



RESEARCH PAPER

Impact of Environmental Degradation, Financial Development and Human Capital on Agricultural Productivity: Insights From Pakistan

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PAPER INFO	ABSTRACT
Received: January 24, 2020	This research investigates the impact of financial development (F.D.), environmental degradation, and human capital on agricultural productivity in the presence of economic growth, technology, and consumer price index. The data from 1975 to 2017 is used for the case of Pakistan, and Autoregressive Distributive Lag (ARDL) bounding technique and Johansen co integration approaches are employed to check long-run co integration among study variables. Similarly, with the ARDL model, the short-run and long-run dynamics are examined. The results of ARDL confirmed the long-run co-integrating relationships. Further, to investigate causality between study variables, the Granger Causality test is used. The results reveal bidirectional causality relationship between environmental degradation-agricultural productivity, financial development, agricultural productivity, and between human capital and agricultural productivity. The study suggests important policy implications to policymakers and research directions for future researchers.
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Introduction

Agricultural productivity is referred to as the growth or decline of the agriculture sector in any agriculture-based economy. Further, in Agri based economy, the financial conditions of farmers primarily rely on agriculture productivity. The historical data and analysis of this study reflect that the agriculture sector has been the largest source of revenue in Pakistan. The continuous decline in agriculture income has lowered the living quality of rural people. Unfortunately, due to some strategic factors, the agriculture sector has devalued to such an extent that its share in economic growth is 18.9% in 2019-2020, while it was 60% in 1947 (the independence year of

Pakistan). Concluding any other sector has never offset such extend decline compare to this sector since 1947. Therefore, examining the factors affecting agricultural productivity remains debatable in the literature review, especially in developing countries, and Pakistan is one of the best ones to study these effects.

This study explores the factors which hamper agriculture productivity in Pakistan. It includes important factors; environmental degradation (CO₂), GDP, agriculture technology, consumer price index, financial development, and human capital, to check their impact on agriculture productivity. Previous researchers have not tested the effects of human capital and consumer price index ever on agriculture productivity in the presence of economic growth and technology in the case of Pakistan. So, the present study fills this literature gap. The results of our study provide valuable information and will help the policymakers to develop an optimal combination to increase agriculture productivity to meet the national food demand in Pakistan.

Over the past 50 years, the degradation of the environment has become a global issue, and every sector faces the dangers of environmental degradation, especially the agriculture sector (Aghapour Sabbaghi, Nazari, Araghinejad, & Soufizadeh, 2020). We select the environmental degradation in our model due to the reasons mentioned above because the implications for the environment are necessary to increase agriculture production and to reduce poverty from less developed countries, especially from Pakistan.

The literature is evident that financial development in countries impacts a significant positive role in agriculture productivity with the improvement of financial reserves, credit disbursement to farmers, easing business deals between the agriculture sector, and all other stakeholders' related agriculture. Better agriculture productivity increases economic and decreases environmental degradation (Seetanah et al., 2019). In Pakistan, the credit disbursement figures show that Science 1947 to present there is a continued increase in credit issuing to formers, but unfortunately, the agriculture productivity is decreasing.

Human capital (H.C.) also plays an essential role in agriculture growth. Good health and education reveal the quality of human resources in a country. The sound human capital works like intellectual capital for formers. Building healthy H.C. and its proper leverage can help to increase agriculture productivity, food security, and livelihoods for farmers, especially for small scale farmers all around the world(Pindado, Sánchez, Verstegen, & Lans, 2018). In developing countries like Pakistan, agriculture production relies on formers education, knowledge, experience, and the availability of skilled labor.

In the modern era, advanced technology in the agricultural sector is essential to gain higher crop productivity (Hornbeck & Keskin, 2015). The agrarian technology helps to reduce the cost of crops by reducing the fuel consumption in tractors,

harvesters, and other agricultural tools. Modern agrarian technology helps to increase land fertility, crop turnover, quality of crops, and the most important it reduces the climate risk and effect on crops. For better agriculture productivity, sustainability, and profitability, it is necessary to develop agricultural techniques and tools with innovation and extension with the help of research (Ebrahimi Sarcheshmeh, Bijani & Sadighi, 2018).

We distribute this research paper in the following sections. Section 2 carries the literature review; section 3 consists of data and collection section and econometric approach, section 4, presents the results and discussion of the study, and the last part # 5 shows the conclusion of the study and policy recommendations based on findings.

Literature Review

Existing literature has identified numerous factors that affect agricultural productivity. But existing studies still are not conclusive because of differences in different types of economies, econometric techniques, and the factors covered. In the following paragraphs, we overview the existing factors to compare their findings with those of this study.

Many authors investigate the impact of financial development (F.D.) on the growth of agriculture by applying various proxies such as market volatility, agriculture credit, inflation, etc. This research has also taken "F.D." as an agriculture credit proxy to examine the association among agriculture productivity (A.P.) and financial development (F.D.) in developing countries like Pakistan. Although increment in the formal credit enhances the agricultural productivity in Bangladesh (Bidisha, Hossain, Alam & Hasan, 2018), in Pakistan, special advisory quality and availability of credit regarding agriculture positively influence A.P. (Elahi, Abid, Zhang, ul Haq, & Sahito, 2018)

Human capital (H.C.) is the key driver of economic growth. The study of Ono Uchida (2018) demonstrated that fiscal policy is dependent on having a degree of altruism by parents for their children. Similarly, a handful of studies found that H.C. has become a direct source of economic progress (Barro, 2001). Still, it is also beneficial indirectly through collaboration with other elements (Gennaioli, La Porta, Lopez-de-Silanes, & Shleifer, 2013).

The previous study of Mourtzinis et al. (2018) indicates that usage of the latest technology can increase the efficiency of the farm field through improving crop production, the finding of this study is also endorsed by (Rattalino Edreira et al., 2018). Furthermore, previous studies have acknowledged the domains of technology transfer, a spatial framework which was too coarse or too subtle and beneficial to describe and measure the agricultural technology robustly and generically (Bailey & Hogg, 1986; Fischer, Velthuizen, Shah, & Nachtergaele, 2002; Muthoni et al., 2017; Padbury et al., 2002; Soil Survey Staff, 2006).

Environmental degradation affects mostly the farmers of less developed countries like Pakistan, as in Pakistan environment change if effecting farmers products badly, the phenomena discussed by different researchers, e.g. (Altieri & Nicholls, 2017; Esham & Garforth, 2013; Lotze-Campen & Schellnhuber, 2009). The developing countries have a low capacity for adaptation and have not modern technology for handling the sophisticated CC (Lotze-Campen & Schellnhuber, 2009).

Material and Methods

In this study, time-series data is used concerning Pakistan from 1975 to 2017. For estimation the data of CPI, GDP, agriculture productivity and CO₂ is derived from the database of World Bank Indicators (World Bank, 2017), while the data on human capital from (PWT) Pen World Table 9.0 and the data of technology and financial development from Pakistan economy survey reports.

Table 1
Definitions of Study Variables

Name of Variable	Unit of measurement	Definition
Agri. Productivity	MAF	Agriculture productivity refers to the measurement of agriculture outputs ratio by agriculture inputs like labor and capital. Simply agriculture productivity measures the efficiency of farms.
CPI	2010=100	Consumer price means the measurement of the purchasing power of the people with a change in the price of goods, services, and change in the value of the currency. Consumer price identifies the inflation rate in the country.
GDP	Constant 2010 U.S. Dollars	GDP identifies the economic growth of the country; it means dividing the domestic products by the total population of the country to acquire per capita Gross Domestic Product.
H.C.	Index	Human capital refers to the standard of living of the people by measuring their education, training, knowledge, health, and skills in any country.
Financial development	% of GDP	Financial development; calculates the amount of credit provided by the financial and private sector (% of GDP) at a domestic level, and the amount of loan to the private sector of the country by banks (% of GDP).
Agri. Technology	Qty in numbers	Agriculture technology means the machinery that farmers use for farming in agriculture production. The agriculture machinery refers to

the different tools like a hand, power and tractors, tubewell, and other helping tools used in land preparation to crop cultivation.

To check the relationship between variables, a standard linear log function used. Furthermore, the following model is used for analytical purposes:

$$\ln Agri_t = c_0 + S_1 \ln Agri_{t-i} + S_2 \ln CO2_{t-i} + S_3 \ln GDP_{t-i} + S_4 \ln HC_{t-i} + S_5 \ln CPI_{t-i} + S_6 \ln Tech_{t-i} + S_7 \ln FD_{t-i} + v_t, \quad (1)$$

Where $\ln Agri$ means a natural lag of agriculture productivity, CO_2 means carbon emission, and GDP represents the gross domestic product. GDP helps to measure the economic growth of the country. $H.C.$ describes the Human capital, and CPI denotes the consumer price index, $Tech$ indicates the technology of tube well used to irrigate the agriculture land. $F.D.$ refers to the amount of credit disbursed to farmers from 1975 to 2018.

Estimation Technique

In this study, the ARDL technique is applied, which represents the autoregressive distributed lag model for the calculation of the long and short-run results of the data. In 2001, (Pesaran, Shin and Smith (2001) found the ARDL approach to test the cointegration among nexus of the variables. Literature shows that different scholars like (Engle, Granger & Granger, 1987b; P. C. B. Phillips & Hansen, 1990; Zaidi, Danish, Hou, & Mirza 2018) in the past and present use various techniques of cointegration. But those techniques have multiple drawbacks like the results of the estimation of the structural break and sequence of integration for variables calculated with these approaches are not unique. Consequently, we use the ARDL approach in this study because this technique estimates the exclusive results considering the structural breaks. The equation for the formulation of the ARDL approach is as follow:-

$$\begin{aligned} \Delta \ln Agri = c_0 + \sum_{i=1}^p \beta_1 \Delta Agri_{t-r} + \sum_{i=0}^q \beta_2 \Delta \ln GDP_{t-r} + \sum_{i=0}^q \beta_3 \Delta \ln CO2_{t-r} + \sum_{i=0}^q \beta_4 \Delta \ln HC_{t-r} + \\ \sum_{i=0}^q \beta_5 \Delta \ln CPI_{t-r} + \sum_{i=0}^q \beta_6 \Delta \ln Tech_{t-r} + \sum_{i=0}^q \beta_7 \Delta \ln FD_{t-r} + \beta_1 \ln Agri_{t-1} + \beta_2 \ln GDP_{t-1} + \\ \beta_3 \ln CO2_{t-1} + \beta_4 \ln HC_{t-1} + \beta_5 \ln CPI_{t-1} + \beta_6 \ln CPI_{t-1} + \beta_7 \ln FD_{t-1}, \end{aligned} \quad (2)$$

Where Δ acts as the 1st difference operator between variables, while p is representing the lag length of the variables, we framed two types of hypotheses from this equation. These hypotheses represent the long-run relationship between the variables. Equation two represents the null hypotheses for no co integration (H_0 :

$\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$. So, we test the 1st hypothesis divergently with the 2nd alternative hypothesis (H1: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq 0$).

Results and Discussion

At the first step, the ADF (Augmented Dickey Fuller) and Philips Pearson (P.P.) tests were applied to check the unit root test of the data. In table 2, the results show that agriculture productivity (A.P.), human capital (H.C.), and technology variables are stationary at level I(0). The environmental degradation (CO₂), GDP, financial development, and CPI variables are stationary at the 1st difference I(1). The Zivot and Andrews results show the structural breaks in the data. Table 3 shows the results of the Zivot and Andrews structural break unit root tests.

Table 2
Unit root tests

Variable	Augmented Dickey-Fuller test statistic				Philips-Pearson test statistic				Order of integration
	At level (Intercept)		1st Difference (Intercept)		At level		1st difference		
	t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.	t-Statistic	Prob.	
LnAgri	-8.3222	0.0000	-7.141	0.0000*	-8.2956	0.000	-37.3021	0.000	I(0)
LnCO ₂	-2.6046	0.1002	-3.846	0.0053	-2.1981	0.209	-3.8964	0.004	I(1)
LnFD	-1.0458	0.7280	-4.003	0.0033	-1.4021	.5721	-4.0150	0.003	I(1)
LnHC	-2.3655	.01645	-4.670	0.0059	-3.1981	0.209	-3.8964	0.018	I(0)
LnTech	-2.6519	0.0908	-1.461	0.5231	-3.516	0.764	-3.133	0.065	I(0)
LnGDP	-7.9626	0.0000	-6.544	0.0000	-7.9626	0.000	-18.447	0.000	I(1)
LnCPI	-0.5784	0.8562	-4.321	0.0906	0.288	0.976	-4.791	.0435	I(1)

Note: * refer to the rejection level at 1%

Table 3
Results of Zivot and Andrews's structural break unit root test

Variables	Z.A. test at level	Integration
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	t-Statistic	Prob.*	Break Year	
lnAgri	-11.35344	0.000911	1997	I(0)
lnCO ₂	-2.629076	0.000882	2004	I(0)
lnGDP	-5.577687	0.014156	2008	I(0)
lnFD	-3.807734	0.003924	2005	I(0)
LnTech	-3.686281	0.045324	1990	I(0)
lnHC	-3.477570	0.073038	2005	I(0)
LnCPI	-6.96018	0.092456	1999	I(0)

The presence of structural breaks in data occurs owing to changes in government policies and the evolution of economic conditions in the country, or owing to introduce and application of new rules regarding study variables. For example, the financial crises of 2008 bring a structural change; these crises affect the economy of most countries of the world.

The unit root tests results permit to apply the ARDL technique, as altogether variables of the model integrate at I(0) and I(1). After applying the unit root and structural break tests on the data, the ARDL bound testing approach was used to check the cointegration of the variables. Table No. 4 is showing the results of ARDL bound tests.

Table 4

ARDL Co-integration results of Bounding testing

Model	Ln Agri= $f(\text{Ln CO}_2, \text{Ln CREDIT}, \text{Ln H.C.}, \text{Ln TECH}, \text{Ln TEMP}, \text{Ln GDP}, \text{Ln RAIN})$
Bond test-F-statistics	6.693418***
Significance	1%
Lower 1(0) Bond	2.65
Upper 1(1) Bonds	3.91

Note, *, **, and *** indicate the significance level at 10%, 5% and 1% respectively.

ARDL bound test estimates the F-Value for the given model; we compare the results of F-value with critical values of upper and lower bounds. Previous studies (Zaidi, Zafar, Shahbaz, & Hou 2019) identify that if F-statistics value is higher than the critical importance of upper bound, then we will reject the null hypothesis of no

integration. We used the Schwarz information criterion to find the best-suited lag order. The appropriate lag order is 1 for further estimations.

Long and short term relationships

After finding the ratification of the cointegration of the data, we checked the long-run and short-run dynamics with the help of the ARDL approach. Table 5 shows the results of the long run and short-run dynamics.

Table5
Long and short-run estimation

Cointegrating Form					
Variable	Coefficient	Std. Error	t-Statistic	Prob.	
D(LNAGRI(-1))	0.266843	0.150117	1.777565	0.089	
D(LNCO2)	5.819338	1.498870	3.882482	0.000	
D(LNCPI)	4.167049	1.797161	2.318685	0.030	
D(LNFD)	4.512846	1.894759	2.381752	0.026	
D(LNFD(-1))	5.029624	1.793772	2.803937	0.010	
D(LNGDP)	0.123194	0.081435	1.512792	0.044	
D(LNTECH)	1.732751	0.858949	2.017291	0.056	
D(LNTECH(-1))	1.539859	0.597103	2.578885	0.017	
D(HC)	10.45390	5.993173	1.744302	0.095	
D(DUMMY)	-0.27389	0.667280	-0.41046	0.685	
D(DUMMY(-1))	1.454314	0.590399	2.463272	0.022	
CointEq(-1)	-2.19308	0.272517	-8.04751	0.000	
Long Run Coefficients					
Variable	nt	Coefficient	Std. Error	t-Statistic	Prob.
LNCO2		-2.65349	0.642685	4.128770	0.000
LNCPI		-1.90008	0.821728	-2.31230	0.030
LNFD		0.738995	0.494223	-1.49526	0.049
LNGDP		0.056174	0.038354	1.464624	0.057
LNTECH		0.353928	0.355331	-0.99605	0.330
HC		-1.13317	0.627747	-1.80515	0.084
DUMMY		-1.50121	0.273671	-5.48548	0.000
C		2.460101	2.434278	1.010608	0.323
R-squared		0.798171			
Adjusted R-squared		0.651386			
S.E. of regression		0.386218			
Sum squared resid		3.281623			
Log-likelihood		-7.07174			
F-statistic		5.437700			
Prob(F-statistic)		0.000173			
Ramsey RESET (F an		0.934322			
ARCH		0.654930			
LM Test		4.963810			

The long-run results of ARDL show negative relationship between CO₂ and agriculture productivity (-2.653498) and highly significant (0.0004). The negative coefficient states that with the increase of CO₂, agriculture productivity decreases. So, the 1% change in CO₂ will change agriculture productivity by 2.653498%. There is a challenging situation of environment and CO₂ emissions in Pakistan, and the efforts are sporadic to overcome these challenges (Zaidi et al., 2018). The core reason for climate change is the frequent use of fossil oil and cutting the trees from agricultural land.

Furthermore, the coefficient of CPI (Consumer Price Index) is (-1.900088); this is showing a positive and significant (.00305) effect on agriculture productivity. The negative relationship between CPI and agriculture growth explains that if the expenditures of consumers (farmers) increase, agriculture productivity decreases because of weak purchasing power parity. A 1% change in CPI changes agriculture productivity by -1.90008%. An increase in price level discourages the farmers from investing more in agriculture farming; for example, when oil prices increase, pesticides will also become expensive.

The financial system is the primary driver of the economic system. The results reveal that the financial development coefficient is (0.738995), which is showing a positive and significant (0.0491) impact on agriculture productivity. A 1% change in financial development increase agriculture productivity by 0.738995%. In the long run, the results are similar to the study done in Pakistan (Chandio et al., 2019).

Economic growth in Pakistan is dependent on agriculture growth, as the results of our study show positive and significant. The GDP coefficient represents (0.056174) value that confirms the positive and significant (0.0572). The significant positive results confirm that with the increase in agriculture productivity, the GDP will also increase. A 1% change in economic growth will bring .056174% changes in agriculture productivity. The results of our study are similar to the previous studies done by McArthur and McCord (2017) on 70 countries and found that with the increase in fertilizers the agriculture productivity will increase that will impact significantly and positively on economic growth.

Moreover, the coefficient of agriculture technology is positive at (0.353928) and insignificant (0.3301). The insignificant positive result shows that there is a lack of modern technology in Pakistani farming. The reason for the insignificant adverse effects is that in Pakistan, most of the farmers belong to small scale category. The results indicate that a 1% change in agriculture technology will change agriculture productivity by 0.353928%. According to (Hu, Li, Zhang, & Wang, 2019), small scale farmers use less modern technology. So, we can conclude that in Pakistan, most of the small scale farmers are not using advanced technology for the crops.

The results of human capital and agriculture growth are positive (1.13317) and significant (0.0848). A 1% change in human capital will change the agriculture sector productivity by 1.13317% in Pakistan.

The results of the short-run diminuendos report a positive and significant relationship between all the variables in the short run. It refers to the subject that the development of environmental degradation, GDP, consumer price index, financial development, agriculture technology, and human capital will increase agriculture productivity in the short-run.

To check the reliability of ARDL results, we used Breusch-Pagan-Godfrey and Ramsey RSET tests, which are presented in table no. 5. Further, for the robustness check of the model, we use CUSUM and CUSUM sum of squares (shown in figs. 1 and 2).

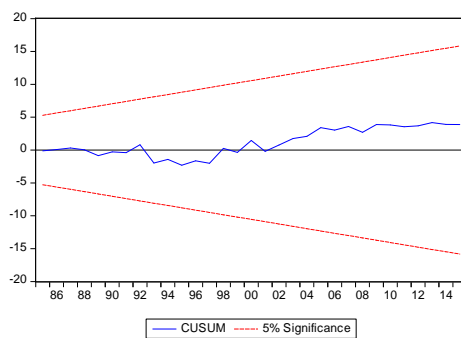


Figure 1

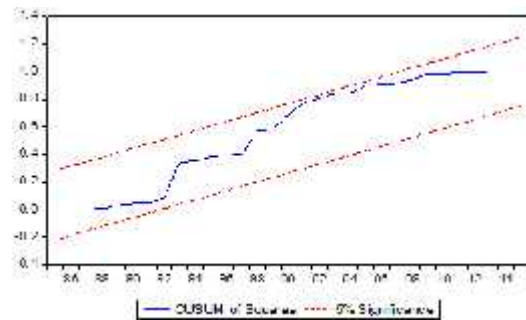


Figure 2

Granger Causality Results

The results of cointegration provide evidence of the existence of a long-run relationship between variables. After finding the testimony of a long-run relationship, we checked the direction of the causal relationship with the help of VECM. According to Phillips (1993), if there is a long-run relationship between the variables, then the error correction model is suitable to find the causal relationship of the variables. ECM also helps and allows differentiating the short-term and long-term granger causality. Wald statistic measures the VECM Granger causality of IV's (independent variables); the VECM results determine the difference and lag difference coefficients. Following equation reveals the functions of Granger causality:

$$\begin{bmatrix} \Delta \ln Agri_t \\ \Delta \ln CO_{2,t} \\ \Delta \ln GDP_t \\ \Delta \ln HC_t \\ \Delta \ln CPI_t \\ \Delta \ln TECH_t \\ \Delta \ln FD_t \end{bmatrix} = \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \\ u_6 \\ u_7 \end{bmatrix} + \sum_{p=1}^q \begin{bmatrix} \alpha_{11p} & \alpha_{12p} & \alpha_{13p} & \alpha_{14p} & \alpha_{15p} & \alpha_{16p} & \alpha_{17p} \\ \alpha_{21p} & \alpha_{22p} & \alpha_{23p} & \alpha_{24p} & \alpha_{25p} & \alpha_{26p} & \alpha_{27p} \\ \alpha_{31p} & \alpha_{32p} & \alpha_{33p} & \alpha_{34p} & \alpha_{35p} & \alpha_{36p} & \alpha_{37p} \\ \alpha_{41p} & \alpha_{42p} & \alpha_{43p} & \alpha_{44p} & \alpha_{45p} & \alpha_{46p} & \alpha_{47p} \\ \alpha_{51p} & \alpha_{52p} & \alpha_{53p} & \alpha_{54p} & \alpha_{55p} & \alpha_{56p} & \alpha_{57p} \\ \alpha_{61p} & \alpha_{62p} & \alpha_{63p} & \alpha_{64p} & \alpha_{65p} & \alpha_{66p} & \alpha_{67p} \\ \alpha_{71p} & \alpha_{72p} & \alpha_{73p} & \alpha_{74p} & \alpha_{75p} & \alpha_{76p} & \alpha_{77p} \end{bmatrix} \times \begin{bmatrix} \Delta \ln Agri_{t-p} \\ \Delta \ln CO_{2,t-p} \\ \Delta \ln GDP_{t-p} \\ \Delta \ln HC_{t-p} \\ \Delta \ln CPI_{t-p} \\ \Delta \ln TECH_{t-p} \\ \Delta \ln FD_{t-p} \end{bmatrix} + \begin{bmatrix} \Gamma_1 \\ \Gamma_2 \\ \Gamma_3 \\ \Gamma_4 \\ \Gamma_5 \\ \Gamma_6 \\ \Gamma_7 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \tilde{\epsilon}_{1t} \\ \tilde{\epsilon}_{2t} \\ \tilde{\epsilon}_{3t} \\ \tilde{\epsilon}_{4t} \\ \tilde{\epsilon}_{5t} \\ \tilde{\epsilon}_{6t} \\ \tilde{\epsilon}_{7t} \end{bmatrix}$$

(eq. 3)

The results of F-statistics are measured with the Wald statistics that determine the short term results, while ECT_{t-1} calculates the long-run causality results. The negative sign of ECT_{t-1} proves the significant result of Granger causality (Danish et al., 2018). Table 6 shows the findings of Granger causality.

Table 6
VECM Granger Causality Results

Variables	$\Delta \ln Agri$ (1)	$\Delta \ln CO_2$ (2)	$\Delta \ln GDP$ (3)	$\Delta \ln HC$ (5)	$\Delta \ln FD$ (4)	$\Delta \ln CPI$ (6)	$\Delta \ln Tech$ (7)	ECT_{t-1}
$\Delta \ln Agri$	-----	2.8327 (0.0924)*	0.0294 (0.0638)**	0.4659 (0.0949)*	0.9458 (0.0308)***	0.7681 (0.0522)	2.8180 (0.0932)*	-0.6297 [0.0332]***
$\Delta \ln CO_2$	0.8180 (0.0139)***	-----	1.4870 (0.0227)***	0.0166 (0.8973)	2.0073 (0.1565)	2.1059 (0.1467)	0.1429 (0.3831)	-0.0447 [0.0505]**
$\Delta \ln GDP$	0.6126 (0.0038)***	7.6829 (0.0056)**	-----	1.6150 (0.0638)	7.7220 (0.0055)**	0.9384 (0.3327)	6.0110 (0.0336)***	-1.7505 [0.0012]***
$\Delta \ln HC$	2.8680 (0.1932)	6.1199 (.0134)***	0.0397 (0.8420)	-----	0.2289 (0.0223)	7.0110 (0.2381)	4.0073 (0.2565)	-0.2984 [0.0049]***
$\Delta \ln FD$	0.9132 (0.0393)***	5.1106 (0.9982)	1.7714 (0.1832)	0.7374 (0.3905)	-----	0.9206 (0.6373)	1.6622 (0.3266)	-0.4625 [0.0020]***
$\Delta \ln CPI$	2.0073 (0.1565)	0.0926 (0.7608)	0.2370 (0.6263)	0.8058 (0.3693)	0.9622 (0.3266)	-----	7.0110 (0.0081)***	0.0065 [0.0638]**
$\Delta \ln Tech$	0.6132 (0.3393)	0.4881 (0.4848)	4.7787 (0.0522)	3.3916 (0.0725)**	6.8180 (0.0939)*	1.9714 (0.1432)	-----	-0.3407 [0.0894]**

Note: ***refers to the 1% significance level. ** depicts the 5% significance level and * refers to the 10% significance level

The results of VECM confirms the bidirectional relationship between agricultural productivity and CO₂ emission (environmental degradation), in the way CO₂ granger causes agrarian productivity, and in response to Agri productivity also granger causes environmental degradation in the short run. Furthermore, the results of GDP show that economic growth Granger causes Agri productivity in the short-run, and response agriculture productivity also granger causes economic growth. The results match the effects of Loizou et al., (2019), who found that agriculture growth is an essential driver of economic growth for the region. Financial development is the proxy of finance available and provided by the financial institutions to the agriculture sector. The F.D. granger causes agriculture productivity, and in response, agriculture productivity also granger causes F.D. The granger causality results between the consumer price index and agriculture growth show that CPI granger causes

agriculture productivity. In contrast, agriculture productivity does not granger cause the consumer price index in the short run; the results of our study are similar to the results of (Tule, Salisu, & Chiemeké, 2019). Furthermore, in short-run agriculture technology, granger causes agriculture productivity while, in return, agriculture productivity does not granger cause of agriculture technology. The results of this research are similar to (Hu et al., 2019) results.

The results of ECT-1 Colum from table no.6 show a bidirectional causality in the long run between agriculture productivity, environmental degradation (CO₂), economic growth, human capital, financial development, consumer price index, and agricultural technology. This bidirectional causality among all variables indicates the feedback effect of agriculture productivity with other study variables.

Conclusion and Recommendations

This study discusses the relationship between agriculture productivity, environmental degradation, CPI, human capital, agricultural credit disbarment, and agricultural technology. We have examined the integration level of data series through different methods of a unit root. To investigate the long-run cointegration relationship, we applied the ARDL bonding test and Johansen Co-integration test. Furthermore, by using the ARDL approach, we review the short-run and long-run elasticity between variables.

The results of ARDL confirm that there is an increasing trend in CO₂ emissions in Pakistan that has affected agriculture productivity severely. The relationship between environmental degradation and agriculture productivity is significant but negative, so an increase in CO₂ will decrease agriculture productivity. Therefore the government of Pakistan must have to take action on immediate bases to control environmental degradation. There are two suggestions to reduce CO₂. First, the government of Pakistan should educate people to reduce their energy consumption produced by fossil oil like coal, diesel oil, and gas.

The results of financial development show a significant and positive effect on agriculture growth in the long run; it indicates that better development of the financial sector for farmers will increase the agriculture growth in Pakistan. For the better performance of the financial sector, the Pakistan government should have to create easement in agriculture credit and should have to provide subsidy on agriculture credit.

The results of CPI are negative signs that show that with the decrease of farmer's expenditure, agriculture productivity will increase. The government of Pakistan must develop such policies that not only focus on formal and informal loans but also regarding farmer's other production expenditure. It is worth mentioning here that the government must facilitate farmers by providing less costly inputs by taking a severe note of inflation and must take some remedial actions like

subsidy on agricultural inputs, seeds and fertilizers, pesticides, and agriculture machinery.

The impact of agriculture technology depends upon the scale level of farmers; it has a positive effect on the large scale farmers, the slight negative impact on medium level farming, and high negative impact on small scale farmers. So, we recommend the government of Pakistan to develop such policies; those focus on a small scale and medium farmers to adopt new technologies. For that government should have to separate the quota of subsidy for small scale & medium scale farmers to purchase modern agriculture technology.

The government of Pakistan should provide subsidy in the form of cheap loans, fertilizers, pesticides, seeds, and agriculture technologies to young pass out graduates to attract them towards the adoption of the agriculture sector as a profession. Furthermore, the higher education commission of Pakistan should have to instruct institutions to conduct seminars in universities and colleges on agriculture importance, so that the young generation takes an interest in this sector. In this way, they will be familiar with the benefits of adopting agriculture as their future career.

Future studies may include information, communication, and technology (ICT) to explore their impact on agriculture productivity further.

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