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Climate Variability, Crop Productivity, and Production Value: Evidence from Wheat and Maize in Pakistan

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ABSTRACT

Climate variability poses increasing challenges to agricultural productivity and food security, particularly in developing economies that depend heavily on climate-sensitive crop production. This study examines the effects of key climatic factors on the productivity and production value of wheat and maize in Pakistan using annual data for the period 1981–2014. The analysis considers annual average rainfall, minimum temperature, and maximum temperature as the principal climatic variables and evaluates their relationships with crop productivity and production value. The empirical findings indicate that average minimum temperature and rainfall are positively associated with wheat and maize productivity and production value, whereas higher average maximum temperature exerts a negative effect on crop outcomes. These results highlight the heterogeneous effects of climatic conditions across temperature measures and demonstrate the vulnerability of major cereal crops to rising temperature extremes. The findings underscore the importance of climate-resilient agricultural policies, including improved water and irrigation management, drought and flood monitoring, climate-informed crop planning, and the adoption of heat- and drought-tolerant crop varieties. Strengthening climate information and early-warning systems can further support farmers and policymakers in reducing climate-related production risks and sustaining agricultural productivity.

Introduction

Climate is the average weather of an area. Change in climate is the variation in the average weather of an area. Climate change could be variation in precipitation level or it could be change in average temperature for a given month or season of a region. There are some natural causes of climate change like variation in earth orbit, changes in ocean, energy coming from the sun and volcanic eruption etc. As changes in climate is a natural phenomenon some scientists say that climate change also results from different human activities like burning of fuel, oil, and gas, use of modern technology, industrialization, urbanization, transport, building construction etc. Over the coming 30-50 years, average temperature of the world will likely to rise by 1^0C, and also concentration of carbon dioxide will rise by 450 parts per million by volume. Climate change has started to affect rural landscapes and agriculture all across the world as agriculture sector is highly dependent on nature. Increasing temperature is expected to shrink crop production (Kalra, et al; 2007). Hydrological cycle now contains more intense floods and droughts in many regions of the world. These events can badly destroy crops production. With this decrease in productivity price will rise for important crops like soya beans, wheat, maize and rice. According to IPCC (2009), it is expected that developing and least developing countries (LDC) will suffer more as compared to developed countries because of their exposure to extreme weathers, their hotter climate baseline and also there is predominancy of agriculture sector in their economies (Hussain, et al; 2007). In a new report, UNEP and WTO states that even a rise of 1^0C in temperature would lead to 5-10 percent decrease in major cereal crops production. South Asian countries are highly exposed to climate impacts of climate variation. It could lose 50 percent of its total wheat production (International Food Policy Research Institute, 2009).

Pakistan is facing serious issues generating from changes in climate like decrease in availability of water which results in changing crop rotation and patterns of crops, decrease in major crops production like wheat, sugarcane, rice and cotton. Recent studies have advanced hybrid decomposition, deep learning, causal estimation, and machine-learning-based forecasting for complex environmental and time-series applications (Qureshi et al., 2025; Abbasi et al., 2026; Noor et al., 2026). These approaches have also been applied to causal and climate-related forecasting problems (Ahmad et al., 2026; Abbas et al., 2026). In southern Pakistan, there is 15-20 percent decrease in cereals production (Ahmed, 2011). Pakistan is an agricultural country and about 70 percent of Pakistan’s population, and their livelihood depends on agriculture production (Sandhu 2003). It contributes 21 percent to GDP and employ 47 percent of total labor force (Source: Labor Force Survey 2016). According to British Risk Assessment Consultancy, Pakistan is considered as 20^{th} most climate exposed country world. KP province was found to be severely damaged by this climate changes. Extreme floods have produced a cost of 2.6 million acre of land resources and wheat crops are assessed to fall by 6-9 % (Source: Mustafa 2011). Also climate change could delay the accomplishment of many of the Millennium Development Goals (MDGs), including child mortality, poverty eradication, malaria and environmental sustainability (Kaiser and Drennen, 1993).

Recent studies have further emphasized the importance of statistical modeling in understanding climate variability in Pakistan. Ali et al. (2026) examined regime shifts and seasonal forecasting of monthly temperature in Karachi, highlighting the importance of accounting for changing temporal patterns in climate series. Similarly, Nasir et al. (2026) investigated rainfall and temperature trends across major Pakistani cities and reported substantial spatial and temporal heterogeneity in climatic patterns, emphasizing the need for location-specific analysis. Mendelsohn, R. et al; (1994) carried out study on the global warming impacts on agricultural production in the United States and found negative impact on agriculture productivity in the United States. Matthews, R. B., et al; (1997) studied impact of variation in climate on total rice production in Asia and showed that rise in CO_2 level rises crop production while rise in temperature reduce agricultural production. Abdoussalam et al (2002) studied climate impact on agriculture sector in the Sanel. They found adverse effects on productivity. Chang, C. C., (2002) conducted research on the climate change impact on agriculture sector of Taiwan showed that rainfall and temperature have significant impact on total crop production. Chipanshi et al; (2003) studied the vulnerability of sorghum and maize crops to change in climate in Botswana. Fischer, G. et al; (2005) suggest that due to socioeconomic and climate change impacts, current consumption and production gaps between developing and developed countries may rise. Guiteras, R. (2009) concludes that for the prediction of the medium run economic impact of change in climate, short run weather effects are applicable if farmers are not able to adopt quickly. Wang, J. (2009) concluded that impact of variation in climate on water availability is more important than its impacts on farms because water availability is a critical issue in many regions in China. Ahmed, M. N., (2011) showed a decrease in production in the arid areas which in turn affects food security through lesser agricultural production. Ashfaq et al; (2011) concluded that during sowing stage wheat productivity will rise by 146.57 kg per hectare due to 1^0C rise in mean minimum temperature. However, wheat productivity will decrease during vegetation stage due to rise in mean minimum temperature. Shakoor, U. et al; (2011) concludes that increase in temperature impose negative impact on agriculture production and increase in rainfall increase revenue in the province of Punjab, Pakistan. Khan, S. et al; (2012) finds that there is about 1.6-degree Celsius rise in temperature and 0.6 inches fall in rainfall from 1960 to 2011. Pakistan's water sector flow shows a more susceptible condition from 1937 to 2004 that has resulted in a severe change in Kharif and Rabi cultivation which needs \adaptations. Babar, S. et al; (2014) conducted study to analyze climatic changes impact on crop productivity in Khyber Pakhtunkhwa and found that in Central regions of the province the climate variation imposes negative impact on crop productivity and while it imposes positive impact on crop productivity in northern regions. Akram et al; (2015) indicate that temperature has a significant and negative impact on GDP, as well as on manufacturing, agricultural output, and services sectors. Reddy (2015) suggests that in order to improve agricultural production there should be proper evaluation of climate variation impact on agriculture. Celia, A.H., et al; (2015) concluded that Malagasy farmers are particularly exposed to any shocks to their agricultural system owing to their high dependence on agriculture for their livelihoods, prolonged food insecurity, physical isolation and lack of access to formal safety nets. This study is an attempt to quantify the impact of climate change on wheat and maize crop productivity and their prices in the agriculture sector of Khyber Pakhtunkhwa, Pakistan.

The study has been carried out to achieve the following main objectives:

- To analyze the impact of climate change on wheat and maize productivity in Khyber Pakhtunkhwa, Pakistan; and
- To calculate the impact of climate variations on the average value of wheat and maize production in Khyber Pakhtunkhwa, Pakistan.

The following hypotheses have been tested in the study:

- H_{01}: Climate factors do not affect wheat production in Khyber Pakhtunkhwa, Pakistan.
- H_{02}: Climate factors do not affect maize production in Khyber Pakhtunkhwa, Pakistan.
- H_{03}: Climate factors do not affect the value of wheat production in Khyber Pakhtunkhwa, Pakistan.

- H_{04}: Climate factors do not affect the value of maize production in Khyber Pakhtunkhwa, Pakistan.

Methods

The area under study is Khyber Pakhtunkhwa, a province of Pakistan. Wheat and maize crops were selected to analyze the impact of climate variation on agricultural productivity. For the purpose of analysis, time series data covering the period 1981 to 2014 were used. Data were collected from non-governmental organizations. Climate variables, namely precipitation level and average temperature, were obtained from the Pakistan Meteorological Department. Other agricultural variables — including irrigated area, area sown, number of tractors, total fertilizer usage, agricultural labor, forest area, total production, and value of production were obtained from the World Development Indicators (https://databank.worldbank.org/source/world-development-indicators).

Models

1. Econometric Model for Total Wheat and Maize Production

Cobb-Douglas production function is used to run regression. Same model was used by Nastis et al. (2012); Ali et al. (2026) to examine the climate change impacts on agricultural productivity in Greek. Cobb-Douglas production model was incorporated by Gupta et al. (2012) to investigate the climate variation impacts on rice, sorghum and millet productivity utilizing panel in India. Total agricultural production (TP) is a function of various variables like fertilizers (TF), agricultural labor (AL), area sown (AS), tractors (TT), forest area (FA) and irrigated area (IA). Functional form of the model is

(TP) = f (AS, TF, IA, FA, TT, AL) ……………………..………..… (I)

To divide TP by AS (for production per unit land or land productivity), equation (I) will then become,

(TP /AS) = f {(TF/AS), (IA/AS), (FA/AS), (TT/AS), (AL/AS),} ……………..… (II)

Production of per unit land for each crop is represented by (TP /AS) in equation (II). After incorporating climate factor, equation (II) will becomes,

(TP/AS) = f{(TF/AS), (IA/AS), (FA/AS), (TT/AS), (AL/AS), (AARF), (AAMNT), (AAMXT)} …. (III)

In equation (III) AARF, AAMXT and AAMNT are the annual average rainfall, annual average maximum and annual average minimum temperature in total crop period respectively. In the Cobb-Douglas production function's original form, equation (III) will be in following form

$\ln(TP/AS) = \beta_0 + \beta_1\ln(TF/AS) + \beta_2\ln(IA/AS) + \beta_3\ln(FA/AS) + \beta_4\ln(TT/AS) + \beta_5\ln(AL/AS)it + \beta_6\ln(AARF)it + \beta_7\ln(AAMXT) + \beta_8\ln(AAMNT) + \mu i$………..(IV)

Now to analyze impact of climate change on total wheat productivity (TWP), eq (IV) can be written as;

$\ln(TWP/AS) = \beta_0 + \beta_1 \ln(TF/AS) + \beta_2 \ln(IA/AS) + \beta_3 \ln(FA/AS) + \beta_4 \ln(TT/AS) + \beta_5 \ln(AL/AS)it + \beta_6 \ln(AARF)it + \beta_7 \ln(AAMXT) + \beta_8 \ln(AAMNT) + \mu i$…..(V)

This equation represents impacts of climate change on total maize productivity (TWP);

$\ln(TMP/AS) = \beta_0 + \beta_1 \ln(TF/AS) + \beta_2 \ln(IA/AS) + \beta_3 \ln(FA/AS) + \beta_4 \ln(TT/AS) + \beta_5 \ln(AL/AS)it + \beta_6 \ln(AARF)it + \beta_6 \ln(AAMXT) + \beta_8 \ln(AAMNT) + \mu i$……..(VI)

2. Econometric Model for Aggregate Value of Wheat and Maize Production

To examine the impact of climatic and other factors on value of production, value of production of both crops is considered by farm harvest price. Per unit productivity of land (in monetary term) is regressed with eight different socioeconomic and climatic factors applying time series data for time period, 1981 to 2014. VWP is aggregate value of wheat production. Same model was incorporated by Nastis et al., (2012);

$\ln(VWP/AS) = \beta_0 + \beta_1 \ln(TF/AS) + \beta_2 \ln(IA/AS) + \beta_3 \ln(FA/AS) + \beta_4 \ln(TT/AS) + \beta_5 \ln(AL/AS) + \beta_6 (AARF) + \beta_7 \ln(AAMNT) + \beta_8 \ln(AAMXT) + Ui$………...(VII)

to analyze the impact of climate change on value of maize production;

$\ln(VMP/AS) = \beta_0 + \beta_1 \ln(TF/AS) + \beta_2 \ln(IA/AS) + \beta_3 \ln(FA/AS) + \beta_4 \ln(TT/AS) + \beta_5 \ln(AL/AS) + \beta_6 \ln(AARF) + \beta_7 \ln(AAMNT) + \beta_8 \ln(AAMXT) + Ui$…..(VIII)

Results and Discussion

Unit Root test

Augmented Dickey Fuller (ADF) test is applied to check the stationary of the variables. The results are given in table 1

Table 1: Results of Augmented Dickey Fuller test:

VARIABLES	LEVEL		FIRST DIFFERENCE	
	T-Stat	Prob	T-Stat	Prob
Ln(IA)	-1.302500	0.6166	-6.718065	0.000
Ln(TF)	-2.098624	0.2465	-7.505108	0.000
Ln(AL)	-3.49337	0.0145	-	-
Ln(TT)	-4.45393	0.0010	-	-
Ln(FA)	-2.50892	0.1225	-6.093805	0.000
Ln(AARF)	-5.299821	0.0001	-	-
Ln(AAMNT)	-21.74334	0.0001	-	-
Ln(AAMXT)	-5.566640	0.0001	-	-
Ln(TWP)	7.81209	0.8109	-8.786685	0.000

Ln(TMP)	-3.8366	0.0063	-	-
Ln(VWP)	-2.3154	0.1733	-5.681331	0.000
Ln(VMP)	-1.3464	0.5960	-4.981723	0.0003

Sources: Eviews Results

Results show that total maize production, agricultural labor, tractors, annual average rainfall, annual average minimum temperature and annual average maximum temperature are stationary at level while irrigated area, total fertilizer, forest area and total wheat production, value of wheat production, value of maize production are stationary at first difference.

Estimation of Econometric Model for Total Wheat Production

Cobb-Douglas production function is applied to estimate the impact of climate change on the wheat production. Table 2 shows the results;

Table 2 OLS estimation

Dependent Variable: D(LNTWP)
Method: Least Squares
Sample: 1981 2014

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.422972	3.050444	-0.138659	0.8908
D(LNFA)	0.039641	0.091979	0.430981	0.6702
D(LNTF)	0.231494	0.124199	1.863902	0.0741
D(LNIA)	3.010767	0.683686	4.403727	0.0002
LNAL	-0.007148	0.141648	-0.050464	0.9602
LNTT	-0.364055	0.105541	-3.449422	0.0020
LNAARF	2.866617	49.5767	0.057728	0.0144
LNAAMNT	0.340040	0.104733	3.246726	0.0031
LNAAMXT	-0.387876	0.325290	-1.192399	0.0435
R-squared	0.952445	Mean dependent var		10.08411
Adjusted R-squared	0.937227	S.D. dependent var		0.243492
S.E. of regression	0.061006	Akaike info criterion		-2.533778
Sum squared resid	0.093042	Schwarz criterion		-2.129742
Log likelihood	52.07423	Hannan-Quinn criter.		-2.395990
F-statistic	62.58833	Durbin-Watson stat		1.638076
Prob(F-statistic)	0.000000			

Results show that all the variables except agricultural labour, total fertilizer and forest area are significant. Forest area have positive but insignificant impact on total wheat production. Irrigated area shows positive and significant relationship with total wheat production. There is positive and insignificant relation between total fertilizers and total wheat production. Agriculture labour is negatively affecting wheat production. Total number of tractors used has negative and significant impact on wheat production. Rainfall affects the wheat production positively. Asha et al: (2012) found that there is positive relation between annual average rainfall and total agricultural production, and concluded that decrease in rainfall is the major reason behind reduction in crop production. There exists positive and significant relationship between average annual minimum temperature and total wheat production. Also results indicate that average annual maximum temperature has negative and significant impact on total agricultural wheat production. Anand (2015) also concluded that there is negative relationship between crop production and annual average temperature. Akram, (2015) also concluded that annual average temperature shows negative relationship with GDP and total agricultural output.

Estimation of Model for Maize Crop

Table 3 OLS estimation for Maize crop

Dependent Variable: LNTMP
Method: Least Squares
Sample: 1981 2014

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.143113	3.783073	0.037830	0.9701
D(LNFA)	0.387876	0.325290	1.192399	0.0435
D(LNIA)	0.235065	0.313564	0.749698	0.4597
D(LNTF)	0.075278	0.200935	0.374638	0.0109
LNAL	-0.037711	0.175668	-0.214673	0.8318
LNTT	0.033852	0.130889	0.258629	0.7980
LNAARF	0.05608	0.175514	2.880718	0.0077
LNAAMNT	0.168669	0.352508	0.478483	0.0360
LNAAMXT	-0.644416	0.13218	-4.662323	0.0001

R-squared	0.624503	Mean dependent var	0.03156
Adjusted R-squared	0.549818	S.D. dependent var	2.076841
S.E. of regression	0.075657	Akaike info criterion	4.710279
Sum squared resid	0.143101	Schwarz criterion	4.769943
Log likelihood	-73.47892	Hannan-Quinn criter.	4.965491
F-statistic	3.662661	Durbin-Watson stat	1.994466
Prob(F-statistic)	0.016045		

This study results show that there is positive and significant relationship between forest area and total maize production. Results of the study show that there exists positive but insignificant relationship between irrigated area and total maize production. Analysis shows that there is positive and significant relationship between total fertilizer and total maize production. There is negative and insignificant relationship between agricultural labor and total maize production. There is positive and significant relationship between tractors and total maize production. According to the results there exists positive and significant relationship between average annual rainfall and maize production. There exists positive and significant relationship between annual average minimum temperature and total maize production. The study results show negative and significant relationship between annual average maximum temperature and total maize production.

Estimation of Model 2 for wheat Crop

Following table shows results of analysis of climate change impact on value of wheat production.

Table 4 OLS Estimation for the value of wheat crop

Dependent Variable:D(LNVWP)
Method: Least Squares
Sample (adjusted): 1982 2014

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	153.4588	42.99933	3.568866	0.0017
D(LNTF)	3.518980	1.153770	3.049983	0.0059
D(LNIA)	-32.79570	12.76541	-2.569107	0.0175
D(LNFA)	-2.040609	1.067725	-1.911174	0.0691
LNTT	-2.011495	3.616903	-0.556137	0.5837
LNAL	-5.618728	1.764037	-3.185153	0.0043
LNAARF	2.058619	0.702947	2.928555	0.0078
LNAAMNT	0.843016	0.229206	3.677986	0.0010
LNAAMXT	-18.56497	12.57695	-1.476111	0.1541
AR(1)	0.248856	0.262455	0.948185	0.3533
MA(1)	0.999665	0.210424	4.750710	0.0001
R-squared	0.908680	Mean dependent var		25.59472
Adjusted R-squared	0.867170	S.D. dependent var		2.184546
S.E. of regression	0.796176	Akaike info criterion		2.643207
Sum squared resid	13.94570	Schwarz criterion		3.142043
Log likelihood	-32.61292	Hannan-Quinn criter.		2.811051
F-statistic	21.89100	Durbin-Watson stat		2.082298
Prob(F-statistic)	0.000000			
Inverted AR Roots	.25			
Inverted MA Roots	-1.00			

Value of coefficient of fertilizer show that total fertilizers used have a significant positive impact on value of wheat production. Results also shows that irrigated area has significant and negative relationship with value of wheat production. According to value of coefficient of forest area there is negative and insignificant relationship between forest area and value of wheat production. There is negative and insignificant relation between total number of tractors used and value of wheat production. There is negative and significant relationship between agricultural labor and value of wheat crop production. There exists positive and significant relationship between annual average rainfall and value of wheat production. There is positive and insignificant relationship between annual average minimum temperature and value of wheat production. Also results showed that annual average maximum temperature has an insignificant and negative impact on value of wheat production.

Estimation of Model 2 for Maize Crop

Following table shows results of the analysis.

Table 5 Estimation of OLS Results for value of Maize crop

Dependent Variable: D(LNVMP)
Method: Least Squares
Sample: 1981 2014

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-205.2433	138.3339	-1.483681	0.1504
D(LNTF)	10.13311	5.632254	1.799121	0.0841
D(LNIA)	70.21210	31.00432	2.264591	0.0325
D(LNFA)	-0.032450	4.171138	-0.007780	0.9939
LNTT	19.67113	4.786146	4.110015	0.0004
LNAL	9.838869	6.423573	1.531682	0.1382
LNAARF	-0.03146	0.01421	-2.212629	0.0351
LNAAMNT	0.232459	0.169380	1.372417	0.0305
LNAAMXT	-0.104919	0.245170	-0.427946	0.0019

R-squared	0.737846	Mean dependent var	34.3529
Adjusted R-squared	0.653957	S.D. dependent var	4.70940
S.E. of regression	2.766524	Akaike info criterion	5.09988
Sum squared resid	191.3414	Schwarz criterion	5.49024
Log likelihood	-77.61479	Hannan-Quinn criter.	5.23776
F-statistic	8.795483	Durbin-Watson stat	1.08336
Prob(F-statistic)	0.000012		

According to the results there exists positive but insignificant relationship between total fertilizers and value of maize production. There is positive and significant relationship between irrigated area and value of maize production. Study results show negative and insignificant relationship between forest area and value of maize production. There is positive and significant relationship between tractors and value of maize production. There exist positive but insignificant relationship between value of maize production and agricultural labor. Results of the study shows that there is negative and significant relationship between annual average rainfall and value of maize production. There is positive and significant relationship between annual average minimum temperature and value of maize production. There is negative and significant relationship between annual average maximum temperature and value of maize production.

Conclusions

Agriculture sector is considered as second largest sector in Pakistan. Agriculture sector is facing serious threats from variation in climate. The main purpose of the study is to analyze impact of climate change on total wheat and maize production and value of wheat and maize production in Khyber Pakhtunkhwa, Pakistan. Secondary data is used in this study for the time period 1981-2014. Different climate variables like annual average rainfall, annual average minimum temperature and annual average maximum temperature have been taken. The results show that climate variables like annual average minimum temperature, and annual average rainfall impose positive impacts while annual average maximum temperature impose negative impacts on total wheat and maize production. The study results show that climate variables like annual average rainfall and annual average minimum temperature have positive relation with value of wheat production. It also shows that average annual maximum temperature has negative impact on value of wheat and maize production. The government needs to upgrade and redesign storm drainage capacity by taking in to consideration the risks related to variation in climate, to construct cyclone shelters in coastal regions that is exposed to climate variation and to strengthen drought monitoring, floods forecasting and early warning system in the country. Future research could further explore advanced molecular featurization and attention-based representation learning to improve the modeling of complex climate properties (Ali, 2026; Ali & Mohlenkamp, 2026; Ali & Bano, 2026).

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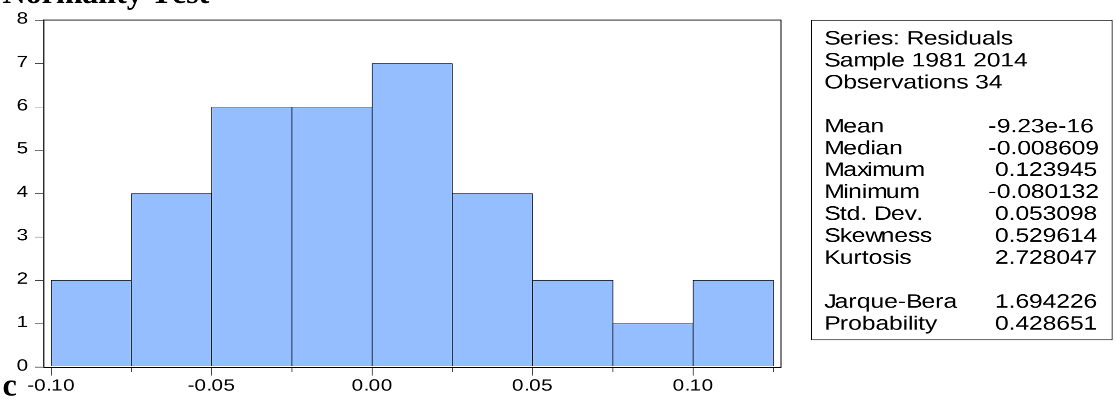
Appendix

Residual Tests for Estimation of Model 1 for Wheat Crop

Normality Test



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Sources: Eviews Results

Figure 1

Results show that probability value of Jarque-Bera is 0.4286 which is greater than 5%. It means we accept null hypothesis i.e. error term of the model is normally distributed.

Breusch-Godfrey Serial Correlation LM Test:

Table Breusch-Godfrey Serial Correlation LM Test:

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.527204	Prob. F(2,23)	0.5972
Obs*R-squared	1.490365	Prob. Chi-Square(2)	0.4746

Sources: Eviews Results

After applying test the results show that Probability of F-statistics is 0.59721 which is greater than 5% and is insignificant. This value indicates that there is no autocorrelation in the model.

Heteroskedasticity Test: Breusch-Pagan-Godfrey

Table Heteroskedasticity Test: Breusch-Pagan-Godfrey

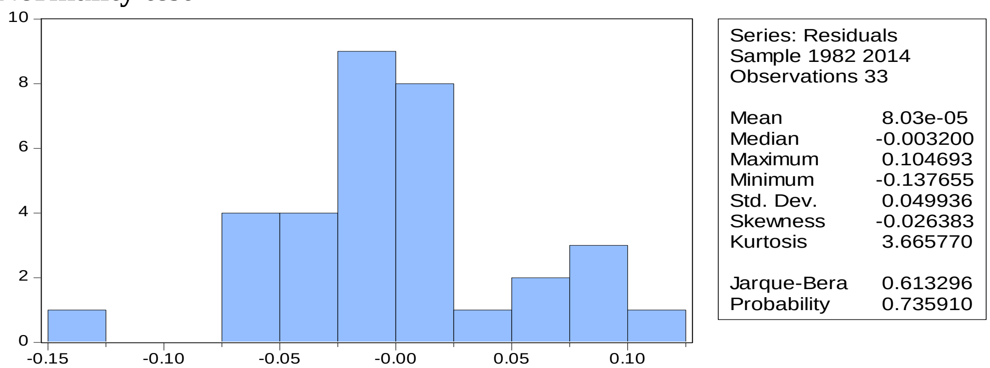
Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.946697	Prob. F(8,25)	0.4975
Obs*R-squared	7.905229	Prob. Chi-Square(8)	0.4428
Scaled explained SS	3.692854	Prob. Chi-Square(8)	0.8837

Sources: Eviews Results

After applying test results show that the Probability of F-statistics is 0.497 which is greater than 5%. These results show that there is no hetroskedasticity in the model.

Residual Tests for Estimation of Model 1 for Maize Crop

Normality test



Sources E-views Results:

Figure 2

From the figure it is clear that Jarque-Bera probability value is 0.735910 which is greater than 5 %. It shows that the error tern is normally distributed.

Breusch-Godfrey Serial Correlation LM Test:

Table Result of Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	4.369022	Prob. F(2,24)	0.0241
Obs*R-squared	9.074846	Prob. Chi-Square(2)	0.0107

Source: Eviews Results

Table shows that probability value of F-statistics is 0.6017 which is greater than 5%. It means that there is no autocorrelation in the model hence we accept null hypothesis

Table Results of Breusch-Pagan-Godfreytest:

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.366608	Prob. F(8,25)	0.9284
Obs*R-squared	3.569898	Prob. Chi-Square(8)	0.8937

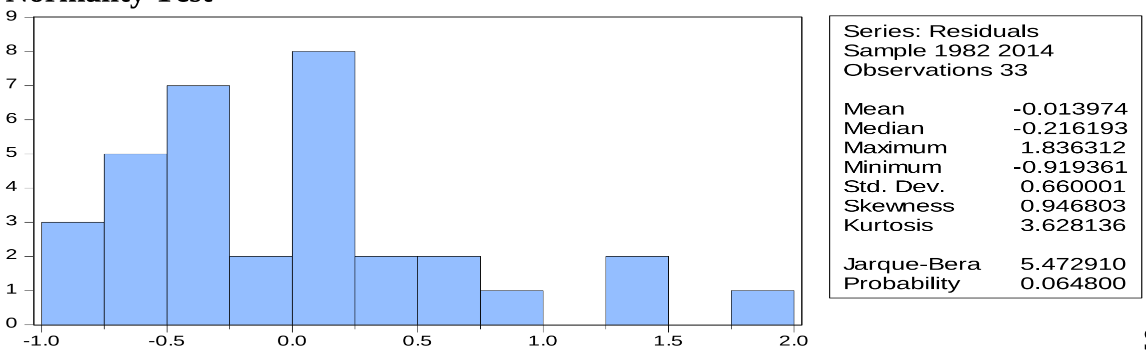
Scaled explained SS	2.963285	Prob. Chi-Square(8)	0.9366

Sources: Eviews Results

Table shows results of Breusch-Pagan-Godfrey test. As probability value of F-statistics is 0.9284 which is greater than 5%. It means that there is no hetroscedasticity in the model and we accept null hypothesis.

Residual Tests for Estimation of Model 2 for Wheat Crop

Normality Test



Sources: Eviews Results

Figure 3

Jarque-Bera probability value is 0.0648 which is greater than 5%. It shows that observations are normally distributed and OLS assumption is satisfied.

Breusch-Godfrey Serial Correlation LM Test:

Table Breusch-Godfrey Serial Correlation LM Test:

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.469649	Prob. F(2,20)	0.2538
Obs*R-squared	4.215113	Prob. Chi-Square(2)	0.1215

Sources: Eviews Results

Breusch-Godfrey Serial Correlation LM Test is used to check autocorrelation. Probability value of F- statistic is 0.2538 which is greater than 5% and is insignificant. This results show that we accept null hypothesis that is there is no auto correlation in the model.

Heteroskedasticity Test: Breusch-Pagan-Godfrey:

Table Results of Heteroskedasticity Test: Breusch-Pagan-Godfrey

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.485096	Prob. F(8,24)	0.8547
Obs*R-squared	4.593323	Prob. Chi-Square(8)	0.8000
Scaled explained SS	2.599005	Prob. Chi-Square(8)	0.9570

Sources: Eviews Results

Results show that Probability value of F-statistics is 0.854. This value shows that it is insignificant and we accept null hypothesis that is there is no heteroscedasticity.

Residual Tests for Estimation of Model 2 for Maize Crop
Normality Test:

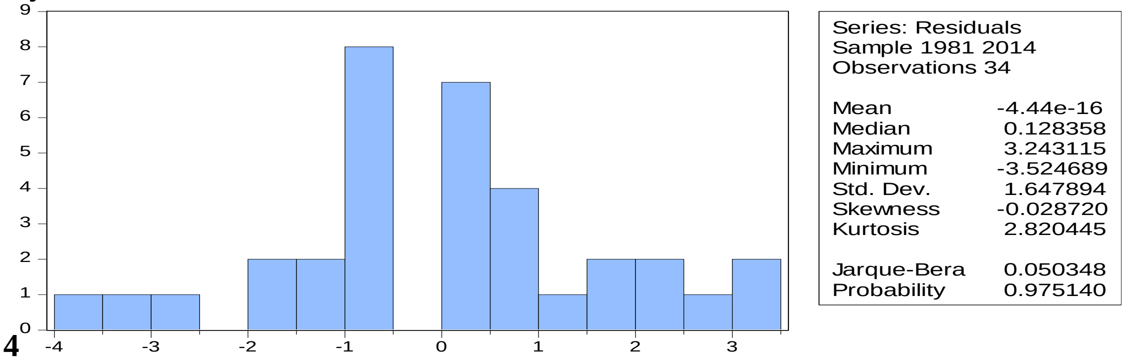


Figure 4

Sources: Eviews Results

After applying test, value of probability Jarque-Bera is 0.975140 which is greater than 5 %. It means that all the observations are normally distributed.

Breusch-Godfrey Serial Correlation LM Test

Table Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.579771	Prob. F(2,27)	0.2245
Obs*R-squared	3.561872	Prob. Chi-Square(2)	0.1685

Sources: Eviews Results

After applying Breusch-Godfrey Serial Correlation LM Test result shows that value of probability of F-statistics is 0.224 which is greater than 5%. This value indicates that there is no auto correlation in the model.

Heteroscedasticity Test: Breusch-Pagan-Godfrey:

Table Results of Heteroscedasticity Test: Breusch-Pagan-Godfrey:

Heteroscedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	1.446428	Prob. F(4,29)	0.2440
Obs*R-squared	5.655027	Prob. Chi-Square(4)	0.2264
Scaled explained SS	3.744729	Prob. Chi-Square(4)	0.4417

Table represent that value of Probability of F-statistics is 0.244 which is greater than 5%. According to this value there is no heteroscedasticity in the model and we accept null hypothesis.