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IMPACT OF CLIMATE CHANGE ON PULSES PRODUCTION IN KHYBER PAKHTUNKHWA, PAKISTAN: A PANEL DATA PERSPECTIVE

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ABSTRACT

Climate change and crop production are intrinsically associated with each other. This research endeavor is designed to analyze the impact of climate variability on pulses production in Southern districts of Khyber Pakhtunkhwa (KP) Province of Pakistan. Two pulses (i.e. chickpea and mung bean) were selected for this research study with respect to climate change. Climatic variables such as temperature, humidity and precipitation along with pulses production and area under cultivation of pulses were encompassed as the major variables of this study. Secondary data of climatic variables and crop variables for the period of thirty-six years (1986-2022) were obtained from Pakistan Metrological Department and Agriculture Statistics of KP respectively. Panel data set of chickpea and mung bean crops was estimated separately. The Shapiro-Wilk test was estimated to assess normality, resulting in a P-value of 0.63 which confirmed P-value as insignificant, hence we accepted the null hypothesis, concluding that the data follow a normal distribution. For the Wooldridge test, F-value was 6.39, with a P-value of 0.0717. This P-value is also insignificant at the 5% level, leading us to accept the null hypothesis and conclude that there is no issue of serial correlation. The analysis validates that both data sets were a balanced panel data. The Hausman specification test was run separately for both the panel data sets whose findings had suggested the fixed effect model can be deemed as an appropriate model for chickpea panel data, however random effect model was appropriate for estimation of the panel data of mung bean. Major findings confirm that maximum temperature is statistically significant for the chickpea yield. This implies if maximum temperature increases by 1 ^{0}C, it can enhance the chickpea yield by 0.0463 units. However, the impact of precipitation was reported insignificant. The overall result suggested that climate has a significant impact on chickpea yield in the study area for the said time span. The R-square value is calculated as 0.537 which means that 53% variation in the chickpea yield is due to explanatory variables. Furthermore, the humidity was statistically significant and has a positive association with chickpea yield. In case of mung bean, the minimum temperature was significantly contributing to the yield of mung bean. The estimates further illustrate that the humidity contribution towards Mung Bean yield is observed as significant which reflects

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that if humidity increase by 1 percent can enhance the mung-bean's yield by 0.023 units. The R-square value is calculated as 0.577 which means that 57 percent variation in the Mung Bean yield is due to explanatory variables. This study concludes that temperature and humidity can significantly contribute to enhance the pulses yield. It is recommended that capacity building of pulses growers may be made to adapt the climate change strategies. Such strategies may include water harvesting methods to ensure sustainable irrigation supply, mitigating the effects of erratic rainfall caused by climate change. Moreover, government may ensure the availability of heat or drought-tolerant varieties of pulses to encourage the pulses cultivation.
Key words: *Climate Change, Pulses, Chickpea, Mungbean, Panel Data, Pakistan, ACIAR*

INTRODUCTION

The impact of climate change has intrinsically association with agriculture sector and particularly has an effect on crop yield. The impact of climatic change is being reported with diverse findings that depends on crop, territory and human activities (Allen 1990, IPCC 2001, McMichael 2001, Centritto and Loreto 2005).
Pakistan economy is largely based on agriculture, however, for last several years its contribution to the country's total GDP has been rapidly drop-off to 19.2 percent. This sector also accounts 38.5 percent by providing direct or indirect employment to the working hands (GOP, 2021). In case of raw materials this sector is really very important for the industries as textiles, sugar based industries, oil seeds industries, furniture industries and much more. The growth of these industries is not only carried out by agriculture but it is a great way to the earning of foreign exchange. According to FAOSTAT, area under cultivation of pulses across the world was reported as 85 million hectares in year 2014. Pulses have the ability to fix approximately 3 to 6 million tonnes of nitrogen worldwide. Consequently, pulses contribute to the more rational use of fertilizers, thus reducing greenhouse gas emissions (FAO, 2016).
Pulses are a very essential source of protein in Pakistan but unfortunately pulses are grown on 5 percent of the total cultivable areas. The estimated area of all major pulses crops of Pakistan is approximately 1.5 million hectares. Chickpea is an important winter legume and Mung bean are important summer legume. Chickpeas cover 73 percent of the total area of pulses and account for 76 percent of the total production, while Mung bean account for 18 percent of the total area and account for 16 percent of the whole production (Mustaq et al, 2020). Pulses are deemed as a significant crop as it is an earning source as well as provide a healthy diet to the farmers and their family. Having the choice to eat and sell the pulses the farmers produce them and help to sustain the family food safety and create financial sustainability.
Pulses are one of the important edibles of our diet and considered as a rich source of protein. However, owing to less mechanization and high manual crop practices in the pulses filed, the pulses growers of KP are switching to other competing crops. Instead of enhancing the pulses yield they usually allocate marginal lands to grow the pulses. One of the substantial issues at the policy level is that government has never announced any support price for pulses and always includes this crop in the category of minor crops. More importantly the climate change impact on pulses yield is also not properly captured. A number of worldwide research studies have shown that climate change will shrink the yield of agriculture crops such as wheat, rice, maize and pulses (FAO, 2016). Therefore, this research study was intended to be undertaken to underscore the nexus of the climate change with the pulses productivity.

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The major objectivities of the study were **1:** To assess the climate change impact on pulses yield in study area, **2:** to estimate the panel data of pulses yield and **3:** to outline recommendations for policy formation based on study's findings.

RESEARCH METHODOLOGY

This section explained the underpinning of research methodology that was employed to undertake this research endeavor for the examination of the impact of climate change on pulses production in Southern districts of Khyber Pakhtunkhwa, Pakistan.

Universe of the study

This study was conducted in the four selected Districts namely Dera Ismail Khan, Lakki Marwat and Karak, Khyber Pakhtunkhwa, Pakistan.

Type of data

Secondary data set i.e. panel data was used from year 1986-2019.The data was acquired from different government organizations. The climatic variable temperature, precipitation and humidity data was obtained from the metrological stations whereas pulses region, production data were taken from Pakistan Bureau of Statistics and Development Statistics of Khyber Pakhtunkhwa to be analyzed.

Conceptual and Analytical Framework

Panel data deals with two dimensional data i.e. cross sectional & time series. Data is recognized as panel when it is accumulated above time and same person. While panel approach is econometrics approach that measure the impact of climate change on average yield and its unpredictability (Barnwal and Kotani, 2010). In addition Panel data approach is thought to be the best as it has abundant boons than cross sectional and time series facts set (Jintian Wing, 2010). Panel data approach could be presented in simple as;

$$Y_{it} = \alpha + \beta x_{it} + \varepsilon_{it} \qquad (1)$$

Where

Y = Dependent variable
X = Independent variable
α and β = Coefficients
ε_{it} = Error term

In more practical way the researcher is now in better position to use a combination of cross-sectional data and time-series data to notice problems that could not be observed in single data set like cross-sectional or time-series (Greene, 2002). General regression for panel data can be presented by:

$$Y_{it} = \alpha_i + x_{it}\beta + \varepsilon_{it} i = 1 \ldots\ldots N,\ t = 1 \ \ldots\ldots T \qquad (2)$$

Where; the subscript *i* shows the sectional aspect while *t* denotes the time series dimension. According to the Baltagi panel data assumption (2008) the one-way error factor model is used for the disturbances.

$$u_{it} = \alpha_i + \varepsilon_{it} \qquad (3)$$

Where; Composite error term, u_{it} is the union of city specific error factor, α_i and individual specific error factor, $\varepsilon_{it.}$

Fixed Effect Model Specification
The model specification of this research study is given as follow:
$Y = \beta_0 + \beta_1 MaxTem + \beta_2 MinTem + \beta_3 Hum + \beta_4 Preci + U_{it}$

Where,

Y = Chickpea yield
β = Expected Coefficient
MinTem = Minimum Temperature
MaxTem = Maximum Temperature
Hum = Humidity
Preci = Precipitation
i = Number of climate station
t = Number of Years
U = Error term

Random effect Model Specification
The model specification of this research study is given as follow:
$Y = \beta_0 + \beta_1 MaxTem + \beta_2 MinTem + \beta_3 Hum + \beta_4 Preci + E_{it}$
Where,

Y = Mung-bean yield
β = Expected Coefficient
MinTem = Minimum Temperature
MaxTem = Maximum Temperature
Hum = Humidity
Preci = Precipitation
i = Number of climate station
t = Number of Years
E = composite Error term

Econometric Diagnostic Tests
While estimating panel data, Hetroscedasticity issues and Serial Autocorrelation problem can be tested by LM (Lagrange Multiplier).

Lagrange Multiplier (LM) test
Baltagi and Li (1995) presented the Lagrange Multiplier (LM) to test the incidence of Heteroscedasticity and serial correlation when examining panel data. In relation to this study, Breusch–Godfrey (BG) serial correlation LM test is suitable for finding the relationship of errors in a regression model whereas, it uses the residual values of the model being considered in a regression analysis, and a test statistic is being computed.

Hausman Specification Test
For the selection of the appropriate model a Durbin Wu Hausman test is used as used by Sonia et al, 2019 to distinguish between random effects and fixed effect models (Gardinar *et al*., 2009).

RESULTS AND DISCUSSION

Descriptive Statistics of Selected Pulses

1. Chickpea

The major climatic variables that includes maximum temperature, minimum temperature, precipitation (rainfall) and humidity in southern districts of KP province are reflected in Table 1. Descriptive statistics of the climatic variables is being shown through mean and standard deviation of each variable. The glance of these variables for the period of thirty four years (1986-2019) demonstrate that mean minimum temperature observed during the chickpea crop season was 10.56 ^{0}C. While mean maximum temperature was recorded as 26.09 ^{0}C during the crop season. Similarly descriptive statistics for other variables such as humidity and precipitation were estimated and are underscored in Table 1.

Table 1: Descriptive statistic of Chickpea (1986-2019)

Variables	Min	Max	Mean	S.D.
Temperature (Min/Low)	7.52	13	10.56	1.44
Temperature (Max/High)	23.10	28.41	26.09	1.14
Humidity (8am)	50.57	82.28	67.08	8.18
Humidity (5pm)	31.42	53.14	41.52	4.94
Precipitation(mm/hour)	1.75	57.40	19.89	12.17

Source: Authors own estimations through Panel Data (1986-2019).

2. Mung Bean

The descriptive statistics of mung bean revealed that the mean maximum temperature observed is 38.85 degree centigrade with a maximum value of 41.12 ^{0}C and minimum is 37 ^{0}C whereas standard deviation is estimated is 0.73 in the mung bean grown region. Similarly descriptive statistics of other variables such as humidity and precipitation were estimated and given in Table 2.

Table 2: Descriptive statistic of Mung Bean (1986-2019)

Variables	Min	Max	Mean	S.D.
Temperature (Min/Low) (C)	22.1	28.05	25.45	1.30
Temperature (Max/High) (C)	37	41.12	38.85	0.73
Humidity (8am) (%)	47.5	73.5	58.00	6.39
Humidity (5pm) (%)	32.5	48.5	39.08	3.91
Precipitation (mm/hour)	5.33	163.7	44.64	26.77

Source: Author's own estimation from panel data (1986-2019)

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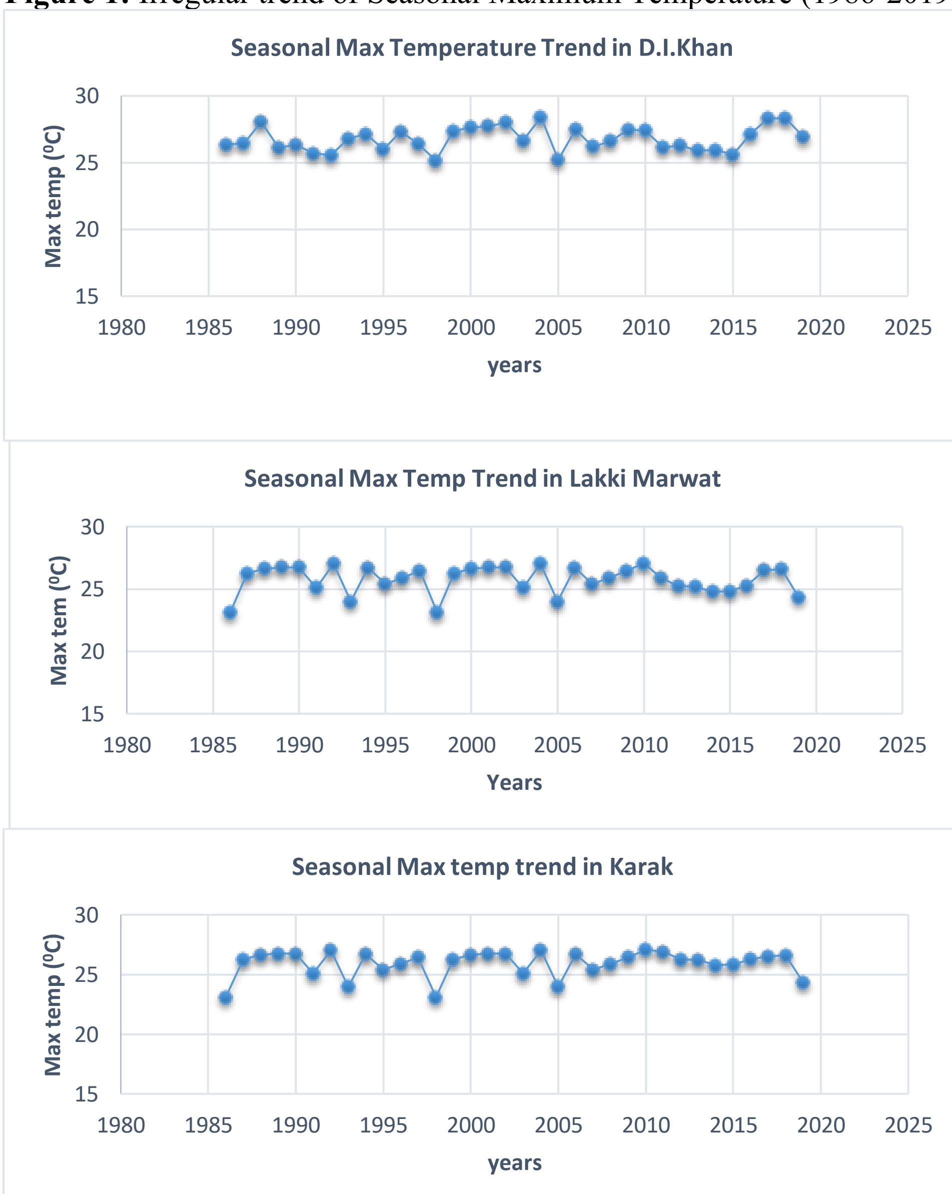
Erratic Trend of Climatic Variables during Season of Chickpea Crop

1. Maximum Temperature Trend

The fluctuating trend of the maximum temperature of the districts D. I. Khan, Lakki-Marwat and Karak for the time period 1986 to 2019 is illustrated in Figure 1. The seasonal highest temperature of 28.41 ^{0}C is recorded in D. I. Khan in 2004 while the lowest temperature of 23.1 ^{0}C was recorded in both Lakki Marwat and Karak. The average maximum temperature in the said districts was recorded as26.76 ^{0}C, 25.75^{0}C and 25.75^{0}C throughout thirty four years. According to the data estimation, D. I. Khan is ranked as higher temperature district than Lakki Marwat and Karak. There is minor fluctuations in maximum temperature for all districts.

Figure 1: Irregular trend of Seasonal Maximum Temperature (1986-2019)



Source: Authors own estimations through Panel Data (1986-2019).

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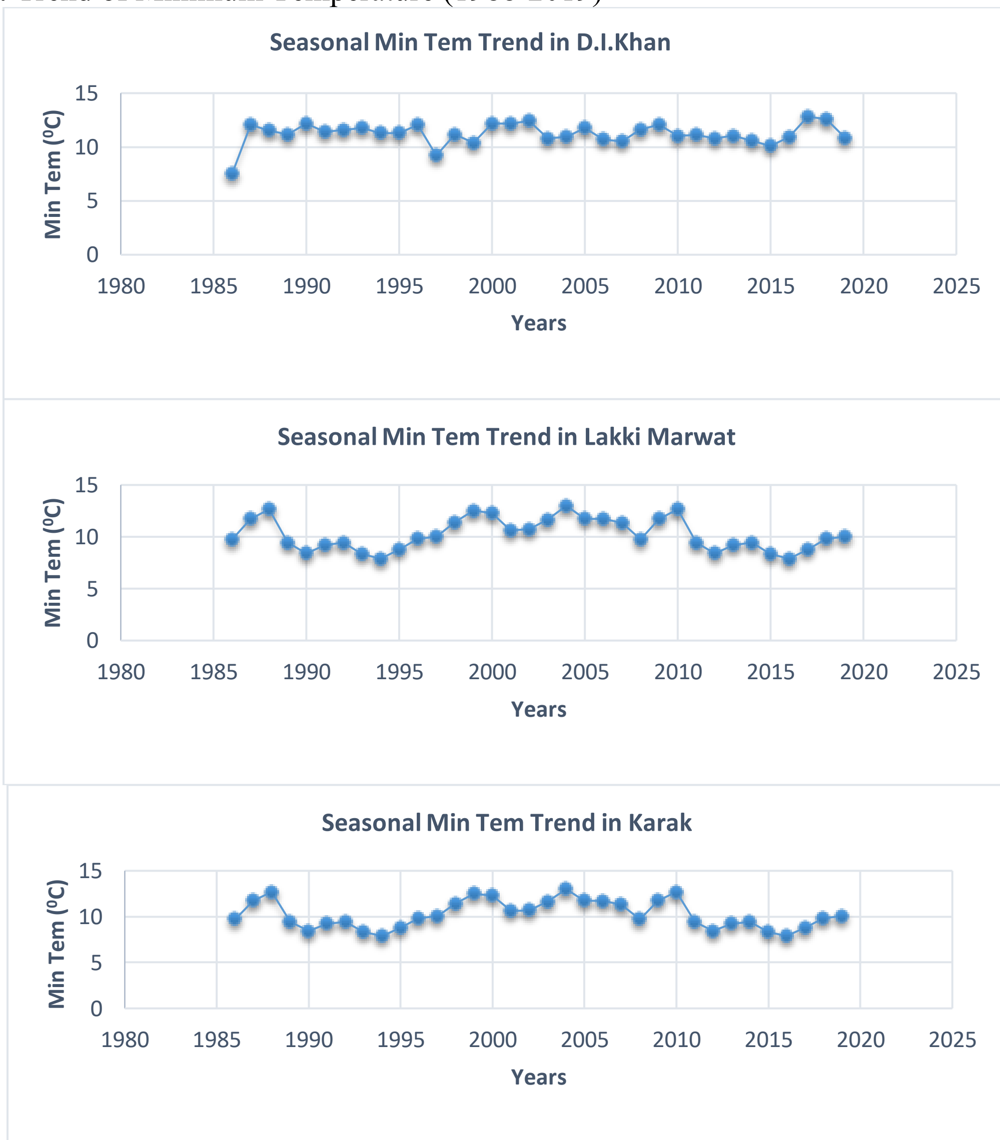
2. Minimum Temperature Trend

Volatility trend of seasonal minimum temperature in the southern districts of KP for the time period of 1986-2019 is highlighted in the Figure 2. There is a slow zigzag movement in minimum temperature of all districts. The trend line is sloping upward for D. I. Khan while downward for both Karak and Lakki-Marwat. The minimum temperature range was recorded 7.52 ^{0}C in the year 1986 in D. I. Khan and 13^{0}C in the year 2004 in Lakki-Marwat.

Figure 2: Trend of Minimum Temperature (1988-2019)

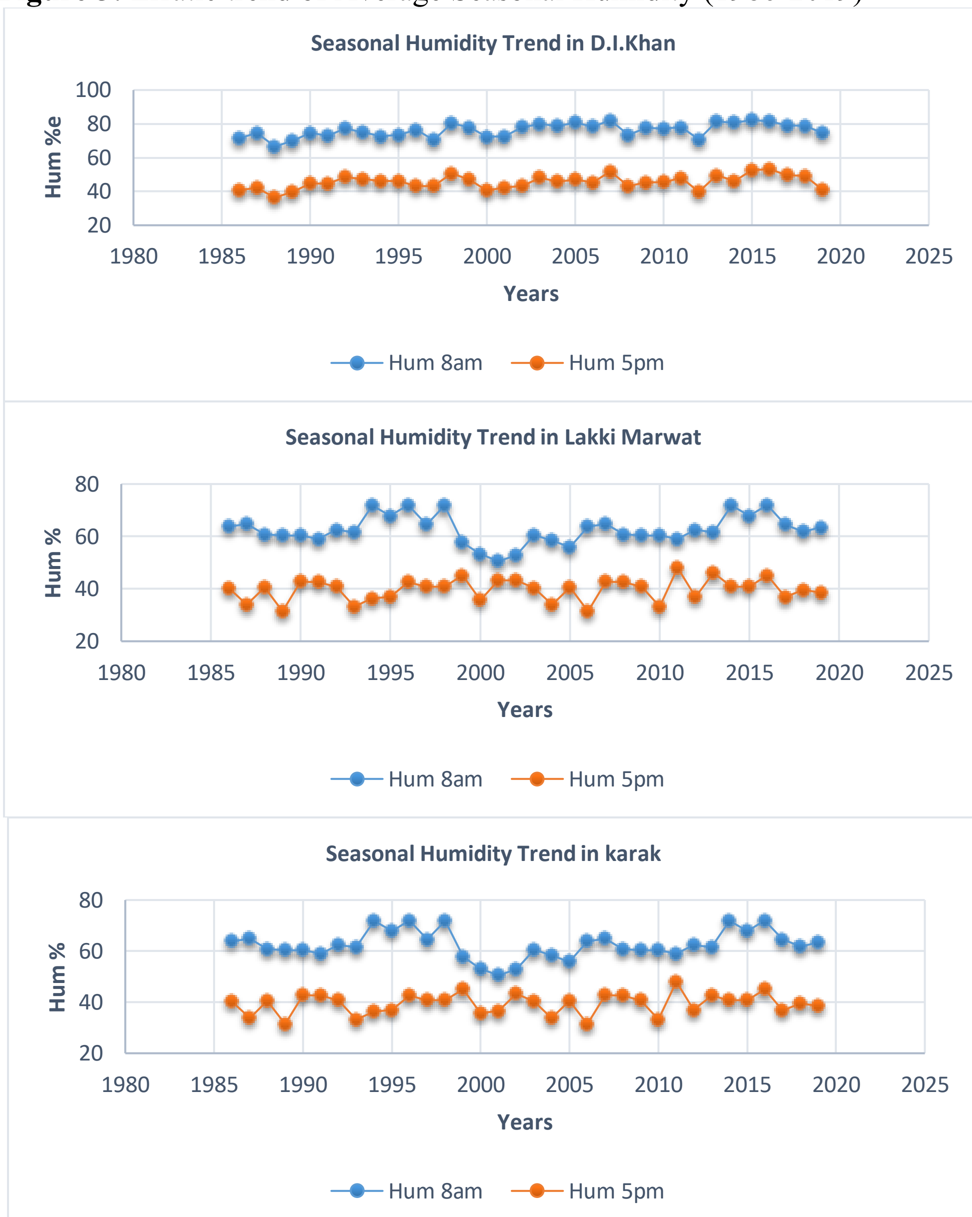


Source: Authors own estimations through Panel Data (1986-2019).

3. Trend of humidity

The two sporadic lines in the figure 3 demonstrates the Seasonal humidity trend noted at 8am and 5pm for 34 years. The humidity at 8am (morning) is higher than the readings which were recorded at 5pm (evening) from 1986-2019. There is a wave-variation in the values of D. I. Khan while raise and falls of values occur in other districts but the pattern of the trend is somewhat similar on both series. In Lakki-Marwat and Karak after 1998, there is a minor raise with semi-linear association of humidity with the year.

Figure 3: Erratic trend of Average Seasonal Humidity (1986-2019)

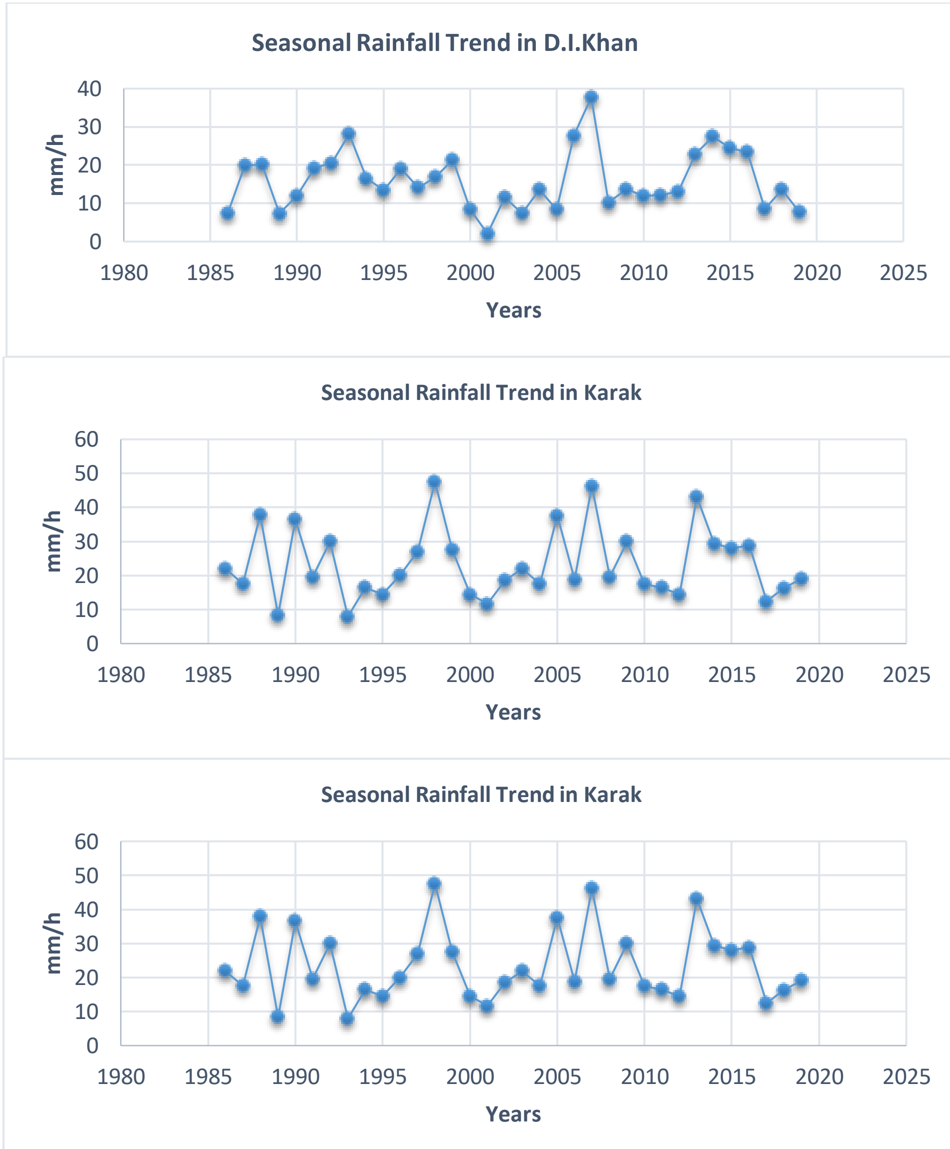


Source: Authors own estimations through Panel Data (1986-2019).

4. Trend of Precipitation

The irregular trend of precipitation during the chickpea crop season i.e. Rabi season for thirty four years period is illustrated in Figure 4. There are sharps sudden ups and downs in all districts throughout the years which shows a separate picture from temperature. The highest and lowest precipitation both were perceived in Lakki-Marwat in the year 1998 and 2001 and which was recorded as 57.40 and 1.75mm.

Figure 4: Irregular seasonal trend of precipitation (1986-2019)



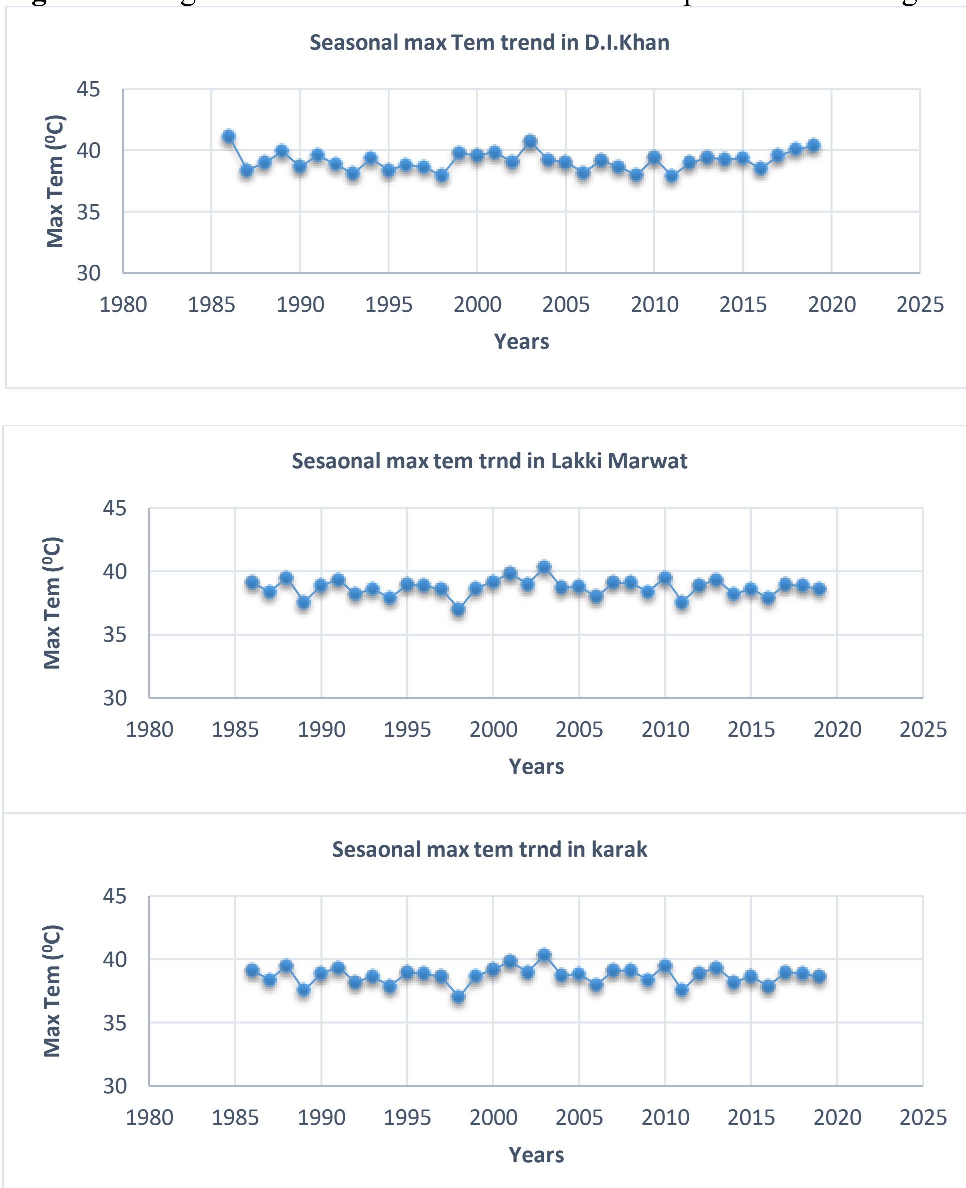
Source: Authors own estimations through Panel Data (1986-2019).

Volatility of Climatic Variables during Season of Mung-Bean

1. Maximum temperature trend

The erratic trend of the maximum temperature of the districts D. I. Khan, Lakki-Marwat and Karak for the given time period (1986 to 2019) is illustrated in Figure 5. The seasonal highest temperature of 41.12 ^{0}C is recorded in D. I. Khan in 2004 while the lowest temperature of 37 ^{0}C was recorded in both Lakki-Marwat and Karak. The average maximum temperature in the said districts was recorded as 39.14 ^{0}C, 38.70 ^{0}C and 38.70 throughout thirty four years. According to the data estimation, D. I. Khan is ranked as higher temperature district than Lakki-Marwat and Karak. There is minor fluctuations in maximum temperature for all districts. The irregular trend of maximum temperature is shown in the figure below.

Figure 5: irregular trend of Seasonal Maximum Temperature for Mung Bean



Source: Authors own estimations through Panel Data (1986-2019).

2. Minimum Temperature Trend

Volatility trend of seasonal minimum temperature during Mung Bean in the southern districts of KP for the time period of 1986-2019 is illustrated via Figure 6. There is a slow zigzag movement in minimum temperature for all districts. The trend line is sloping upward for D. I. Khan while downward for both Karak and Lakki-Marwat. The minimum temperature range was recorded 22.1 ^{0}C in the year 2017 and 28.05 ^{0}C in the year 1989 in Lakki-Marwat.

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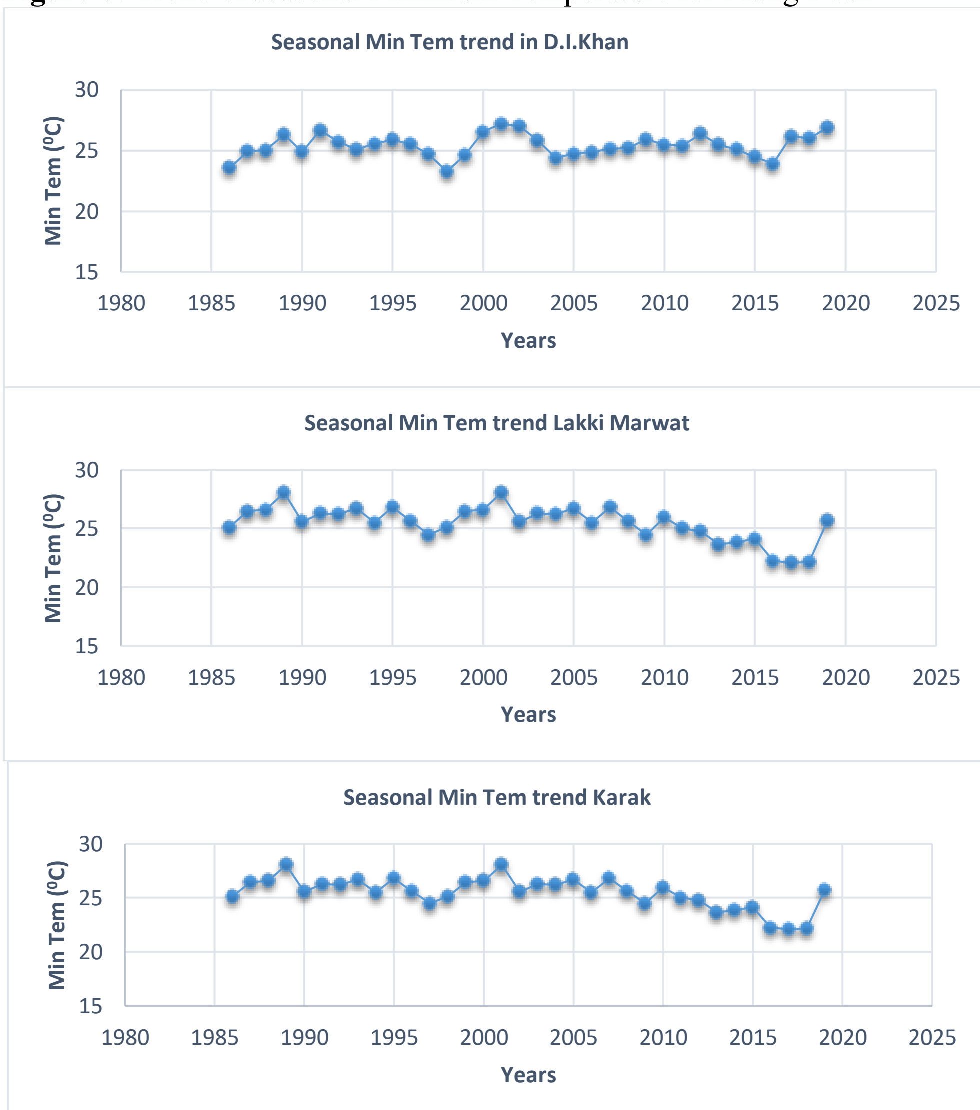
Figure 6: Trend of seasonal Minimum Temperature for Mung Bean



Source: Authors own estimations through Panel Data (1986-2019).

3. Trend of Humidity

The two sporadic lines in the Figure 7 show the Seasonal humidity trend reported at 8am and 5pm for 34 years. The humidity at 8am (morning) is greater than the readings which were recorded at 5pm (evening) from 1986-2019. There is a wave like variation in the values of D. I. Khan while raise and falls of values occur in other districts but the pattern of the trend is somewhat similar on both series. In Lakki-Marwat and Karak after 1998, there is a minor raise with semi-linear association of humidity with the year.

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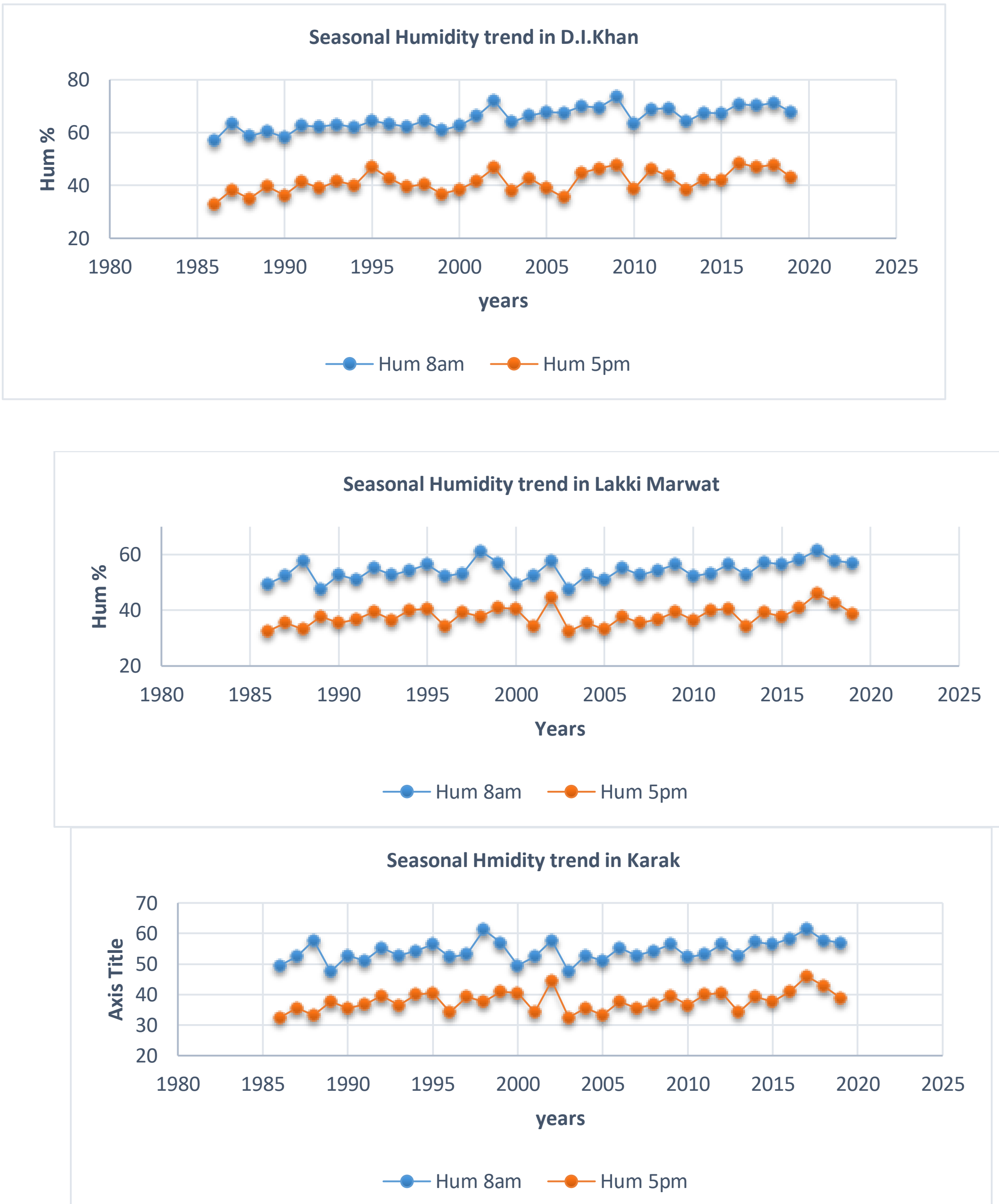
Figure 7: Erratic trend of Average Seasonal Humidity for Mong Bean

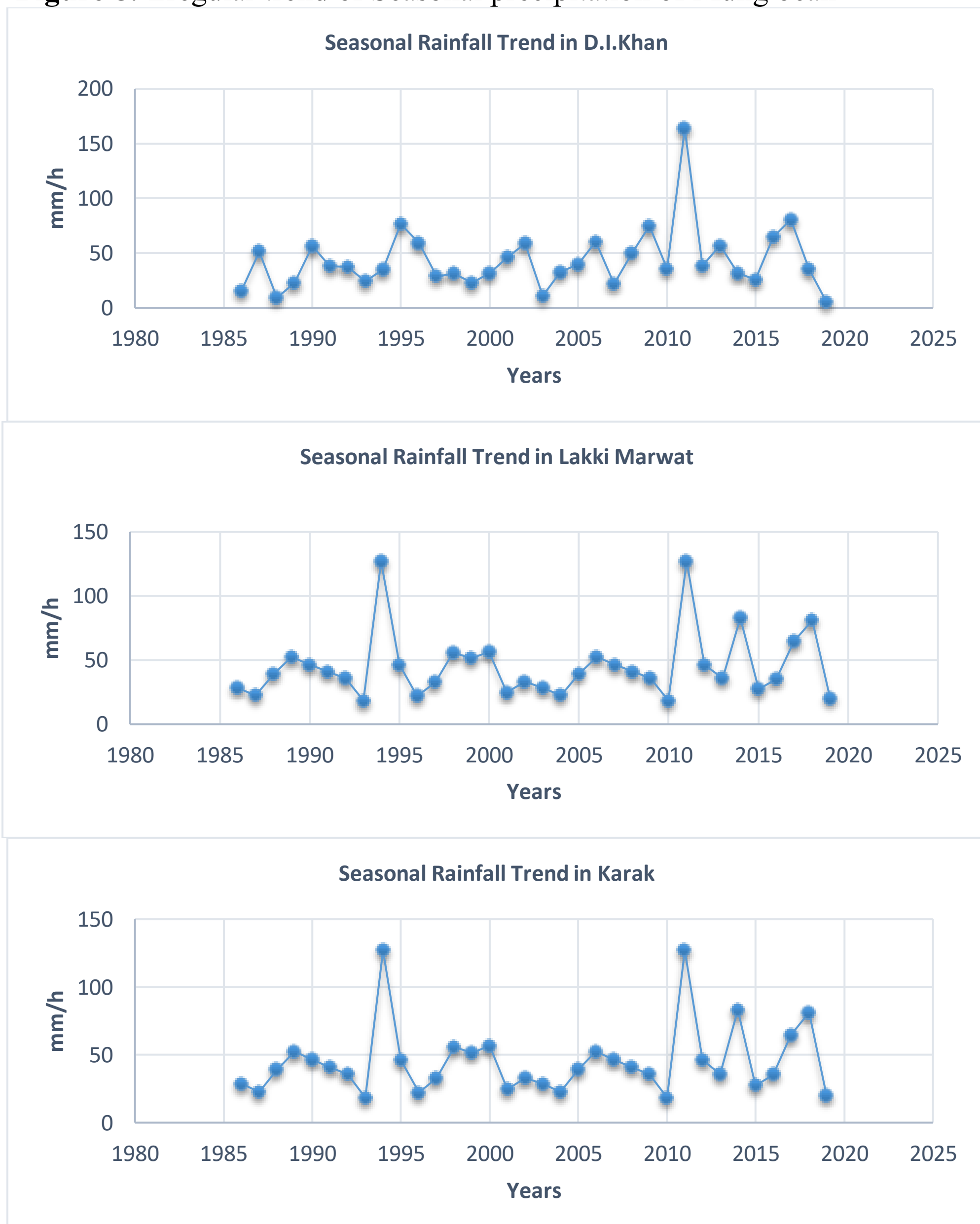


Source: Authors own estimations through Panel Data (1986-2019).

4. Trend of Precipitation

The irregular trend of precipitation during the Mung bean crop season i.e. Kharif season for the period of 34 years is illustrated in Figure 8. There are sharps and sudden ups and downs in all districts throughout the years which shows a separate picture from temperature. The highest and lowest precipitation both were perceived in D. I. Khan in the year 2011 and 2019 and which was recorded as 163.7 and 5.33mm.

Figure 8: irregular trend of Seasonal precipitation of Mung bean



Source: Authors own estimations through Panel Data (1986-2019).

Model Diagnostic Test Estimates for Chickpea

Shapiro-Wilk test was used to examine normality. The estimated P-value of Shapiro-Wilk test are 0.63. As the P-value is insignificant at significance level 5%. So we accept the null hypothesis and conclude that the data fallows a normal distribution. For checking heteroscedasticity problem in panel data Bruesh-Pagan test was used. Results for the Bruesh-Pagan test was estimated and computed values of Chi2 = 28.10 and P-value = 0.50. The estimated P-value was found insignificant suggest homoscedasticity in model.

Woolridge test was used to examine correlation of errors in the regression model. Results for the Woolridge test were estimated and are F calculated = 6.39 and P-value = 0.0717. As the P-value was insignificant at 5% level of significance. So we accept the null hypothesis and conclude that there is no serial correlation problem.

Levin-Lin-Chu test was used for examining stationary problem in panel data. The P-value (0.000) was significant at 5% level of significance. Therefore, null hypothesis are rejected and suggest that panels are stationary.

Huasman Test for Chickpea panel data

The Hausman Test was used to choose between random effect and fixed effect model. The null hypothesis is that the ideal model is random effects; the alternate hypothesis is that the model is fixed effects. The calculated values of Hausman test are Chi^2 = 10.64 and P-value = 0.05. The p-value is equal to 0.05 therefore, we reject the null hypothesis and consider fixed effect model as an appropriate model for this panel data analysis of chickpea.

Model Diagnostic Test Estimates for Mung-bean

To examine normality Shapiro-Wilk test was used. The calculated P-value of Shapiro-Wilk test are 0.36 which is greater than P-value (0.05). Therefore we reject the alternative hypothesis and

Bruesh-Pagan test was used in panel data for checking heteroscedasticity problem. Results for Bruesh-Pagan test was estimated and suggest homoscedasticity in model.

For checking serial correlation in panel data Wooldridge test was applied. The estimated results for Wooldridge test are F calculated = 4.18 and P-value = 0.0939. The estimated P-value was found insignificant at significance level 5%. Therefore null hypothesis is accepted which suggest that there is no issue of serial correlation.

Hausman test for Mung Bean panel data

The Hasman test estimated value of the Chi^2 = 8.24 and P-value = 14.35. The p-value is greater than 0.05, so we accept the null hypothesis and opt the Random Effect Model to analyzed the panel data for mung bean.

Fixed Effect Model Estimates for Chickpea Crop

The panel data estimated results for fixed effect model are highlighted in Table 4.3. The finding shows an association between chickpea yield and climatic variable in the research area. All the explanatory climatic variables were found significant except the rainfall which was reported as insignificant, which shows that precipitation has insignificant effect on chickpea's yield in the research region.

The result further explains that maximum temperature is reported as statistically significant with positive coefficient that implies that maximum temperature has positive impact on the chickpea yield. This confirms that 1 ^{0}C increase in temperature can cause 0.046 unit rise in chickpea yield. The result further illustrates that the minimum temperature contribution towards chickpea yield is significant which means by increasing minimum temperature of 1 ^{0}C there can be 0.792 unit

increase in chickpea yield. These results are similar with Ali et al, (2017) and are contrary to Chandran and Kashype (2016), Dait (2015), Gupta et al (2014) and Haneef et al (2010).
Moreover, humidity shows a positive and highly significant contribution toward chickpea yield. This implies that one percent increase in humidity level can increase chickpea yield in the study area by 0.025 units. These results are corroborated by Holder & Cockshell (1990) and Barker (1990).

The overall result suggested that climate has a significant impact on chickpea yield in the study area for the given time period 1986-2019. The R-square value is calculated as 0.537 which means that 53% variation in the chickpea yield is due to explanatory variables. Furthermore fixed effect results explore the impact of maximum temperature, minimum temperature and humidity in the southern districts of Khyber Pakhtunkhwa.

Table 3: Fixed Effect Model Estimates for Chickpea Crop

Yield	Coefficient	S.E	t-ratio	p-value
Max Temp	0.0463	0.018	2.55	0.014
Min Temp	0.792	0.241	3.28	0.002
Precipitation	-0.0004	0.0036	-0.11	0.911
Humidity	0.0251	0.0071	3.53	0.001
Constant	5.0838	1.117812	4.55	0.000
Sigma u	0.17627405			
Sigma e	0.20004312			
R-Square	0.5370			

Source: Estimated from panel data, 1986-2019.

Random Effect Model Estimates for Mung Bean

The computed results of random effect model are highlighted in Table 4.4. The finding shows a relationship between mung bean yield and climatic variable in the research area. Minimum temperature and humidity were found significant while maximum temperature and rainfall were reported as insignificant, this shows that the two of the climatic variable affect mung bean yield in the research region.
The result explains that minimum temperature is reported as statistically significant with positive coefficient that implies that minimum temperature has positive impact on the mung bean yield. This mean that by increasing 1 ^{0}C of temperature can cause 0.063 unit rise in mung yield, our finding are similar to the results of Gupta et al (2014) and Haneef et al (2010) who had reported a significant association of minimum temperature with crops yield.
The result further illustrates that the humidity contribution towards Mung Bean yield is observed as significant which means when humidity increasing by 1 percent can increase mung bean yield by 0.023 units. These results are alike to the research findings of Holder & cockshell (1990) and Barker (1990).Whereas rest of the climatic variables (i.e. maximum temperature & precipitation) were found insignificant

The overall result suggested that climate has a significant impact on Mung Bean yield in the study area for the given time period 1986-2019. The R-square value is calculated as 0.577 which means that 57 percent variation in the Mung Bean yield is due to explanatory variables. Furthermore, random effect results have elaborated the impact of maximum temperature, minimum temperature and humidity in the southern districts of Khyber Pakhtunkhwa.

Table 4: Random Effect Model Estimates for Mung Bean Crop

Yield	Coefficient	S.E	t-ratio	p-value
Max Temp	0.0380	0.0407	0.93	0.350
Min Temp	0.0631	0.0206	3.06	0.002
Precipitation	0.0003	0.0011	0.27	0.741
Humidity	0.0231	0.0059	3.91	0.000
Constant	3.9356	1.6274	2.47	0.016
Sigma u	0.18234			
Sigma e	0.2145			
R-Square	0.5770			

Source: Estimated from panel data, 1986-2019.

CONCLUSION

Fixed and Random effect model showed the impact of climate change on pulses (i.e. chickpea & mung-bean) production in southern districts of Khyber Pakhtunkhwa, Pakistan through panel data record of thirty-four years 1986 to 2019. The fixed effect model were estimated for chickpea while Random effect model was estimated for mung bean. The fixed effect model results revealed that climatic variables are contributing significantly to the chickpea yield. Maximum and minimum temperature both were significant at 5% significance level. Rainfall results come insignificant, that means the precipitation did not affect chickpea yield in the research area. Humidity contributed significant towards chickpea yield. Humidity was significant at 1% level of significance. The random effect model were estimated which showed that the minimum temperature and humidity were significant and have positive relationship with mung bean yield. The results further declared that maximum temperature and precipitation were noted insignificant.

RECOMMENDATIONS

- The major findings suggest that climatic variables have a significant impact on both chickpea and mung bean yield in the study area therefore; capacity building of the pulses growers may be enhanced through trainings, seminars and field days to adapt the climate change strategies.
- Government may ensure the availability of climate change resistant varieties of pulses to encourage the pulses cultivation.
- Climate change policy may be implemented by KP Government in the agriculture sector of KP.

- There should be satisfactory spending on agriculture research and development in relation to climate change to handle the current scenario of climate change.
- Provincial Pulses Policy may be developed by the concerned policy makers.

Authors' Contribution:

1. **Dr. Khuram Nawaz Sadozai**: Data analysis and major estimates were made.
2. **Dr. Munawar Raza Kazmi:** Major research theme and idea was generated.
3. **Tajala Ahmad: Data** entry, Diagnostic Tests and literature review were prepared.
4. **Awais Habib:** Obtained secondary data and develop literature cited.

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