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# An Investigation of Fluctuating Productivity of Major Food Crops in Khyber Pakhtunkhwa, Pakistan (1984-2014)

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## ABSTRACT

***Objectives: The*** *aim of the present research is to look into the fluctuating production of main crops grown in Pakistan's Khyber Pakhtunkhwa province.*
***Materials and Methods:*** *This research utilized data covering the period from 1984 to 2014 from the Khyber Pakhtunkhwa, Pakistan, crop reporting agency as a secondary source. Wheat, maize, sugarcane, and rice production statistics are evaluated to determine the growth and variability of main food crops. The cubic growth model is shown to be the best suited model for wheat, sugarcane, and rice, In the case of maize, the power growth model has been found as being the most suitable.*
***Results:*** *The findings of the data analysis revealed that growth for all key food crops is considerable, with calculated values of growth for wheat, maize, sugarcane, and rice being 10.96 percent, 8%, 45.31 percent, and 1.19 percent, respectively. The cuddy Della-vella index was also used to calculate the variability of main food crops. The variability in important food crops, such as wheat, maize, sugarcane, and rice, is found to be 1.53%, 1.23%, 0.44%, and 0.79%, respectively, utilizing the results of studied data. As an outcome of the studied data, it can be inferred that the expansion of key food crops is accompanied by an increase in production over time, and that this is attributable to the employment of enhanced high-quality seeds as well as advanced new technology.*
***Conclusion:****It can be concluded that there has been serious change in the production of key food crops, however wheat crop variability is slightly more than some other food crops such as sugarcane and maize.*



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## INTRODUCTION

Agriculture is a vital part of Pakistan's economy, accounting for 23.1% of GDP and employing 43.7% of the country's workforce. Agriculture is particularly important for Pakistan's economic development since it provides raw materials to the industrial sector. Wheat, maize, rice, and sugarcane, among other main food crops, account for around 25.6 percent of Pakistan's value addition and 5.4% of its GDP. (Pakistan Economic Survey 2013-14). Maize is a nutritionally dense food when compared to all other food crops. In 2013-14, maize provided 2.1 % to agriculture's value added and 0.4 percent to Pakistan's GDP. Wheat is also Pakistan's most important food crop, accounting for 10.3% of the value contributed in agriculture and 2.2% of GDP. Sugarcane, on the other hand, is one of Pakistan's most important and valuable cash crops. It is critical for the manufacturing of sugar. In the 2013-14 fiscal year, sugarcane contributed 3.4% to agriculture value addition and 0.7% to GDP. Rice is also an important food and economic crop in Pakistan, as it is among the food crops. It is Pakistan's second most significant food crop, behind wheat. Rice is also an important food and economic crop in Pakistan, as it is among the food crops. After wheat, it is Pakistan's second most significant food grain, as well as the country's second-largest source of foreign exchange earnings after cotton. It accounts for 3.1% of the value added in agriculture and 0.7% of Pakistan's GDP. (Pakistan Economic Survey, 2013-14)

Nature has blessed the province of Khyber Pakhtunkhwa with enormous potential for developing food crops, as well as relatively acceptable soil, pleasant weather conditions, and a plentiful supply of farm workers. Food crops are important in developing nations like Pakistan because they provide food security while also conserving scarce foreign cash that would otherwise be spent on wheat and rice imports. In Khyber Pakhtunkhwa, cost-effective variables such as sources of revenue, labour force employment and investments, marketing initiatives, consumption pattern, pluses and returns are the most widely linked. There are diverse pre and post reap procedures implicated in food crop production, which hold cost-effective importance. To obtain highest yields from diverse varieties of food crops, Introduction of advanced practices are profitable. The overall area of Khyber Pakhtunkhwa is 8452299 hectares, with an area under cultivation of 1880985 hectares, a cultivated area of 1834835 hectares, an uncultivated area of 6571314 hectares, culturable waste of 1253568 hectares, and a territory under forests of 1307199 hectares. (Khyber Pakhtunkhwa Crop Reporting Service, 2013-14).The overall goal of this research is to look into the growth fluctuations of the key food crops in Khyber Pakhtunkhwa. However, the study's precise aims are as follows: 1. To analyse the unstable growth of main food crops in Khyber Pakhtunkhwa over the last thirty years.2. To examine the instability of main food crops in Khyber Pakhtunkhwa over the last thirty years. 3. To make recommendations for the growth of the agricultural sector in general, and main crops in particular, based on the study's findings.

The rest of the paper is arranged in the following manner. The literature review is the second section. Data and approach are covered in the third part. The nature of the data, how it was collected, and the analytical procedures that were employed are all discussed. The fourth chapter examines the economics of food crops. The findings are presented, as well as a summary of the conversation. Findings and conclusions are presented in the fifth chapter.

## LITERATURE REVIEW

The evaluation of related material lays the groundwork for further investigation. It stresses the context of the subject of study. Furthermore, earlier research papers provide valuable information about research approaches. This chapter presents a comprehensive assessment of previous work on the examination of changing productivity of food crops.

(Mehra(1981) says that the adoption of enhanced and high-quality seeds, as well as modern technology, has increased the variability in India's overall food crops. (Hazell, 1982) highlighted that the employment of new production techniques increases volatility in global food and Indian food crop yields.(Deb et al., 1991) studied the yields instability of six food crops employing time series data from two time frames, namely (1968-69 to 1986-87) and (1968-69 to 1986-87). (1947-48 to 1967-68). Furthermore, they observed that there was instability in both relative and absolute terms, and that the drop in yield was mostly attributable to the growth of modern technologies compared with the pre technology.(Myung-Hwan, 1993) The importance of the rice crop was investigated. According to the study, the number of agriculture households farming paddy rice has decreased, but the proportion of overall agriculture households has increased. He discovered that there were a number of rice milling plants, benefits for rice stock, and rice retailers and wholesalers, all of which helped the backward districts find work. He believes that lowering production costs is critical for Korean rice to become more profitable..(Jabber et al., 1994) studied the degree of hindrance to rice production due to shrimp society, and the economic disadvantages of split use of the land resources. Estimation in increasing rice and shrimp together was recommended, with the convention of better varieties of rice is helpful to constant production and growers' profit in the area. (Santha, 1993) In 1992, researchers looked into the relevance of rice farming in India. In three distinct seasons, he examined the cost of production, the utilization of inputs, and the significance of rice production. The crops are virrupu, mundakan, and punja. Rice was primarily farmed as a crop during the Mundkudan season and as a sown crop during the rest of the year. In terms of benefit price tag ratio and cost of production, he decided that farming during the Mundakan season was by far the most suited and profitable.(Pandey, 1998) In order to increase rice output and producers' revenue, it is necessary to improve strategy and institutional expansion, according to the authors. In the most difficult irrigated areas, where scientific fertilizer use was formerly high, efficiency was advised as a means of achieving high yields and productivity.(Wasim, 2001) Another study discovered that the efficiency of Sindh's food production in the second stage is higher than the efficiency of food grains in the first stage. (Wasim, 1999) studied the yield in fluctuations of Pakistan's primary food grains using secondary data from Pakistan over two separate time periods, 1971-1985 and 1985-1998. He noticed that yields have been very volatile in recent years. Due to the increased usage of contemporary technologies such as High Yielding Varieties in majority of Sindh's crops.

## METHODOLOGY

### Data Nature and Sources

The research is conducted utilizing time series data during 1984 to 2014, a period of 30 years, to discover the optimum growth model among the models tested for determining the actual growth and corresponding instability of important food crops in Khyber Pakhtunkhwa. Secondary sources for data on key food crops include "Crop Statistics," Crop Reporting Service (CRS), Khyber Pakhtunkhwa, Peshawar, Pakistan.

## Empirical Model

To begin, stationarity in time series data for Khyber Pakhtunkhwa's primary food crops must be checked. The augmented dickey fuller (ADF) test is employed for stationarity. Furthermore, the statistical packages SPSS version 22 and Gretl are utilized to detect growth and instability in important food crops.

**STATIONARITY TEST:**

First, it can be determined whether data is stationary or not in the current investigation. There are several tests that can be performed for stationary. Because of its simplicity and power, the Augmented – Dickey Fuller (1981) test is the most widely used in literature. ADF can be stated mathematically as follows given a time series variable "Y":

$$(\Delta Y)_{t.} = \alpha_0 + (\beta Y)_{t-i} + \alpha_1 t + \sum_{i=1}^{p} \beta\, i(\Delta Y)_{i-1} + \varepsilon_i$$

Where • "$\alpha_o$ " is model's intercept

• "t" is the time trend in time series.

The following growth models were used to discover the optimal growth model for main food crops in Khyber Pakhtunkhwa. The best model is chosen using the "$R^2$" and "best fitting trend line" criteria. The following are the models' descriptions.

**Models:**

1. **Linear Model**

$(Y)_t = \beta_0 + \beta_1 t + e_t$……………. **(1)**

**ii. Quadratic Model**

$(Y)_t = \beta_0 + \beta_1 t + \beta_2 t^2 + e_t$……….**(2)**

**iii. Exponential Growth Model**

$(Y)_t = \beta_0 * \beta 1^t + e_t$………………. **(3)**

**iv. Cubic Model**

$(Y)_t = \beta_0 + \beta_1 * t + \beta_2 * t^2 + \beta_3 * t^3 + e_t$………… **(4)**

**v. Power Model**

$$(Y)_t = \beta_0 * t^{\beta 1} + e_t \ldots\ldots\ldots\ldots\ldots (5)$$

**vi. Logarithmic Model**

$$(Y)_t = \beta_0 + \beta_1 * ln(t) + e_t \ldots\ldots\ldots\ldots (6)$$

**vii. Inverse Model**

$$(Y)_t = \beta_0 + \frac{\beta_1}{t} + e_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

**viii. Compound Growth Model**

$$(Y)_t = \beta_0 * {\beta_1}^t + e_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

**ix. Growth Model**

$$(Y)_t = e^{(\beta_0 + \beta_1 * t)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

**x. S-curve**

$$(Y)_t = e^{(\beta_0 + \beta_1 / t)} + e_t + \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

**xi. Logistic Model**

$$(Y)_t = 1/(\frac{1}{u} + \left(\beta_0 * {\beta_1}^t\right) + e_t \ldots\ldots\ldots\ldots\ldots (11)$$

Where "$(Y)_t$" =Output at period "t",

"t" = Time index,

"$\beta_0$" = Intercept,

"$\beta_1$", "$\beta_2$" and "$\beta_3$"=Annual change in production,

"$e_t$"=Error term.

The Cuddy Della Valle Index is used to determine the stability of important food crops in Khyber Pakhtunkhwa.

## Instability Analysis

In developing industries, such as agricultural output, instability is one of the most crucial choice characteristics. The wide variety in crop output not only causes dramatic fluctuations, but it also causes wide variations in farmer income. The size of the changes is determined by the current state of technology, the economic climate, weather sensitivity, material input fluctuation, and a variety of other factors. The Cuddy-Della Valle Index is being used to investigate the level of variability in the growth of major food crops. In practice, the Cuddy-Della Valle index normalizes the coefficient of variation of connected time series data, whilst the CV measures the level of volatility in time series data characterized by a long-term trend. The Cuddy-Della Valle index (I) is used to measure the relative instability of major fruit crop yields.

$$I=\sqrt{1-AdR^2}$$

Where I=Instability Index (in percent), CV=Coefficient of Variation (in percent)

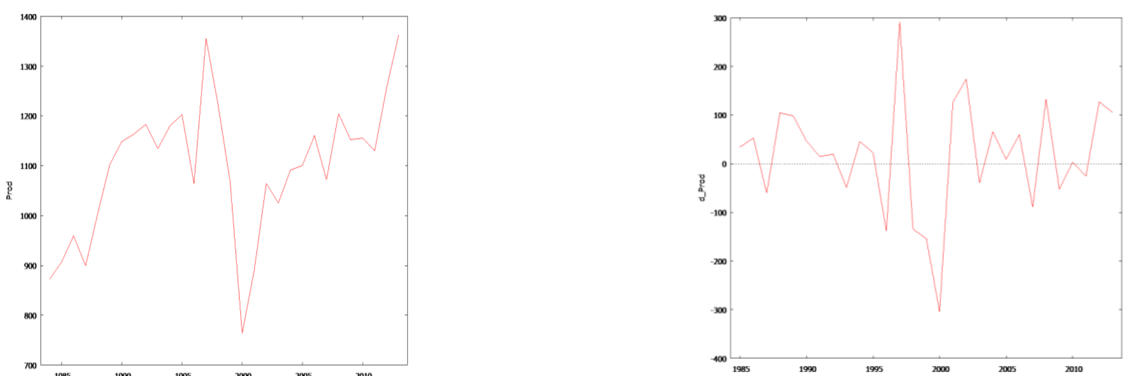
AdR=Coefficient of Determination from Time Trend Regression modified by the number of degrees of freedom.

## RESULTS AND DISCUSSIONS

The growth and fluctuation of major food crop production in Pakistan's Khyber Pakhtunkhwa province. Data on foremost food crop's output has been used to determine the most appropriate model among the tested subgroup models. The most suitable model was used to calculate the growth rate and variability of each key food crop. The following sections provide more information.

### Wheat Crop:

The stationarity of wheat output must first be validated. It's crucial to figure out which order difference in the wheat production time series sequence meets the stationarity condition. It is checked both theoretically and graphically using the Dickey bigger unit root test and plotting time series of wheat production, as shown in Figure-4.1.




***Original series of Wheat production*** ***I<sup>st</sup> Order differenced series of Wheat production***

**Figure 4.1: Graphically Stationarity Checking of Wheat Production**

From Table-4.1, it is evident that there is unit root in the original series of Wheat output, while at first order difference it show stationarity.

**Table-4.1. ADF test for Wheat Crop**

| **Lag Length** | **Level of Sig:** | **Unit root** | **P-Values** |
|---|---|---|---|
| Original | α = 0.05 | a =1 | 0.1512 |
| Ist Difference | α = 0.05 | a =1 | 0.000044 |

By first differencing, it is discovered that the stationarity criterion is met with a p-value of 0.000044, indicating that there is no unit root at the first order difference in wheat production at the 5% level of significance. Figures 4.2 and 4.3 exhibit the graphical stationarity test of ACF and PACF plots, respectively. The original wheat production series, as shown in Figure-4.2, does not have constant variance, however the first order differenced series, as shown in Figure-4.3, has more stable variance than the original series. Also, the ACF and PACF plots reveal that the ACF plot has some notable spikes, showing the presence of a moving average effect in the original series, indicating that the series is not stationary. Accordingly, there have been no significant spikes in the ACF and PACF plots of first order differenced series, indicating that the series is stationary at first order differenced series, which depicts stable variance and also indicates there were no lasting impacts of Autoregressive moving average of differencing series of order one. Also, from the graphical representation of wheat production, it is evident that at first order difference, the series become stationary.

**Table 4.2: Model Summary and Parameter Estimates**

<table>
<tr><th rowspan="2">Equation</th><th colspan="5">Model Summary</th><th colspan="4">Parameter Estimates</th></tr>
<tr><th>R Square</th><th>F</th><th>df1</th><th>df2</th><th>Sig.</th><th>Constant</th><th>b1</th><th>b2</th><th>b3</th></tr>
<tr><td>Linear</td><td>0.192</td><td>6.67</td><td>1</td><td>28</td><td>0.015</td><td>989.972</td><td>6.876</td><td></td><td rowspan="11">0.151</td></tr>
<tr><td>Logarithmic</td><td>0.251</td><td>9.369</td><td>1</td><td>28</td><td>0.005</td><td>894.331</td><td>81.259</td><td></td></tr>
<tr><td>Inverse</td><td>0.235</td><td>8.592</td><td>1</td><td>28</td><td>0.007</td><td>1142.697</td><td>-346.515</td><td></td></tr>
<tr><td>Quadratic</td><td>0.194</td><td>3.25</td><td>2</td><td>27</td><td>0.054</td><td>976.362</td><td>9.428</td><td>-0.082</td></tr>
<tr><td>Cubic</td><td>0.511</td><td>9.07</td><td>3</td><td>26</td><td>0</td><td>729.239</td><td>97.917</td><td>-7.103</td></tr>
<tr><td>Compound</td><td>0.184</td><td>6.327</td><td>1</td><td>28</td><td>0.018</td><td>984.863</td><td>1.006</td><td></td></tr>
<tr><td>Power</td><td>0.247</td><td>9.172</td><td>1</td><td>28</td><td>0.005</td><td>898.579</td><td>0.077</td><td></td></tr>
<tr><td>S</td><td>0.239</td><td>8.815</td><td>1</td><td>28</td><td>0.006</td><td>7.036</td><td>-0.333</td><td></td></tr>
<tr><td>Growth</td><td>0.184</td><td>6.327</td><td>1</td><td>28</td><td>0.018</td><td>6.893</td><td>0.006</td><td></td></tr>
<tr><td>Exponential</td><td>0.184</td><td>6.327</td><td>1</td><td>28</td><td>0.018</td><td>984.863</td><td>0.006</td><td></td></tr>
<tr><td>Logistic</td><td>0.184</td><td>6.327</td><td>1</td><td>28</td><td>0.018</td><td>0.001</td><td>0.994</td><td></td></tr>
</table>

**Maize Crop:**

Determining the data's stationarity for maize output is crucial. The stationarity criterion was used to identify which order difference of the maize production time series sequence satisfies it. The Dickey larger unit root test and charting time series of maize production demonstrate it both theoretically and graphically, as illustrated in Figure-4.5 below. FromTable-4.3, the dickey fuller test satisfy stationarity condition at original maize production series as there is no unit root in the data series.

**Table-4.3. ADF test for Maize Crop**

| **Lag Length** | **Level of Sig:** | **Unit root** | **P-Values** |
|---|---|---|---|
| Original | $\alpha = 0.05$ | a =1 | 0.002894 |

Furthermore, the ACF and PACF plotting reveal no significant spikes, indicating that the original series has really no auto regressive or moving average effect, signaling that the series is stationary. The trend analysis process is used to verify the best fitted trend model for maize production. The best suited model among the trend models is selected using the R2 criterion and fitted trend curves, and the power growth trend is the best fitted curve, as seen in Table 4.4 and Figure 4.7.

**Table 4.4 Model Summary and Parameter Estimates of Maize Production**

| Equation | Model Summary | | | | | Parameter Estimates | | | |
|---|---|---|---|---|---|---|---|---|---|
| | R Square | F | df1 | df2 | Sig. | Constant | b1 | b2 | b3 |
| Linear | 0.553 | 34.692 | 1 | 28 | 0 | 673.195 | 8.226 | | |
| Logarithmic | 0.744 | 81.401 | 1 | 28 | 0 | 554.971 | 98.742 | | |
| Inverse | 0.617 | 45.053 | 1 | 28 | 0 | 853.451 | -396.129 | | |
| Quadratic | 0.743 | 39.039 | 2 | 27 | 0 | 570.169 | 27.544 | -0.623 | |
| Cubic | 0.768 | 28.731 | 3 | 26 | 0 | 521.035 | 45.137 | -2.019 | |
| Compound | 0.543 | 33.276 | 1 | 28 | 0 | 671.271 | 1.011 | | |
| Power | 0.772 | 95.033 | 1 | 28 | 0 | 568.868 | 0.134 | | |
| S | 0.686 | 61.147 | 1 | 28 | 0 | 6.752 | -0.557 | | 0.03 |
| Growth | 0.543 | 33.276 | 1 | 28 | 0 | 6.509 | 0.011 | | |
| Exponential | 0.543 | 33.276 | 1 | 28 | 0 | 671.271 | 0.011 | | |
| Logistic | 0.543 | 33.276 | 1 | 28 | 0 | 0.001 | 0.989 | | |

**Sugarcane Crop:**

It can be checked using the Dickey fuller unit root test and visualizing time series of Sugarcane Production. There are big spikes in the ACF plotting, as shown in Figure-4.8, shows the presence of a moving average effect in the original Sugarcane yield and also indicating that the series does have a unit root.

From the Table-4.5, it is evident that ADF test the sugarcane production series satisfies unit root test at first order difference and hence stationarity condition issatisfied.

### Table-4.5. ADF test for Sugarcane Crop

| **Lag Length** | **Level of Sig:** | **Unit root** | **P-Values** |
|---|---|---|---|
| Original | α = 0.05 | a =1 | 0.3375 |
| Ist Difference | α = 0.05 | a =1 | 0.01388 |

Figure-4.9, the original Sugarcane production series shows non-stationarity because the ACFand PACF Plots does not indicate constant variance over time. Now, the ACF and PACF plots of the first order differenced sugarcane production series in Figure-4.10 show that there is also a unit root and that the variance is not constant, with no major spikes. According to the dickey fuller unit root test, the stationarity requirement is satisfied at first order difference, with a p-value of 0.01388 at the 5% level of significance, strongly implying that no unit exists at first order difference. To verify the best fitted trend model for sugarcane yield, the trend analysis is used. On the basis of R2 criteria and fitted trend curve, the cubic trend curves the best matched curve, as shown in Table 4.6 and Figure 4.11.

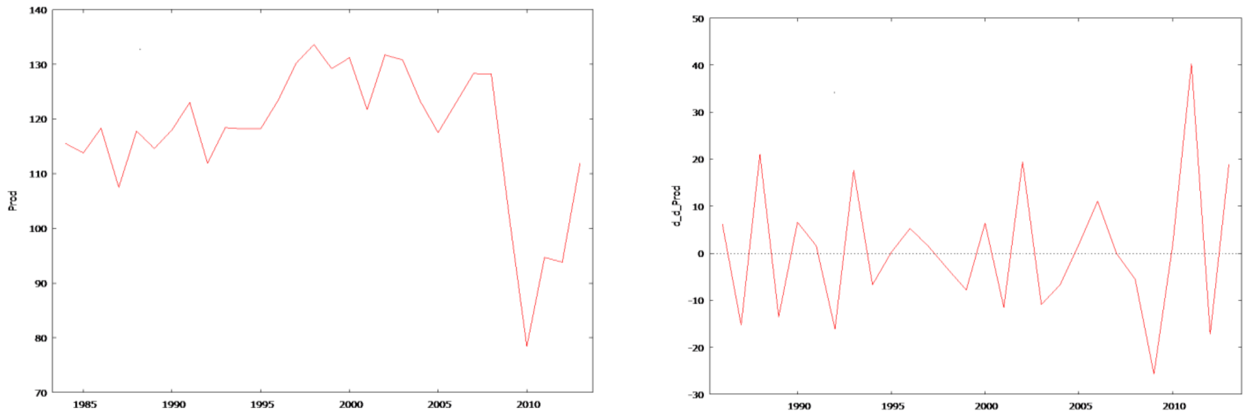
**Table 4.6: - Model Summary and Parameter Estimates of Sugarcane Production**

| Equation | Model Summary | | | | | Parameter Estimates | | | |
|---|---|---|---|---|---|---|---|---|---|
| | R Square | F | df1 | df2 | Sig. | Constant | b1 | b2 | b3 |
| Linear | 0.353 | 15.262 | 1 | 28 | 0.001 | 4095.121 | 28.219 | | |
| Logarithmic | 0.56 | 35.611 | 1 | 28 | 0 | 3616.759 | 367.977 | | |
| Inverse | 0.485 | 26.334 | 1 | 28 | 0 | 4733.425 | -1508.75 | | |
| Quadratic | 0.591 | 19.467 | 2 | 27 | 0 | 3599.58 | 121.132 | -2.997 | |
| Cubic | 0.716 | 21.801 | 3 | 26 | 0 | 3129.472 | 289.467 | -16.353 | |
| Compound | 0.352 | 15.211 | 1 | 28 | 0.001 | 4077.031 | 1.007 | | |
| Power | 0.575 | 37.882 | 1 | 28 | 0 | 3637.385 | 0.087 | | |
| S | 0.509 | 29.011 | 1 | 28 | 0 | 8.462 | -0.359 | | 0.287 |
| Growth | 0.352 | 15.211 | 1 | 28 | 0.001 | 8.313 | 0.007 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Exponential | 0.352 | 15.211 | 1 | 28 | 0.001 | 4077.031 | 0.007 | | |
| Logistic | 0.352 | 15.211 | 1 | 28 | 0.001 | 0 | 0.993 | | |

## Rice Crop:

To begin, examine the stationarity condition using the Dickey Fuller test unit root test, which compares the original and differenced series to see if the stationarity requirement is satisfied. For the sake of simplicity, the first order difference series (which does not satisfy the stationary condition) and second order difference series (which does satisfy the stationary condition) for rice production are illustrated in Figure-4.12.




***Original series of Rice production*** ***second Order differenced series of Rice production***

**Figure 4.12*: Graphically Stationarity Checking of Rice Production***

From the Table-4.7, it is clear that augmented Dickey fuller unit root test satisfies stationarity condition at second order difference.

**Table-4.7. Augmented Dickey Fuller Unit Root test for Rice Crop**

| **Lag Length** | **Level of Sig:** | **Unit root** | **P-Values** |
|---|---|---|---|
| Original | α = 0.05 | a =1 | 0.7104 |
| Ist order Diff: | α = 0.05 | a =1 | 0.9722 |
| $2^{nd}$order Diff: | α = 0.05 | a =1 | 0.0436 |

The ACF and PACF figures are displayed in Figure-4.13 and Figure-4.14, respectively, as a result of the formal test of the Augmented Dickey Fuller unit root and the graphical stationarity test. According to the Dickey Fuller test, the stationarity requirement is met at difference order two with a p-value of 0.0436, indicating that there is no unit root at the second order difference in rice production at the 5% level of significance.

The fitted model trend model for sugarcane yield is evaluated using the trend analysis technique. Based on R2 criteria and fitted trend curve, the cubic trend curve is demonstrated is the best matched curve in Table 4.8 and Figure 4.16 below.

**Table 4.8: -Model Summary and Parameter Estimates of Rice Production**

| Equation | Model Summary | | | | | Parameter Estimates | | | |
|---|---|---|---|---|---|---|---|---|---|
| | R Square | F | df1 | df2 | Sig. | Constant | b1 | b2 | b3 |
| Linear | .053 | 1.574 | 1 | 28 | .220 | 122.689 | -.327 | | |
| Logarithmic | .003 | .070 | 1 | 28 | .793 | 119.442 | -.735 | | |
| Inverse | .002 | .068 | 1 | 28 | .796 | 118.039 | -3.193 | | |
| Quadratic | .459 | 11.471 | 2 | 27 | .000 | 103.334 | 3.302 | -.117 | |
| Cubic | .524 | 9.523 | 3 | 26 | .000 | 113.397 | -.302 | .169 | -.006 |
| Compound | .070 | 2.107 | 1 | 28 | .158 | 123.398 | .997 | | |
| Power | .008 | .213 | 1 | 28 | .648 | 120.402 | -.012 | | |
| S | .000 | .013 | 1 | 28 | .910 | 4.763 | -.013 | | |
| Growth | .070 | 2.107 | 1 | 28 | .158 | 4.815 | -.003 | | |
| Exponential | .070 | 2.107 | 1 | 28 | .158 | 123.398 | -.003 | | |
| Logistic | .070 | 2.107 | 1 | 28 | .158 | .008 | 1.003 | | |

Table 4.9 depicts the increase and inconsistency in the production of valuable crops in Khyber Pakhtunkhwa to provide a better understanding of the province's growth and instability.

**Table 4.9: - Growth and Variability of major food crops of Khyber Pakhtunkhwa**

| Food Crop | CV (%) | AdR$^2$ | Variability Index $(I) = CV * \sqrt{1 - AdR^2}$ | Growth (%) |
|---|---|---|---|---|
| **Wheat** | 12.586 | 0.985383 | 1.53 | 10.96558 (3.64e-028)* |
| **Maize** | 12.158 | 0.989827 | 1.23 | 8.002201 (1.89e-030)* |
| **Sugarcane** | 9.2278 | 0.997722 | 0.44 | 45.30842 (7.10e-040)* |
| **Rice** | 10.626 | 0.994462 | 0.79 | 1.187342 |

| | | | | |
|---|---|---|---|---|
| | | | | (2.80e-034)* |

***"*" represents significant p-values of the corresponding t-ratios at 5% level of significance***

Using the SPSS Package, the trend analysis procedure is used for checking the best fitted trend model for output sugarcane. The best fitted model is selected on the basis of R2 criteria and fitted trend curve among the trend models. The cubic trend plot is proven to be the dominant fitted graph as shown in Table, 4.8 and Figure, 4.16 below.

For the years 1984-85 to 2013-14, the growth and variability in production of important food crops are estimated. Sugarcane has the largest growth rate of production, 45.31 percent, with the lowest instability among the food crops, 0.44, according to Table-4.5, followed by wheat, which has a growth rate of production of 10.97 percent and relative variability of 1.53. Similarly, maize crop growth rate is estimated to be 8% with a 1.23 variability index, while rice crop growth rate is estimated to be 1.19 percent with a 0.79 variability index.

Furthermore, Farming of food crops can create robust growth, and fluctuations in production growth rates can be influenced by a range of reasons including unpredictable agricultural water resources, price behaviour of competing crops. A sufficient and large increase in production, accompanied by a low degree of unpredictability, for any food crop that may be required for agriculture's long-term viability, as opposed to a high increase in production and a high level of variability. Furthermore, due to the high degree of instability index, the farmer's income is highly volatile, and the variations in production are primarily due to the combined consequence of changes in crop area and crop productivity. The mentioned growth figures, as well as the trend, suggest that production is increasing in relation to the time index.

## RESULTS

The purpose of this study was to look into the varying productivity of main food crops in Khyber Pakhtunkhwa. The ADF test was used to verify stationarity of the major food crops, as well as growth models to find the best model for the major food crops among the subset models. The growth and variability (as measured by the Cuddy-Della Valle Index) of major food crops were also investigated. The following results were revealed: 1. Wheat production data was determined to be stationarity at first order difference utilizing the ADF unit root test among the major food crops. The all-possible growth models were used. Among the subset models, the cubic growth model had a higher value of Coefficient of Determination i.e., "R2" i.e., 0.511, and the production growth rate was recorded to be 10.97 percent. Furthermore, the variability of wheat crop yield was calculated to be 1.53. 2. The initial data series in maize crop production demonstrated stationarity. To choose the optimum subset model, growth models were used. The power growth model was chosen as the best fitted model, with a coefficient of determination of 0.772 and a growth rate of production for maize crop of 8.0023 percent, according to the studied results. Moreover, using the Cuddy Della Vella index, the maize crop's variability was calculated to be 1.23. 3. Using the augmented dickey fuller test of unit root to analyse sugarcane crop production, it is obvious that the data follows stationarity at first order difference. To fit the best model among the subgroup models, all potential growth models were used. The cubic growth model with the highest coefficient value has been discovered. The cubic growth model was observed to have the largest coefficient of variation, i.e., "R2" equals 0.716, and the production growth rate was predicted to be 45.31 percent. Furthermore, the equivalent food crop's Variability Index was found to be 0.44. Using the augmented dickey fuller test of unit root, the examined data series of rice crop production exhibited stationarity at second order difference. The cubic growth model with coefficient of determination "R2" equal to 0.524 was discovered among the subset models, and the growth rate of production was computed to be 1.19 percent. In addition, the variability index was found to be 0.79.

## CONCLUSION

It can be stated from the study's examined data and findings that the output of each main food crop, such as wheat, maize, sugarcane, and rice, follows a rising pattern over time. When compared to other major food crops with the least measure of variability, the sugarcane crop's growth rate was much higher. Furthermore, rice crop production had the lowest increase rate of production, while wheat crop production had the highest measure of variability. It's worth noting that the increased growth rate could be attributable to increased area, the use of high-quality seed, advanced new technology, new production processes with higher-quality fertilizers, and favourable environmental circumstances. As a result, it is largely agreed upon. As a result, all main food crops are thought to have increased growth and variability patterns. The utilization of high-quality seeds, the cultivation of additional area, and improved modern technology are all factors.

### Policy Recommendations

The following suggestions are given founded on the study findings:

1. The authorities should make a concerted effort to bring more land into food yielding farming in order to increase food crop production.
2. Growers should always be made aware of the importance of producing better varieties rather than standard types. Growers must plant the most beneficial food crop varieties in accordance with the province's climatic conditions.
3. The growers only utilize suggested seeds that are vigorous, resistant to disease, and standard.
4. A fertilizer application schedule that is well-timed and unbiased should be followed.
5. Pest spoils should be reduced to acceptable levels using a logical and well-timed combination of strategies, such as the employment of natural enemies, the enhancement of difficult crop varieties, pest habitat adaptations, and, where necessary, the use of insecticides.
6. Proper storage services for food crop growers should be made available. Furthermore, storage foundations and their surroundings should be meticulously patented in order to provide high-quality output to markets.
7. Farm research stations must work together to solve difficulties faced by farmers. It should improve the relationship with the farmers. It needs to figure out why production is poor and how to improve current practices. It should also hold workshops and seminars to inform farmers about farm developments. It should be able to function without the help of the government.
8. In the research region, a multi-cropping system should be established to exploit the holdings and increase food grain production, as well as sell them in lethal marketplaces.

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