayatullah Jan: Investigation, Validation

Title Page

Addressing the effect of climate change in the framework of financial and technological development on cereal production in Pakistan

Abbas Ali Chandio[1,*], Yuansheng Jiang[1,*], Waqar Akram[2], Sultan Adeel[2], Muhammad Irfan[3], Inayatullah Jan[4]

[1]College of Economics, Sichuan Agricultural University, Chengdu 611130, China

[2]Department of Business Administration, Sukkur IBA University, Sukkur, Sindh, Pakistan

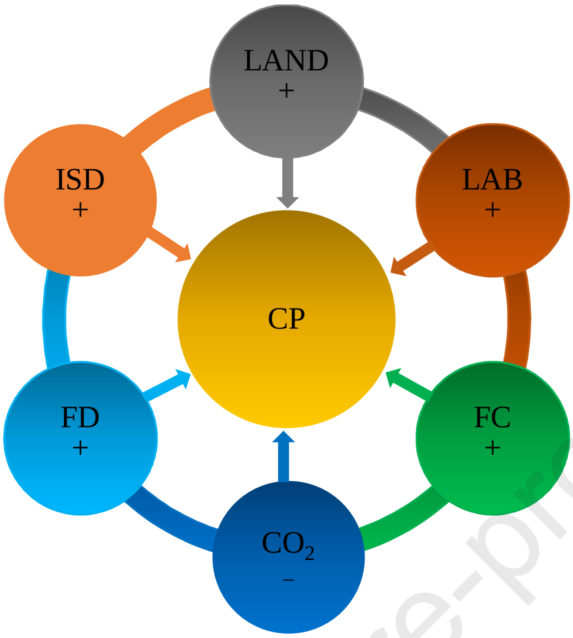
[3]Beijing Key Laboratory of New Energy and Low Carbon Development, School of Economics and Management, North China Electric Power University, Beijing, 102206, China

[4]Institute of Development Studies (IDS), The University of Agriculture Peshawar, Pakistan

*Corresponding Authors: Abbas Ali Chandio and Yuansheng Jiang

Email: alichandio@sicau.edu.cn; yjinag@sicau.edu.cn

Graphical Abstract



Long-run nexus between the study variables

Addressing the effect of climate change in the framework of financial and technological development on cereal production in Pakistan

Abstract

The current study examines the effect of global climate change (CO_2 emissions), financial development, and technical progress (fertilizer consumption and improved seed distribution) on cereal production in Pakistan over the 1977–2014 period. The study undertakes the autoregressive distributed lag (ARDL) bounds testing approach to investigate the long-term interrelation among the variables. The outcomes of the ARDL bounds-testing approach confirmed the presence of a long-term relationship among the variables. Empirical results revealed that CO_2 emissions have a negative impact on cereal production in the short-run and long-run. It means that increase in global climate change will decrease cereal production. Findings further showed that financial development has a positive impact on cereal production in both cases. It suggests that increasing financial development will enhance cereal production, which will ensure the country's food security. In addition, technical progress has a significantly positive impact on cereal production in both cases. The dynamic OLS, fully modified OLS, and the canonical cointegrating regression estimators confirmed the robustness of the findings. Financial development is essential for sustainable agriculture production; therefore, policymakers should devise a comprehensive agriculture policy that addresses the financial needs of the agriculture sector and attracts investment. The financial institutions may use carbon financing as a tool to intervene in the financial market to generate funds for the application of cleaner production principles and the use of best practices for agriculture development and sustainable production.

Keywords: Financial development, Climate change, Cereal production, ARDL approach

1. Introduction

Climate change is defined as a change in climate over a long period of time due to human and non-human actives. It has become the limelight issue that drastically impacts the global economies (Chandio et al., 2020a). Climate change can alter rain patterns, decrease water for agriculture, and increase the frequent droughts and overall temperature (IFAD, 2009). In agriculture, in particular, it severely impacts water and land and can vary the output by 60% (Matiu et al., 2017). It can also stimulate the timing of agricultural seasons, water stress, and the magnitude and duration of heat (Lemma et al., 2016). Carbon dioxide (CO_2) emission is a vital sign of climate change. Global CO_2 emissions have risen to 36,138,285 kt in 2014 from 24,689,911 kt in 2000; in Pakistan, it rose to 182,414 kt in 2014 from 106,449 kt in 2000 (WB, 2014). The trend of CO_2 emissions from 1960 to 2014 is shown in Figure 1.

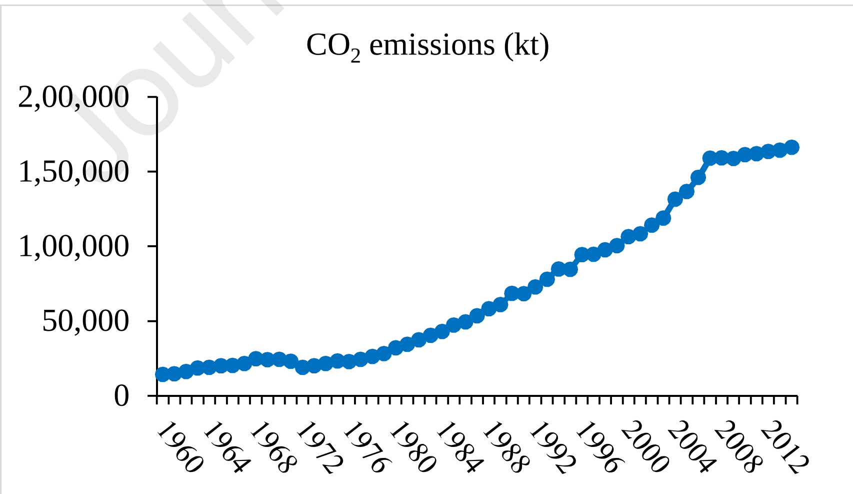


Figure 1. The trend of CO_2 emissions in Pakistan

Data Source: World Bank, (2014)

At the macro level, due to the looming climatic effects, agriculture has hampered harshly. The food security concern is growing in developing countries, particularly in

Africa and Asia, containing 92% undernourished people, 35% in South Asia (FAO, 2013). The current unsustainable mode of production and consumption has severe implications for economic growth, societal unrest, and environmental degradation in the future (Clark, 2007). These also require considerable modification to develop a sustainable system (Grin et al., 2010).

In retrospect, the United Nations Environment Protection (UNEP) in 1990 introduced the concept of cleaner production, defined as "the continuous application of an integrated environmental strategy to processes, products, and services to increase efficiency and reduce risks to humans and the environment." Since then, the international community has realized the benefits of cleaner production and adjusted its production processes. For instance, China closed 57,000 small factories, producing effluent material, and contaminating freshwater. In Australia, the lead level decreased in petrol that resulted in reduced blood levels in the general population—health implications. Asia Pacific Economic Corporation (APEC) also formed a working group in 1997 to work on a cleaner production strategy, improving the living conditions of newly developed cities in developing countries (Van Berkel, 2007). At the micro-level, sustainable production in agriculture emphasize the use of eco-friendly technologies (Mahallati et al., 2015) and optimal use of inputs without compromising profits (Müller et al., 2015).

In specific to Pakistan, World Bank studies (2006, 2011) suggest a 6% annual environmental degradation cost to GDP. Only in Sindh province, the environmental risk factor is more than 15% of GDP, owing to soil erosion, low soil fertility, worsen air quality, and water pollution. Thus, sustainable agriculture production (crops) demand cleaner production technologies and the best practices following ecological and economic consequences (Blok et al., 2015). In parallel, the share of agriculture to

GDP has declined from 30% to 19% from 1970 to 2020 accompanied by low credit availability to the crop sector. For example, in 2019, only 392 billion (PKR) was disbursed to the crop sector, which is relatively low compared to the volume and vitality of this sector for food security (GoP, 2020).

Given the statistics and identified potential risks and threats to food security, financial development is crucial to combat and mitigate such adverse situations. Financial development is a key to the economic growth of the country and is used as an instrument to minimize the risk of economic activity (King and Levine, 1993). One way for financial development is credit, which is widely characterized by development economists (Raifu and Aminu, 2019). Available literature elaborates that credit supply and access help in achieving and strengthening sustainable growth, technology adoption, and poverty reduction (Chandio et al., 2017). Specifically, credit supplied to the agricultural sector positively impacts the output and development of the economy (Rehman et al., 2017) and works as a catalyst for increased farmers' participation and transformation of agriculture (Saqib et al., 2016).

In their research, Chandio et al. (2018a) conducted a primary data study in Pakistan to investigate the impact of long-term (LT) and short-term (ST) loans on wheat productivity. They found a positive and significant impact of both types of loans on wheat productivity. Similarly, Ahmad et al. (2015) examined the impact of credit on wheat productivity based on primary data in the case of Pakistan. They also found a positive and significant impact on wheat productivity. However, Bashir and Mehmood (2010) investigated the impact of credit on the production of rice crop by using survey data in Pakistan. The survey-based data of 114 sugarcane farmers suggested that formal credit improved sugarcane production in Punjab, Pakistan (Bashir et al. 2007). Using the ARDL, Abbas (2020) analyzed the short-and long-term effect of climate change on production of cotton and concluded that temperature has positive insignificant influence on cotton production. Likewise, Ahmad et al. (2020) observed that temperature has negative significant effect on agricultural output while Chinese FDI improved agricultural output in both short-and long-term period.

The present study add-ons in the current literature gap through investigating the robust long-run and short-run relationship among financial development, carbon dioxide emissions, area used for cereal production, improved seed distribution, consumption of fertilizer, labor force, and cereal production in Pakistan during 1977–2014 by utilizing the time-series data. The main objective of this study is realized by employing various econometric approaches, including the ADF and KPSS conventional unit root tests, the ARDL bounds-testing, the Johansen co-integration, DOLS, and FMOLS. Also, the stability of the model is tested through several diagnostic tests. The remaining study has been ordered as follows; section 2 discusses financial development and climate change-related empirical studies and research hypotheses, whereas section 3 provides data and methodology. Sections 4 and 5 present the estimated empirical results and conclusion of the study.

2. Critical Literature Review and Research Hypotheses

The current study attempts to investigate the short-run and long-run impacts of climate change (CO_2 emissions), financial development, and technical progress (fertilizer consumption and improved seed distribution) on cereal production from 1977 to 2014 and suggest policy implications for food security in Pakistan. This study divides the literature review part into two segments; firstly, the literature on the association between financial development and cereal production, and secondly, the interaction between climate change and cereal production.

2.1. Association between financial development and cereal production

Credit to the agricultural sector is a catalyst in increasing farmers' participation in agricultural finance and agricultural transformation in Pakistan. For instance, agricultural credit helps in adopting modern technologies and the efficient use of resources. Along with institutional support, i.e., subsidies, taxes, and crop insurances, it supports the development of the agriculture sector (Chandio et al., 2018b). Anetor et al. (2016) advocate that agricultural financing in the shape of credit to small landholders are critical in achieving macro-economic development through agriculture by using time series data for 1981–2013 in Nigeria. They found that commercial loans to the farming sector significantly affect production in the country. Therefore, it has been suggested that the government should encourage commercial banks to provide credit at lower interest rates to the farmers.

Shahbaz et al. (2013) examined the long-term empirical interactions between agricultural progress and financial development using the Cobb-Douglas function over the data from 1971 to 2011. Results predicted the bidirectional causality between agricultural progress and financial development and its positive impact on agricultural progress. Authors suggest policymakers to improve the financial sector efficiency to trigger the growth of the farming sector. Zakaria et al. (2019) explored the same phenomenon in South Asia during 1973–2015. The results predicted the inverted U-shaped outcome of financial development on agricultural production. Other variables like industrialization, trade openness, and income level also improve agricultural production, whereas the terms of trade, CO_2 emission, and rural labor force negatively affect agricultural production.

Rehman et al. (2019) attempted to explore the causal connections of agricultural GDP with land, fertilizer, agricultural credit, and water availability in Pakistan utilizing time-series data from 1978 to 2015. Researchers found a significantly positive impact of fertilizer, improved seed, and agricultural credit on agricultural GDP. However, the effect of water availability was significantly negative. It has been suggested that the government should formulate policies and develop funding schemes to develop and improve the irrigation system.

Agbodji and Johnson (2019) evaluated the effects of credit on maize, sorghum, and rice productivity in Togo and found that the impact of agricultural credit is significantly positive. Similarly, Omoregie et al. (2018) examined the effect of credit supply for the rice output in Nigeria from 1981 to 2016 and explored that if the credit supply increased, it would increase rice output. However, any shock in investment and labor possesses the ability to reduce the rice output. Therefore, it has been suggested that the government should develop interest-free loan schemes for farmers in partnership with banks. Based on a survey of previous related studies following hypothesis is extracted.

H_1: Financial development has a positive impact on cereal production in Pakistan.

2.2. Association between climate change and cereal production

Agriculture is highly vulnerable to climate change (Bannayan et al., 2014). Climate change has threatened agricultural production worldwide (Enete and Amusa, 2010).

Hussain and Mudasser, (2007) stated that climate change affects are significant in the arid and semi-arid zones of South Asia. Studies suggest that climate change can significantly impact the long-run global food production and food security (Ammani et al., 2012). The previous literature confirms this conception that climate change has hampered agricultural production. For instance, Qureshi et al. (2016), with the help of data from 1980 to 2013, suggest that greenhouse gas severely impacts agricultural production, i.e., cotton, wheat, and rice. Hussain et al. (2020) review that South Asia is facing the vulnerability of climate to a greater extent, and have low adaption and mitigation awareness. In Pakistan, it is least due to poverty, limited physical and financial resources, life-threatening climatic conditions and continuous flooding, and melting of glaciers. Also, the saturation of indigenous lakes, earthquakes and storms, water issues and pest attacks, a threat to ecosystem and biodiversity, reduction in forests and rural land conversion, and health crisis which make agriculture more susceptible in the future. On the other hand, per capita impact of climate change in Pakistan is high, which has also impacted the agricultural growth, livestock, forest, weather patterns, as well as food, water and energy security in Pakistan.

According to Mersha and Leta (2019), the impacts of climate change on agricultural suggest that subsistence farmers in Sub-Saharan Africa have adopted diversified cropping strategy and mixed cropping, altered plantation dates concerning the precipitation pattern, and adapted from high water required crops to low water needed crops. Mahmood et al. (2019) explored the effects of change in climate on the level of yield and suggested that wheat is highly dependent on precipitation. The findings elaborated on the adverse impact of the rise in temperature on the average yield of wheat, whereas rainfall positively affects it.

Khan et al. (2019) explored how corn productivity is affected by the change in climate in the KP province of Pakistan by undertaking the panel date from 1996 to 2015. Results depicted the negative effect of maximum temperature and the positive impact of precipitation on the productivity of maize. Policymakers are suggested to put an eye on this issue of climate change. Harvey et al. (2018) explored by surveying 860 small landholders of Central America that nearly 95% of the total farmers face climate changes and reduction in the yield of a crop. Therefore, researchers called for the urgency to help small landholders to cope with the current climatic changes.

Chandio et al. (2020b) investigated the dynamic effects of average temperature, CO_2 emissions, and average rainfall on the Turkish cereal yield from 1968 to 2014. Researchers found the diverse impacts of CO_2 emissions and the annual average temperature on cereal yield. However, the yearly average rainfall positively affects the long-run yield of cereal. The authors found the long-run equilibrium interrelationship prevailing among CO_2 emissions, mean temperature, per annum rainfall, and production of cereal crops. The study concluded that rainfall and temperate owing to CO_2 emissions affect cereal yield more than land and labor use. Therefore, it has been suggested to revamp the adaption policies related to farmers to develop them and make them resilient.

Wang et al. (2018) determined the potential of greenhouse gas release from cereal crops, the climate change impacting cereal yield, and discussed the potential solutions to reduce the impacts of climate change, i.e., drought-tolerant breeds of cereal crops, upsurge in the production of these breeds, enhanced irrigations, and effective usage of fertilizer. Findings predicted that climate change negatively affects cereal yield except millet crop owing to its inbuilt ability to grow in drought conditions. It has been suggested growing millets to reduce the impact of global warming potential.

Attiaoui and Boufateh (2019) examined climate change affecting cereal farming in Tunisia during 1975 to 2014. Findings depicted that climate change is negatively impacting the cereal production that felt more when there was a shortage of rainfall. Sarkar et al. (2020) suggested that there are more negative effects of climate change than positive on the production of agricultural products, and worked on finding the influence faced by Malaysian oil palm production due to change in climatic conditions from 1980 to 2010. Results suggested the significant and negative relationship between average annual temperature and palm oil production. Based on a survey of the above-stated previous empirical works, the following hypothesis can be formulated.

H_2: CO_2 emissions have a negative impact on cereal production in Pakistan.

3. Data and methodology

The present study attempts to systematically investigate the short-run and long-run effects of financial development, change in climate, and technical progress on the production of cereal in Pakistan from 1977 to 2014. The time-series data regarding concerned parameters such as cereal production (metric tons), domestic credit to the private sector by banks (% of GDP) used as a proxy of financial development, and CO_2 emissions (kt) to measure climate change, land under cereal production (hectares), improved seed distribution (thousand tons), fertilizer consumption (thousand nutrient tons), and rural population (millions) used as a substitution for the labor force, were extracted from World Development Indicators[1] and the Pakistan Bureau of Statistics[2]. Table 1 reports the descriptive statistics of the study variables used in the estimation. The average of cereal production, financial development, CO_2 emissions, land, improved seed distribution, fertilizer used, and labor (in their logarithmic form) are 17.02, 3.15, 11.28, 16.30, 4.82, 7.66, and 18.24, respectively. All the selected variables, as indicated by the J-B test, are found to be normally distributed. Figure 2 shows the chosen variables' trend used in the model.

Table 1. Descriptive statistics.

Variable	lnCP	lnFD	$\ln CO_2$	lnLUC	lnISD	lnFC	lnLAB
Std. Dev.	0.301	0.154	0.595	0.079	0.648	0.523	0.268
Mean	17.029	3.153	11.286	16.305	4.827	7.660	18.243
Median	17.040	3.181	11.402	16.313	4.704	7.738	18.263
Maximum	17.550	3.394	12.021	16.451	5.883	8.380	18.646
Minimum	16.507	2.740	10.101	16.145	3.879	6.448	17.762
Skewness	0.062	-0.942	-0.434	-0.242	0.229	-0.572	-0.204
Kurtosis	1.827	3.863	2.007	2.255	1.570	2.398	1.822

[1] http://data.worldbank.org/

[2] http://www.pbs.gov.pk/

J-B	2.200	4.807	2.756	1.2489	3.570	2.650	2.459
P value	0.332	0.106	0.251	0.535	0.167	0.265	0.292
OBS	38	38	38	38	38	38	38

$lnCP$, $lnFD$, $lnCO_2$, $lnLUC$, $lnISD$, $lnFC$, and $lnLAB$ indicate the natural log of cereal production, financial development, CO_2 emissions, land under cereal, improved seed distribution, fertilizer used, and labor force, respectively.

Figure. 2 Trend of the selected variables.

$(a) lnCP$,$(b) LnFD$,$(c) lnCO_2$,$(d) lnLUC$,$(e) lnISD$, $(f) lnFC$, and $(g) lnLAB$ denote the natural log of cereal production, financial development, CO_2 emissions, land under cereal, improved seed distribution, fertilizer used, and labor force, respectively.

The linear relationship among cereal production, financial development, CO_2 emissions, land under cereal crop, improved seed distribution, fertilizer consumption, and the labor force is expressed as follows:

$$CP_t = \delta_0 + \delta_1 FD_t + \delta_2 CO_{2t} + \delta_3 LUC_t + \delta_4 ISD_t + \delta_5 FC_t + \delta_6 LAB_t + \varepsilon_t \quad (1)$$

4. Empirical results and discussion

4.1. Unit root tests results

There are several approaches to inspect the stationarity properties of the series. The conventional augmented Dickey-Fuller (ADF) test, the Phillips–Perron (PP) test, and the KPSS test are the most popular unit root tests. The ADF and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) unit root-test are used in the current paper. The investigated series is a mixed order of integration, as observed in both unit root tests (see Table 2).

Table 2. Unit root tests results.

	ζ		Δ	
Unit root tests	Π	Π and τ	Π	Π and τ
ADF				
lnCP	-0.448	-6.103***	-11.296***	-11.159***
lnFD	-1.528	-2.228	-4.788***	-4.932***
lnCO_2	-3.417***	-1.355	-2.542	-7.728***
lnLUC	-1.334	-3.687**	-7.135***	-7.085***
lnISD	-1.189	-2.493	-7.252***	-7.257***
lnFC	-2.371	-3.559**	-6.726***	-2.441
lnLAB	-5.316***	-0.601	-0.906	-5.230***
KPSS				
lnCP	0.798***	0.062	0.127	0.135*
lnFD	0.294	0.148**	0.158	0.050
lnCO_2	0.778***	0.199**	0.600**	0.039
lnLUC	0.792***	0.106	0.241	0.156**
lnISD	0.671**	0.104	0.141	0.141*
lnFC	0.783***	0.211**	0.313	0.143*
lnLAB	0.792***	0.210**	0.717**	0.072

***, **, and * indicate that the null hypothesis of the ADF and the KPSS unit root tests is rejected at the (1%), (5%), and (10%) levels of significance, respectively. ζ denotes at level, Δ represents the first difference, Π stands for the intercept, and τ indicates the trend, respectively.

4.2. Co-integration testing results

The result of the ARDL bounds test is presented in Table 3. The calculated F-statistics i.e. 6.047, 4.582, 3.400, 3.431, 6.870, 6.026, and 14.876 clearly exceed the upper bound at various significant levels when cereal production (lnCP), financial development (lnFD), CO_2 emissions ($lnCO_2$), land under cereal crop (lnLUC), improved seed distribution (lnISD), fertilizer consumption (lnFC), and labor force (lnLAB) are used as dependent variable in the estimation, respectively. It predicts the presence of seven co-integration vectors; thus, the current paper rejects the undertaken hypothesis of the "non-availability of long-run co-integration among the study variables. Therefore, this study can determine the presence of long-term interactions among cereal production (lnCP), financial development (lnFD), CO_2 emissions ($lnCO_2$), land under cereal crop (lnLUC), improved seed distribution (lnISD), fertilizer consumption (lnFC), and labor force (lnLAB), respectively. Also, to verify the estimated findings of the ARDL bounds test, the current study applied the Johansen co-integration test. The outcomes of the test were reported in Table 4. Also, the existence of long-term linkages among the selected variables is conformed through Johansen co-integration test.

Table 3. Results of the ARDL-bound-test.

Variable	lnCP	lnFD	$lnCO_2$	lnLUC	lnISD	lnFC	lnLAB
F-statistics	6.047***	4.582***	3.400**	3.431*	6.870***	6.026***	14.876***
Optimal lag structure	(1, 2, 1, 2, 1, 2, 2)	(1, 0, 2, 1, 2, 2, 1)	(1, 0, 0, 0, 2, 2, 1)	(1, 2, 0, 1, 0, 2, 1)	(1, 1, 1, 2, 1, 2, 1)	(1, 0, 0, 2, 2, 2, 1)	(1, 2, 2, 2, 1, 2, 0)
Critical Value Bounds	1%	5%	10%				
Upper bounds I(1)	4.43	3.61	3.23				
Lower bounds I(0)	3.15	2.45	2.12				
Diagnostic tests							
Adjusted R-squared	0.789	0.460	0.489	0.581	0.478	0.600	0.967
R-squared	0.879	0.662	0.642	0.717	0.674	0.740	0.980
F-statistic	9.848	3.274	4.194	5.278	3.447	5.294	6.523
Prob(F-statistic)	0.000	0.004	0.000	0.000	0.003	0.000	0.000
Heteroskedasticity	0.953 (0.528)	0.919 (0.555)	0.667 (0.757)	1.109 (0.392)	0.626 (0.825)	0.137 (0.712)	1.034 (0.458)
Serial correlation	1.947 (0.394)	1.540 (0.215)	2.396 (0.110)	1.135 (0.337)	1.227 (0.311)	2.102 (0.144)	0.495 (0.616)

*** (1%), ** (5%), and * (10%) statistical significance rejection levels, respectively.

Table 4. Johansen co-integration test results.

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.
None	0.820	219.019***	125.615	0.000
At most 1	0.733	151.972***	95.753	0.000
2	0.660	100.345***	69.818	0.000
3	0.549	58.269***	47.856	0.003
4	0.383	27.195	29.797	0.096
5	0.152	8.329	15.494	0.430
6	0.046	1.864	3.841	0.172
		Maximum Eigenvalue		
None	0.820	67.046***	46.231	0.000
At most 1	0.733	51.626***	40.077	0.001
2	0.660	42.076***	33.876	0.004
3	0.549	31.073***	27.584	0.017
4	0.383	18.866	21.131	0.100
5	0.152	6.464	14.264	0.554
6	0.046	1.864	3.841	0.172

*** indicates that the null hypothesis of no co-integration is rejected at the (1%) significant level.

4.3. ARDL long-run and short-run results

The current study employs the ARDL approach to estimate the long and short-way connection between financial development, CO_2 emissions, land under cereal crop, improved seed distribution, fertilizer usage, agricultural labor force, and cereal production in the context of Pakistan. Table 5 presents the findings of the ARDL method, and the long-run summary is demonstrated in Figure 3.

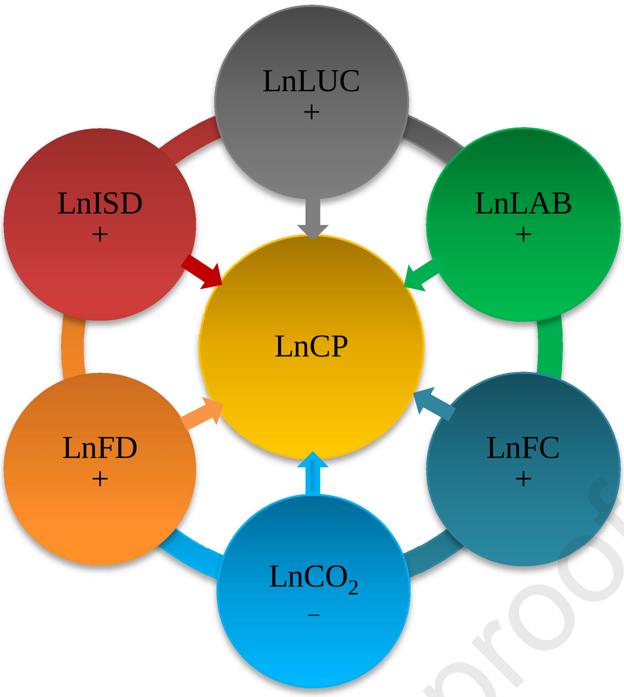


Figure 3. Summary of long-run analysis.
$lnCP$, $lnFD$, $lnCO_2$, $lnLUC$, $lnISD$, $lnFC$, and $lnLAB$ show the natural log of cereal production, financial development, CO_2 emissions, land under cereal, improved seed distribution, fertilizer used, and labor force, respectively.

As illustrated in Table 5, financial development positively impacts cereal production in the long-run; which means a 1% surge in financial development will boost cereal production by 0.03%. This result is in line with the outcomes of (Chandio et al., 2016; Zakaria et al., 2019). Moreover, Akmal et al. (2012) found the agricultural credit to be the important determinant of agricultural production in Pakistan. On the other hand, Das and Hossain (2019) found a positive impact of agricultural credit on rice production in the case of Bangladesh. Financial institutions allocate agricultural credits to farming households at low interest rates and enables them to adopt advanced agricultural technologies and to stimulate farming activities, and hence agricultural progress. This indicates that financial developm ent not only increases capitalization in the agricultural sector that significantly contributes to the national economy but also enriches agricultural output (Shahbaz et al., 2013).

The observed impacts on the cereal production of CO_2 emissions is significant and negatively related in the long-run. The coefficient of CO_2 emissions is 0.69, which implies that a 1% increase in CO_2 emissions will decrease cereal production by 0.69%. This outcome is consistent with the outcomes of (Qureshi et al., 2016; Sossou et al., 2019). In Pakistan, greenhouse gas (GHG) emissions are the main sources of changes in climate and due to several human activities for instance urbanization, transportation, and deforestation. Besides, agricultural sector is also significantly contributing to CO_2 emissions (Hussain et al., 2018).

Land under cereal crop, improved seed distribution, and fertilizer consumption played a vital role, and these are the core elements of agricultural production. These non-climate factors positively and significantly affect cereal production. Interpretively, a 1% increase in land under cereal crop, distribution of improved seed, and fertilizer use will increase the cereal production by 2.41%, 0.10%, and 0.47% in the long-run, respectively. These findings are consistent with the results of (Afrin et al., 2017; Shiyan et al., 2017). Furthermore, agricultural labor force exhibits a positive relationship with the production of cereal in the long-run. Faleye et al. (2013) reported that the main agricultural inputs significantly enhance cereal production and provide foods to the region.

The estimated results of the short-run dynamics are reported in Table 5. In the short-run, lagged financial development has a significant positive effect on cereal production in the current period, concluding that a 1% increase in financial development will enhance the cereal production in the country by 0.20%. The results further indicated that CO_2 emissions have significantly negative effect on cereal production. The coefficient of short-run value suggests that with a 1% surge in CO_2 emissions the cereal production will decrease by 0.33%. In the short run, empirical outcomes further showed that land under cereal crop, improved seed distribution, fertilizer use, and agricultural labor force significantly and positively impact the cereal production. The results suggest that a 1% increase in these necessary inputs will increase the cereal production by 1.92%, 0.07%, 0.18%, and 1.02%, respectively. These findings are consistent with the previous literature (Nordjo and Adjasi, 2019; Ahmad, 2011). To check the ARDL model constancy, this study used various diagnostic tests, the estimated results of diagnostic tests showed that there is no evidence of serial correlation, normality, heteroscedasticity, and misspecification issues (see Table 5). The stability of the ARDL model is confirmed by the estimated results of CUSUM and CUSUM of squares tests. Figures 4 and 5 exhibit the predicted standards of the ARDL model and proves that these are constant over the sample period.

Table 5. The ARDL long-run and short-run results.

Variables	Coefficient	Standard error	*t*-Statistic	Prob.
Long-run analysis: lnCP as the dependent variable				
lnFD	0.035	0.086	0.407	0.687
lnCO$_2$	-0.695***	0.243	-2.858	0.008
lnLUC	2.411***	0.527	4.576	0.000
lnISD	0.100***	0.029	3.364	0.002
lnFC	0.473***	0.172	2.744	0.011
lnLAB	0.456	0.576	0.791	0.436
Constant	-26.332***	7.662	-3.436	0.002
Short-run dynamics: ΔlnCP as the dependent variable				
ΔlnCP(-1)	-0.010	0.171	-0.058	0.953
ΔlnFD	0.071	0.093	0.769	0.449
ΔlnFD(-1)	0.207*	0.114	1.810	0.083
ΔlnFD(-2)	-0.243**	0.107	-2.274	0.032
ΔlnCO$_2$	-0.331	0.263	-1.258	0.221
ΔlnCO$_2$(-1)	-0.370*	0.201	-1.837	0.079
ΔlnLUC	1.926***	0.325	5.913	0.000
ΔlnLUC(-1)	-0.589	0.505	-1.166	0.255
ΔlnLUC(-2)	1.098***	0.345	3.184	0.004
ΔlnISD	0.071**	0.029	2.427	0.023
ΔlnISD(-1)	0.029	0.025	1.143	0.264
ΔlnFC	0.181**	0.086	2.105	0.046
ΔlnFC(-1)	0.064	0.093	0.686	0.499
ΔlnFC(-2)	0.232**	0.110	2.098	0.047
ΔlnLAB	1.027	17.102	0.060	0.952

ΔlnLAB(-1)	-27.944	28.187	-0.991	0.331
ΔlnLAB(-2)	27.378**	12.318	2.222	0.036
ECT (−1)	-0.921***	0.171	-5.901	0.000
R^2	0.994			
Adj-R^2	0.990			
Prob(F-statistic)	0.000			
F-statistic	256.993			
Diagnostic tests				
Test	F-statistic	Prob.		
Normality	1.878	0.390		
Serial correlation	2.771	0.110		
Heteroskedasticity	0.027	0.869		
RESET test	0.121	0.730		
CUSUM	Stable			
CUSUMSQ	Stable			

***, ** and * indicate level of significance at (1%), (5%), and (10%), respectively.

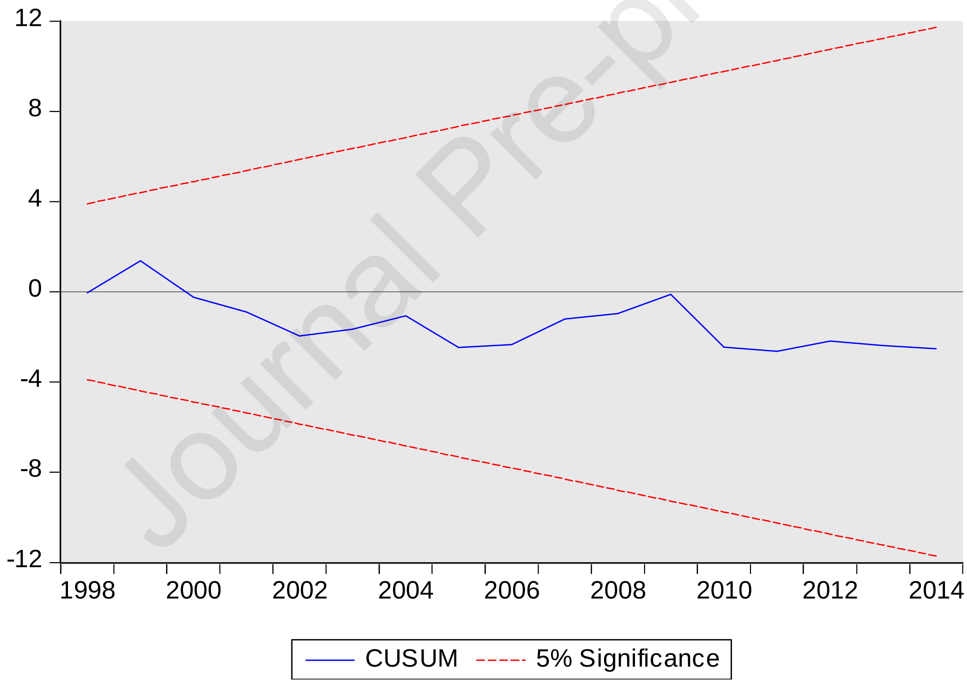


Figure 4. CUSUM test for the constancy of the ARDL model

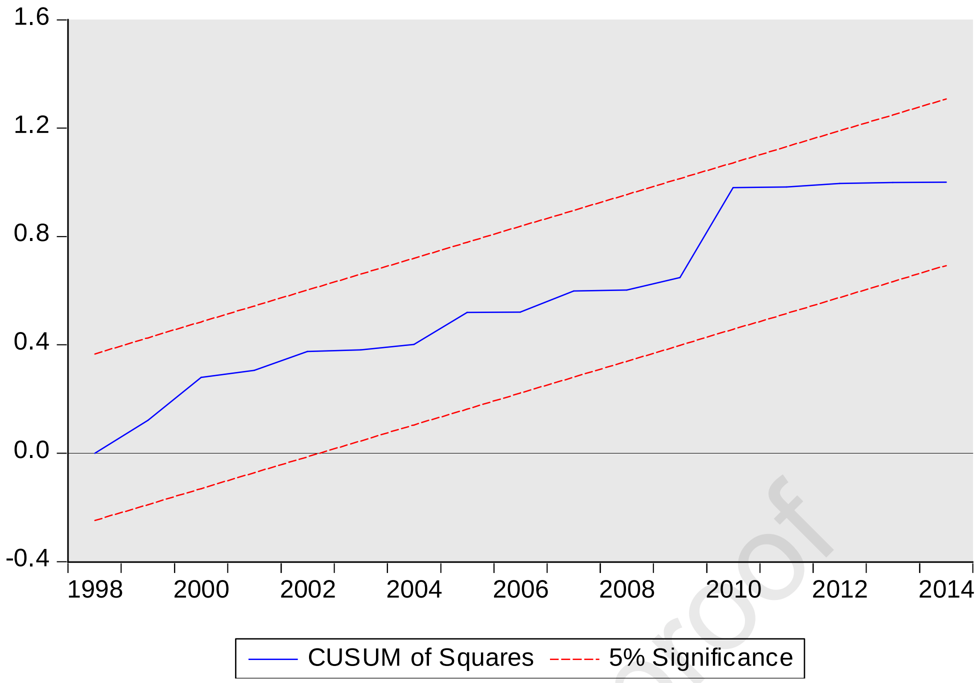


Figure 5. CUSUM of squares test for the constancy of the ARDL model

For robustness check, the present study employed the dynamic OLS, fully modified OLS, and canonical cointegrating regression techniques, and Table 6 reports the obtained results. These results of three estimators confirmed that financial development positively impacts cereal production, while climate change (CO_2 emissions) have significant negative impact on cereal production. These estimated results are consistent with the obtained results of the ARDL method.

Table 6. Results of the DOLS, FMOLS, and CCR techniques.

	DOLS		FMOLS		CCR	
Variables	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
lnFD	0.031	0.317	0.045	0.738	0.041	0.592
lnCO_2	-1.181	-2.917	-0.513	-3.230	-0.514	-2.462
lnLUC	2.141	4.213	1.792	6.242	1.827	5.720
lnISD	0.072	2.083	0.070	3.512	0.075	3.033
lnFC	0.766	3.007	0.088	1.050	0.084	0.795
lnLAB	0.970	1.481	1.421	4.372	1.410	3.584
Constant	-27.727	-3.085	-33.502	-5.874	-33.823	-4.846
R^2	0.995		0.984		0.984	
Adj-R^2	0.989		0.981		0.981	

5. Conclusions

This study examined the impacts of financial development, global climate change (CO_2 emissions), and technical progress on cereal production in Pakistan from 1977 to 2014. The study included land under cereal crop and labor force as additional variables in the ARDL model to examine their impacts on cereal production. This study used conventional the ADF and KPSS unit root tests to check the stationarity of underlying variables. The ARDL-bounds testing approach was applied to explore the long-term co-integration connections among the study variables. To verify the long-run ARDL estimates, the study also employed the DOLS, FMOLS, and CCR approaches.

The findings of this study revealed the presence of the association among variables in the long-term. The ARDL model estimates showed that financial development improves cereal production, whereas CO_2 emissions decrease cereal production in the long-run and short-run. Furthermore, other essential input variables, for example, land under cereal crop, improved seed distribution, fertilizer used, and agricultural labor force significantly and positively affected the cereal production in both cases. The results of DOLS, FMOLS, and CCR approaches also confirmed the long-run results of the ARDL model. These outcomes suggest that financial development not only increase cereal production but also sustain the agriculture sector. It has essential implication for sustainable consumption and production of cereals because 20.5% population in Pakistan is unnourished (WFP, 2020a), 36.9% population faces food insecurity (NNS, 2018) 18% children (under five) face acute malnutrition, 40% are stunted, and 29% are underweight (WFP, 2020b). As documented, the economic damages (cost) due to environmental degradation are substantial to the Pakistan economy, and crops sector share to agriculture is declining. This scenario provides enough reason for cleaner production initiatives, in particular to cereal crop production. Pakistan can quickly meet the challenges of food security by adopting sustainable production practices reducing fertilizer use, and the availability of quality seed. Rice exports may also overcome the obstacles of exports by meeting international quality standards. The earned financial resources may be directed to the adoption of sustainable agriculture technologies at the farm level.

It requires a new business model that attracts the resources to agriculture and develop the capacity of the supply chain to satisfy the local and international consumers. The role of the financial sector is crucial; for example, agriculture development bank and commercial banks to design the products for cleaner production. Banks can fund the universities' research to develop crop varieties that are beneficial for human health and adapt to adverse climate change.

The findings suggest that financial institutions should supply more credit to farmers because, with the help of credit, farmers can quickly adapt to climate change and purchase of improved inputs, and adopt cleaner technologies to increase cereal production sustainably. Also, it is suggested that the realized benefits of cleaner production technologies use must be documented and highlighted at the policy level.

Also, future studies should investigate the impact of climatic and non-climatic factors on significant food, and non-food crops yield and exports in Pakistan by using country-level time series data since the present study assessed the impact of financial development and global climate change (carbon dioxide emissions) on the production of cereal in Pakistan by undertaking the ARDL model.

Appendix A

Autoregressive distributed lag estimation

The present study applied the ARDL co-integration approach to examine the short- and long-run interactions among financial development, climate change, technical progress (fertilizer consumption and improved seed distribution), and cereal production. Other control variables included in the estimation, such as land under cereal crop and labor force, which may impact Pakistan's cereal production during 1977 to 2014.

The ARDL method extended by Pesaran et al. (2001), which has several advantages.

i. This technique can be used for small sample size estimation.
ii. It analyzes the long- and short-run parameters of the model simultaneously and reports the outcomes separately.
iii. The procedure presents valid t-statistic (irrespective of endogeneity) and unbiased estimates of the long-run.
iv. The co-integration association between the study variables can be assessed using the ordinary least squares (OLS) regression estimator.

The ARDL model is specified as follows:

$$\begin{aligned}\Delta LnCP_t = \psi_0 &+ \sum_{i=1}^{p} \psi_1 \Delta LnCP_{t-i} + \sum_{i=1}^{q} \psi_2 \Delta LnFD_{t-i} + \sum_{i=1}^{q} \psi_3 \, \Delta LnCO_{2t-i} \\ &+ \sum_{i=1}^{q} \psi_4 \Delta LnLUC_{t-i} + \sum_{i=1}^{q} \psi_5 \Delta LnISD_{t-i} + \sum_{i=1}^{q} \psi_6 \Delta LnFC_{t-i} \\ &+ \sum_{i=1}^{q} \psi_7 \Delta LnLAB_{t-i} + \beta_1 LnCP_{t-1} + \beta_2 LnFD_{t-1} + \beta_3 LnCO_{2t-1} \\ &+ \beta_4 LnLUC_{t-1} + \beta_5 LnISD_{t-1} + \beta_6 LnFC_{t-1} + \beta_7 LnLAB_{t-1} \\ &+ \varepsilon_t \qquad (2)\end{aligned}$$

where $lnCP$ is the log of cereal production, $lnFD$ is the log of financial development, $lnCO_2$ is the log of CO_2 emissions, $lnLUC$ is the log of land under cereal crop, $lnISD$ is the log of improved seed distribution, $lnFC$ is the log of fertilizer consumption, $lnLAB$ is the log of the labor force, and t denotes the time. The Δ stands for the first difference operator, and ε is the error term. The long-run coefficients are denoted by $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ and $\psi_1, \psi_2, \psi_3, \psi_4, \psi_5, \psi_6, \psi_7$ are indicated in the short-run dynamics.

To confirm the long-term interrelationship exists among the undertaken variables, the following null and alternative hypotheses of the ARDL-bounds procedure are tested:

$$H_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$$

$$H_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$$

The null hypothesis of the ARDL-bounds test cannot be rejected when the computed F-statistic is lower than the upper bound, but it can be rejected in the condition where the estimated F-statistic increases the upper bound. In a case where the outcome of F-statistic is lesser than the lower bound, the estimated outcomes of this test are inconclusive.

To estimate the interrelationship in the long-run among the undertaken variables, the conditional ARDL long-run model expressed as follows:

$$LnCP_t = \lambda_0 + \sum_{i=1}^{p} \lambda_1 LnCP_{t-i} + \sum_{i=1}^{q} \lambda_2 LnFD_{t-i} + \sum_{i=1}^{q} \lambda_3\, LnCO_{2t-i} + \sum_{i=1}^{q} \lambda_4 LnLUC_{t-i} + \sum_{i=1}^{q} \lambda_5 LnISD_{t-i} + \sum_{i=1}^{q} \lambda_6 LnFC_{t-i} + \sum_{i=1}^{q} \lambda_7 LnLAB_{t-i} + \varepsilon_t \quad (3)$$

To estimate the short-run dynamics with the error correction model (ECM) linked with the long-run estimates expressed as follows:

$$\Delta LnCP_t = \delta_0 + \sum_{i=1}^{p} \delta_1 \Delta LnCP_{t-i} + \sum_{i=1}^{q} \delta_2 \Delta LnFD_{t-i} + \sum_{i=1}^{q} \delta_3 \, \Delta LnCO_{2t-i} + \sum_{i=1}^{q} \delta_4 \Delta LnLUC_{t-i} + \sum_{i=1}^{q} \delta_5 \Delta LnISD_{t-i} + \sum_{i=1}^{q} \delta_6 \Delta LnFC_{t-i} + \sum_{i=1}^{q} \delta_7 \Delta LnLAB_{t-i} + \phi ECM_{t-i} + \varepsilon_t \quad (4)$$

Where δ s represents the short-run dynamics, and ECM denotes the error correction terms it must be negative and significant. The stability of the ARDL model will be checked by using the CUSUM and the CUSUMSQ tests.

References

Abbas, S., 2020. Climate change and cotton production: an empirical investigation of pakistan. Environmental Science and Pollution Research(5).

Afrin, S., Haider, M.Z., Islam, M.S., 2017. Impact of financial inclusion on technical efficiency of paddy farmers in Bangladesh. Agricultural Finance Review.77,484-505.

Agbodji, A.E., Johnson, A.A., 2019. Agricultural Credit and Its Impact on the Productivity of Certain Cereals in Togo. Emerging Markets Finance and Trade, 1-17.

Ahmad, S., Tariq, M., Hussain, T., Abbas, Q., Elham, H., Haider, I., Li, X., 2020. Does Chinese FDI, Climate Change, and CO_2 Emissions Stimulate Agricultural Productivity? An Empirical Evidence from Pakistan. Sustainability, 12.

Ahmad, N., 2011. Impact of Institutional Credit on Agricultural Output: A Case Study of Pakistan. Theor. Appl. Econ 18, 99-120.

Ahmad, N., Jan, I., Ullah, S., Pervez, S., 2015. Impact of agricultural credit on wheat productivity in district Jhang, Pakistan. Sarhad Journal of Agriculture 31(1), 65-69.

Akmal, N., Rehman, B., Ali, A., Shah, H., 2012. The Impact of Agriculture Credit on Growth in Pakistan. Asian Journal of Agriculture and Rural Development, 2(393-2016-23882), 579-583.

Ammani, A., Ja'Afaru, A., Aliyu, J., Arab, A., 2012. Climate change and maize production: empirical evidence from Kaduna State, Nigeria. Journal of Agricultural Extension 16(1), 1-8.

Anetor, F., Ogbechie, C., Kelikume, I., Ikpesu, F., 2016. Credit supply and agricultural production in Nigeria: a vector autoregressive (VAR) approach. Journal of Economics and Sustainable Development 7(2).

Attiaoui, I., Boufateh, T., 2019. Impacts of climate change on cereal farming in Tunisia: a panel ARDL–PMG approach. Environmental Science and Pollution Research 26(13), 13334-13345.

Bank, W., 2006. Pakistan Strategic Country Environmental Assessment, Volume I: Main Report No. 36946-PK, World Bank, Washington, DC.

Bank, W., 2011. Policy Options for Air Quality Management in Pakistan. Report submitted to the Government of Pakistan. Washington, DC.

Bannayan, M., Mansoori, H., Rezaei, E.E., 2014. Estimating climate change, CO2 and technology development effects on wheat yield in northeast Iran. International Journal of Biometeorology 58(3), 395-405.

Bashir, M.K., Gill, Z.A., Hassan, S., Adil, S.A., Bakhsh, K., 2007. Impact of credit disbursed by commercial banks on the productivity of sugarcane in Faisalabad district [Pakistan]. Pakistan Journal of Agricultural ences 44, 361-363.

Bashir, M.K., Mehmood, Y., 2010. Institutional credit and rice productivity: a case study of District Lahore, Pakistan. China Agricultural Economic Review 2(4), 412-419.

Blok, V., Long, T.B., Gaziulusoy, A.I., Ciliz, N., Lozano, R., Huisingh, D., Csutora, M., Boks, C., 2015. From best practices to bridges for a more sustainable future: Advances and challenges in the transition to global sustainable production and consumption: Introduction to the ERSCP stream of the Special volume. Journal of Cleaner Production 108, 19-30.

Chandio, A.A., Jiang, Y., Joyo, M.A., Rehman, A., 2016. Impact of area under cultivation, water availability, credit disbursement, and fertilizer off-take on wheat production in Pakistan. Journal of Applied Environmental and Biological Sciences 6(10), 10-18.

Chandio, A.A., Jiang, Y., Wei, F., Rehman, A., Liu, D., 2017. Famers' access to credit: Does collateral matter or cash flow matter?—Evidence from Sindh, Pakistan. Cogent Economics & Finance 5(1), 1369383.

Chandio, A.A., Jiang, Y., Wei, F., Guangshun, X., 2018a. Effects of agricultural credit on wheat productivity of small farms in Sindh, Pakistan. Agricultural Finance Review.78, 592-610.

Chandio, A.A., Jiang, Y., Rehman, A., 2018b. Credit margin of investment in the agricultural sector and credit fungibility: the case of smallholders of district Shikarpur, Sindh, Pakistan. Financial Innovation 4(1), 27.

Chandio, A.A., Jiang, Y., Rehman, A., Rauf, A., 2020a. Short and long-run impacts of climate change on agriculture: an empirical evidence from China. International Journal of Climate Change Strategies and Management.12,201-221.

Chandio, A.A., Ozturk, I., Akram, W., Ahmad, F., Mirani, A.A., 2020b. Empirical analysis of climate change factors affecting cereal yield: evidence from Turkey. Environmental Science and Pollution Research, 1-14.

Das, M. R., Hossain, M. A., 2019. Impact of Agricultural Loan Disbursement and Chemical Fertilizer Use on the Rice Production in Bangladesh. Bangladesh Journal of Public Administration, 27(2), 84-96.

Enete, A.A., Amusa, T.A., 2010. Challenges of agricultural adaptation to climate change in Nigeria: A synthesis from the literature. Field Actions Science Reports. The Journal of Field Actions 4.

Faleye, T., David, J., Dadajoel, O.T., Chukwu, U.C., Ademiluyi, Y.S., 2013. Determination of energy consumption in lowland rice production in Nigeria. International Research Journal of Agricultural Science and soil Science 3(10), 336-342.

FAO, 2013. The State of Food Insecurity in the World 2013: The multiple dimensions of food security. Retrieved from http://www.fao.org/3/i3434e/i3434e01.pdf. Accessed on March 01, 2020.

GoP, 2020. Economic Survey of Pakistan, Ministry of finance, Islamabad.

Grin, J., Rotmans, J., Schot, J., 2010. Transitions to sustainable development: new directions in the study of long term transformative change. Routledge.

Harvey, C.A., Saborio-Rodríguez, M., Martinez-Rodríguez, M.R., Viguera, B., Chain-Guadarrama, A., Vignola, R., Alpizar, F., 2018. Climate change impacts and adaptation among smallholder farmers in Central America. Agriculture & Food Security 7(1), 57.

Hussain, M., Butt, A.R., Uzma, F., Ahmed, R., Irshad, S., Rehman, A., Yousaf, B., 2020. A comprehensive review of climate change impacts, adaptation, and mitigation on environmental and natural calamities in Pakistan. Environmental monitoring and assessment 192(1), 48.

Hussain, M., Liu, G., Yousaf, B., Ahmed, R., Uzma, F., Ali, M.U., Ullah, H., Butt, A.R., 2018. Regional and sectoral assessment on climate-change in Pakistan: social norms and indigenous perceptions on climate-change adaptation and mitigation in relation to global context. J. Clean. Prod. 200, 791–808.

Hussain, S.S., Mudasser, M., 2007. Prospects for wheat production under changing climate in mountain areas of Pakistan - An econometric analysis. Agricultural Systems 94(2), 494-501.

IFAD, 2009. Research and innovation for smallholder farmers in the context of climate change. Discussion paper for Round Table 3, thirty-second session of the Governing Council, Rome, 18–19 February.

Khan, A., Ali, S., Shah, S.A., Khan, A., Ullah, R., 2019. Impact of climate change on maize productivity in Khyber Pakhtunkhwa, Pakistan. Sarhad Journal of Agriculture 35(2), 594-601.

Khan, R.E.A., Hussain, T.,, 2011. Demand for formal and informal credit in agriculture: a case study of cotton growers in Bahawalpur. Interdisciplinary Journal of Contemporary Research in Business and Economic Horizons 2(10), 308-314.

King, R.G., Levine, R., 1993. Finance, entrepreneurship and growth. Journal of Monetary economics 32(3), 513-542.

Lemma, M., Alemie, A., Habtu, S., Lemma, C., 2016. Analyzing the impacts of on onset, length of growing period and dry spell length on chickpea production in Adaa District (East Showa Zone) of Ethiopia. Journal of Earth Science and Climatic Change 7(5), 349.

Mahmood, N., Arshad, M., Kächele, H., Ma, H., Ullah, A., Müller, K., 2019. Wheat yield response to input and socioeconomic factors under changing climate: Evidence from rainfed environments of Pakistan. Science of the Total Environment 688, 1275-1285.

Matiu, M., Ankerst, D.P., Menzel, A., 2017. Interactions between temperature and drought in global and regional crop yield variability during 1961-2014. PloS one 12(5), e0178339.

Mersha, F., Leta, A., 2019. Climate Change and Its Impact on Agricultural Production: An Empirical Review from Sub-Saharan African Perspective. Journal of Agricultural Economics 5(3), 627-633.

Müller, K., Holmes, A., Deurer, M., Clothier, B.E., 2015. Eco-efficiency as a sustainability measure for kiwifruit production in New Zealand. Journal of Cleaner Production 106, 333-342.

NNS, 2018. Government of Pakistan & UNICEF (June 2019). National Nutrition Survey 2018 - Key Findings Report: A summary of the key insights and statistics. Retrieved from https://www.unicef.org/pakistan/reports/national-nutrition-survey-2018-key-findings-report on February 29, 2020.

Nordjo, R.E., Adjasi, C.K., 2019. The impact of credit on productivity of smallholder farmers in Ghana. Agricultural Finance Review.80,91-109.

Omoregie, K., Ikpesu, F., Okpe, A.E., 2018. Credit Supply and Rice Output in Nigeria: Empirical Insight from Vector Error Correction Model Approach. International Journal of Economics and Financial Issues 8(5), 68-74.

Pesaran, M.H., Shin, Y., Smith, R.J., 2001. Bounds testing approaches to the analysis of level relationships. Journal of applied econometrics 16(3), 289-326.

Qureshi, M.I., Awan, U., Arshad, Z., Rasli, A.M., Zaman, K., Khan, F., 2016. Dynamic linkages among energy consumption, air pollution, greenhouse gas emissions and agricultural production in Pakistan: sustainable agriculture key to policy success. Natural hazards 84(1), 367-381.

Raifu, I.A., Aminu, A., 2019. Financial development and agricultural performance in Nigeria: what role do institutions play? Agricultural Finance Review.80,231-254.

Rehman, A., Chandio, A.A., Hussain, I., Jingdong, L., 2019. Fertilizer consumption, water availability and credit distribution: Major factors affecting agricultural productivity in Pakistan. Journal of the Saudi Society of Agricultural Sciences 18(3), 269-274.

Saqib, S.E., Ahmad, M.M., Panezai, S., 2016. Landholding size and farmers' access to credit and its utilisation in Pakistan. Development in Practice 26(8), 1060-1071.

Sarkar, M.S.K., Begum, R.A., Pereira, J.J., 2020. Impacts of climate change on oil palm production in Malaysia. Environmental Science and Pollution Research, 1-11.

Shahbaz, M., Shabbir, M.S., Butt, M.S., 2013. Effect of financial development on agricultural growth in Pakistan. International Journal of Social Economics.40,707-728.

Shiyan, Z., Genxin, S., Yaochen, Q., Xinyue, Y., Jay, L., Wei, W., 2017. Modeling the impacts of climate change and technical progress on the wheat yield in inland China: An autoregressive distributed lag approach. Plos One 12(9), e0184474.

Sossou, S., Igue, C.B., Diallo, M., 2019. Impact of Climate Change on Cereal Yield and Production in the Sahel: Case of Burkina Faso. Asian Journal of Agricultural Extension, Economics & Sociology, 1-11.

Van Berkel, R., 2007. Cleaner production and eco-efficiency initiatives in Western Australia 1996–2004. Journal of Cleaner Production 15(8-9), 741-755.

Wang, J., Vanga, S.K., Saxena, R., Orsat, V., Raghavan, V., 2018. Effect of climate change on the yield of cereal crops: A review. Climate 6(2), 41.

WB, 2014. World Bank (2014) World development indicators—2014. World Bank,Washington D.C.https://data.worldbank.org/indicator.

WFP, 2020a. WFP Pakistan: Country Brief, January 2020. Retrieved from https://www.wfp.org/countries/pakistan on February 29, 2020.

WFP, 2020b. World Food Program Pakistan: Country Brief, January 2020. Retrieved from https://www.wfp.org/countries/pakistan on February 29, 2020.

Zakaria, M., Jun, W., Khan, M.F., 2019. Impact of financial development on agricultural productivity in South Asia. Agricultural Economics 65(5), 232-239.

Highlights

- We examined the impact of financial development, climate change, and technical progress on cereal production.
- The ARDL approach is employed to explore the long-run relationship among the variables.
- Findings reveal that financial development improves cereal production in both long-run and short-run.
- CO_2 emissions have adverse impact on cereal production in both cases.
- Technical progress will leads to increase cereal production in both long-run and short-run.

Conflict of Interest Statement

The authors of this research work declare no conflict of interest.