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Impact of Climate Change on Total Factor Productivity of Agriculture in District Multan

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ABSTRACT

Agriculture is particularly vulnerable to climate change because it faces open weather conditions. In uncontrolled open weather circumstances, it's difficult to attain better total factor productivity (TFP), which characterizes agriculture growth in an economy. The study estimated the TFP growth of Pakistan's agriculture in first step by employing the Tornqvist- Theil index number approach for the period 1990-2019. The time series data for thirteen crops and four livestock categories from 1990 to 2019 were collected from different sources to estimate the TFP. The average annual TFP growth of agriculture was estimated to be 2.14 percent for the study period, and it contributed about 56 percent to total agricultural output growth. The results also indicated that TFP growth in agriculture sector was highest (0.05 percent) during the 1990-2000, while lowest (-2.14 percent) during the last decade. After, TFP index that was calculated in first step was used as dependent variable in second step of analysis. Then we estimated the impact of climate change on TFP in agriculture sector in Multan district. For this first we used ARDL bound test approach for estimation of long run impact of climatic variables. The results showed that there are positive effects of both minimum and maximum temperature on TFP in the study area. The drought and floods have negative impact on TFP but in first lag their effects became positive on TFP. One of the important variables of climate is rain that had positive impact on the TFP growth, with 1% increase in rainfall there was 0.22% increase in TFP at first lag. Improving the adaptation and mitigation practices related to floods and droughts would be required for sustainable growth in TFP in agriculture sector in Multan District.

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1. Introduction

It is essential for every government to assist the agricultural industry in order to alleviate the problem of food insecurity and promote economic development (Aşıcı, 2013; Chang & Zepeda, 2001). Global food security depends on the ability of agricultural output to keep pace with rising food demand. In order to enhance food production and cut prices, agricultural productivity must be raised. Many techniques are used to measure the growth of an economic sector, one suitable measuring technique is Total Factor Productivity (TFP). It is real output that produced by the individual firm or industry or sector of the economy by using real inputs (Nadeem, Javed, Hassan, & Adil, 2010). TFP is usually measured as the ratio of aggregate output to aggregate inputs. Growth in TFP is the portion of growth in output not explained by growth in traditionally measured inputs of labour and capital used in production. Numerous studies focused on the impact of climate on total factors productivity (TFP) of agriculture show that TFP had been facing decline trend on world level. In recent past, climate change is major issue discussed related to food security. Climate change can impact on the total factors productivity (TFP) of Pakistan positively or negatively, but negative impact is more evident on agriculture sector (Nhamo et al., 2019).

Identifying climatic variability and its impact on agriculture is the first step in addressing climate change (Deressa, Hassan, & Ringler, 2011). South Asian nations are said to be particularly sensitive to climate change, with significant repercussions in several parts of Pakistan (Fahad & Wang, 2018). Over the previous two decades, important crops including rice, cotton, wheat, and sugarcane have been badly hit by devastating floods in 2010 and 2014, as well as droughts from 1999 to 2003 (Abid, Scheffran, Schneider, & Ashfaq, 2015).

Against this backdrop, the major objective of this study is to estimate the Total factor productivity and the impact of climate change on Total Factor productivity of agriculture in District (independent administrative units) Multan. This study covers all the major crops produced in the said the district and the original meteorological data is available for each district since early 1990s. Nonetheless, district represent all cropping systems prevailing in the country well. This research incorporates climatic as well as non- climatic explanatory variables and differentiates between the effects of climate change and weather shocks on TFP. More importantly, we have also tried to corroborate the results obtained from quantitative analyses using Auto Regressive Distributive Lag (ARDL) Model. On these accounts, it can safely be said that the present study contributes to the existing literature by enlarging the scope of work and the nature of analysis.

2. Materials and Methods

The present study has been conducted to estimate the productivity growth of agriculture at the district level, causes of low productivity growth in agriculture, and identify the causes of low productivity growth in grain crops in Multan. The Tornqvist-Theil index approach was used to assess the production, input, and TFP index of Pakistan's principal grain crops. Tim Coelli's (1996) TFPIP version 1.0 software was used to produce the TFP index for the most major grain crops. To establish the agriculture sector's growth rates in Multan, Pakistan, these predicted grain crop indices are set to 100 for the base year of 1990.

Based on observed or measured productivity, it is easy to overestimate the contribution of labour to production while underestimating the role of capital to output. As a consequence, researchers choose to quantify the change in total output per unit of total input. It is a measure of productivity that takes into account all factor inputs, avoiding the drawbacks associated with partial productivity measurements. The bulk of productivity studies include only labour and capital as production inputs. Numerous researchers (for example, Fernald and Ramnath (2004), Javed, Ali, Nadeem, Gulzar, and Kamran (2018)) have acknowledged the shortcomings of input coverage, but the resulting productivity measures are now referred to as "multifactor" rather than "total factor" measures. There are several ways of estimating TFP in the growth literature. This section discusses three of the most frequently used techniques for estimating TFP: growth accounting, index number accounting, and econometric accounting. Each of these strategies is discussed in detail below to aid in the comprehension of empirical research.

3. Data and Econometric Model

Total factor productivity (TFP) can only be accurately assessed by collecting information on its produce and inputs. This research was planned to span from 1990 until 2019. It seems that this figure is much lower than the data for the agricultural sector, but it isn't accounted for in national income accounting. Using the perpetual inventory technique, gross fixed capital formation (GFCF) has been calculated. Agricultural outputs such as crops, fodder, fruits and vegetables, and gross domestic product per capita (GDP/capita) are provided by the Punjab Development Statistics (PDS), Pakistan Economy Survey (PES), Federal Bureau of Statistics (FBS), and the Statistics Division, Government of Pakistan, Islamabad. During the course of this research, any data gaps were filled up using the agricultural marketing information system (AMIS).

There are two different methodologies given in the literature: one is an econometric approach (Armagan & Ozden, 2007; Dhrymes, 1965; Kmenta, 1967; Qizheng, Zhang, & Chen), and the other is growth accounting techniques (Ahmad, Chaudhary, & Ilyas, 2008; Diewert, 1978; Kendrick, 1961). In the present study, we used the growth accounting technique. In growth accounting, we used the index number approach, and in the literature, two types of indices were commonly used: the Malmquist Theil index number (Bannor, Dikgang, & Gelo, 2021; Conradie, Piesse, & Thirtle, 2009; Lele, Agarwal, & Goswami, 2015), and the Tornqvist Theil index number (A. Ali et al., 2016; Nadeem et al., 2010). These approaches are used to estimate total factor productivity (TFP).

The index number technique extends the growth accounting approach by using a sequence of index numbers to compute TFP. Despite the fact that both systems mainly depend on indexes, they have the same shortcomings. A production function aggregate is not required when using the index-based technique. An economic method may be used to determine an acceptable index value in certain instances. Index numbers may be used to verify the correctness of growth accounting data.

The word "productivity" refers to the measuring of efficiency in a certain way. It is simple to estimate productivity when a single input, like labour, is used to generate one output. A simple method for determining efficiency is to divide output by the amount of effort put in. In this case, both the partial and total factor productivity will be equal. If many factors are involved in the production of multiple products, such as X and Y, the process becomes more complicated. Weights for individual outputs and individual inputs in the output index and input index, respectively, need to be determined. Standard forms of TFP index are:

$$A = \frac{Q}{L^{\alpha}K^{\beta}} \quad (1)$$

$$A = \frac{Q}{\alpha L + \beta K} \quad (2)$$

Arithmetic index is represented by formula 1; geometric index is represented by formula 2. Factor inputs and their corresponding weights are indicated by L and K, whereas the output index is denoted by Q and the TFP index is denoted by A. Calculating total factor productivity (TFP) requires first overcoming the barrier of picking an index value from the numerous that are available for TFP measurement in order to use equation.

There are two methods for determining an acceptable index number for TFP measurement. The axiomatic technique is first used to compute TFP, in which a set of 'preferred characteristics' is used to compare the attributes of various index number forms. Then, the axiomatic method is used to calculate TFP.

Second, the economic approach assigns a certain production technique an index number. A wide range of production function models may be found in the academic literature. Transcendental (also known as trans-log) and other trans-log variants are also often used in the creation of functions. Diewert proved that the Theil-Tornqvist discrete approximation to the Divisia index is consistent in aggregate and superlative for a linear homogeneous trans-logarithmic production function (Kumar, 2003). For this inquiry, the Divisiaw-Tornqvist index was selected because of its advantages over alternative index number formats.

When calculating the Divisia-Tornqvist index, it presupposes that the manufacturing technique is linear and homogenous. In addition, companies are presumed to be self-interested profiteers, operating in highly competitive marketplaces. An index of output amount is defined using these assumptions:

$$Q_t = \prod_{i=1}^{ni} \left(\frac{Y_{it}}{y_{it-1}}\right)^{\frac{1}{2}[R_{it}+R_{it-1}]} \quad (3)$$

Where Qt is Tornqvist output quantity index.
Yit is quantity of ith output.
and Rit is share of i1h output in total revenue.
Rit is composed of:

$$R_{it} = \frac{P_{it}y_{it}}{\sum_{i=1}^{m} P_{it}y_{it}} \quad (4)$$

Where Pit is price of ith output. Similarly, the Tornqvist input quantity index is defined as:

$$I_t = \prod_{j=1}^{n} \left(\frac{x_{jt}}{x_{jt-1}}\right)^{\frac{1}{2}[S_{jt}+S_{jt-1}]} \quad (5)$$

Where:
I_t is Tornqvist input quantity index;
Xjt is quantity of jth input;
and Sjt is the share of jth input in total cost.
Sjt is composed of:

$$S_{jt} = \frac{w_{jt}x_{jt}}{\sum_{j=1}^{n} w_{jt}x_{jt}} \quad (6)$$

Where Wjt is price of jth input.

Given the output and input quantity indexes the Tornqvist TFP index is simply the ratio of Tornqvist output quantity index to Tornqvist input quantity index.

$$TFP_t = \frac{Q_t}{I_t} \quad (7)$$

Equation 7 can be used to calculate TFP index for successive periods.

As a result of market imperfections, factor markets, particularly in developing nations, have demonstrated significant volatility, and factor payments are often not equal to the value of marginal production under these circumstances. When factor prices are employed to estimate total factor productivity, it is probable that large biases in TFP calculations would arise.

Furthermore, the absence of reliable data on factor income is a problem in developing countries. The factor income share of each input may be replaced by a partial output elasticity with respect to that input as a solution to these problems. Using the Cobb-Douglas production function, we attempted to replicate the findings of Wizarat and Shahida, (2002). In this study we used Equation 9, which uses factor income shares instead of input elasticities, allows us to rename Tornqvist's Input Quantity Index.

In addition, the lack of trustworthy data series for factor incomes is a challenge that emerging nations have to deal with as well. One way to address these concerns is to replace each input's factor income share with a partial elasticity of output with reference to that input. The term for this is "partial elasticity." In this work, we have approximated the Cobb-Douglas production function in the manner of Wizarat (2002) in order to get estimates of the partial elasticities of each input. To reflect the substitution of input elasticities for factor income shares, the Tornqvist input quantity index in equation 4.14 may be rewritten as:

$$I_t = \prod_{j=1}^{n} \left(\frac{x_{jt}}{x_{jt-1}}\right)^{\alpha_j} \quad (8)$$

From the Cobb-Douglas production function, the partial elasticity of input j is determined as $\alpha_j = \frac{MP_{xj}x_j}{y_j}$.

The following are some of the most noteworthy benefits of using the index number strategy. Since this method is clear and easy to apply, it has been extensively used in development literature. Second, this method may be used to estimate total factor productivity in situations when data is few or only available for a few years (TFP). If you're interested in gauging how the economy or a particular industry is doing in terms of growth, this is a great tool for doing so. After applying the T-T index number, we were apply ARDL approach to find out the impact of climatic factor on TFP.

$$\ln(TFP) = f\ (Max_{Temp}, Mini_{Temp}, RF, F, D, H) \quad (9)$$

4. Results and Discussion

The total factor productivity results are given in table 1 which shows indices of input, output and TFP. In 1991-92 the output and input were decreased as compared to the previous year, but the TFP growth rate was increased, one of the reason of decreasing in output and input growth was that in this period the politically instability of government from 1990-1993 caused inefficiency in the agriculture sectors (GOP, 1992). Therefore, the agriculture productivity faced declining trend. In 1994-95 the steady growth in output and inputs show a slight change in input and output index, but TFP index declined from 115.9 to 114.3, one percent change in TFP.

In 1995-96 the TFP was increased from 114.3% to 142.5% due the heavy flood in 1994-95 major portion of the Punjab was effected by the flood so in which the Multan district was also effected the in the next year 1995-96 that’s why the agriculture growth ate shouted-up in output and input but in next year 1996-97 agriculture sector could not maintain his growth and decreased the productivity in this time overall the decline in the production of major crops like wheat, rice, sugarcane, maize etc. and in this period Multan district face drought condition of due to low rainfall and high temperature in summer. In 1996-97 the average rainfall was 17.63mm.

Table 1: Indices of agricultural output, input, and TFP in Multan: 1990-2020

Years	output	input	TFP
1990-91	100	100	100
1991-92	92.39	71.98	128.36
1992-93	86.51	72.6	119.15
1993-94	86.47	74.93	115.39
1994-95	92.34	80.79	114.3
1995-96	102.76	72.1	142.52
1996-97	73.13	73.43	99.59
1997-98	77.71	75.15	103.41
1998-99	78.19	79.27	98.63
1999-00	82.38	82.01	100.46
2000-01	85.26	87.47	97.48
2001-02	86.05	84.4	101.96
2002-03	88.61	82.61	107.27
2003-04	92.41	84.39	109.51
2004-05	97.49	96.27	101.27
2005-06	102.15	95.94	106.47
2006-07	94.37	94.02	100.38
2007-08	92.35	88.49	104.37
2008-09	93.24	90.09	103.5
2009-10	95.24	98.99	96.21
2010-11	95.03	94.82	100.22
2011-12	91.68	98.11	93.44
2012-13	93.39	93.12	100.29
2013-14	92.04	99.05	92.93
2014-15	91.6	114.87	79.75
2015-16	88.76	105.64	84.02
2016-17	92.67	113.36	81.75
2017-18	94.11	119.33	78.86
2018-19	92.35	114.67	80.53
2019-20	91.26	122.91	74.25

Source: Author’s own calculation

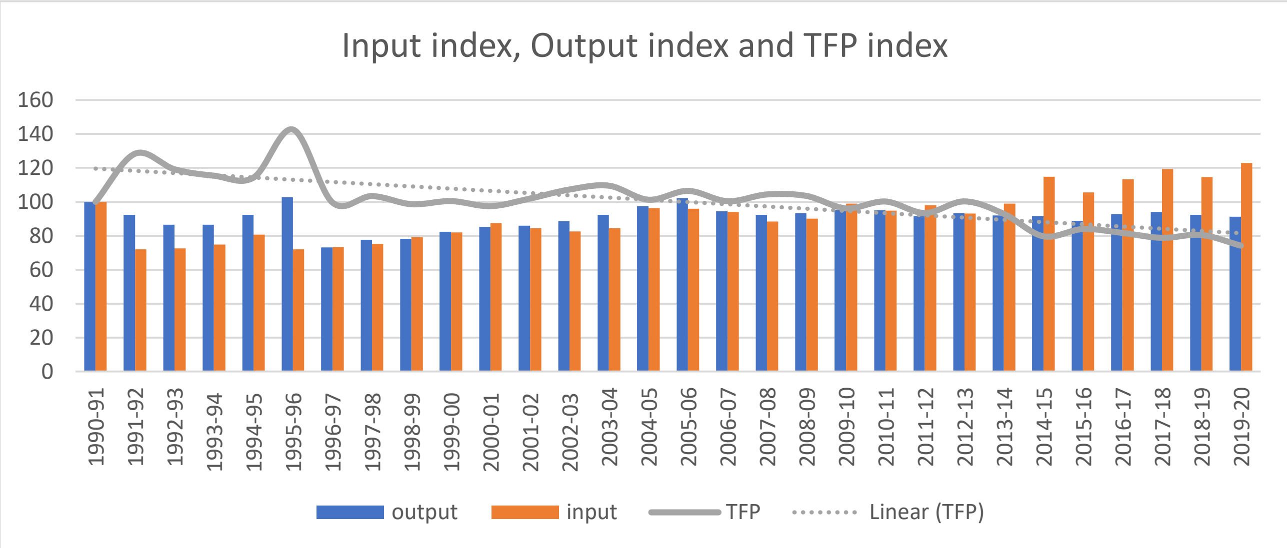
In coming year, 1997-98 TFP become increased from 99.3% to 103% due increase in output share in as compared to input used. In this period the inputs are efficiently used to produce the production in agriculture.in other words the farmers were more efficient to produce agriculture produce. In next year, 1998-99 the change in climatic conditions the use of inputs increases and high fluctuation in temperature the use of inputs like pesticides, irrigation, fertilizers etc.

Further, in 1998-99 the usage of input in agriculture increased but the productivity was not increase in as compared to input therefore the TFP growth in this period the fall down. In this period the heavy use of pesticides to control the pest attacked as well as the fertilizers used was increased. While, in 1999-2000 the output growth and input growth almost constant, the input share was increased from previous year to this year79.27% to 82.01% and the output share was also increased from 78.19% to 82.38% therefore, the change in TFP of agriculture was 98.63%

to 100.46%. overall, TFP growth from 1990-2000 consider as negligible in Multan district that showed that farmers were not change their cropping pattern and no move forward to modern techniques.

In 2000-01 period the output index showed that output of agriculture increased from 82% to 85%. This increased due to new verities were introduced and also the mango which major fruit of Multan production was also increased, and input index was also increased from 82% to 87% that showed that the used of input increase rapidly as compared to change in output growth. So, the TFP of this year become decreased from 100% to 97%. More, in 2001-02 the growth in TFP showed increased due the increased in the output of agriculture sector and the in this year farmer used input efficiently. Therefore, the output index increased from 85% to 86% but reasonable decreased in use of input, the decrease of input was 87% to 84%. Hence, we faced the increased in TFP.

Figure 1: Relationship between output, input and TFP indices



The given graph showed the relationship between input output and TFP of the Multan district the trend showed that TFP continually decreased in last three decade

As a result of a combination of input growth and total factor productivity (TFP) increase, between 1970 and 2003, output grew by one-half, while input growth accounted for the other half (Mubarik Ali & Byerlee, 2002). There is a low level of efficiency in the use of resources and inputs, and the TFP growth rate of 1.5% is lower than in other countries and regions undergoing rapid technological transformation, such as northwest India, China and Brazil. TFP growth in these countries and regions has been higher than in others.

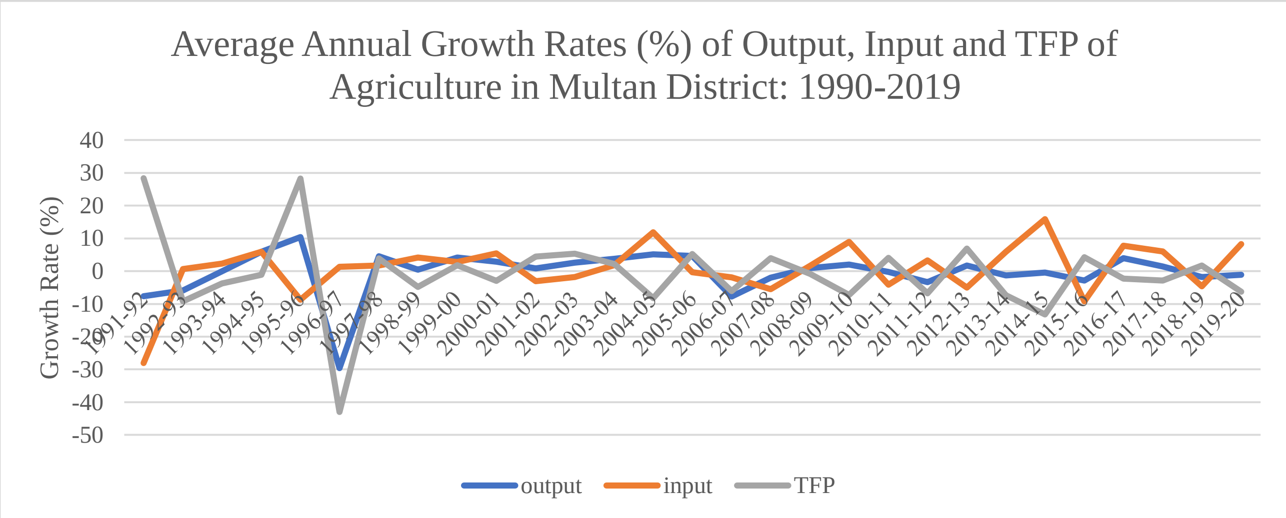
Table 2: Average Annual Growth Rates (%) of Output, Input and Total Factor Productivity (TFP) of Agriculture in Multan: 1990-2019

Years	output	input	TFP
1991-92	-7.61	-28.02	28.36
1992-93	-5.88	0.62	-9.21
1993-94	-0.04	2.33	-3.76
1994-95	5.87	5.86	-1.09
1995-96	10.42	-8.69	28.22
1996-97	-29.63	1.33	-42.93
1997-98	4.58	1.72	3.82
1998-99	0.48	4.12	-4.78
1999-00	4.19	2.74	1.83
2000-01	2.88	5.46	-2.98
2001-02	0.79	-3.07	4.48
2002-03	2.56	-1.79	5.31
2003-04	3.8	1.78	2.24
2004-05	5.08	11.88	-8.24
2005-06	4.66	-0.33	5.2

2006-07	-7.78	-1.92	-6.09
2007-08	-2.02	-5.53	3.99
2008-09	0.89	1.6	-0.87
2009-10	2	8.9	-7.29
2010-11	-0.21	-4.17	4.01
2011-12	-3.35	3.29	-6.78
2012-13	1.71	-4.99	6.85
2013-14	-1.35	5.93	-7.36
2014-15	-0.44	15.82	-13.18
2015-16	-2.84	-9.23	4.27
2016-17	3.91	7.72	-2.27
2017-18	1.44	5.97	-2.89
2018-19	-1.76	-4.66	1.67
2019-20	-1.09	8.24	-6.28

Source: The year 1990 serves as the starting point for growth rates since it is the base year. An annual growth rate for output, input, and TFP was determined using the Tornqvist-Theil (T-T) indices derived in the present research.

Figure 2: Average Annual Growth Rates (%) of Output, Input and Total Factor Productivity (TFP) of Agriculture in Multan: 1990-2019



In the above figure show that TFP of Multan district follow fluctuation with passage of time. It shows that TFP at peak in 1995-96 in the time period the output index was more than input but in 1996-97 it fall down in this time period the flood damage the agriculture out therefore the output deceases and use of input are more than its production.

Table 3: Decade wise Growth Rates (%) of Output, Input and Total Factor Productivity (TFP) of Agriculture in Multan: 1990-2019

Period	Output	Input	TFP
Decade Wise Average Growth Rates			
1990-2000	-1.96	-1.99	0.05
2001-2010	1.29	1.69	0.42
2011-2020	-0.39	2.39	-2.19
Total Period			
	-0.30	0.79	-0.89

Source: Author's own calculation

4.1. Total Factor Productivity (TFP) Growth Rate: 1990-2000

For each time period, output, input, and total factor productivity (TFP) growth rates are shown in Table 4.3. Table 2 shows that TFP and output grew at a rate of 0.05 percent and -1.96 percent, respectively, over the first decade of the research period (1990-2000). In the 1990s, output growth was negative because of increased government policy changes and uncertainty in the development of inputs. There was a twofold decrease in fertilizer and pesticide usage, as well as three floods in Multan, Pakistan, in the 1990s and early 2000s. During the 1990s, TFP grew at a rate of 0.93%, 0.96 %, 0.57 %, and -0.1 % (A. Ali et al., 2016; Khan & Singh, 1997; Wizarat, 2002).

4.2. Total Factor Productivity (TFP) Growth Rate: 2000 to 2010

For the period 2000-2010, Table 4.3 also illustrates the production, input, and TFP growth rates of main grain crops. The output, input, and total factor productivity (TFP) growth rates were 1.29 percent, 1.69 percent, and 0.42 percent, respectively, which was low compared to the 1990s. Both Anh, Ali, Anh, and Ha (2004) and Mubarik Ali and Byerlee (2002) found similar findings (2008). Output, input, and total factor productivity of Multan's agricultural sector all grew throughout the 2000-2010 decade at a positive pace. Since grain crop input usage grew faster than output, agriculture's total factor productivity (TFP) growth has lagged behind that in the 1990s. Farmer-friendly policies, such as raising the price of wheat and rice before planting, have also been introduced in this decade. This has resulted in a higher income from these commodities. This decade had the greatest rise in agricultural inputs due to a huge subsidy on fertilizers, tube wells, and pesticides. The good TFP growth rate throughout this decade was largely due to the favorable environment and the timely supply of inputs at subsidized prices for farmers (MH Ali & Talukder, 2008).

4.3. Total Factor Productivity (TFP) Growth Rate: 2011 to 2019

Table 4.3 illustrates that this decade (the 1990s) had greater growth rates than the 2000–2010 decade. TFP growth, on the other hand, is predicted to be negative during the next decade (2011-2019). The -0.39 percent growth rate in output throughout the decade 2011-2019 is lower than the previous decade's growth rate. This indicates that total factor productivity contributed less to production growth throughout the 2011–2019 decade. Numerous factors, including the government, led to this period's drop in output growth. Both the weather and other external variables had an effect on productivity.

The primary issue limiting TFP development in Multan was climate change and natural calamities like as floods and drought. Floods in 2010-11 and again in 2013-14, as well as adverse meteorological conditions, hindered output growth. This time period is advantageous for input growth because it allows for the increased use of major inputs such as fertilizers and pesticides. Between 2011 and 2019, locust attacks had a negative effect on the TFP Growth Rate. For these years, the conclusions of the present study are not significantly different from those of this examination. Different output and factor inputs were used to generate output and input indices, which resulted in the findings being inconsistent. Throughout this decade, high oil prices, food inflation, a scarcity of crucial inputs for these crops, and, more importantly, unfavorable government policies affecting these crops were the major causes contributing to low output, input, and negative TFP growth rates.

5. Statistical analysis for ARDL

5.1. Stationarity of Data

This study is conducted on annual time series data over time from 1990 to 2019. Before the analysis of data, the Stationarity Test is very important for data as we used secondary data in our study. Augmented Phillips–Perron test is used to check the Stationarity of data.

Table 4: Stationarity Analysis

Variable	Test	Coefficient (probability) (0)	Coefficient (probability) (1)	Result
DROUGHT	PP	-6.4266	-12.2886	Stationary at level
FLOOD	PP	-5.1814	-13.2381	Stationary at level
HUMIDITY	PP	-3.8257	-9.9045	Stationary at level
MAX_TEMP	PP	-4.1457	-11.9602	Stationary at level
MIN_TEMP	PP	-2.5804	-18.2901	Stationary at 1^{st} difference
RAINFALL	PP	-5.8321	-16.1812	Stationary at level
TFP	PP	-1.802	-13.379	Stationary at 1^{st} difference

After applying unit root test for test that variables are stationary or not. Table 4 represent those variables are stationary on different levels. In given variable of interest Agricultural credit, minimum temperature and TFP are stationary at 1^{st} difference and other variables are stationary at level.

5.2. Results of ECM Equation

Results of error correction model for our first model are presented in the following table: Dependent variable is lnTFP.

Table 5: Estimates of ECM

	$ln\,TFP = f(max_{temp}, min_{temp}, RF, D, H, Flood)$			
Variables	**Coefficients**	**Standard error**	**t-statistics**	**Probability**
D(FLOOD)	-0.02676	0.018131	-1.4756	0.1708
D(DROUGHT)	-0.15829	0.029426	-5.37941	0.0003
D(LNHUMI)	0.70334	0.200489	3.508122	0.0056
D(LNHUMI(-1))	0.560508	0.1738	3.225017	0.0091
D(LNMAXTEMP)	-0.95292	0.572911	-1.6633	0.1272
D(LNMAXTEMP(-1))	-3.97938	0.652717	-6.09665	0.0001
D(LNRAIN)	-0.02902	0.029089	-0.99755	0.342
CointEq(-1)*	-1.2281	0.11707	-10.4903	0.000

This is documented that 1% increase in diesel oil global prices will rise the average local price of edible oil by 0.07% in long run, Our results are supported by (Baumeister & Kilian, 2013; Lahn, 2016; Meyer, Sanusi, & Hassan, 2018; Murti, 2017).

Coefficient of exchange rate is appeared with positive sign indicating that 1% rise in exchange rate will raise the price increment by 0.018%. Our findings are consistent with (Kiatmanaroch & Sriboonchitta, 2014; Priyati & Tyers, 2016), who described positive effect of exchange rate on local prices of imported products. While Palm Oil global price have positive impact on carbon emission. 1% rise in palm oil global price will result in increases the average local price of edible oil by 0.501%.

The error correction term -0.11, here is significant but negative meaning that there exists a long-term relationship from independent to dependent variable. It is also proved that all variables are co-integrated or have long term association.

5.3. Lag Length Criteria

Rarely is the relationship between Y (the result variable or the regressed) and X (the predictor or regression) in economics an immediate one. There is a lot of time delay when Y reacts to X. We refer to this as a lag when it occurs. Consequently, in time series analysis, caution must be used while including delays into the model.

The duration of the lag is entirely up to the user. This is mostly a matter of observation. Because of this, there is no definitive guideline for the maximum duration of lag, as indicated in Damodar Gujarati Basic Econometrics (DGMBE). There are fewer degrees of freedom to work with when one estimates consecutive delays, making statistical inference a little iffier. There aren't many economists who have access to a lengthy enough data set to estimate several delays. In economic time series data, lags tend to be strongly correlated, which raises the possibility of multicollinearity in the model (Gujarati, 2022). Many times, in economics, the link between X (the predictor or regression) and Y (the outcome variable) is not an obvious one. When Y responds to X, it takes a long time. The word "lag" is used to refer to this interval. Because of this, in time series analysis, attention must be used while including delays.

There is no universally applicable standard for the duration of a lag. Observation is the most effective method for resolving issue. There are no a priori conditions for the maximum duration of the lag, according to Damodar Gujarat Basic Econometrics. It is critical for researchers to keep in mind that there are fewer degrees of freedom available when anticipating future delays, which makes statistical inference more uncertain. On the other hand, economists often lack access to a large enough data set to continue estimating various delays. In economic time series data, lags are often intimately related, increasing the risk of model multicollinearity (Gujarati, 2022).

Table 6: Lag Length Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	135.5686	NA	1.52E-14	-9.11204	-8.731413*	-8.99568
1	229.5546	127.5524	2.16E-15	-11.2539	-7.82823	-10.2066
2	336.1364	83.74287*	4.05e-16*	-14.29546*	-7.82475	-12.31730*

5.4. ARDL Model Results

The results after the ARDL model in EViews the results of our model are given below:

Table 7: Results of ARDL Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNTFP(-1)	-0.2281	0.178289	-1.27938	0.2297
FLOOD	-0.02676	0.040172	-0.666	0.5205
FLOOD(-1)	-0.10352	0.047817	-2.16482	0.0557
DROUGHT	-0.15829	0.075252	-2.10349	0.0617
DROUGHT(-1)	-0.102293	0.050502	2.025542	0.0703
LNHUMI	0.70334	0.563786	1.247531	0.2406
LNHUMI(-1)	0.053943	0.354213	0.152289	0.882
LNHUMI(-2)	-0.56051	0.399532	-1.40291	0.1909
LNMAXTEMP	-0.95292	1.952138	-0.48814	0.636
LNMAXTEMP(-1)	2.185183	1.091277	2.002409	0.0731
LNMAXTEMP(-2)	3.979382	1.244541	3.197469	0.0095
LNMINTEMP	-0.187529	1.395368	0.134394	0.8958
LNRAIN	-0.02902	0.091151	-0.31835	0.7568
LNRAIN(-1)	0.222362	0.057862	3.843004	0.0032
C	-20.1576	7.611736	-2.64823	0.0244
R-squared	0.938729	Mean dependent var		-0.01395
Adjusted R-squared	0.834567	S.D. dependent var		0.141076
S.E. of regression	0.05738	Akaike info criterion		-2.62214
Sum squared resid	0.032925	Schwarz criterion		-1.76572
Log likelihood	54.70992	Hannan-Quinn criter.		-2.36032
F-statistic	9.012242	Durbin-Watson stat		2.228494
Prob(F-statistic)	0.000593			

From table 7, our long run model, ARDL model is now expressing the relationship among the dependent variables and independent variables. The Lag value of the natural log of all climatic variables which that was include in our study. First of all, we took log of dependent variable which is TFP and then we took log for independent variables which are average rainfall, minimum temperature, maximum temperature, Humidity and agriculture credit. These variables were affected the TFP of agriculture sector.

Flood has negative impact on TFP. The results show that when a flood is recorded the future it can decline effect on TFP it causes 2% decline in TFP but this result is insignificant at 10% level of significant. While we check the impact of flood on TFP in first lag value this shows a significant result. In the first lag 10% decrease if the flood is taken place in the Multan district. First lag is significant at 5% level of significant.

Second dummy variable is drought. Last thirty years drought data is collected from drought department of Pakistan metrological department. Results shows that drought had negative impact on TFP. When drought is present then 0.15% decrease in TFP, but it is insignificant at 5% level of significant but significant at 10% of level of significant. Additional, humidity has significant impact on TFP of agriculture. Because of agriculture faced open weather condition. Results of our model show positive effect on TFP if 1% increase in humidity 0.7% increase in TFP but it is insignificant at 10% level of significant. Whereas we move to next lag of humidity positively impact on TFP at 10% level of significant.

Average Maximum temperature has negative impact on TFP. If the temperature increased to 1% then the TFP decreases up to 0.95% and in first lag o maximum temperature have positively impact in the TFP of Multan district. in the literature shows that the increase in temperature in significant positive impact in short run and literature explain the positive impact of temperature Attiaoui and Boufateh (2019) and Abbas (2022) explained in his research, they found that temperature had positive impact on cereals crops and our results are favor in it. If 1% increase in temperature increase in TFP will be 2.18% but is insignificant at 5% level of significant but it significant at 10% level of significant. Minimum temperature in night has positive impact on TFP. In our results 1% in minimum temperature 0.18% increase and in the results rain is one of the most important factors that affect

The value of the quantum index number for long run manufacturing in the country has the negative and insignificant impact on the average local prices of edible oil. As 1% increases in the value of qin the average local prices of edible oils will decreases by 0.005% but the impact is insignificant, the result showed. The R-Square value shows that the regressor variables explain the regressed variable 99.34%. The value of the R-Square is supported by the F-Statistics 9. 012242 having the significant level of 1%.

5.5. Bounds Test

To perform this test, it is essential that the data should be stationary at same level difference. To ensure this condition we change the data in log form.

The model for bound is as follows:

$$\ln TFP = \beta \ln max\_temp + \beta \ln \min\_temp + \beta \ln Rain + \beta \ln D + \ln Fd + \ln H + \mu t$$

The process of autoregressive distributive lag bound test needs lag length of all variables. Optimum lag order for our first model was based on the automatic value of Akaike Information Criteria (AIC) that is 2. In results F-statistics was greater than UCB 1(1) indicates that there was a long-term relationship between the variables. The estimation test illustrates the long run association in the model.

Table 8: Bound Test Estimates

Estimated equation	$\boldsymbol{ln\,TFP = f(max_{temp}, min_{temp}, RF, D, H, Flood)}$	
F-statistics	8.091654	
Lag order	1, 1, 1, 1, 2, 2, 0, 1	
Significant level	1(0)	1(1)
10%	2.38	3.45
5%	2.69	3.83
2.5%	2.98	4.16
1%	3.31	4.63
Diagnostic test	Statistic	
R^2	0.938729	
R^2 Adjusted	0.834567	
Regression Std. Error		0.05738
F-statistics (prob.)		9.012242
Durbin Watson	1.9513	

5.6. Stability Diagnostics

Brown, Durbin, and Evans (1975) developed the CUSUM and CUSUM-of-squares tests as two of the most extensively used tests for parameter constancy in a linear regression. One of the many reasons they are so widely used is because they may be used to test the null hypothesis of parameter stability against a variety of other possibilities. Prior knowledge of model parameters, such as what type and when structural alterations could be predicted, is required for other tests as compared to other options.

Figure 3: CSUM Graph

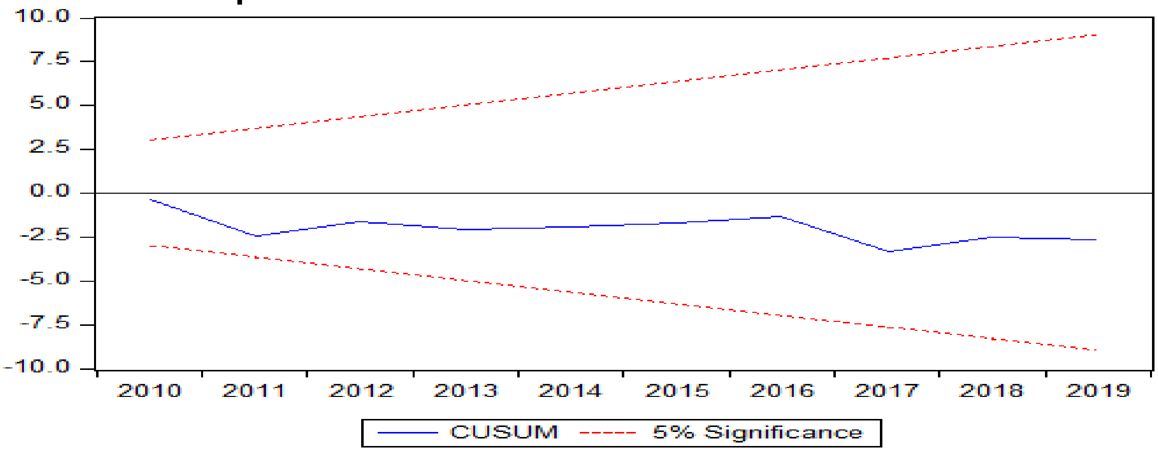
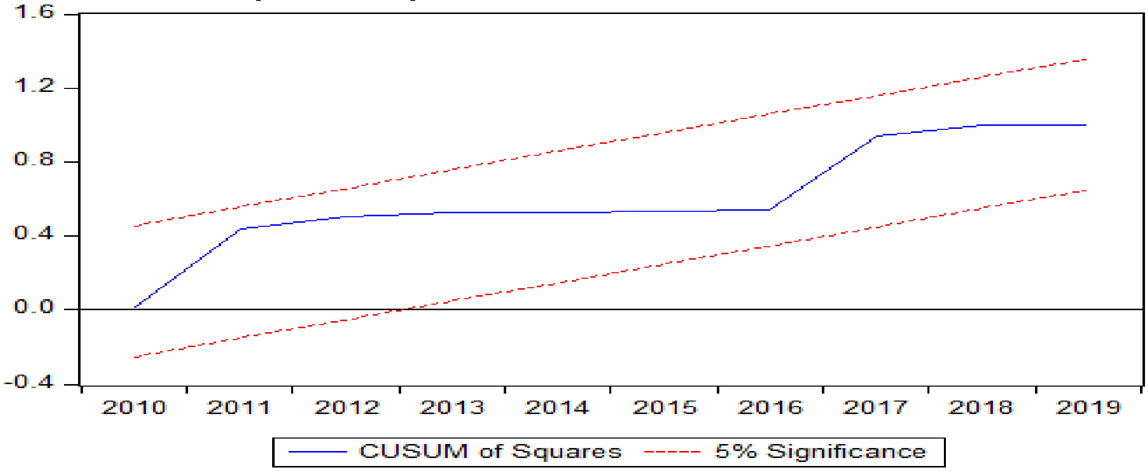


Figure 4: CUSUM of Squares Graph



The CUSUM test is based on the cumulative sum of the recursive residuals (Brown et al., 1975). It is possible to choose this option, which shows the cumulative total and the five percent most important lines on a single graph. The test identifies an issue with the parameters if the cumulative total surpasses the two critical lines. Statistic: On the basis of CUSUM,

$$W_t = \sum_{t=k+1}^{t} \omega_t / s$$

While there are many methods to describe this, the simplest is to use wt as a standard deviation for the residual standard deviations. As a result, if the beta (β) vector remains constant over time, then wt will tend to diverge from the zero mean value line. The significance of a variation from zero is measured by the increase in distance between two sets of five percent significance lines. In order to acquire the 5% lines, you must link all of the spots

$$\left[k, \pm 0.948(T-k)^{\frac{1}{2}}\right] \; and \; \left[T, \pm 3 \times 0.948(T-k)^{\frac{1}{2}}\right]$$

The CUSUM of squares test (Brown et al., 1975) is based on the test statistic:

$$S_t = \frac{\sum_{r=k+1}^{t} w_r^2}{\sum_{r=k+1}^{t} w_r^2}$$

The expected value of S_t under the hypothesis of parameter constancy is:

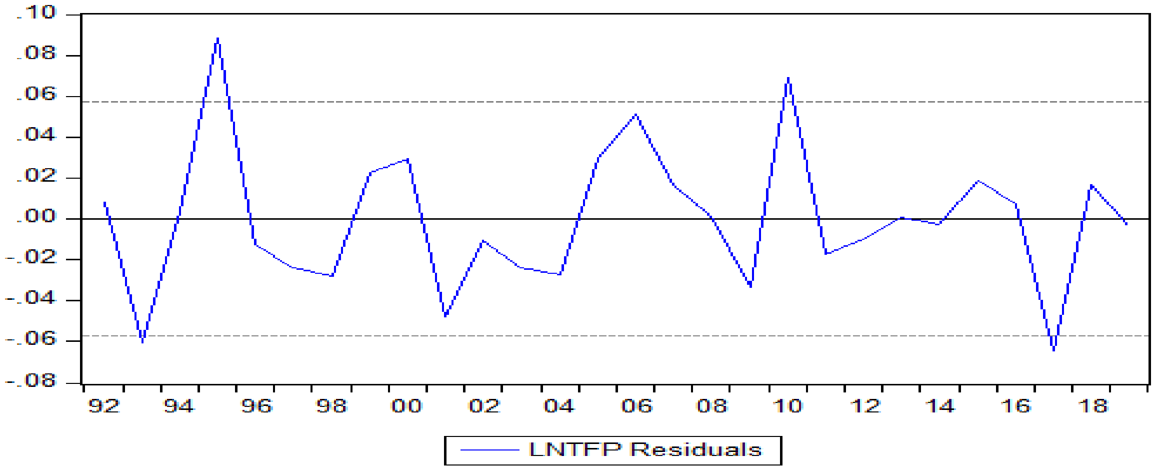
$$E(S_t) = \frac{t-k}{T-k}$$

This reaches unity at t=T and 0 at t=k. The significance of S's divergence from the projected value may be assessed using a pair of parallel straight lines around the predicted value. Reading Brown et al. (1975) may provide you with the significant lines for a CUSUM of squares test (1997). St and t have an inverse connection in this test, and the 5% important line may be seen when doing the CUSUM OF SQUARES test. Variance or parameter instability is indicated by any movement outside of the critical lines, same as with the CUSUM test. The cumulative sum of squares is inside the 5% significance lines, which suggests a constant residual variance.

5.7. Residual Plot of ARDL Model

A residual value is created when a regression line does not intersect a data point vertically. In statistical terms, regression lines offer the best fit for a given collection of data. Certain data points may fall inside the line, while others may not. This occurs often. The residual axis depicts the percentage of the independent variable to the total.

Figure 5: Residual Plot of the ARDL Model



6. Conclusion

Agriculture is exposed to open weather conditions, making it particularly vulnerable to the effects of climate change. The improvement of Total Factor Productivity (TFP), a gauge of agricultural growth within an economy, is hampered by this susceptibility. This study used the Tornqvist-Theil index number approach to estimate the TFP increase in Pakistan's agricultural sector from 1990 to 2019. The results showed that over the study period, TFP grew on average by 2.14 percent annually, greatly (by 56 percent) contributing to the growth in agricultural output as a whole. TFP growth, however, changed over time, with the biggest growth seen between 1990 and 2000 and the lowest during the most recent ten years.

The study also looked at the effect of climate change on TFP in the Multan district. The long-term effects of climatic factors were examined using the ARDL bound test methodology. The outcomes showed that TFP in the study area responded favorably to both minimum and maximum temperatures. Additionally, whereas droughts and floods initially had a detrimental influence on TFP, they started to have a favorable benefit after a short delay. Another important climate variable, rainfall, had a favorable effect on the rise of TFP, with a 1% increase in rainfall translating into a 0.22% increase in TFP at the first lag.

Focusing on enhancing flood and drought adaption and mitigation practices is essential to ensuring sustainable TFP growth in the agriculture sector of Multan District. These steps ought to be taken in an effort to lessen the negative consequences of such harsh weather conditions. Additionally, for promoting sustainable TFP growth, methods to increase agriculture's resilience to climate change are crucial. Examples include installing effective irrigation systems and using climate-smart agricultural practices. The agriculture industry in Multan District may work towards increased productivity and long-term economic growth by addressing the issues caused by climate change and putting in place the necessary solutions.

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